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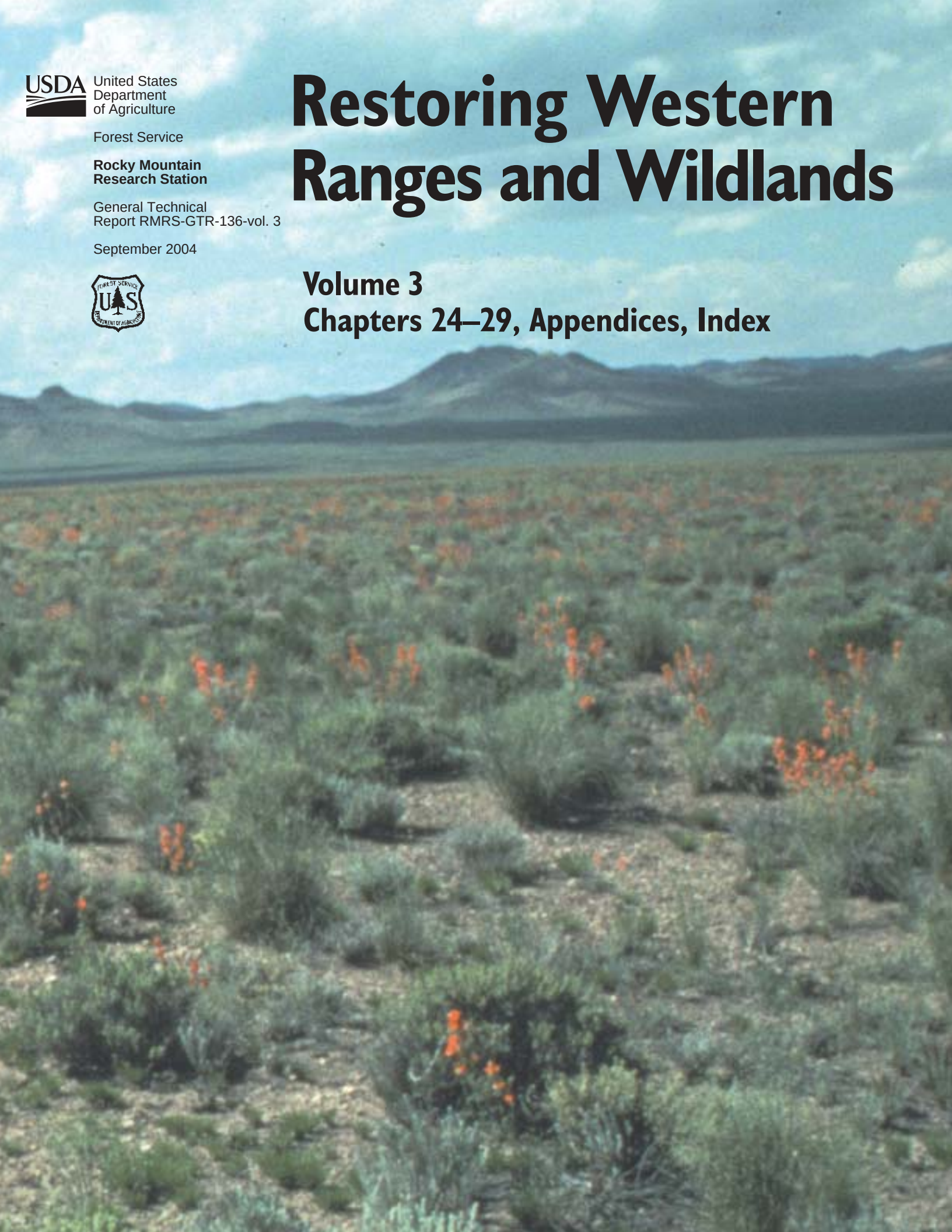
Restoring Western Ranges and Wildlands

Volume 3
Chapters 24–29, Appendices, Index



Abstract

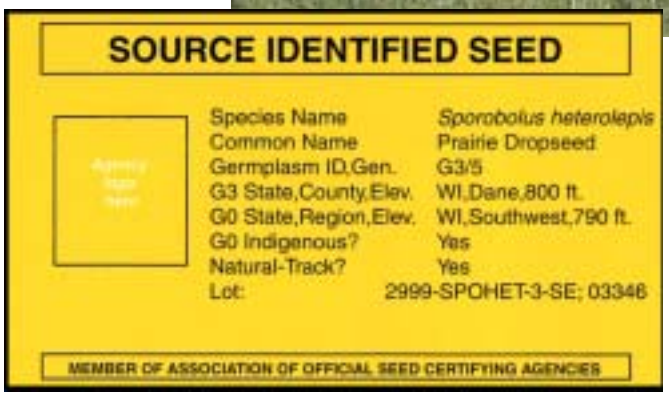
Monsen, Stephen B.; Stevens, Richard; Shaw, Nancy L., comps. 2004. **Restoring western ranges and wildlands**. Gen. Tech. Rep. RMRS-GTR-136-vol-3. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. Pages 699–884 plus appendices and index.

This work, in three volumes, provides background on philosophy, processes, plant materials selection, site preparation, and seed and seeding equipment for revegetating disturbed rangelands, emphasizing use of native species. The 29 chapters include guidelines for planning, conducting, and managing, and contain a compilation of rangeland revegetation research conducted over the last several decades to aid practitioners in reestablishing healthy communities and curbing the spread of invasive species. Volume 3 contains chapters 24-29 plus appendices and index.

Keywords: rehabilitation, revegetation, plant ecology, seed, plant communities, wildlife habitat, invasive species, equipment, plant materials, native plants

A

B



A—Hand-harvesting grass seed.

B—Certification tag.

C—Native plant propagation in greenhouse.

D—Brush machine.

E—Flail-vac harvesting needle-and thread grass.

Restoring Western Ranges and Wildlands

Compilers

Stephen B. Monsen
Richard Stevens
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Volume 3
Chapters 24–29, Appendices, Index

C

D

E

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Contents

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Chapter 24

Seed Collection, Cleaning, and Storage

Seed Collection

Acquisition of quality seed in the quantity needed is essential for successful restoration and revegetation programs. Seed is grown and harvested as a crop, or collected from native stands. In the past, when native species were seeded, it was either collect the seed yourself, or go without. Now, there are dealers who supply seed of many native species on a regular basis. Some seed companies will contract for collection of specific species.

There are many grass and forb species that are cultivated for seed. Some of the more common species are: bluebunch wheatgrass, crested and desert wheatgrass, pubescent wheatgrass, intermediate wheatgrass, Russian wildrye, smooth brome, orchardgrass, Indian ricegrass, alfalfa, arrowleaf balsamroot, small burnet, Palmer penstemon, Rocky Mountain penstemon, Lewis flax, cicer milkvetch, crownvetch, Utah sweetvetch, and sainfoin. Seed of a few shrubs, including mountain and Wyoming big sagebrush, fourwing saltbush, and antelope bitterbrush are sometimes produced in orchards. Seed of many shrubs and forbs, and a few grass species are available only from native stands (table 1).

Table 1—Selected seed characteristics, seed collection, and seed cleaning requirements for important Intermountain grasses, forbs, and shrubs.

Species	Acceptable percent		Germination rating[b]	Seed per lb at 100 percent purity	Seed maturity month/day	Seed collection method[c]	Seed cleaning equipment[d]	Reproductive structure harvested	Reproductive structure seeded	Storage time[e]	After-ripening[f]	Stratification[f]
	Purity[a]	Germination[a]										
Grasses												
Barley, bulbous	90	60	3	40,770	7/1-8/15	1-2-5	6-1-3	Spikelet	Floret	2	N	N
Bentgrass, red	90	90	2	4,851,200	7/15-9/15	1-2-4	6-2-9	Floret	Floret	2	U	U
Bluegrass, big	90	70	3	843,000	7/1-8/15	1-4-5	6-2-4	Floret	Floret	4	U	U
Bluegrass, Canada	90	80	3	1,998,240	8/1-9/30	1-4-5	6-2-4	Floret	Floret	2	Y,0,1	Y,1-2,0
Bluegrass, Sandberg	95	85	2	925,000	6/15-7/30	1-4-5	6-2-4	Floret	Floret	2	Y,0,1	Y,1-2,0
Brome, meadow	90	85	1	118,745	7/15-8/30	1-2-4-5	6-2-4	Floret	Floret less awn	2	Y,0,1	Y,1-2,0
Brome, mountain	95	90	1	60,475	8/1-9/15	1-2-4-5	6-2-4	Floret	Floret less awn	4	Y,0,1	Y,0,1
Brome, smooth	95	90	1	135,600	7/20-9/30	1-4-5	6-2-4	Floret	Floret	4	Y,0,1	Y,1-2,0
Brome, subalpine	90	80	2	120,640	8/1-9/15	1-2-4-5	6-2-4	Floret	Floret	3	Y,0,1	Y,0,1
Dropseed, sand	90	80	3	5,600,000	9/1-10/30	1-4-5	6-2-4	Grain	Grain	3	Y,0,1	Y,4,0
Fescue, desert	95	85	2	162,000	7/20-9/30	1-4-5	6-2-4	Floret	Floret	2	U	U
Fescue, hard sheep	95	85	2	633,520	7/10-8/30	1-4-5	6-2-4	Floret	Floret less awn	2	Y,0,1	Y,2-4,0
Fescue, Idaho	95	85	2	497,370	7/1-8/30	1-4-5	6-2-4	Floret	Floret less awn	2	Y,0,1	Y,2-4,0
Fescue, sheep	95	85	2	680,000	7/10-8/30	1-4-5	6-2-4	Floret	Floret less awn	2	Y,0,1	Y,2-4,0
Foxtail, meadow	90	80	2	440,390	7/1-8/15	1-4	6-2-4	Spikelet	Spikelet less awns	3	Y,0,1	Y,2-4,0
Foxtail, reed	90	80	2	156,415	7/1-8/15	1-4	6-2-4	Spikelet	Spikelet less awns	3	Y,0,1	Y,0,1
Junegrass, prairie	90	80	2	4,123,635	7/10-8/30	1-4	6-2-4	Floret	Floret	2	Y,0,1	U
Needlegrass, green	90	50	3	162,450	7/15-9/30	1-4	6-2-4	Floret	Floret less awn	4	Y,0,1	Y,1-2,0
Needlegrass, Letterman	90	50	3	206,180	8/1-10/15	1-4	6-2-4	Floret	Floret less awn	4	Y,0,1	Y,1-2,0
Needlegrass, needle-and-thread	90	50	3	94,895	8/1-9/30	1-4	6-2-4	Floret	Floret less awn	4	Y,0,1	Y,1-2,0

(con.)

Table 1 (Con.)

Species	Acceptable percent		Germination rating[b]	Seed per lb at 100 percent purity	Seed maturity month/day	Seed collection method[c]	Seed cleaning equipment[d]	Reproductive structure harvested	Reproductive structure seeded	Storage time[e]	After-ripening[f]	Stratification[f]
	Purity[a]	Germination[a]										
Grasses												
Oatgrass, tall	90	80	3	189,000	8/15-9/30	1-5	6-2-4	Floret	Floret less awn	2	Y,0,1	Y,0,1
Oniongrass	90	75	3		7/1-8/30	1-4-5	6-2-4	Floret	Floret	2	U	U
Orchardgrass	90	85	3	477,200	7/20-9/15	1-4-5	6-2-4	Floret	Floret	3	Y,0,1	Y,1-2,0
Reedgrass, chee	90	70	4	574,120	7/15-8/30	1-5	6-2-4	Floret	Grain	5	U	U
Ricegrass, Indian	95	65	4	161,920	6/30-7/15	1-2-5	6-2-4	Floret	Floret less hairy lemma	5	Y,0,1	Y,0,1-2
Sacaton, alkali	90	80	3	1,750,000	8/15-10/1	1-4-5	6-2-4	Grain	Grain	3	N	N
Squirreltail, bottlebrush	90	85	2	191,555	7/15-8/15	1-2-4-5	6-2-4	Spikelet	Floret less awn	4	N	N
Sunflower, annual	90	70	2	60,000	7/15-8/30	1-2-4-5	6-2-4-5	Achene	Achene	1	U	U
Timothy	90	90	2	1,246,000	7/15-8/30	1-5	6-2-4	Spikelet	Grain or spikelet	2	Y,0,1	Y,1-2,0
Timothy, alpine	90	85	2		7/15-8/30	1-5	6-2-4	Spikelet	Grain or spikelet	2	Y,0,1	Y,0,1
Wheatgrass, bearded bluebunch	90	85	2	142,640	7/15-9/15	1-2-4-5	6-2-4	Floret	Floret less awn	4	Y,0,1	Y,0,1
Wheatgrass, beardless bluebunch	95	85	2	125,680	7/15-9/15	1-4-5	6-2-4	Floret	Floret	4	Y,0,1	Y,0,1
Wheatgrass, western	95	80	3	115,000	8/15-11/30	1-4-5	6-2-4	Floret	Floret	3	Y,0,1	Y,0,1
Wheatgrass, fairway	95	85	1	319,660	7/15-10/15	1-4-5	6-2-4	Floret	Floret	3	Y,0,1	Y,1-2,0
Wheatgrass, crested	95	85	1	192,785	8/1-10/15	1-4-5	6-2-4	Floret	Floret	3	Y,0,1	Y,1-2,0
Wheatgrass, intermediate	95	90	1	88,110	8/1-10/30	1-4-5	6-2-4	Floret	Floret	3	Y,0,1	Y,1-2,0
Wheatgrass, pubescent	95	85	1	87,000	8/15-10/15	1-4-5	6-2-4	Floret	Floret	3	Y,0,1	Y,1-2,0
Wheatgrass, Siberian	95	85	1	212,855	9/1-12/10	1-4-5	6-2-4	Floret	Floret	3	Y,0,1	Y,0,1
Wheatgrass, slender	95	85	2	133,360	8/15-10/15	1-4-5	6-2-4	Floret	Floret	3	Y,0,1	Y,0,1
Wheatgrass, streambank	90	85	1	137,830	8/15-10/30	1-4-5	6-2-4	Floret	Floret	2	Y,0,1	Y,1-2,0

(con.)

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Species	Acceptable percent		Germination rating[b]	Seed per lb at 100 percent purity	Seed maturity month/day	Seed collection method[c]	Seed cleaning equipment[d]	Reproductive structure harvested	Reproductive structure seeded	Storage time[e]	After-ripening[f]	Stratification[f]
	Purity[a]	Germination[a]										
Grasses												
Wheatgrass, tall	95	90	2	76,805	8/1-10/30	1-4-5	6-2-4	Floret	Floret	2	Y,0,1	Y,1-2,0
Wheatgrass, thickspike	95	85	1	137,000	7/25-9/30	1-4-5	6-2-4	Floret	Floret	3	Y,0,1	Y,0,1
Wildrye, Great Basin	95	85	1	130,760	8/4-9/20	1-2-5	6-2-4	Floret	Floret	4	Y,0,1	Y,1-2,0
Wildrye, mammoth	95	85	1	47,130	7/15-8/30	1-2-5	6-2-4	Floret	Floret	4	Y,0,1	Y,1-2,0
Wildrye, Russian	95	85	1	168,240	7/15-8/30	1-4-5	6-2-4	Floret	Floret	4	Y,0,1	Y,1,0
Forbs												
Alfalfa	95	85	1	213,760	9/1-10/30	1-5	6-5	Legume	Seed	5	N	N
Aster, blueleaf	40	70	3	540,000	10/1-10/30	1-2-6	6-2-4	Achene	Achene less pappus	2	Y,0,1	Y,2-4,0
Aster, Englemann	40	70	3	200,000	9/15-10/30	1-2-6	6-2-4	Achene	Achene less pappus	2	Y,0,1	Y,2-4,0
Aster, Pacific	40	70	3	2,668,235	9/15-10/30	1-2-6	6-2-4	Achene	Achene less pappus	2	Y,0,1	Y,2-4,0
Balsamroot, arrowleaf[g]	95	40	3	55,245	5/15-7/25	1-2-4	6-2-4	Achene	Achene	2	Y,0,1-3	Y,0,2-3
Balsamroot, cutleaf[g]	95	40	3	32,220	6/20-7/30	1-2-4	6-2-4	Achene	Achene	2	Y,0,1-3	Y,0,2-3
Burnet, small	95	90	1	55,115	8/1-9/30	1-5	6-4	Achene	Achene	5	Y,0,1	N
Butterweed, groundsel	50	70	3	3,489,230	7/20-10/15	1-2	6-2-4	Achene	Achene less pappus	1	Y,0,1	Y,2,0
Clover, Alsike	95	80	2	680,400	7/20-8/25	1-6	6-2-4	Legume	Seed	4	Y,0,1	N
Clover, strawberry	95	80	2	288,000	7/20-9/30	1-6	6-2-4	Legume	Seed	4	Y,0,0	N
Cowparsnip	85	25	2	44,850	8/15-9/30	1-2	6-0-4	Schizocarp	Schizocarp	1	Y,0,1	Y,0,1-3
Crownvetch	95	75	2	138,160	8/15-9/30	1-5	6-2-4-5	Legume	Seed	4	Y,0,1	Y,0,1-3
Flax, Lewis	95	85	2	278,280	7/1-9/10	1-2-4-5	6-2-4-5	Seed	Seed	3	Y,0,1-2	Y,2-4,0
Geranium, Richardson	95	60	3	65,500	8/15-9/30	1	6-4	Capsule	Seed	3	Y,0,1	Y,0,2
Geranium, sticky	95	60	3	52,550	8/15-9/30	1	6-4	Capsule	Seed	3	Y,0,1	Y,0,2
Globemallow, scarlet	90	20	4	500,000	7/5-8/5	1-2-4	6-2-4-5	Schizocarp	Seed	5	Y,0,1	Y,0,1-3
Globemallow, gooseberryleaf	90	20	4	500,660	7/10-7/30	1-2-4	6-2-4-5	Schizocarp	Seed	5	Y,0,1	Y,0,1-3

(con.)

Table 1 (Con.)

Species	Acceptable percent		Germination rating[b]	Seed per lb at 100 percent purity	Seed maturity month/day	Seed collection method[c]	Seed cleaning equipment[d]	Reproductive structure harvested	Reproductive structure seeded	Storage time[e]	After-ripening[f]	Stratification[f]
	Purity[a]	Germination[a]										
Forbs												
Goldeneye, Nevada	50	40	3	1,000,000	8/1-9/15	1-4	6-2-4	Achene	Achene	2	Y,0,1	U
Goldeneye, showy	50	40	3	1,054,885	8/20-9/20	1-4	6-2-4	Achene	Achene	2	Y,0,1	Y,0,1
Goldenrod, Canada	50	70	3	770,000	10/1-12/15	1-2	6-2-4	Achene	Achene less pappus	1	Y,0,1	Y,0,1
Helianthella, oneflower	60	75	2	52,560	8/15-9/20	1-5	6-4	Achene	Achene	2	Y,0,1	Y,2-4,0
Kochia, Belvedere	85	85	1	745,890	9/1-11/5	1-2	6-2-4	Bracked utricle	Bracked utricle	1	Y,0,1	N
Ligusticum, Porter	90	40	3	69,275	7/25-8/20	1-2	6-4	Schizocarp	Schizocarp	2	Y,0,1	Y,0,1-3
Lomatium, nineleaf	75	70	3	42,225	7/1-8/15	1-2	6-4	Schizocarp	Schizocarp	2	Y,0,1	Y,0,1
Lomatium, Nuttall	75	70	3		7/1-8/15	1-2	6-4	Schizocarp	Schizocarp	2	Y,0,1	Y,0,1
Lupine, mountain	95	90	1	12,530	7/25-8/30	1-4	6-4	Legume	Seed	5	Y,0,1	Y,0,1
Lupine, silky	95	90	1	12,915	7/15-8/10	1-4	6-4	Legume	Seed	5	Y,0,1	Y,2-4,0
Lupine, silvery	95	90	1		7/25-9/15	1-4	6-4	Legume	Seed	5	Y,0,1	Y,2-4,0
Milkvetch, Canada[h]	95	85	2		8/10-11/15	1-5	6-2-4	Legume	Seed	5	Y,0,1-3	Y,0,1
Milkvetch, cicer[h]	95	85	2	113,715	8/10-4/1	1-5	6-2-4-5	Legume	Seed	5	Y,0,1-3	Y,0,1
Penstemon, Eaton	95	70	3	351,085	7/1-8/30	1-2	6-2-4-5	Capsule	Seed	3	Y,0,1	N
Penstemon, low	95	70	3		9/1-11/15	1-2	6-2-4-5	Capsule	Seed	3	Y,0,1	Y,2-4,0
Penstemon, Palmer	95	80	3	609,675	10/1-1/15	1-2	6-2-4-5	Capsule	Seed	3	Y,0,1-3	N
Penstemon, thickleaf	95	70	3	336,000	8/1-8/30	1-2	6-2-4-5	Capsule	Seed	3	Y,0,1-3	N
Penstemon, Wasatch	95	70	3	234,785	8/1-9/10	1-2	6-2-4-5	Capsule	Seed	3	Y,0,1-3	Y,2-4,0
Sage, Louisiana	10	80	1	2,504,400	10/5-12/15	1-2-4-5	6-2-4	Achene	Achene	2	Y,0,1	Y,2-4,0
Sainfoin	95	90	1	26,305	8/1-9/30	1-2-5	6-2-4	Loment	Loment	4	Y,0,1	N
Salsify, vegetable-oyster	85	65	2	306,695	7/1-7/25	2-5	6-2-4	Achene	Achene less pappus	2	Y,0,1	Y,2-4,0

(con.)

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Species	Acceptable percent		Germination rating[b]	Seed per lb at 100 percent purity	Seed maturity month/day	Seed collection method[c]	Seed cleaning equipment[d]	Reproductive structure harvested	Reproductive structure seeded	Storage time[e]	After-ripening[f]	Stratification[f]
	Purity[a]	Germination[a]										
Forbs												
Sweetanise	95	60	3	29,845	8/10-9/10	1-2-5	6-4	Schizocarp	Schizocarp	2	Y,0,1	Y,0,1
Sweetclover, yellow	95	85	1	258,560	9/1-10/30	1-2-5	6-4	Legume	Seed	5	N	N
Sweetvetch, Utah[h]	90	60	3	33,585	7/5-8/10	1-2-4-5	6-2-4	Loment	Seed	2	Y,0,1	Y,2-4,0
Yarrow, western	50	80	1	4,123,635	8/10-11/30	1-2-5	6-2-4	Achene	Achene	2	Y,0,1	Y,2,0
Shrubs												
Apache plume	80	75	3	546,500	7/15-9/30	2-6	2-4	Achene	Achene less style	1	N	N
Ash, single leaf	90	40	3	20,350	7/15-9/10	1-2	2-4	Samara	Samara	1	Y,0,1-3	Y,0,1-2
Barberry, creeping	95	85	3	71,120	8/5-9/10	1	3-6-4	Berry	Seed	5	Y,0,1-3	Y,0,3
Barberry, Fremont	95	85	3	41,770	7/15-8/20	1	3-6-4	Achene	Seed	5	Y,0,1	U
Bitterbrush, antelope	95	90	1	15,370	6/15-7/20	2	4-2-4-5	Achene	Seed	5	Y,0,1-2	Y,0,2-3
Bitterbrush, desert	95	90	1	20,370	6/25-8/15	2	4-2-4-5	Achene	Seed	5	Y,0,1-2	Y,0,2-3
Blackbrush	95	70	3	27,015	7/1-8/30	1-2	6-2-4	Achene	Achene	4	Y,0,1	Y,0,1
Buckwheat, wild California flattop	95	75	3	907,200	7/28-8/30	1-2	6-2-4	Achene	Achene	2	N	N
Buckthorn, cascara	95	40	3	12,300	7/15-9/15	1-2	3-6-4	Drupe	Stone	3	Y,0,1-3	Y,0,1-3
Buffaloberry, roundleaf	98	75	2	6,855	7/5-7/30	1-2	3-6-4	Drupe	Stone	3	Y,0,1-2	Y,0,1-3
Buffaloberry, russet	98	75	2	59,215	7/15-8/30	1-2	3-6-4	Drupe	Stone	4	Y,0,1-2	Y,0,1-3
Buffaloberry, silver	98	80	2	10,980	8/1-9/30	1-2	3-6-4	Drupe	Stone	4	Y,0,1-2	Y,0,1-3
Ceanothus, deerbrush[j]	98	85	3	70,000	6/10-8/15	1-2	6-4	Capsule	Seed	5	Y,0,6	Y,0,1-3
Ceanothus, Martin[j]	98	75	3	82,900	7/10-8/15	1	6-4	Capsule	Seed	5	Y,0,6	Y,0,1-3
Ceanothus, redstem[j]	98	85	3	131,860	7/10-8/15	1-2	6-4	Capsule	Seed	5	Y,0,6	Y,0,1-3

(con.)

Table 1 (Con.)

Species	Acceptable percent		Germination rating[b]	Seed per lb at 100 percent purity	Seed maturity month/day	Seed collection method[c]	Seed cleaning equipment[d]	Reproductive structure harvested	Reproductive structure seeded	Storage time[e]	After-ripening[f]	Stratification[f]
	Purity[a]	Germination[a]										
Shrubs												
Ceanothus, snowbrush[j]	98	85	3	124,275	8/1-8/30	1-2	6-4	Capsule	Seed	5	Y,0,6	Y,0,1-3
Ceanothus, prostrate[j]	98	85	3	41,000	7/1-8/20	1-2	6-4	Capsule	Seed	5	Y,0,6	Y,0,1-3
Ceanothus, wedgeleaf[j]	98	85	3	49,000	7/1-8/20	1-2	6-4	Capsule	Seed	5	Y,0,6	Y,0,1-6
Cherry, Bessey	98	70	3	2,965	8/1-9/15	1-2	3-6-7-4	Drupe	Stone	2	Y,0,1-3	Y,0,1-6
Cherry, bitter	98	70	3	7,020	7/1-9/30	1-2	3-6-7-4	Drupe	Stone	2	Y,0,1-3	Y,1-6
Chokecherry	98	80	3	4,150	7/25-9/15	1-2	3-6-4	Drupe	Stone	2	Y,0,1-3	Y,0,1-6
Cinquefoil, bush	70	70	3		7/10-9/30	1	2-4	Achene	Achene	2	Y,0,1	Y,0,1
Cotoneaster, Peking[i]	98	80	2	32,210	5/5-11/15	1-2	3-6-7-4	Pome	Seed	5	Y,0,1-3	Y,0,1-3
Cliffrose, Stansbury	95	85	4	64,615	7/5-8/10	2	2-4-5	Achene	Achene less style	5	Y,0,1	Y,0,1-3
Currant, golden	95	65	3	356,180	7/20-8/10	1-2	3-6-7-4-5	Berry	Seed	5	Y,0,1-6	Y,0,1-2
Currant, sticky	95	65	3	298,000	8/15-9/30	1-2	3-6-7-4-5	Berry	Seed	5	Y,0,1-6	Y,0,1-4
Currant, wax	95	70	3	251,000	7/15-8/30	1-2	2-6-7-4-5	Berry	Seed	5	Y,0,1-6	Y,0,1-4
Cypress, Arizona	95	75	3	40,000	10/1-2/5	1	6-7-4	Cone	Seed	2	Y,0,1	Y,0,1
Dogwood, Redosier	95	85	2	17,260	8/20-9/10	1-2	3-6-7-4	Drupe	Stone	2	Y,0,1-3	Y,0,1-3
Elaeagnus, autumn	98	90	2	27,600	8/20-12/15	1-2	3-6-7-4	Drupe	Stone	5	Y,0,1-3	Y,0,1-3
Elderberry, blue	95	50	4	216,770	8/15-9/25	1-2	3-6-7-4-5	Berry	Stone	5	Y,0,1-3	Y,0,1-6
Elderberry, red	95	50	4	286,000	8/15-9/30	1-2	2-6-7-4-5	Berry	Seed	5	Y,0,1-3	Y,0,1-6
Ephedra, green	95	85	2	24,955	7/15-9/1	2	6-2-4	Seed	Seed	5	Y,0,1-3	Y,2-4,0
Ephedra, Nevada	95	85	2	19,875	7/10-7/25	2	6-2-4	Seed	Seed	5	Y,0,1-3	Y,2-4,0
Ephedra, Torrey	90	85	2		7/1-8/1	2	6-2-4	Seed	Seed	5	U	U
Eriogonum, cushion	80	80	1	170,000	8/15-11/30	1-2	6-4	Achene in perianth	Achene	2	U	U

(con.)

Table 1 (Con.)

Species	Acceptable percent		Germination rating[b]	Seed per lb at 100 percent purity	Seed maturity month/day	Seed collection method[c]	Seed cleaning equipment[d]	Reproductive structure harvested	Reproductive structure seeded	Storage time[e]	After-ripening[f]	Stratification[f]
	Purity[a]	Germination[a]										
Shrubs												
Eriogonum, Wyeth	95	75	3	141,310	7/25-8/20	1-2	6-2-4	Achene in perianth	Achene	2	U	U
Forestiera, New Mexican	95	85	2	32,400	7/1-10/15	1-2	3-6-4	Drupe	Stone	4	Y,0,1	Y,0,1
Goldenweed	15	90	2	1,630,000	10/1-11/30	1-2	2-4	Achene	Achene less pappus	1	N	N
Greasewood, Bailey	85	40	2		9/15-11/15	2	1-4	Bracted utricle	Bracted utricle less bract wings	1	Y,0,1	Y,2-4,0
Greasewood, black	85	40	2	253,400	9/15-11/15	2	1-4	Bracted utricle	Bracted utricle less wings	1	Y,0,1	Y,2-4,0
Hawthorn, river[i]	95	70	4	15,050	8/15-10/15	1-2	3-6-7-4	Pome	Seed	5	Y,0,1-3	Y,0,1-3
Honeylocust, common[i]	98	80	4	2,800	9/1-2/15	1	7-4	Legume	Seed	5	Y,0,1-3	Y,0,1-3
Honeysuckle, Tatarian	90	85	4	16,525	7/15-8/10	1-2	2-6-7-4	Berry	Seed	5	Y,0,1-3	Y,0,1-3
Honeysuckle, Utah	90	85	4		7/15-8/10	1-2	2-6-7-4	Berry	Seed	5	Y,0,1-3	Y,0,1-3
Hopsage, spineless	75	80	1	189,950	9/10-12/15	1	2-4	Bracted utricle	Bracted utricle	1	Y,0,1	Y,0,1
Hopsage, spiny	90	80	1	166,765	7/1-9/10	1-2	2-4	Bracted utricle	Bracted utricle	1	Y,0,1	Y,0,1
Horsebrush, cottonthorn	10-15	70	3		10/1-11/30	1-2	2-4	Achene	Achene less pappus	1	U	U
Horsebrush, gray	10-15	70	3		10/1-11/30	1-2	2-4	Achene	Achene less pappus	U	U	U
Horsebrush, littleleaf	10-15	70	3		10/1-11/30	1-2	2-4	Achene	Achene less pappus	U	U	U
Horsebrush, Nuttall	10-15	70	3		10/1-11/30	1-2	2-4	Achene	Achene less pappus	U	U	U
Indian apple	95	50	3	23,000	7/5-8/20	1-2	3-6-7-4	Pome	Seed	3	Y,0,1-3	Y,0,1-2
Juniper, common mountain	98	60	4	36,500	7/1-12/30	1-2	2-6-4	Berry-like cones	Berry-like cones	5	Y,0,1-3	Y,0,1-6
Juniper, Rocky Mountain	98	60	4	22,660	9/1-12/30	1-2	2-6-4	Berry-like cones	Berry-like cones	5	Y,0,1-3	Y,0,1-6

(con.)

Table 1 (Con.)

Species	Acceptable percent		Germination rating[b]	Seed per lb at 100 percent purity	Seed maturity month/day	Seed collection method[c]	Seed cleaning equipment[d]	Reproductive structure harvested	Reproductive structure seeded	Storage time[e]	After-ripening[f]	Stratification[f]
	Purity[a]	Germination[a]										
Shrubs												
Juniper, Utah	98	60	4	8,110	9/1-12/30	1-2	2-6-4	Berry-like cones	Berry-like cones	5	Y,0,1-3	Y,0,1-6
Kochia, forage[k]	90	90	4	520,000	9/25-12/15	1-2-5	2-4	Bracted utricle	Bracted utricle	1	Y,0,3	N
Lilac, common	90	70	2	86,000	8/20-10/10	1	6-7-4	Capsule	Seed	1	Y,0,1	Variable
Locust, black[i]	98	85	1	23,875	9/1-11/30	1-2	2-4	Legume	Seed	4	Y,0,1-2	Y,0,1-6
Mahogany, birchleaf mountain	90	80	2	55,000	7/1-9/15	2	2-4-5	Achene	Achene less style	2	Y,0,3	Y,0,1-3
Mahogany, curlleaf mountain	90	80	2	51,865	7/10-9/1	2	2-4-5	Achene	Achene less style	5	Y,0,3	Y,0,1-3
Mahogany, littleleaf mountain	90	80	2	50,910	7/10-7/25	2	2-4-5	Achene	Achene less style	4	Y,0,3	Y,0,1-3
Mahogany, true mountain	90	80	3	59,030	7/5-9/1	2	2-4-5	Achene	Achene less style	2	Y,0,3	Y,0,1-3
Manzanita, bearberry[i]	95	70	4	42,400	6/1-8/30	1	3-6-7-4	Berry	Berry	5	Y,0,3-6	Y,0,0-6
Maple, Rocky Mountain[l]	90	85	2	13,430	8/1-9/30	1-2	2-4	Samara	Samara	1	Y,0,2	N
Mockorange, Lewis	95	65	4	5,500,000	9/1-10/15	1-2	2-4	Capsule	Seed	4	Y,0,1-2	Y,0,1-3
Mountain-ash, American	90	70	3	138,125	7/15-9/30	1-2	3-6-4	Pome	Seed	3	Y,0,1-3	Y,0,1-3
Mountain lover	90	60	4		7/1-8/30	1-2	2-4	Capsule	Seed	5	Y,0,1-3	Y,0,1-6
Ninebark, mallow	98	40	3	756,000	8/10-9/30	1-2	2-4	Capsule	Seed	3	Y,0,1-2	Y,0,1-3
Oak, Gambel	95	80	3	200	8/10-9/30	1-2	4	Acorn	Acorn	1	Y,0,1	N
Peachbrush, Anderson	98	70	3		7/1-9/15	1	3-6-7-4	Drupe	Drupe	2	Y,0,1-3	Y,0,1-6
Peachbrush, desert	90	70	3	4,500	6/30-7/20	1-2	4	Drupe	Drupe	2	Y,0,1-3	Y,0,1-6
Penstemon, bush	85	80	2	1,260,000	7/1-9/15	1-2	2-4	Capsule	Seed	4	U	U

(con.)

Table 1 (Con.)

Species	Acceptable percent Purity[a]	Acceptable percent Germination[a]	Germination rating[b]	Seed per lb at 100 percent purity	Seed maturity month/day	Seed collection method[c]	Seed cleaning equipment[d]	Reproductive structure harvested	Reproductive structure seeded	Storage time[e]	After-ripening[f]	Stratification[f]
Shrubs												
Plum, American	98	70	3	810	9/5-10/5	1-2	3-6-7-4	Drupe	Stone	2	Y,0,1-3	Y,0,1-6
Rabbitbrush, alkali	10-15	75	2		10/15-12/30	1-2-6	2-4	Achene	Achene less pappus	1	Y,0,1	Y,2,0
Rabbitbrush, dwarf	10-15	75	2		10/1-12/15	1-2-4-6	2-4	Achene	Achene less pappus	1	Y,0,1	Y,2,0
Rabbitbrush, Greene's	10-15	75	3		10/1-12/15	1-2-4-6	2-4	Achene	Achene less pappus	1	Y,0,1	Y,2,0
Rabbitbrush, low	10-15	75	2		10/1-12/15	1-2-4-6	2-4	Achene	Achene less pappus	1	Y,0,1	Y,2,0
Rabbitbrush, low mountain	10-15	75	2	782,070	10/15-12/30	1-2-4-6	2-4	Achene	Achene less pappus	1	Y,0,1	Y,2,0
Rabbitbrush, low narrowleaf	10-15	75	2		10/15-12/15	1-2-4-6	2-4	Achene	Achene less pappus	1	Y,0,1	Y,2,0
Rabbitbrush, low stickyleaf	10-15	75	2		10/15-12/15	1-2-4-6	2-4	Achene	Achene less pappus	1	Y,0,1	Y,2,0
Rabbitbrush, Parry	10-15	75	2		10/1-11/30	1-2-4-6	2-4	Achene	Achene less pappus	1	Y,0,1	Y,2,0
Rabbitbrush, Parry, Nevada	10-15	75	2		10/1-11/30	1-2-6	2-4	Achene	Achene less pappus	1	Y,0,1	Y,2,0
Rabbitbrush, rubber, Green	10-15	75	2		10/15-12/30	1-2-6	2-4	Achene	Achene less pappus	1	Y,0,1	Y,2,0
Rabbitbrush, rubber, leafless	10-15	75	2	432,000	10/15-12/30	1-2-6	2-4	Achene	Achene less pappus	1	Y,0,1	Y,2,0
Rabbitbrush, rubber, leiospermus	10-15	75	2		10/15-12/30	1-2-6	2-4	Achene	Achene less pappus	1	Y,0,1	Y,2,0
Rabbitbrush, rubber, mountain	10-15	75	2	426,000	10/5-12/15	1-2-6	2-4	Achene	Achene less pappus	1	Y,0,1	Y,2,0
Rabbitbrush, rubber, mountain white stem	10-15	75	2	693,220	10/15-12/30	1-2-6	2-4	Achene	Achene less pappus	1	Y,0,1	Y,2,0
Rabbitbrush, rubber, threadleaf	10-15	75	2	756,000	10/5-11/30	1-2-6	2-4	Achene	Achene less pappus	1	Y,0,1	Y,2,0
Rabbitbrush, rubber, tubinatus	10-15	75	2		10/5-12/15	1-2-6	2-4	Achene	Achene less pappus	1	Y,0,1	Y,2,0
Rabbitbrush, spreading	10-15	75	2		10/5-12/15	1-2-6	2-4	Achene	Achene less pappus	1	Y,0,1	Y,2,0

(con.)

Table 1 (Con.)

Species	Acceptable percent		Germination rating[b]	Seed per lb at 100 percent purity	Seed maturity month/day	Seed collection method[c]	Seed cleaning equipment[d]	Reproductive structure harvested	Reproductive structure seeded	Storage time[e]	After-ripening[f]	Stratification[f]
	Purity[a]	Germination[a]										
Shrubs												
Rabbitbrush, vasey	10-15	75	2		10/5-12/15	1-2-6	2-4	Achene	Achene less pappus	1	Y,0,1	Y,2,0
Rockspirea	95	80	3	5,340,000	8/1-8/30	1	2-4	Achene	Seed		U	U
Rose, Woods	95	70	4	45,300	9/1-8/30	1-2	3-6-7-4	Berry-like hip	Achene	5	Y,0,1-3	Y,0,4-8
Russian-olive	98	90	2	2,870	8/25-1/15	1-2	3-6-7-4	Drupe	Stone	5	Y,0,1	Y,2,0
Sage, purple	95	70	3	349,500	5/15-7/15	1-2	2-4	Nutlet	Nutlet	1	Y,0,1	Y,2,0
Sagebrush, basin big	8-12	80	1	2,575,940	11/1-1/15	1-2-3	1 or 2-4	Achene	Achene	2	Y,0,1	Y,2,0
Sagebrush, mountain big	8-12	80	1	1,924,000	10/1-11/30	1-2-3-4	1 or 2-4	Achene	Achene	2	Y,0,1	Y,2,0
Sagebrush, big	8-12	80	1	2,466,000	10/15-12/30	1-2-3-4	1 or 2-4	Achene	Achene	2	Y,0,1	Y,2,0
Sagebrush, Bigelow	8-12	80	1	2,520,000	9/25-11/15	1-2	2-4	Achene	Achene	2	Y,0,1	Y,2,0
Sagebrush, black	8-12	80	1	907,200	10/15-11/30	1-2-3-4	1 or 2-4	Achene	Achene	2	Y,0,1	Y,2,0
Sagebrush, bud	8	50	2	1,680,000	5/15-6/20	1-2	2-4	Achene	Achene	1	Y,0,1	Y,2,0
Sagebrush, fringed	8-12	80	1	4,536,000	9/15-11/30	1-2-4	1 or 2-4	Achene	Achene	2	Y,0,1	Y,2,0
Sagebrush, longleaf	8-12	70	1	1,080,000	10/1-11/30	1-2	1 or 2-4	Achene	Achene	2	Y,0,1	Y,2,0
Sagebrush, low	8-12	80	1	972,000	10/1-12/5	1-2-4	1 or 2-4	Achene	Achene	2	Y,0,1	Y,2,0
Sagebrush, pygmy	8	70	1	472,500	10/1-12/10	1-2-4	1 or 2-4	Achene	Achene	2	Y,0,1	Y,2,0
Sagebrush, sand	8-12	70	1		9/15-12/10	1-2-4	1 or 2-4	Achene	Achene	2	Y,0,1	Y,2,0
Sagebrush, silver	8-12	80	1	846,000	8/15-11/30	1-2-3-4	1 or 2-4	Achene	Achene	2	Y,0,1	Y,2,0
Sagebrush, stiff	8	70	1	498,480	10/1-11/30	1-2	1 or 2-4	Achene	Achene	2	Y,0,1	Y,2,0
Sagebrush, tall threetip	8-12	75	1	2,212,700	10/15-12/15	1-2	1 or 2-4	Achene	Achene	2	Y,0,1	Y,2,0
Sagebrush, timberline	8-12	70	1		10/1-11/30	1-2	1 or 2-4	Achene	Achene	2	Y,0,1	Y,2,0

(con.)

Table 1 (Con.)

Species	Acceptable percent Purity[a]	Acceptable percent Germination[a]	Germination rating[b]	Seed per lb at 100 percent purity	Seed maturity month/day	Seed collection method[c]	Seed cleaning equipment[d]	Reproductive structure harvested	Reproductive structure seeded	Storage time[e]	After-ripening[f]	Stratification[f]
Shrubs												
Saltbush, big	90	70	1	889,410	10/15-3/15	1-2-6	1-4	Bracted utricle	Bracted utricle	2	Y,0,1	N
Saltbush, Bonneville	95	40	2	84,000	10/1-12/30	1-2-6	1-4	Bracted utricle	Bracted utricle	4	Y,0,1	Y,0,1
Saltbush, broadscale	90	40	2	207,630	10/20-2/15	1-2	1-4	Bracted utricle	Bracted utricle	4	U	U
Saltbush, Castle Valley	95	45	2	81,660	10/15-12/30	1-2-6	1-4	Bracted utricle	Bracted utricle	4	Y,0,1	Y,2-4,0
Saltbush, cattle	90	40	1	490,000	10/15-2/15	1-2-6	1-4	Bracted utricle	Bracted utricle	4	Y,0,1	N
Saltbush, desert holly	90	40	2	216,825	9/1-12/15	1-2	1-4	Bracted utricle	Bracted utricle	4	Y,0,1	N
Saltbush, falcate	90	40	1	197,215	9/1-12/30	1-2-6	1-4	Bracted utricle	Bracted utricle	4	Y,0,1-3	Y,0,1
Saltbush, fourwing	95	50	2	55,365	10/20-3/1	1-2-6	1-4	Bracted utricle	Bracted utricle less bract wings	5	Y,0,6	Y,0,1-3
Saltbush, Gardner	90	45	2	111,450	9/10-3/1	1-2-6	1-4	Bracted utricle	Bracted utricle	5	Y,0,3	Y,0,1
Saltbush, Garrett	95	45	2	66,175	7/25-11/1	1-2	1-4	Bracted utricle	Bracted utricle	4	Y,0,1	Y,0,1
Saltbush, mat	95	45	2	66,835	10/1-12/15	1-2	1-4	Bracted utricle	Bracted utricle	4	Y,0,1	Y,0,1
Saltbush, Navajo	90	45	2	44,040	10/1-12/15	1-2	1-4	Bracted utricle	Bracted utricle	4	Y,0,1	U
Saltbush, shadscale	95	35	4	64,920	10/15-3/1	1-2-6	1-4	Bracted utricle	Bracted utricle	5	Y,0,10	Y,0,1-6
Saltbush, trident	90	50	2	168,000	9/10-12/30	1-2	1-4	Bracted utricle	Bracted utricle	4	Y,0,1	U
Serviceberry, Saskatoon	95	85	2	45,395	7/10-9/15	1-2	3-6-7-4	Pome	Seed	5	Y,0,3-6	Y,0,2-6
Serviceberry, Utah	95	85	2	25,800	8/25-4/1	1-2	3-6-7-4	Pome	Seed	4	Y,0,3-6	Y,0,2-6
Snowberry, common	95	80	3	76,000	8/1-9/30	1-2	3-6-7-4	Berry	Seed	3	Y,0,1-3	Y,0,1-4
Snowberry, longflower	95	80	3	68,000	8/10-9/30	1-2	3-6-7-4	Berry	Seed	3	Y,0,1-3	Y,0,1-4
Snowberry, mountain	95	80	3	54,065	8/10-9/15	1-2	3-6-7-4	Berry	Seed	3	Y,0,1-3	Y,0,1-4

(con.)

Table 1 (Con.)

Species	Acceptable percent Purity[a]	Acceptable percent Germination[a]	Germination rating[b]	Seed per lb at 100 percent purity	Seed maturity month/day	Seed collection method[c]	Seed cleaning equipment[d]	Reproductive structure harvested	Reproductive structure seeded	Storage time[e]	After-ripening[f]	Stratification[f]
Shrubs												
Spiraea, Douglas	80	80	2	1,000,000	7/15-9/30	1-2	4	Follicle	Seed	2	N	N
Sumac, Rocky Mountain smooth	90	40	4	62,430	9/5-3/30	1-2	3-6-7-4	Drupe	Stone	5	Y,0,1-3	Y,0,1-6
Sumac, skunkbush[i]	95	40	4	18,895	6/20-10/10	1-2	3-6-7-4	Drupe	Stone	5	Y,0,1-3	Y,0,1-6
Virginsbower, western	50	70	3	315,000	10/5-12/30	1-6	1-2-4	Achene	Achene , styles removed	1	Y,0,1	Y,0,2-4
Winterfat	50	85	1	112,270	9/25-11/25	1-2-5-7	2-4	Bracted utricle	Bracted utricle	1	Y,0,1-2	N
Wormwood, oldman	8-12	70				1-2	2-4	Achene	Achene	2	U	U
Whortleberry, big	80	80	3	1,500,000	7/10-9/30	1-2	3-6-7-4	Berry	Seed	3	U	U

[a]Commonly accepted purity and germination percentage of marketed seed. Purity x total germination = pure live seed (PLS).
[b]1 = Excellent, easy to germinate; 2 = Good germinator; 3 = Medium germinator; 4 = Hard to germinate.
[c]1 = Hand strip into container; 2 = Beat into container; 3 = Clip into container; 4 = Reel-type harvester; 5 = Combine; 6 = Vacuum harvester.
[d]1 = Hammermill; 2 = Barley debearder; 3 = Dybvig with water; 4 = Air-screen separator; 5 = Gravity table; 6 = Dry; 7 = Grinder-macerator.
[e]Years seed can be stored dry without significant Dybvig loss in viability: 1 = 0 to 3 years; 2 = 4 to 6 years; 3 = 7 to 10 years; 4 = 11 to 15 years; 5 = 16 or more years.
[f]Y = Afterripening or stratification is required. Duration: First number = weeks; second number = months.
N = No afterripening or stratification required. U = Afterripening and stratification characteristics unknown.
[g]Treat seed with pesticide prior to storage.
[h]Inoculate seed prior to seeding.
[i]Treat seed with sulfuric acid to germinate in laboratory.
[j]Treat seed with hot water bath to germinate in laboratory.
[k]Store seed at ≤7 percent moisture in sealed container.
[l]Store seed at <15 percent moisture.

Figure 1—Collecting seed from a wildland stand of Salina wildrye with a reel-type, vehicle-mounted harvester.

Seed of some native grasses and forbs can be mechanically collected (fig. 1) if stands are pure and the topography is flat; if not, beating or stripping seed by hand into shoulder hoppers (fig. 2), tubs, boxes, trash cans, or other appropriate receptacles is the most widely used harvesting procedure. Fleshy fruits are beaten or hand picked (fig. 3). A resourceful seed collector can innovate new and easier ways to harvest seed of most species.

Seeds of most shrubs are obtained by hand harvesting from wildland stands. Seeds can be stripped or flailed directly into canvas hoppers (fig. 1) of various designs, or into tubs, baskets, boxes, or trash cans. These seed-collecting containers may be attached to the harvester by shoulder straps, or placed directly under the bushes and the seed stripped or beaten into them. Seed of species like curlleaf mountain mahogany, true mountain mahogany, Apache plume, and cliffrose with plumed seeds are harvested by shaking or by dislodging the seed onto canvas, heavy cloth, or plastic that is spread under the plant. When collecting seed from extra large shrubs or small trees, ladders or platforms may be necessary to pick or dislodge the fruits from the crowns.

Seed of species such as curlleaf mountain mahogany, true mountain mahogany, and cliffrose can be picked up directly off the ground, using an ordinary sweep rake to pile the seed and then fork it into sacks or boxes. Care must be taken to ensure that rocks and large limbs are not picked up because they will damage cleaning machines. Dealers will not purchase collected seed containing sticks, rocks, or other foreign objects. Ground collected seed must be picked up soon after the fruits drop or the seed will be lost to field mice, chipmunks, birds, and other small animals (Plummer and Jorgensen 1978).

Figure 2—Hand collecting seed into a shoulder-mounted seed hopper.

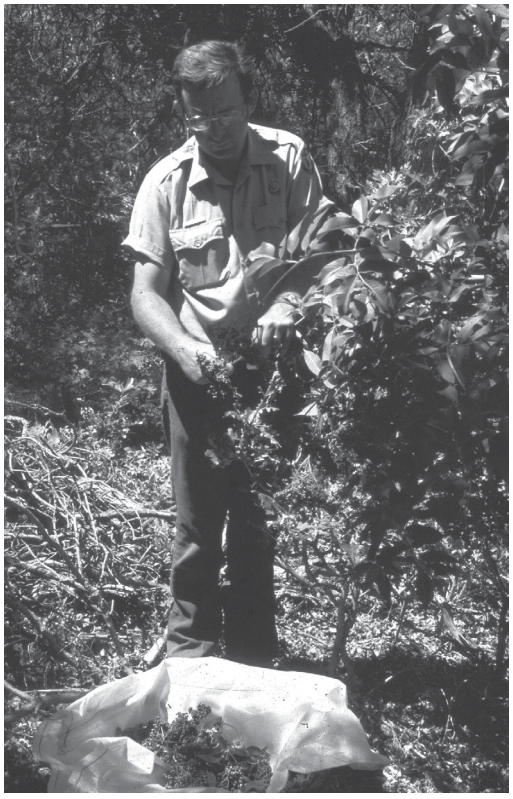

Figure 3—Collecting fruits of blue elderberry.

A number of techniques have been developed for collecting cones—cutting trees down, climbing trees, shooting cones off the trees, and raiding rodent caches. A cache may contain just a few cones or many bushels of cones. Favorite spots for caches are small ground depressions, cavities in and around logs, stumps, roots, rocks, moist seeps, and along banks of small creeks and seeps (Schopmeyer 1974b).

With the increasing demand for many species, more interest is being shown in harvesting native seed, especially shrub and forb species, with machines. Mechanical harvesters, such as combines and strippers, can be effective in harvesting seed from native stands of low-growing forbs, shrubs, and grasses (fig. 1). The land, however, must be level, and the species being harvested must be in a relatively pure stand. Some species that have been harvested successfully using some type of combine or stripper are winterfat, black sagebrush, low rabbitbrush, lupine, penstemon, globemallow, balsamroot, showy goldeneye, mountain brome, and salina wildrye.

Several vacuum-type seed harvesters have been developed by the USDA Forest Service, San Dimas Equipment Development Center (Jorgensen 1979). A large truck-mounted seed harvester was developed (Plummer and others 1970a,b) and has been useful for collecting seed of fourwing saltbush, shadscale saltbush, cliffrose, the mountain mahoganies, and a number of forbs and grasses. Custom made backpack vacuum seed harvesters have also been developed. When using vacuum seed harvesters, a machine is needed that does not route the fruits through the impeller, as it usually damages the seed.

Federal and State agencies require seed collecting permits to harvest seed from their lands. Requirements for collecting seed from private land vary with owner. Permits or permission should always be obtained before harvesting seed.

Seed Cleaning

Cleaning seed is necessary to facilitate seeding and to meet acceptable purity levels (table 1). Manufacturers of seed cleaning machinery, researchers, and seed industry personnel have done an outstanding job in developing seed processing equipment and techniques. With a little ingenuity by the processor, equipment and techniques for cleaning seed of most species is now available. The processor must learn the proper operation of each machine and the best cleaning methods for each species. Experience is the best teacher. To clean seed, more than one step is usually required. Table 1 outlines the seed cleaning sequence and lists the equipment required for cleaning seed of grasses, forbs, and shrubs.

When cleaning seed of dry or fleshy fruited species, care must be taken to keep the seed dry to prevent severe damage to the embryo during the cleaning process. Fleshy fruit should not be allowed to "heat up" or ferment; this can reduce viability and may kill the seed. Cleaning consists of removing unwanted appendages, floral parts, seedcoats, fleshy material, and debris. Following is a description of the most commonly used equipment items and the function of each in cleaning and processing seed.

Hammermill

Hammermills (fig. 4) are used to extract seed from floral parts and to remove appendages. Hammermills come in many sizes, consisting of a hooded inlet or hopper, a central chamber with a rotating shaft that has rows of protruding "hammers," an interchangeable outlet screen, and a bagger. A number of outlet screens with various hole sizes and shapes to accommodate various seed sizes are available. The holes must be large enough to let the seed pass through without damage, but small enough to remove appendages. Rotation speed of the central shaft should be variable. Processors must use their best judgement and ingenuity to set the speed of the hammermill and choose the proper screen size to meet the requirements of the species being cleaned. Excessive rotation speed may not allow the seed adequate time to pass through the screen holes with the result that seed will be damaged. Too slow a rotation speed may not allow for the appendages to be completely broken off. Some species that can be successfully processed through a hammermill include the saltbushes, sagebrushes, hopsage, penstemons, greasewood, vetches, and Lewis flax.

Debearder

A debearder (fig. 5) consists of a horizontal beater assembly that rotates inside a steel drum. The beater

Figure 4—Hammermill used to remove seed appendages.

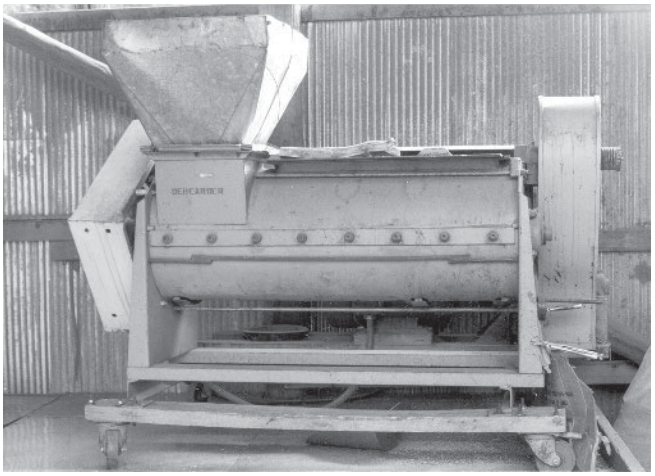

Figure 5—Debearder used to clean seed of a large number of grass, forb, and shrub species.

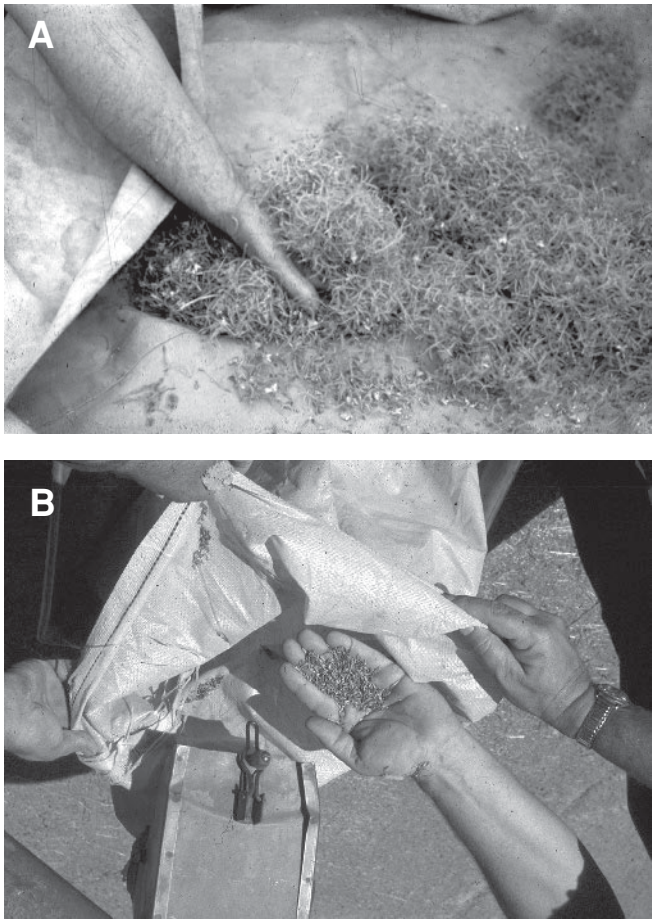

Figure 6—(A) Freshly collected cliffrose seed with styles. (B) Cleaned cliffrose seed that has been run through a debearder to remove styles, and an air-screen separator to remove debris from the seed.

assembly consists of a shaft with projecting arms that are pitched to move the seed through the drum. Stationary posts protrude inward from the drum and restrain the seed from rotating with the beaters, causing vigorous rubbing action between seeds, pods, heads, and multiple seeds against the arms, posts, and each other. The time seed remains in the unit is varied by regulating a weighted discharge gate. Care should be taken to ensure that seeds do not remain in the debearder until they overheat. This machine can be used to remove awns, tails, styles (fig. 6), and husks to separate seed from flower heads and capsules, break up stems (fig. 7), and to polish seed. Considerably less seed is damaged in the debearder than in the hammermill. The debearder is versatile and can be successfully used to clean seed of many species.

Dybvig Separator

The Dybvig (fig. 8) is a large macerator that consists of a spinning, flanged plate at the bottom of a seed hopper. The rotation speed of the flanged plate can be changed to meet the requirements of each species. A Dybvig is used to clean both fleshy and dry fruits.

The first step in cleaning fleshy fruits is to run the fruit through a Dybvig. The fleshy fruit is thrown against the plate and side of the hopper, which removes the flesh from the seed. A stream of water is required when cleaning fleshy fruits. There are several other types of macerators, but none that outperforms the Dybvig in removing seed from fleshy fruit. When working with small lots of fruit, a home blender has been successfully used. To reduce damage, the steel blades in the blender should be replaced with heavy rubber blades or covered with rubber tubing (Plummer and Jorgensen 1978). Seed appendages can

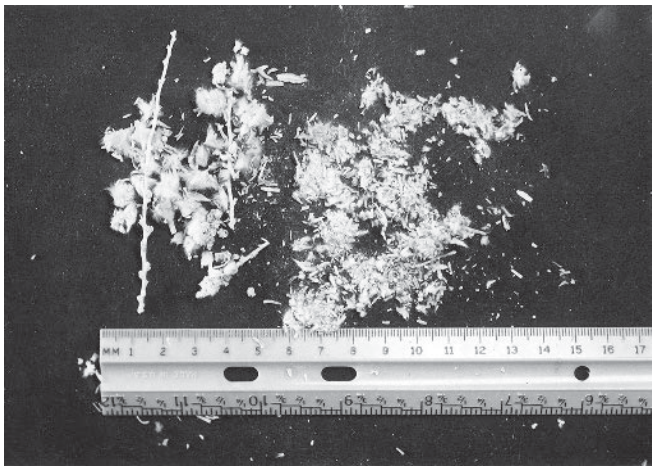

Figure 7—Unprocessed winterfat seed (left) and seed processed through a debearder (right).

Figure 8—Dybvig seed cleaner used to remove seed from fleshy fruits.

be removed from dry fruits with a Dybvig separator. Dry seed is put in the Dybvig and treated until the appendages are removed.

Air-Screen Separator

The air-screen separator combines air, gravity, and screens with various hole sizes to clean and separate seed from impurities. Cleaners vary in size from two-screen (fig. 9) models to large eight-screen types. Regardless of the number of screens, the seed cleaning principle is the same. The top screen removes the large material and impurities, letting the seed and smaller trash pass through. The second and subsequent screens retain and separate the seed from impurities (fig. 6). The seed then passes through a stream of air that blows out empty and light seed and other trash. The heavy seed is then dropped or augered into a collection container.

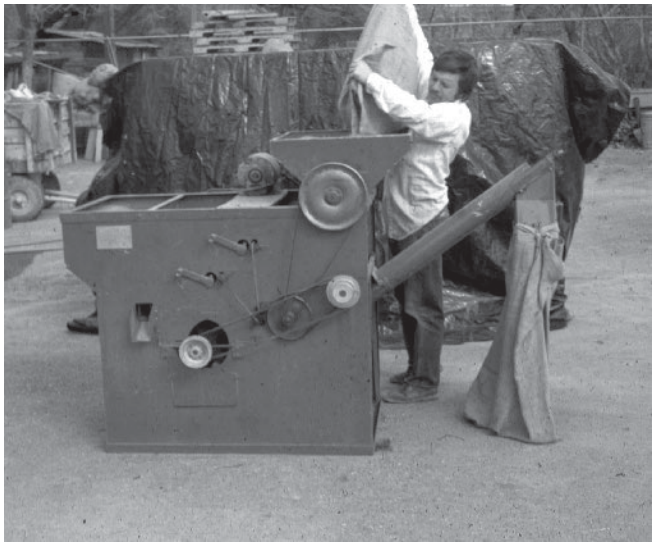

Figure 9—Air-screen separator used to remove floral parts, leaves, chaff, and debris from seed.

Gravity Separators

A gravity table is used to separate light, medium, and heavy seed and impurities from each other. A gravity table consists of a table with a cloth or wire screen that can be tilted in two directions at various pitches and a flow of air that comes up through the table top. As the table moves back and forth and air moves up through and between the seed, the seed and material are separated by weight and deposited in appropriate containers. This machine has great utility for separating and removing sticks and other debris of the same size as, but of different weight than the seed being cleaned. Seed of the same species and seed lot can be separated into various size-weight classes. Depending on the size of the machine, 200 to 500 lb (91 to 227 kg) of seed per hour can be separated and brought to the desired purity. Seed of many species can be cleaned to 98 percent or greater purity with a gravity table.

Grinder-Macerator

The grinder-macerator consists of a rotating shaft with fingers that beat and rub the seed collection. After fleshy fruit is run through the Dybvig water process, all material is dried. It is then run through a macerator to separate dried skin and pulp from the seed. Seed is then separated out with an air-screen separator and gravity table. Dry seed in capsules can be removed from the capsules with a macerator.

Seed Storage

A seed inventory is essential to any successful seeding project. Quality seed must be available when needed. Many species do not produce a high yield of viable seed every year. Therefore, seed must be harvested and stored during years of good seed production to offset years when poor or no seed crops are produced. Storage of commercially produced seed is also required.

Seed must be stored properly to ensure retention of maximum viability. The seeds must be well dried before they are stored in a warehouse or granary, and then they must be kept dry (Justice and Bass 1978). In arid climates such as Nevada and Utah, no special seed storage facilities or techniques are required for most species, other than making sure the seed is dry when put in storage. Seed of some species are best stored at

a specific moisture content. In order to maintain viability of forage kochia seed, moisture content must be lowered to and maintained below 7 percent (Jorgensen and Davis 1984). In more moist or humid climates, some means of artificial drying is necessary before and during storage (Schopmeyer 1974b). With proper storage conditions, seed viability can be retained for many years (Stevens and Jorgensen 1994).

Regardless of the storage method, certain steps should be taken to properly store seed: (1) the seed should remain dry; (2) temperature and humidity should be kept low, preferably with little fluctuation; (3) seed should be kept in rodent-free storage areas; and (4) good housekeeping practices pay dividends (Schopmeyer 1974b).

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Chapter 25

Shrub and Forb Seed Production

The success or failure of range restoration and revegetation programs depends on procurement of an adequate supply of quality grass, forb, and shrub seed. Rangeland species seed is either grown commercially or collected from wildland stands. Commercially produced seed of numerous grass species is available (Asay and Knowles 1985b; Horton and others 1990; Sours 1983). A few site-specific grass species of limited commercial demand are collected from native stands, but in general the seed of most grasses are grown under cultivation. The latter is not true for many forbs, or most shrubs. Seed of several native and introduced forbs seeded on rangelands are now commercially available. They include cultivars of alfalfa, cicer milkvetch, crownvetch, various clovers, arrowleaf balsamroot (fig. 1), flax, sainfoin, globemallow, small burnet (fig. 2), western yarrow, Utah sweetvetch (fig. 3), and several penstemon species (Rumbaugh and Townsend 1985; Stevens and others 1985c; Van Epps 1966). Seed of numerous forbs must still be collected from wildland stands. This is especially true for some site-specific forbs. Also, seeds from nearly all shrub species are collected from wildland populations.

Figure 1—Balsamroot seed production field in full bloom.

Figure 2—Seed production field of small burnet 'Delar'.

Figure 3—'Timp' Utah sweetvetch starting to flower in a seed production field.

Recently, however, specific ecotypes of several shrubs species have been released (Carlson and others 1984; Noller and others 1984) and some seed is being produced commercially (fig. 4, 5). Considerable work is being done on selection, breeding and improvement of a number of shrub species that may eventually lead to commercial seed production (McArthur and others 1985; Monsen and Davis 1985; Stevens and others 1996; Stutz and Carlson 1985; Van Epps 1966).

A prime requirement for successful restoration and revegetation of range and wildlands is the use of plant material from a seed source of proven adaptability to the planting site. Often, the amount of seed required is not available from either wildland populations or from materials previously released from breeding and selection programs. This void can be filled by encouraging development of shrub seed orchards and forb and grass seed fields. Seed production principles, procedures and techniques are fairly well established for many grass and legume species.

Figure 4—Seed orchard of 'Immigrant' forage kochia.

Figure 5—Antelope bitterbrush seed orchard.

Utah (Horton and others 1990) has developed a grass seed production guide. Wyoming and Montana have guides for grass and legume seed production (Holzworth and Wiesner 1985). Seed production information can be obtained from Agricultural Experiment Stations, the Natural Resources Conservation Service, and State Crop Improvement Associations. The technology for growing seed crops of forbs (except legumes) and shrubs is extremely limited. Researchers in Utah (Stevens and others 1996) have recently published a guide for seed production of a number of forbs and shrubs. Available cultural and management practices have been adapted from agronomic, horticultural, and forestry seed production principles and techniques, from initial studies of a few shrub and forb seed production plantations, and from years of observations.

Seed is harvested from native stands, cultivated orchards, and croplands. Seed quality and genetic identity (verification of the source) are of prime importance.

Official seed certifying agencies in every State provide third party verification of cultivar/germplasm source, identity, and purity. The parent certification organization, the Association of Official Seed Certifying Agencies, has established minimum requirements and standards, defined seed classes and generations, and developed tagging specifications for member agencies. These are explained in detail in chapter 27.

In Utah, seed certification is a service performed by the Utah Crop Improvement Association (UCIA) in cooperation with the Utah Agricultural Experiment Station at Utah State University and the Division of Plant Industry of the Utah Department of Agriculture and Food. Anyone may apply to grow certified seed, but the UCIA must be contacted before planting to consider land eligibility, germplasm/variety origin, and ensure familiarity with certification procedures. Application forms and copies of the seed certification standards may be obtained by contacting: Utah Crop Improvement Association, Utah State University, Logan, UT 84322-4855.

After planting, fields must be rogued to remove other species and off-types. Weeds, particularly noxious prohibited or restricted ones, must be controlled. Seed fields will be inspected at least once before harvest by a UCIA representative. Wildland stands are also inspected by UCIA representatives. Once inspected, seed from these stands can be certified to the appropriate class. Seed identity and freedom from contamination must be maintained during harvest and storage. Conditioning facilities are also inspected. A sample of the cleaned seed is submitted to an approved seed laboratory for analysis. If the seed sample meets the certified seed analysis standards, certification is completed by proper labeling. *Only seed produced in accordance with the regulations of the UCIA and labeled with an official tag or bulk certificate can be represented as Utah Certified Seed* (Stevens and others 1996).

Management of Native Seed Production Areas

Advantages associated with use of seed collected from wildlands are: (1) species adaptation to the seed collection site is known; (2) the plants are established and generally mature; (3) there is normally a large choice in species from which to choose; (4) ecotypes can normally be found that are adapted to most site conditions; and (5) natural biological insect controls may be present. Some disadvantages are: (1) it is sometimes difficult to acquire the right to harvest or manage for seed production; (2) distance, time, and expense is involved in traveling to check on the potential seed crop, its maturity, and in harvesting; (3) often, the seed crop is small due to unfavorable weather conditions, animal grazing, or insect damage; (4) seeds may be costly to harvest; and (5) seed sources available may not be adapted to the site intended for rehabilitation.

Several management practices have been used to improve seed production from selected wildland populations. They include: fencing to prevent game and livestock grazing, removal of undesirable plants (even from within the species being managed), and thinning to enhance seed production and facilitate harvesting. All of the above practices have the potential for increasing seed production and improving seed quality. The removal or flagging of rocks and removal of scattered plants of other species from a native stand may change a normally hand collected population to one in which machine harvesting could be used, thereby increasing harvesting efficiency and the amount of seed harvested. A good example would be the use of a head stripper or beater mounted on the front of a vehicle (see chapter 24) for harvesting arrowleaf balsamroot. Pruning some species may be advisable to improve seed harvesting. Proper and timely spraying for insect control may also increase seed yield and seed quality. Timely seed harvest is very important with some species; especially those whose seed is shed quickly after maturity.

Shrub and Forb Seed Orchard Establishment and Management

Cultivation of seed crops has a number of advantages. Management practices that can enhance seed production include: time of seeding, seedbed preparation, depth of seeding, row spacing, planting methods, fertilization, irrigation, weed and insect control,

and time and method of harvest. Utah, Wyoming, and Montana have published guides for the field production of grass and legume seeds (Holzworth and Wiesner 1985; Horton and others 1990). Shrub and forb seed production practices have been developed for a few species (Stevens and others 1996).

The prospective seed producer needs to select a species or variety, and decide whether to plant seeds, seedlings, or vegetative propagules based on plant release specifications and available resources.

Seed orchards of dioecious species such as fourwing saltbush (fig. 6) should be planted from stem cuttings to establish the proper ratio of pistillate to staminate plants.

Location of the orchard or seed field is of the utmost importance. It can be the most critical factor in determining if a seed production operation succeeds or fails. Questions that should be addressed in selecting the location of a seed orchard or seed field are: is the site suitable for the species being established with respect to soil, climatic conditions, terrain, accessibility; are: labor force and equipment available; what type of irrigation is available if needed; and what kind of isolation is there from plants of the same species? Location of the seed orchard at a slightly lower elevation and more southerly latitude than the site from which the mother plants originated could be beneficial. Selection of this type of site has the potential for providing a longer growing season and improving accessibility for performing necessary cultural practices and seed harvesting. Soil characteristics should meet the needs of the species being planted. Antelope bitterbrush, for example, can be found on both acidic and basic soils, but seed from sources originating on acid soils grow poorly on basic soils and do not produce good seed crops. Species such as bitterbrush, sagebrush, and rabbitbrush should be planted on wind-free areas to reduce seed losses during the time of seed maturity. Mature seed crops can easily be lost when a strong wind disperses the seed just prior to the planned collection dates. Species that mature late should be planted in areas with fairly open winters or late snowfall.

Seed orchards should be located near an available labor force so that cultural practices and seed harvesting can be accomplished efficiently. Availability of adequate equipment for the various cultural practices must be considered.

Plants within orchards that have been developed through hybridization or selection should be isolated from other plants of the same species to prevent undesirable crossing and to comply with seed certification isolation requirements.

The design of a seed orchard is influenced by several factors. These include: plant size, which has an influence on spacing and population density; row width, which will affect the type of mechanical equipment used and cultural treatments; row planting directions in relation to land slope, wind, snow accumulation, spraying, seed harvesting; and the sexual nature of the plant (hermaphroditic, dioecious, or monecious); adequate pollination; and the concept of including several plant species in an orchard to encourage biological insect control.

Individual plants, when allowed to grow without competition, are often much larger than anticipated. In wildland situations, they are normally observed growing where they are in equilibrium with the environment. This should be considered for each species and ecotype when designing a seed orchard. Rows must be wide enough to operate cultivation, spraying, and harvesting equipment. Plant density will affect the amount of seed produced. However, distances between plants need to be such as to lessen the stress for moisture and space as the plants grow to maturity. Planting of rows along the contour should be considered for better erosion control, equipment use, and more effective seed harvest on slopes. Where plant size allows close spacing in the rows, consideration might be given to running the rows in the direction that will make the most effective use of moisture from precipitation, especially snow. The method of seed harvesting must also be considered when designing a seed orchard, as some orchards may be in production for 25 years or longer.

In areas receiving 11 to 13 inches (280 to 330 mm) of annual precipitation, large varieties of fourwing saltbush should have a minimum spacing of 10 ft (3.0 m) by 16 ft (4.9 m) (fig. 6). This is more than the 8 ft (2.4 m) by 10 ft (3.0 m) spacing suggested by McArthur and others (1978c), 15 ft (4.6 m) by 5 ft (1.5 m) suggested by Briggs (1984), and 9 ft (2.7 m) by 12 ft (3.7 m) suggested by Noller and others (1984)

Figure 6—Seed orchard of 'Rincon' fourwing saltbush.

working with medium-sized plants. Plant spacing of 12 to 16 ft (3.7 to 4.9 m) has been used successfully with an upright type of bitterbrush. However, on a per-unit of ground basis, wide spacing may not equal ideal spacing, for example, more plants may produce less seed per plant but more seed per unit of ground than will fewer, larger, higher producing plants. Recommended plants and row spacing for 22 forbs and 8 shrubs have been developed by Stevens and others (1996).

The sex of individual plants of dioecious species such as fourwing saltbush should be considered prior to orchard planting (Briggs 1984; Noller and others 1984). The greater the number of pistillate plants per unit area that can be planted and still obtain optimum pollination, the greater will be the seed yield for the area. One suggested design consists of several rows of pistillate plants alternating with a single row of staminate plants, with the rows running at right angles to the prevailing wind (McArthur and others 1978c). The outer rows should be staminate plants. Source of the staminate plants should be the same as the pistillate plants to ensure compatibility and uniformity in anthesis, and to maximize seed yields. It is possible to use clonal material from several sources grown under similar environments to prevent inbreeding, and also to increase the gene pool of desirable characteristics in the progeny. McArthur and others (1978c), recommend that monecious plants of a primarily dioecious species not be used in seed orchards because they usually produce fewer seeds.

The concept of including several plant species, including grasses and forbs, in a shrub seed orchard for biological insect control has not been adequately studied. A single species seed orchard can create an unnatural condition that can encourage a population explosion of injurious insects (Moore and Stevens 1984; Moore and others 1982). This was pointed out by a case of walnut spanworm infestation in an antelope bitterbrush seed orchard in central Utah, on the Nephi Experimental Farm (Furniss and Van Epps 1981). If planting more than one species proves to be a useful control measure, then the idea of including several species in an orchard for maximum benefit while still maintaining the primary purpose of the orchard for seed production would require careful planning.

The planting design for forbs and small shrubs will depend on mature plant size, type of material used for planting, equipment needs, seed harvesting techniques, and method of irrigation. Some species such as cicer milkvetch may develop a dense stand, while others such as Lewis flax, small burnet, or winterfat should be maintained in rows. Row width will vary, depending on plant size, growth habit, and equipment used.

Items to Consider When Establishing a Forb Seed Field

A forb seed field should be planted with seed prepared similarly to a field being prepared for a field crop. The seedbed for transplants, however, will not need the same preparation. One or more years fallowing of the land for soil moisture accumulation and weed control prior to planting is an excellent management practice that can pay big dividends, especially in direct seeded stand establishment and future labor requirements. Competition from weeds must be controlled through pre-cultivation or through the use of herbicides prior to planting. Weed control is a must in seed production for several reasons: (1) weeds compete for soil moisture, nutrients, and space; (2) weeds can become rodent habitats; (3) weeds can interfere with harvesting; and (4) weed seed can cause seed crop contamination at harvest time and may prevent the sale of seed or its certification.

Injurious insects can damage plants and seed, and present one of the most serious obstacles to profitable seed production. Serious infestations of seed insects in seed fields require aggressive pest management to prevent loss of the seed crop.

Rodents may become a problem in seed fields. They can eat or cache large quantities of seed, and kill plants by girdling the stems or damaging roots during winter periods.

If irrigation is used, the particular irrigation system chosen may have to be installed prior to planting, and should be considered in the overall design. Optimum rates of irrigation or fertilizer application, and their effects on plant growth and seed production, have not yet been determined for most forb and shrub species.

Several low-growing shrubs and forbs such as cicer milkvetch, penstemon, Lewis flax, small burnet, forage kochia, and winterfat can be successfully combine-harvested. There are some problems with cylinders clogging when combining cicer milkvetch and winterfat, and this may also occur with other species. The leaves and stems of cicer milkvetch can be killed in late September or early October, using a defoliant followed by direct combining with the header being placed on the ground. A defoliant can reduce the amount of green forage, and facilitate threshing.

Various suction-type seed harvesting machines have been used experimentally in seed fields. These include backpack units, as well as those mounted on trailers, tractors, and trucks. Under wildland conditions, the most successful method has been hand harvesting with the use of a hopper (see chapter 24) or other containers, though mechanical harvesting of seed from a few species shows promise.

Items to Consider When Establishing a Shrub Seed Orchard

1. Selecting planting material (if not a released variety)
   a. Select plant materials according to orchard objectives.
   b. Use rooted stem cuttings or other types of vegetative propagules from selected clones possessing the desired characteristics.
   c. Plant seed from plants possessing desirable characteristics.
   d. Plant quality seeds and plants to assure maximum survival. A good seed orchard may be in production for 25 years or longer.

2. Location
   a. Plant within the area of adaptation. Many ecotypes of species are site-specific. Elevation, temperature, precipitation, and soil characteristics must be considered.
   b. For ease in cultivating, spraying, harvesting, and to reduce erosion under clean cultivation, plant on level or minimal slope.
   c. For species whose seeds are easily shattered or disseminated, plant in wind-sheltered areas.
   d. To facilitate seed harvesting, species that mature seed late in the year (sagebrushes, rabbitbrushes, and saltbushes) should be planted in areas with open winters or with late snowfall.

3. Design
   a. Design the row width and plant spacing within rows according to: mature plant size and plant status; whether a plant is dioecious, monecious or hermaphroditic; and the intended method of seed harvest.
   b. Plant rows on contour for erosion control.
   c. When practical, plant rows east and west to maximize soil moisture benefits from precipitation and snow accumulation.
   d. Plant wind pollinated species with rows at right angles to prevailing winds.

4. Management
   a. Lead time and timeliness in operation are of extreme importance. Lead time is required for seed or clone selection, propagation of stem cuttings, site preparation, and planting design. Timeliness in the practices of planting, spraying, and seed harvesting is necessary.
   b. Seedbed preparation should be similar to that prepared for small grain crops.
   c. Mechanical and herbicide fallowing of the soil for a year or more prior to planting will help control undesirable plants and improve moisture accumulation.
   d. Fence orchards for protection from livestock and wildlife.
   e. Clean cultivate within and around seed producing areas. This will decrease the likelihood of destruction by wildfire.
   f. Prune for more effective seed production and harvesting and for removal of broken or dead branches.
   g. Weekly observations and sweeping are necessary to assess status of destructive insects. Identify insects causing problems and develop a control program. Care must be taken to minimize harm to pollinator, parasite, and predator insects that may be present.
   h. For bee pollinated species, introduce bees for more effective pollination.

5. Seed Harvesting
   a. The collector must discern between good viable seed, and poor seed that may be insect-damaged or underdeveloped. He must know when seed is ripe and ready for harvesting.
   b. Consider the use of combines or head and seed strippers where possible.
   c. Seed harvesting with various beaters, hoppers, and hand strippers are presently the most efficient and fastest methods for some species. Precautions must be taken to ensure that seed is not mechanically injured during harvest or subsequent processing.

Kent R. Jorgensen
G. Richard Wilson

Chapter 26

Seed Germination

Seed germination represents the means for survival and spread of many plants (McDonough 1977). Germination consists of three overlapping processes: (1) absorption of water, mainly by imbibition, causing swelling of the seed; (2) concurrent enzymatic activity and increased respiration and assimilation rates; and (3) cell enlargement and divisions resulting in emergence of root and plumule (Evanari 1957; Schopmeyer 1974b).

Germination is most commonly expressed as germination capacity, which is the percentage of seed that germinates during a period of time that ends when essentially all germinable seed have germinated. Germination energy is sometimes used in the literature. Germination energy is the percentage of seed that germinates during a specific time interval that is determined by the peak of germination. Germination capacity and germination energy will generally vary considerably within a seed lot (table 1).

Table 1—Mean germination energy and mean germination capacity of 18 grass, 27 forb, and 28 shrub species following specified number of days. Germinated in the dark at 34 to 38 °F (1.1 to 3.3 °C).

Species	Germinative energy[a]		Germinative capacity[b]		Number of accessions[c]
	Percent	Days	Percent	Days	
Grasses					
Bluegrass, Kentucky	27	70	30	365	6
Brome, mountain	54	38	77	120	7
Brome, meadow, 'Regar'	90	28	92	42	6
Brome, smooth southern	67	21	80	49	12
Fescue, hard sheep	58	30	82	60	12
Foxtail, meadow	75	30	80	75	8
Orchardgrass	70	28	91	45	7
Orchardgrass, 'Paiute'	30	56	72	112	16
Rye, mountain	45	30	49	60	5
Squirreltail, bottlebrush	75	28	95	49	8
Wheatgrass, bluebunch	85	21	93	45	8
Wheatgrass, standard crested	78	30	88	80	8
Wheatgrass, fairway crested 'Ephraim'	90	28	92	42	30
Wheatgrass, intermediate	70	28	93	50	24
Wheatgrass, pubescent 'Luna'	70	28	93	50	10
Wheatgrass, tall	75	30	90	120	10
Wildrye, Great Basin 'Magnar'	53	50	75	250	18
Wildrye, Russian	70	28	91	49	12
Forbs					
Alfalfa 'Ladak'	85	14	92(3)[d]	28	30
Alfalfa 'Nomad'	56	14	94(3)[d]	45	16
Aster, Pacific	34	120	59	180	8
Aster, Engelmann	80	150	83	180	4
Aster, blueleaf	26	90	48	180	4
Balsamroot, arrowleaf	26	98	40	175	12
Balsamroot, cutleaf	17	98	35	180	10
Burnet, small	80	21	91	35	16
Clover, strawberry	56	60	91	365	4
Cowparsnip	30	150	64	365	6
Crownvetch	35	45	55(20)[d]	180	12
Flax, Lewis 'Appar'	70	45	80	75	22
Geranium, Richardson	16	180	22	365	4
Goldeneye, showy	20	150	27	365	7
Helianthella, oneflower	50	90	90	180	10
Lomatium, narrowleaf	49	130	72	365	8
Lupine, mountain	63	36	77	98	16
Lupine, silky	73	56	95	98	10
Milkvetch, cicer	20	75	32(65)[d]	150	18
Penstemon, low	21	150	42	365	4
Penstemon, Palmer 'Cedar'	62	49	86	63	10
Sainfoin	80	21	91	35	10
Salsify, vegetable oyster	48	35	63	130	8
Sweetanise	34	180	60	365	8
Sweetvetch, Utah (shelled)	40	50	63	200	20
Sweetvetch, Utah (unshelled)	28	50	34	210	10
Sweetclover, yellow	75	14	90	42	22
Shrubs					
Apache plume	23	60	63	180	8
Bitterbrush, antelope	72	42	90	56	40
Bitterbrush, desert	58	28	86	70	12
Ceanothus, Martin[e]	33	120	38	240	8
Chokecherry, black	32	150	72	365	8

(con.)

Table 1 (Con.)

Species	Germinative energy[a]		Germinative capacity[b]		Number of accessions[c]
	Percent	Days	Percent	Days	
Shrubs					
Cliffrose	70	70	84	91	18
Currant, golden	37	90	70	365	7
Ephedra, green	74	56	91	70	18
Ephedra, Nevada	80	21	93	35	12
Greasewood, black[e]	30	45	46	180	4
Hopsage, spiny	60	40	82	120	18
Kochia, forage 'Immigrant'	60	35	87	49	30
Mountain mahogany, curlleaf	53	105	68	365	16
Mountain mahogany, true	64	63	83	112	20
Peachbrush, desert	57	45	75	180	8
Rabbitbrush, mountain low	63	180	73	365	6
Rabbitbrush, mountain rubber	55	49	72	63	8
Rabbitbrush, whitestem rubber	60	42	70	56	22
Sagebrush, basin big	60	63	61	70	36
Sagebrush, black	59	42	75	91	14
Sagebrush, fringed	15	74	36	365	4
Sagebrush, mountain big	45	48	82	104	32
Sagebrush, Wyoming big	38	48	76	104	12
Saltbush, fourwing[e]	26	42	39	63	60
Saltbush, Gardner[e]	16	90	24	180	8
Serviceberry, Saskatoon	63	330	80	365	12
Serviceberry, Utah	77	104	94	210	10
Winterfat	55	14	84	28	24

[a]Percentage of seed that germinate during a specific time interval that is determined by the peak of germination.
[b]Percentage of seed that germinate during a period of time ending when essentially all germatable seed have germinated.
[c]Number of accessions used in determining results. Two 100 seed samples per accession were evaluated.
[d]Percent hard seed in parenthesis.
[e]Fifty percent fill, all other species 95 to 100 percent fill.

A mature, viable nondormant seed (fig. 1) will germinate (fig. 2) if placed under favorable conditions of moisture, temperature, gas exchange, and light (for some species). There is an interdependence between these factors as well as between age of seed and storage conditions. The conditions that allow germination to occur and the time required for germination can vary dramatically between seed lots of a species (Meyer and Monsen 1990; Meyer and Pendleton 1990; Meyer and others 1987, 1989; Stevens and Jorgensen 1994; Young and others 1984d).

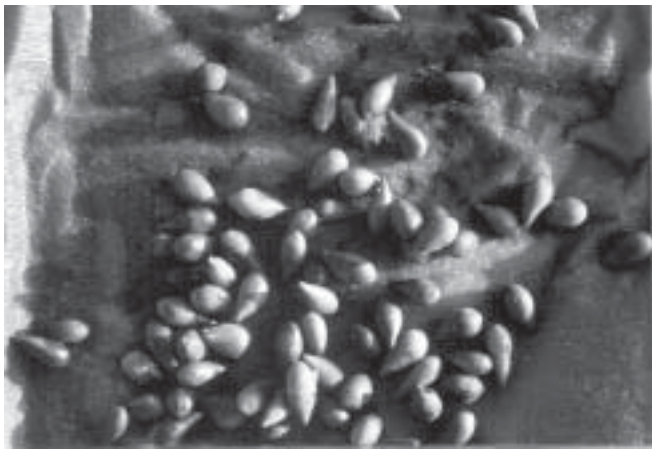


Figure 1—Mature, viable antelope bitterbrush seed.

Figure 2—Germinating antelope bitterbrush seed.

Moisture

The cells of the germinating seed cannot carry on the vital process of germination without sufficient water. The rate of water absorption is largely dependent upon the degree of seedcoat permeability and availability of water. Seedcoat permeability and rate of water uptake can be increased in some species by mechanical, chemical, or hot water treatments (see chapter 24). Seeds of some species will absorb the amount of water required for germination in a short period; others take a much longer period. Rubber rabbitbrush will absorb the amount of water required for germination in about 36 hours, whereas seed of blue elderberry requires a much longer period: 180 days or more.

Too much water can be harmful to some seeds. Most can be soaked in water for 3 to 5 days without decreasing germination, but care should be taken if seed is soaked for longer periods.

Temperature

Seeds of many species can germinate over a wide range of temperatures. Others germinate only within narrow temperature ranges (Schopmeyer 1974b). Seed of several plant species have the capacity to germinate at temperatures close to 32 °F (0 °C). Right after snow melt, soil temperatures are generally low and soil water levels are high. Under these conditions, those seeds that germinate at low temperatures have a good chance for survival, with adequate moisture being available for continued growth.

Knowing the temperature or combination of temperatures at which a species will exhibit maximum germination can help in determining the most ideal time to sow the seed. Optimum germination temperatures have been determined for a number of shrubs (Allen and others 1986a,c, 1987; Dettori and others 1984; Evans and Young 1977a; Springfield 1972a; Young and others 1981a; Young and Evans 1981b), cool season grasses (Allen and others 1986b; Young and Evans 1978a, 1981a, 1982, 1984; Young and others 1981a), and forbs (Allen and Davis 1986; Allen and others 1986b; Young and Evans 1979).

Extreme high temperature, such as in a fire can increase germination and emergence of species like buckbrush, smooth sumac, and lodgepole pine. Rupture of the seedcoat structure and heat inactivation of inhibitors are possible explanations for the effect fire has on seed germination (McDonough 1977).

Gas Exchange

Most seeds will not germinate when the soil is too wet, when seeds are planted too deep, or when conditions limit the supply of oxygen. Oxygen has to be present for germination to take place. A low rate of oxygen uptake permits only the earliest stages of germination to occur. If a continual source of oxygen is not available, germination will stop and the seed will die. Oxygen is also essential for normal seedling development. Oxygen requirements can affect seeding time, seeding depth, and selection of areas to seed. The rate of oxygen absorption during seed germination and seedling development is highly variable among species (Schopmeyer 1974b).

Light

Under natural conditions, some seeds become buried and germinate without light. However, light is essential for seed germination of many species. Depth of seeding should be controlled as well as possible when sowing seeds of species having a light requirement (Schopmeyer 1974b). Indian ricegrass, western wheatgrass, and Great Basin wildrye are a few species that germinate best in the dark (seed covered). Mountain brome, slender wheatgrass, blue grama, big sagebrush, and forage kochia are species that require light to germinate.

Afterripening

Another factor encountered in the germination process is afterripening or a continuation of the maturing process after harvest. There are a number of grasses, forbs, and shrubs that exhibit afterripening (Stevens and Jorgensen 1994) (table 2; also see chapter 24). Seed that has been collected before fully ripening, or seed freshly harvested can, initially, exhibit low germination that will increase after a period of air-dry storage. This process hardens the embryo, and in some instances helps increase the ability of the seed to absorb the water needed for the germination process. Whether or not afterripening occurs depends upon a number of factors, including site differences, degree of seed maturity at harvest, conditions of storage, and ecotypic differences within species (McDonough 1977).

Dormancy

Viable and uninjured seeds of most shrub species will not germinate without seed dormancy being broken or overcome. The degree of seed dormancy varies between species (fig. 3; table 2; also see chapter 24). For example, forage kochia and winterfat only require afterripening, whereas, wildrose and blue elderberry require 1 or 2 years or cold moist stratification to break dormancy. Most grasses exhibit little dormancy. An exception is Indian ricegrass (Young and Evans 1984), which exhibits a profoundly dormant embryo. Seed of most forb species, with the exception of the legumes, posses a moderate level of dormancy. Many

Table 2—Mean percent germination of seed from 39 plant species after 2 to 25 years of storage in an open warehouse (Stevens and Jorgensen 1994).

Species	Source	Years of storage								
		2	3	4	5	7	10	15	20	25
		Percent germination[a,b,c,d]								
Grasses										
Intermediate wheatgrass	Washington	95	96	93	94	80	78–	63	13	1
Smooth brome	Colorado	70	71–	52	39–	15	11	3	1	0
Winter rye	Idaho	89	88	82	75–	56	48	32–	2	0
Forbs										
Alfalfa	Canada	69	76	75	75	70	77	66	73	67
	same + hard seed	92	95	94	92	79	86–	71	78	71
Balsamroot, arrowleaf	Paradise Valley, NV	40	42		37–	20	1	0	0	0
Balsamroot, cutleaf	Bountiful, UT	35	28–	17	20–	4	0	0	0	0
Burnet, small	Ephraim, UT	88*+	93	91	96–	82	87	88–	69+	83
Cowparsnip	Pleasant Cr. Canyon, UT	7	8–	2	1	0	0	0	0	0
Eriogonum, Wyeth	Brigham City, UT	51*+	87		90–	64–	16–	5	–	0
Flax, Lewis	Ephraim, UT	66*	72*+	85	93	83	70–	25	8	0
Globemallow, gooseberry	Benmore, UT	7	7	6	9	6	7	6	–	2
Goldeneye, showy	Ephraim Canyon, UT	18	17	11	13	13–	1	0	0	0
Ligusticum, Porter	Ephraim Canyon, UT	41	28	24	36–	13	0	0	0	0
Lomatium, Nuttall	Ephraim Canyon, UT	69	73		73–	37–	8	2	0	0
Lupine, mountain	Ephraim Canyon, UT	58	77	69	60–	26	28	13	6	1
Lupine, silky	Ephraim Canyon, UT	97	99	100	99–	86	85	92–	75	76
Penstemon, Palmer	Ephraim Canyon, UT	83	81		79–	65	50		–	0
Salsify, vegetable-oyster	Mt. Pleasant, UT	65	65	66	66–	46	31–	13	0	0
Sweetvetch, Utah	Orem, UT	59	67	58	55–	25	40	16	11	21
Shrubs										
Bitterbrush, antelope	Mt. Dell, UT	79*+	86	87	94	88	88	85	84–	74
Bitterbrush, desert	Bishop, CA	78	86	80	80	69	73	65	61	60
Ceanothus, Martin	Manti Canyon, UT	3	5	5	12	10+	40	36–	5	6
Cliffrose	American Fork, UT	80*+	89		89	84	89	91–	66	63
Currant, golden	Manti, UT	48		–	28		27–	6	2	0
Ephedra, green	Manti, UT	88	92	92	84	80	82	88–	24	2
Ephedra, Nevada	Wah-Wah Valley, UT	90	93	91	85	89	91	85–	79	77
Hopsage, spineless	Escalante, UT	87	92	86–	57–	13	6	0	0	0
Indian apple	Ephraim Canyon, UT	42	42	42	37	39–	21	10–	–	0
Mountain mahogany, curlleaf	Mayfield, UT	67	63		80	76	69	64–	44	28
Mountain mahogany, true	Ephraim Canyon, UT	63	65	61	68–	46–	25–	3	0	0
Rabbitbrush, whitestem rubber	Richfield, UT	80–	65–	34–	14	11–	7	0	0	0
Sagebrush, basin big	Ephraim, UT	73	82	67	70–	24–	1	0	0	0
Sagebrush, black	Manti, UT	81–	66	55–	34–	5	1	0	0	0
Saltbush, fourwing	Panaca, NV	32	47	40	40	50	43	37–	18	11
Serviceberry, Saskatoon	Spring City Canyon, UT	91	80		91	85–	72	76–	1	0.3
Serviceberry, Utah	Henrieville, UT	97	99		99	96	90–	67–	5	0
Snowberry, mountain	Spanish Fork Canyon, UT	80	64		92	80–	44–	8	10	8
Winterfat	Corona, NM	90	83	74–	18	7	0	0	0	0

[a]Results based on four samples of 100 seeds each at 98 percent or better fill and 100 percent purity, except fill for fourwing saltbush (52 percent fill) and Martin ceanothus (59 percent fill).
[b]Asterisk (*) indicates significant afterripening.
[c]Plus sign (+) indicates significant increase in germination between adjoining years at the 0.5 level.
[d]Minus sign (–) indicates significant decrease in germination between adjoining years at the 0.5 level.

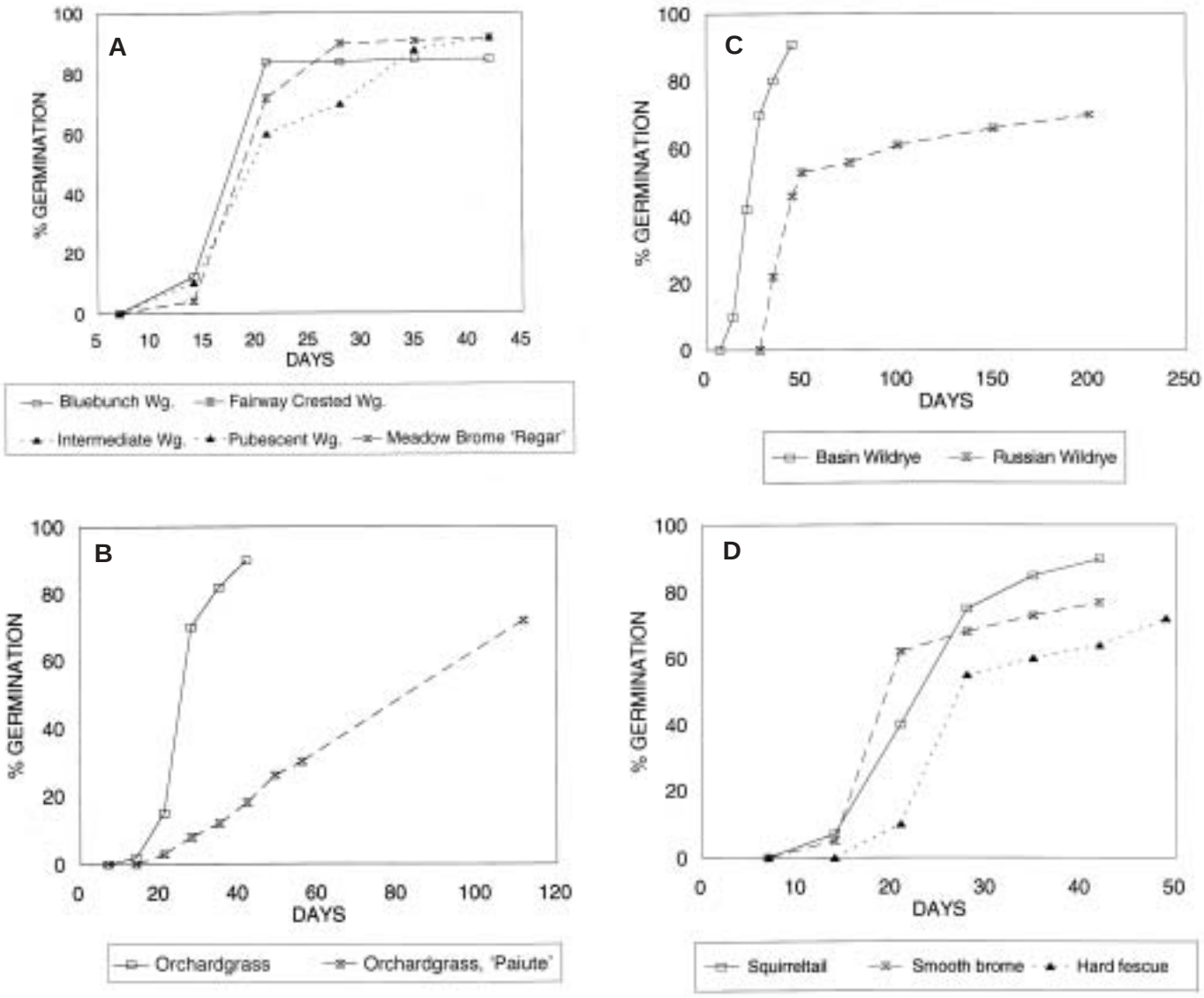
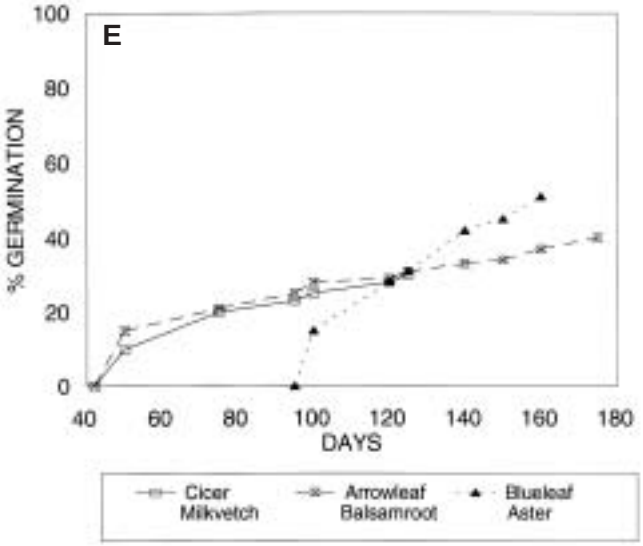
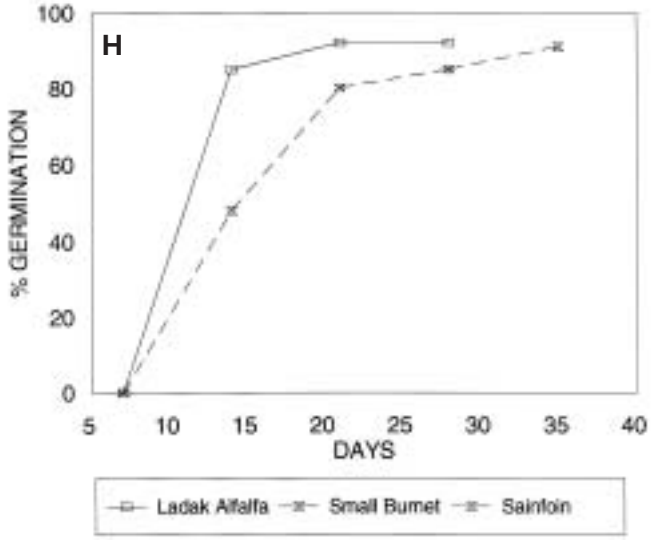


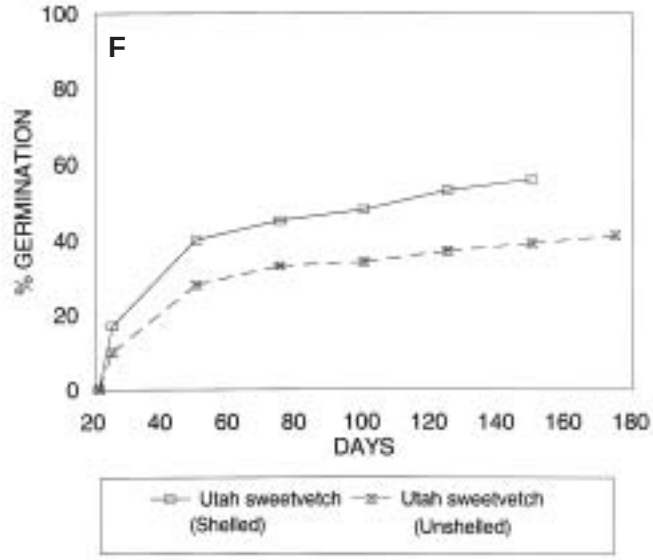
Figure 3—Mean germination over time of multiple accessions (number of accessions listed in parenthesis following common name) of selected grasses, forbs, and shrubs in the dark at 34 to 38 °F (1.0 to 3.3 °C). Two samples of 100 seeds each examined for each accession.

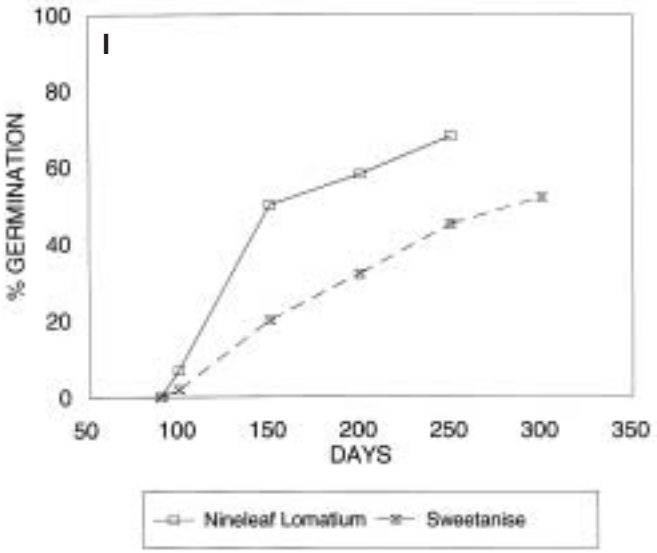
A. Bluebunch wheatgrass (8), fairway crested wheatgrass (8), meadow brome, 'Regar' (6), intermediate wheatgrass (24), and pubescent wheatgrass (10).
B. Orchardgrass (7), and orchardgrass, 'Paiute' (16).
C. Great Basin wildrye (18) and Russian wildrye (12).
D. Bottlebrush squirreltail (8), smooth brome (6), and hard sheep fescue (12).
E. Cicer milkvetch (18), arrowleaf balsamroot (8), and blueleaf aster (8).
F. Utah sweetvetch with seed out of loment (10), and Utah sweetvetch with seed in loment (20).
G. Yellow sweetclover (22), Palmer penstemon (10), and Lewis flax (32).
H. 'Ladak' alfalfa (30) and small burnet (10).
I. Nineleaf lomatium (8) and sweetanise (8).
J. Mountain lupine (16) and silky lupine (10).
K. Wyoming big sagebrush (12), basin big sagebrush (36), mountain big sagebrush (32), and black sagebrush (14).
L. Antelope bitterbrush (40) and cliffrose (18).
M. Winterfat (24), forage kochia (30), and fourwing saltbush (61).
N. Whitestem rubber rabbitbrush (22), green ephedra (18), and true mountain mahogany (20).
O. Curlleaf mountain mahogany (16) and black chokecherry (8).

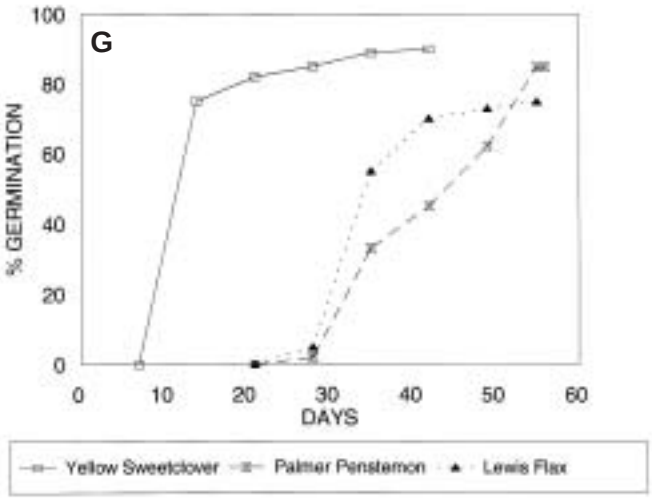
Figure 3 (Con.)


E
% GERMINATION
DAYS
Cicer Milkvetch
Arrowleaf Balsamroot
Blueleaf Aster


H
% GERMINATION
DAYS
Ladak Alfalfa
Small Burnet
Sainfoin


F
% GERMINATION
DAYS
Utah sweetvetch (Shelled)
Utah sweetvetch (Unshelled)


I
% GERMINATION
DAYS
Nineleaf Lomatium
Sweetanise


G
% GERMINATION
DAYS
Yellow Sweetclover
Palmer Penstemon
Lewis Flax

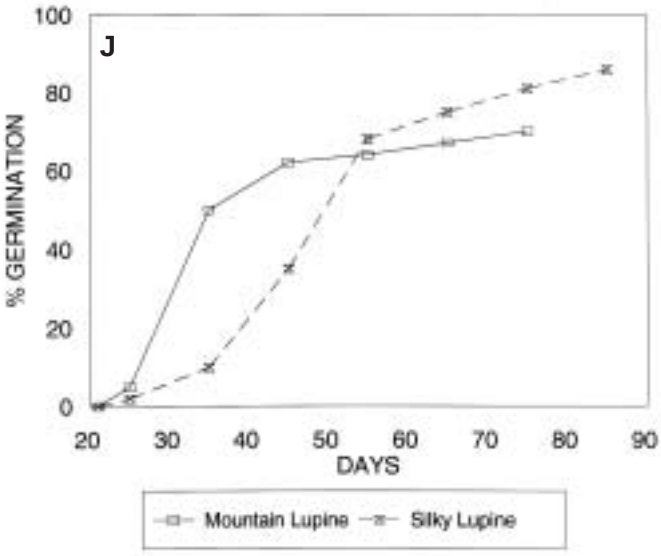
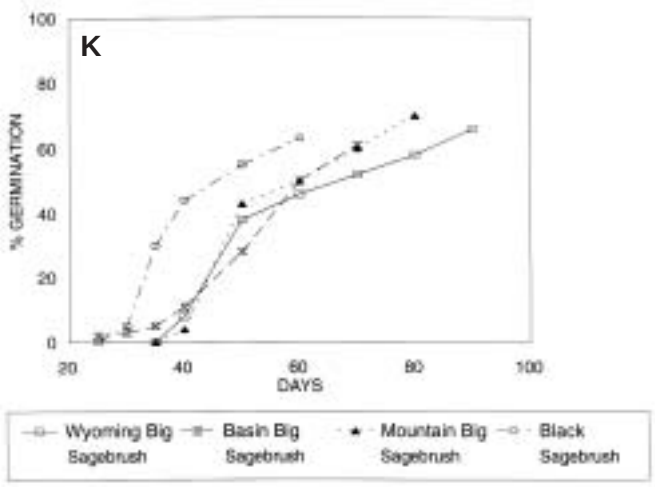
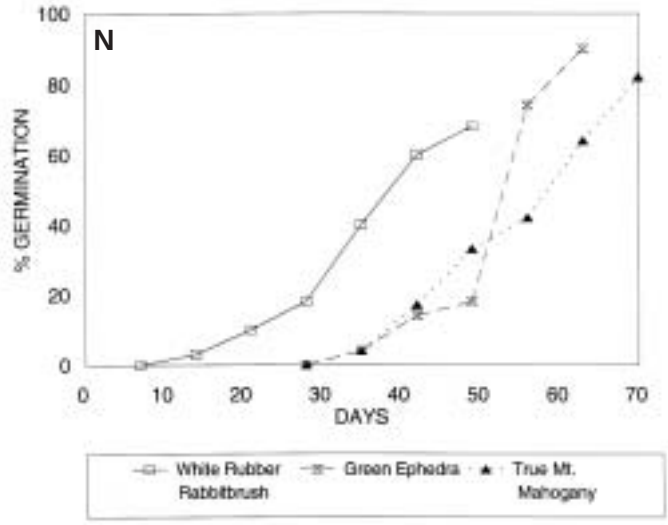
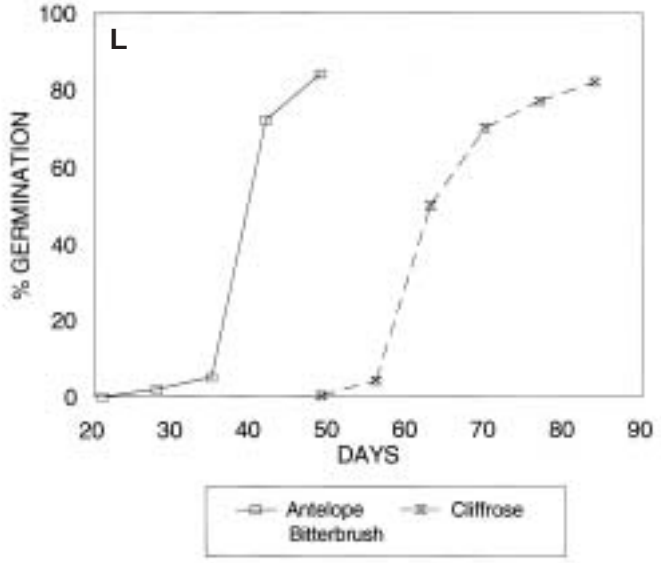
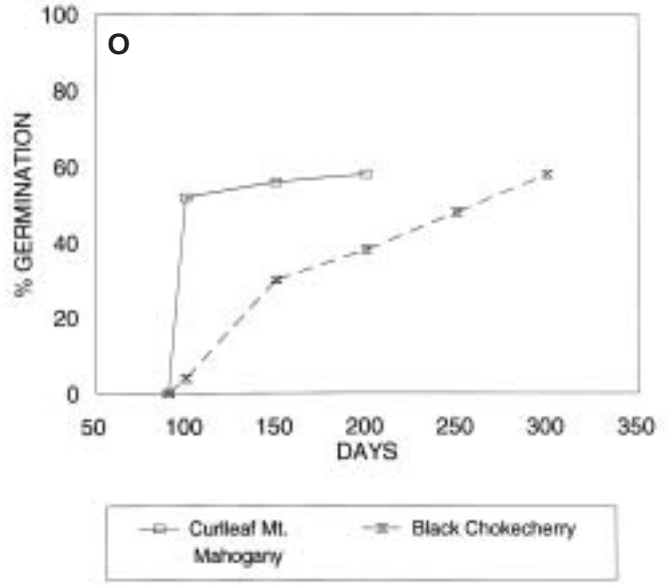

J
% GERMINATION
DAYS
Mountain Lupine
Silky Lupine

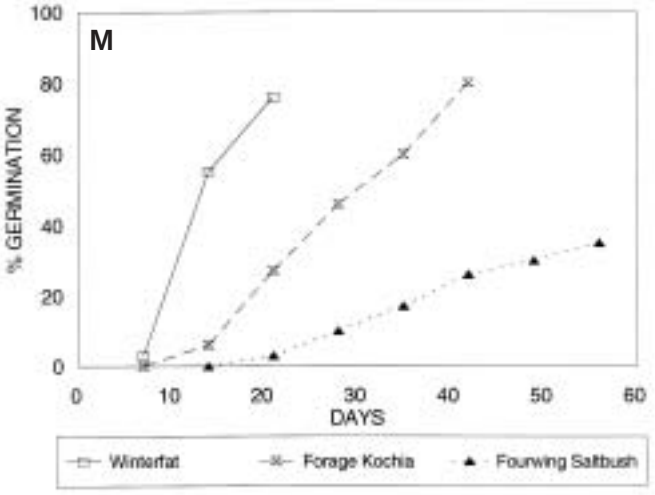
Figure 3 (Con.)











shrubs exhibit considerable seed dormancy. Time required for germination to occur varies between species and among accessions within a species (tables 1, 2, and 3; fig. 3) (Meyer and Monsen 1990; Meyer and others 1987, 1989; Stevens and Jorgensen 1994). Species that require more than 4 weeks to germinate should be fall-seeded to allow the seed sufficient time to overcome seed dormancy. This will also ensure that germination occurs at a time when the seedling can take full advantage of available seasonal soil moisture. Species exhibiting little dormancy can be spring-seeded if the date of seeding allows sufficient time for germination and seedling establishment prior to the usual soil drying experienced as the growing season progresses.

Longevity

The life span of seeds is affected by many variables such as: (1) the inherent nature of individual plant species; (2) condition of seed at harvest; (3) cleaning techniques; (4) storage conditions; (5) age of seed; (6) degree of infestation by disease organisms and insects; and (7) exposure to harmful chemicals. Fluctuating seed moisture content and high temperatures are especially damaging to seed longevity. Storing dried seed at low temperatures in vapor-tight containers will preserve seed viability for extended periods of time. Seed of forage kochia, dried to a 7 percent moisture content, and stored at room temperatures in airtight containers, have exhibited over 90 percent germination after 3 years. Undried seed stored at room temperature had only 14 percent germination after 3 years (Jorgensen and Davis 1984). In general, seed with hard coats and low water content are longer-lived, while seed with either relatively high water content, soft seedcoats, or both are shorter-lived (Quick 1961). There are exceptions to this generalization. Stevens and Jorgensen (1994) have reported on the longevity of many commonly used Intermountain species (tables 2, 3).

Location and Year of Production

Most species have a wide range of distribution, some larger than others. Populations of the same species growing under different climatic and edaphic conditions can exhibit different germination requirements.

Table 3—Percent germination of the same seed lots for grass, forb, and shrub seed the year of collection and following various years of storage in an open warehouse (Stevens and Jorgensen 1994).

	Years of storage											
Common names	**0**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
	Percent germination[a,b,c,d,e]											
Grasses												
Brome, smooth	91	94	0	0	0	0	0	0	0	0	0	0
Fescue, meadow	69*	0	+	0	99	0	0	0	0	0	0	0
Needle-and-thread	88	0	–	63	0	0	0	0	0	0	0	0
Ricegrass, Indian	55	0	0	0	0	0	63	0	0	0	0	0
Ricegrass, Indian	9*	0	+	0	0	0	0	0	0	0	49	0
Spike muhly	14*	0	+	62	0	0	0	0	0	0	0	0
Wheatgrass, tall	72*	0	+	0	0	91	0	0	0	0	0	0
Wheatgrass, tall	85	0	0	0	0	87	0	0	0	0	0	0
Wheatgrass, tall	85	0	0	0	0	92	0	0	0	0	0	0
Forbs												
Astragalus, giant	88	0	0	89	0	0	0	0	0	0	0	0
Crownvetch	41*	0	+	0	70	0	0	0	0	0	0	0
Goldeneye, showy	44	0	–	0	0	0	0	0	0	0	0	1
Goldeneye, showy	30*	0	+	0	0	0	75	0	0	0	0	0
Goldeneye, showy	39	0	–	0	0	0	0	0	0	0	0	0
Milkvetch, cicer	73	0	0	0	65	0	0	0	0	0	0	0
Milkvetch, cicer	51*	0	+	89	0	0	0	0	0	0	0	0
Penstemon, Eaton	63*	0	+	0	0	0	0	0	0	82	0	0
Penstemon, Eaton	71*	0	+	0	0	0	0	0	0	87	0	0
Penstemon, Palmer	89	0	0	0	0	0	0	0	0	82	0	0
Penstemon, thickleaf	74	0	0	0	0	0	0	0	0	0	68	0
Sweetanise	94	0	–	0	0	0	0	0	0	44	0	0
Shrubs												
Buffaloberry, silver	85	0	0	0	0	88	0	0	0	0	0	0
Honeysuckle	57	0	–	0	0	0	0	0	31	0	0	0
Indian apple	67	0	–	0	49	0	0	0	0	0	0	0
Indian apple	58	0	0	58	0	0	0	0	0	0	0	0
Oregon grape	25	0	0	0	0	0	0	0	0	23	0	0
Peashrub, Siberian	88	0	85	0	0	0	0	0	0	0	0	0

[a]Results based on two samples of 100 seeds, each at 100 percent purity.
[b]Asterisk (*) indicates significant afterripening.
[c]Plus sign (+) indicates significant increase in germination between germination years at the 0.05 level.
[d]Minus sign (–) indicates significant decrease in germination between germination years at the 0.05 level.
[e]Zero (0) indicates no data.

In work with rubber rabbitbrush, big sagebrush, and hopsage, clear relationships between collection site climate and seed germination patterns have been found (Meyer and Monsen 1990; Meyer and Pendleton 1990; Meyer and others 1987, 1989). Seed source should, therefore, be considered when purchasing seed. Seed from sources similar to that of the proposed planting site should be given preference over sources from locations having significantly different environmental conditions.

Often, germination percentage of a species from the same site will vary between years. Generally, percent germination is higher during years of high seed production than in years of poor seed production. Antelope bitterbrush collected in central Utah during high production years usually exhibits 95 percent or more germination, but during years of poor seed production the germination has varied from a low of 8 percent to a high of 68 percent.

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Chapter 27

Seed Testing Requirements and Regulatory Laws

Federal and State seed laws require that seed used on range and wildland sites be officially tested and appropriately labeled or tagged. It is the responsibility of the seed distributor (who may be the producer, collector, or broker) toward the end user to properly tag each container of seed to comply with these laws. An analysis tag is always required. If seed has been Certified, a seed certification tag will also be attached.

Seed-testing laws and truth-in-labeling laws require that all commercial seed be tagged with the appropriate analysis tag, and that each tag has minimum statements about seed quality and origin. Improperly tagged seed may be subject to legal actions that stop sale movement and use. Violation of State and Federal laws can result in considerable fines.

Information on the analysis tag comes from two sources: 1. The seed producer or dealer provides the common and scientific name, variety (if applicable), lot number, State of origin, year of harvest, and name and address of seller. 2. The laboratory performing the seed test reports percent purity, inert matter, other

crop seed, weed seed, noxious weed seed, germination, hard or dormant seed, total viable seed, and test date on the seed sample they are provided (fig. 1). The seed laboratory also verifies the species (or crop kind) of the seed, but cannot normally verify the cultivar or particular germplasm or accession (ecotype) of the species as claimed by the seed producer or dealer on the analysis tag.

All Federal, State, and private seed-testing laboratories in the United States and Canada are required to use standard procedures as outlined in "Rules for Testing Seeds," published and updated annually by the Association of Official Seed Analysts (1999). Each State has an official seed laboratory that performs standard tests and answers pertinent seed-testing and regulatory questions (Stevens and Meyer 1990). Contact information for these laboratories may be found at www.aosaseed.com. Seed quality testing standards are now in place for some shrubs and forbs, and for most grass species used on Western ranges and wildlands (Association of Official Seed Analysts 1999; Stevens and Meyer 1990). Testing procedures for many other forbs and shrubs have not yet been standardized, accepted, and published. As a result, laboratory tests may be inconsistent.

The certification tag identifies seed species/cultivar/germplasm identity and purity. The Association of Official Seed Certifying Agencies (Utah Crop Improvement Association 1999; Young 1995; Young and others 1995) has established four germplasm development levels: Variety/Cultivar, Tested, Selected, and Source Identified. Generations of a Variety/Cultivar are designated as Breeder, Foundation (fig. 2), Registered (fig. 3), and Certified (fig. 4). Classes of Pre-Variety Germplasm (for which the generations are numerically stated on the tag) are Tested (fig. 5), Selected (fig. 6), and Source Identified (fig. 7). These class names are registered trademarks and can only be used when referring to seedlots that have been Certified by an official agency. Technically, Certified seed can only be offered for sale or sold as Certified Breeder Class, Certified Foundation Class, Certified Registered Class, Certified Certified Class, Certified Tested Class, Certified Selected Class, and Certified Source Identified Class. Noncertified seed is often referred to as "common" or "variety not stated" seed.

In Utah, seed certification is a service of the Utah Crop Improvement Association. Certification provides verification for the variety and germplasm. This is accomplished through wildland and site or field increase inspections, verification of seed stock records, and maintenance of seed identity through harvest, storage, conditioning, bagging, and tagging. Certified seed by definition has known germplasm identity, high genetic purity, high germinating ability, and minimum amounts of other crop seed, weed seed, and inert matter.

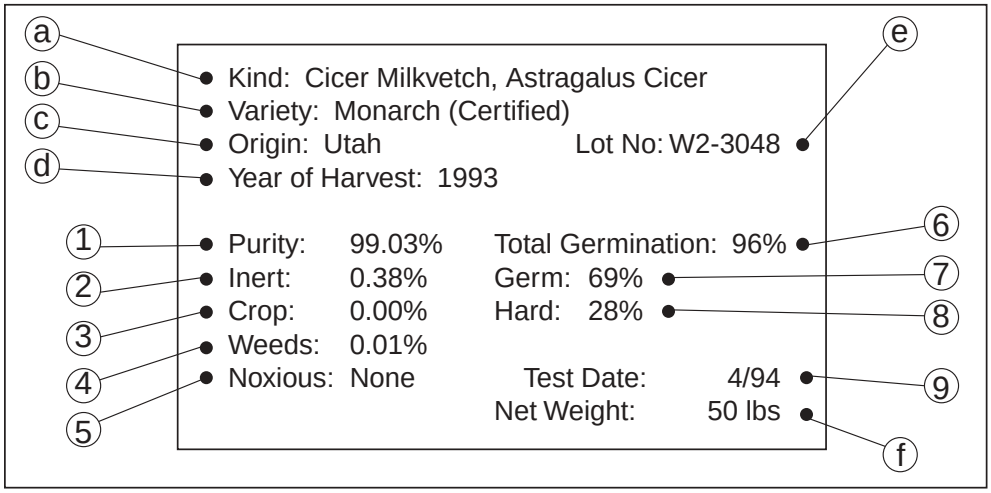


Figure 1—Diagram of a typical analysis tag (dealers name and address deleted). The seed dealer provides the following information: (a) common and scientific name, (b) variety (or "variety not stated" when variety is not known or no variety where none are released), (c) seed origin, (d) date of harvest, (e) lot number, and (f) net weight. The testing laboratory provides results of: (1) percent purity, (2) percentage of inert matter, (3) percentage of other crop seed, (4) percentage of weed seed, (5) presence of noxious weed seed, (6) total viable seed percentage (combination of numbers 7 and 8), (7) actual germination percentage, (8) hard or dormant seed percentage, and (9) test date.

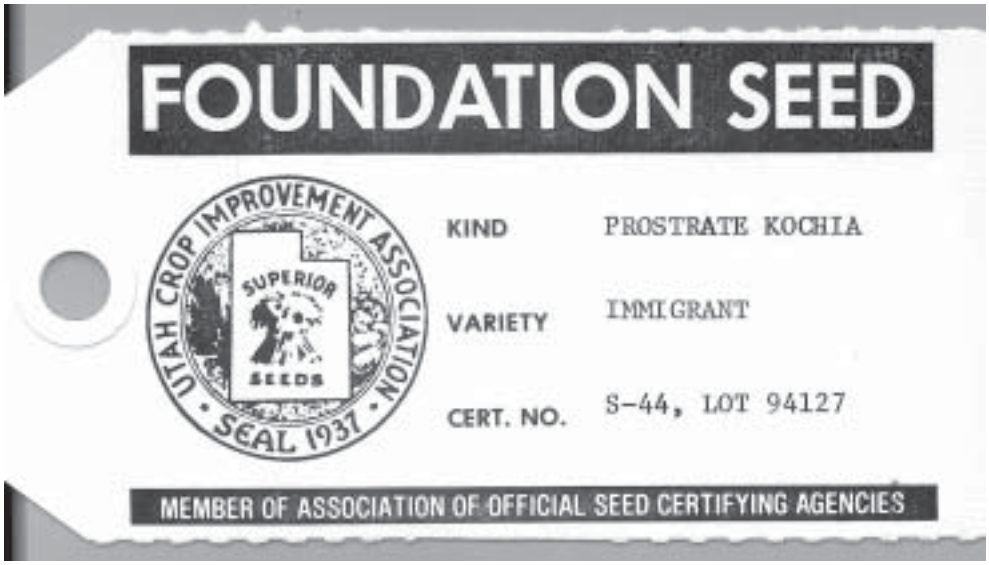


Figure 2—Certified "Foundation Seed" identification tag. Foundation seed is a class of certified seed. It can be the progeny for breeder or foundation seed and is established for the purpose of maintaining genetic purity and identification. Designated color for this tag is white.

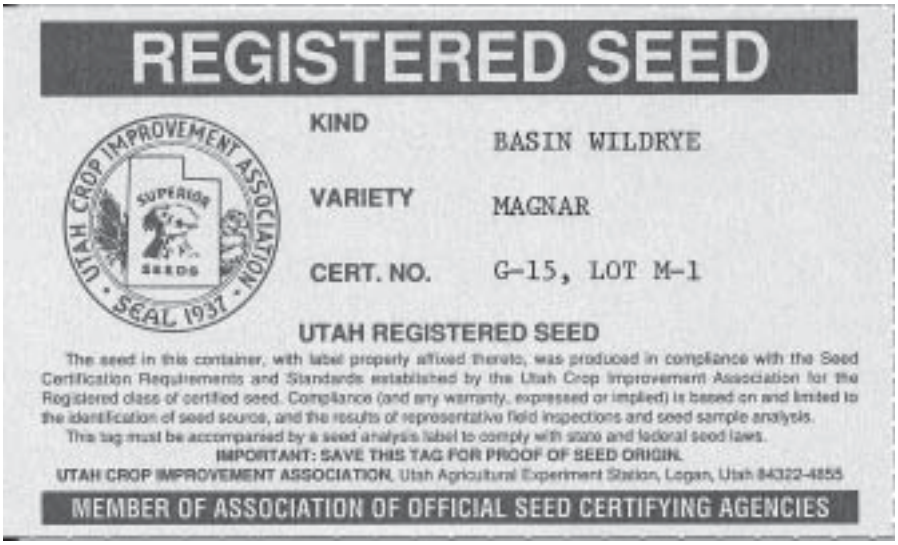


Figure 3—Certified "Registered Seed" identification tag. Registered seed is progeny of breeder or foundation seed. It is used to produce certified seed and to maintain genetic purity and identification. Designated color for this tag is violet.

The majority of native seed occurs on Federal, State, and State wildlife lands. Most agencies require collecting permits. Seed is also collected from private lands. Collectors must obtain required permits and permission to collect seed from any lands.

Agronomic seed crops are usually sold on a bulk-weight basis; seed for range and wildland seedings are more commonly marketed on a pure live-seed (PLS) basis. Seed analysis reports become extremely important when the pure live-seed method is used. To arrive at a PLS value, percent purity is multiplied by total percent germination. For example, if a seedlot has a purity value of 50 percent and a total germination (germination plus hard or dormant seed) of 80 percent, the PLS percentage would be 0.50 x 80 = 0.40 or 40 percent. A 100 lb bag from this seedlot would contain 40 lbs of pure live-seed (40 PLS lbs) (weight x PLS) (Stevens and others 1996).

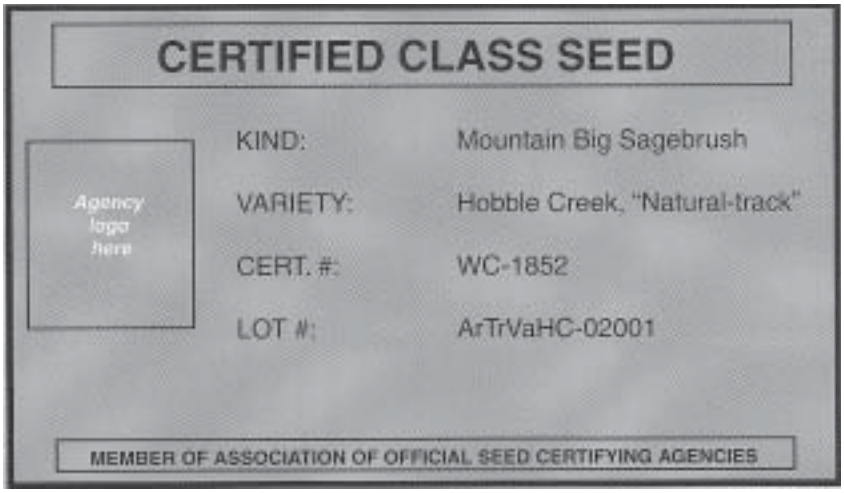


Figure 4—Certified "Certified Seed" identification tag. Certified seed is produced from breeder, foundation, or registered seed. It is the class commonly sold to individuals and agencies for range and wildland seedings. Designated color for this tag is light blue.

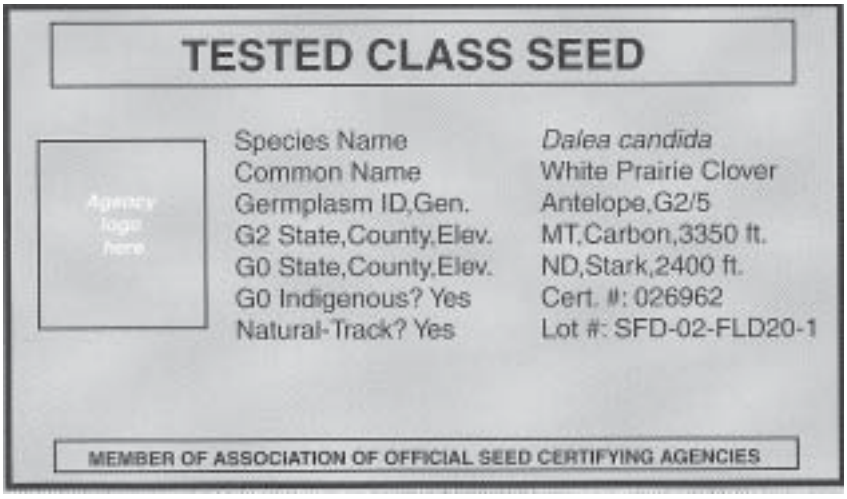


Figure 5—Certified "Tested Class Seed" identification tag. A germplasm that has undergone progeny testing to prove that preferred traits are heritable to succeeding generations. Seed can come from wildland shrubs and cultivated fields and orchards. Designated color for this tag is light blue.

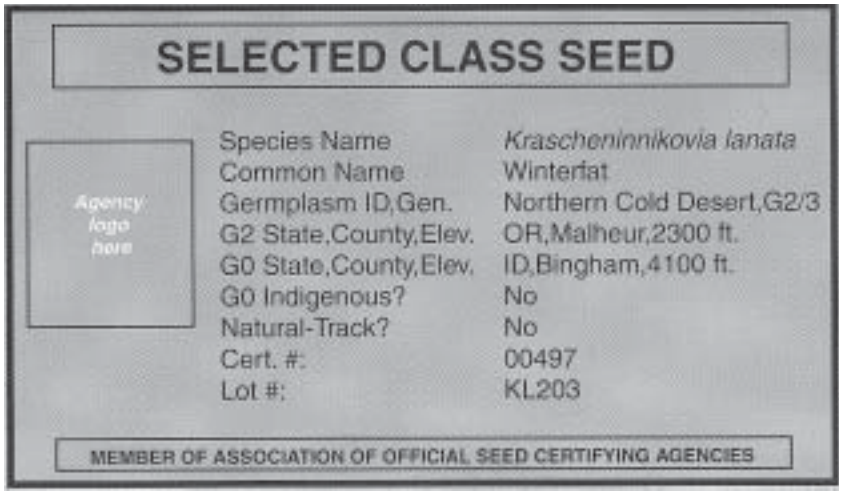


Figure 6—Certified "Selected Class Seed" identification tag. A germplasm that has been compared with other germplasms and shows some promising or identifiable trait. Seed can come from wildland stands or cultivated seed fields and orchards. Designated color for this tag is green.

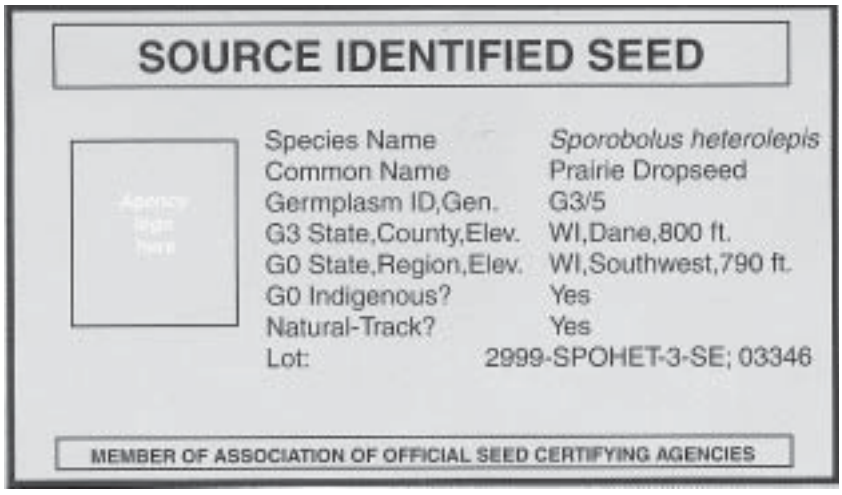


Figure 7—Certified "Source Identification Seed" tag. The original range or wildland collection site is known and certified. Designated color for this tag is orange.

Richard Stevens

Chapter 28

Establishing Plants by Transplanting and Interseeding

Transplanting

Many shrubs, trees, forbs, and grasses can be successfully established to provide rapid, effective soil stabilization, forage, and cover through transplanting bareroot or container-grown stock, wildings, and stem cuttings (McArthur and others 1984a; Monsen 1974; Shaw 1981; Stevens 1980a, 1994; Tiedemann and others 1976).

Successful transplanting requires that strict procedures be followed. When transplanting by hand or when using a mechanical transplanter, general rules that need to be followed with wildings, bareroot or container-grown stock, and stem cuttings are: (1) never allow roots or stem ends to dry, (2) keep plants cool—do not allow them to overheat prior to planting, (3) plant during cool periods with adequate soil moisture, (4) compact soil around the roots at planting time, and (5) eliminate plant competition around the transplant (Ferguson and Monsen 1974; Penrose and Hansen 1981; Ryker 1976; Stevens 1981).

Transplanting during the most desirable period is essential. Within the Intermountain West, transplanting should generally be done in the spring when chances of frost heaving have passed, soil moisture is high, temperatures are low, and chance of rainfall is high.

Proper handling of plant materials can determine success or failure. Roots of bareroot stock can dry out with as little as 30 seconds exposure to air, particularly with wind or high ambient temperatures. Roots must be kept damp, and, if possible, cool at all times. Roots of container stock, once out of the container, will dry out but will tolerate longer periods of exposure than bareroot stock. Temperatures in plastic bags and cardboard boxes can be damaging or lethal, especially when containers are placed in direct sunlight for short periods of time.

Plants must to be properly placed in the soil. Care should be taken to ensure that roots are placed vertical, with no "J" or "S" root configuration. Following proper plant placement, soil should be firmly compacted around the roots. All air pockets must be eliminated. Air pockets and loose soil can result in poor anchoring, dry roots, little or no uptake of water and nutrients, and death of the plant. Transplanting is most successful when soil moisture is high, ambient temperatures are low, and one or more storms (snow or rain) are expected within 5 weeks following transplanting. In central Utah, at 4,500 ft (1,370 m) elevation, transplanting projects completed before March 15 will most likely occur in moist soil and receive three to four storms within 4 to 5 weeks. At 6,000 ft (1,830 m) elevation, transplanting should be completed by April 1.

An important factor contributing to success is the selection of plants adapted to the planting site (Penrose and Hansen 1981; Rehfeldt and Hoff 1977; Stevens 1981). Selected species must be able to establish and maintain themselves. This does not mean that the wilding transplants, or seed source for nursery stock need to come from or near the proposed treatment area, but it does mean that they need to be adapted to the site.

Size of transplants can affect establishment success. Plant tops and roots can be too short or too long. In working with shrub transplants of various sizes, the most successful results were obtained with bareroot stock having roots from 6 to 12 inches (15 to 30 cm) long and tops at least 13 inches (33 cm) long (McKenzie and others 1980; Stevens 1979; Stevens and others 1981b) (fig. 1). Container-grown stock should have roots as long as the container.

Transplanting results can vary between species (Everett 1980; Ferguson and Monsen 1974; Stevens 1980a,b; Tiedemann and others 1976) (table 1). Most sagebrush (fig. 2) and rabbitbrush species, as well as rhizomatous forbs and grasses transplant with good success (Stevens and others 1981b).

Figure 1—Wilding bareroot stock of basin big sagebrush (right) and Wyoming big sagebrush (left).

The success of shrubs and forbs transplanted into grass stands can be increased when planting is done on spots or in strips that have been sprayed with an effective herbicide, or on scalps that are wide and deep enough to remove competition during establishment, and that are effective water harvesters (fig. 3). However, scalping too deep can result in removal of the most fertile soil and reduced plant growth (Stevens 1985a).

A specially designed implement hitch has been developed (USDA Forest Service, Equipment Development Center, San Dimas, California Drawings No. RM 35-1 through 09) (McKenzie and others 1980) that will keep a transplanter at a constant depth, with balanced pressure on the compact wheels even on rough terrain. This hitch meets special requirements for transplanting (Moden and others 1978a).

Very successful shrub, forb, and grass transplanting can be rapidly accomplished using a heavily

Table 1—Expected success of establishment, using bareroot, container-grown, and stem-cutting planting stock[a].

Species	Bareroot and wilding stock	Container-grown stock	Stem cuttings
Shrubs			
Bitterbrush, antelope	6	4	
Bladdersenna	5	4	
Cliffrose	5	4	
Currant, golden	8	8	
Elderberry, blue	5	4	
Ephedra, green	4	1	
Greasewood, black	3	1	
Indian apple	5	4	
Kochia, forage	8	8	
Mountain mahogany, curlleaf	5	2	
Mountain mahogany, true	5	2	
Oak, Gambel	5	2	
Rabbitbrush, low mountain	7	7	
Rabbitbrush, greenstem rubber	8	7	
Rabbitbrush, threadleaf rubber	8	7	
Rabbitbrush, whitestem rubber	8	7	
Rabbitbrush, spreading	10	10	
Rose, Woods	8	8	4
Sagebrush, basin big	10	10	
Sagebrush, mountain big	10	10	
Sagebrush, Wyoming big	8	8	
Sagebrush, black	10	10	
Sagebrush, silver	10	10	
Saltbush, fourwing	3	1	4
Serviceberry, Saskatoon	6	4	
Snowberry, mountain	9	9	3
Sumac, Rocky Mountain smooth	5		
Sumac, skunkbush	5		
Winterfat	6	2	
Wormwood, oldman		10	10
Forbs			
Alfalfa	6	8	
Aster, spp.	10	10	
Balsamroot, arrowleaf	1		
Balsamroot, cutleaf	1		
Bluebell	9		
Burnet, small	6	7	
Crownvetch	10	10	
Flax, Lewis	8	8	
Geranium spp.	3		
Globemallow, gooseberryleaf	8	8	
Globemallow, scarlet	8	8	
Goldeneye, showy	6	9	
Iris, German	10		
Lupine spp.	2	6	
Milkvetch, cicer	8	9	
Sagebrush, Louisiana	10	10	
Sainfoin	6	8	
Salsify	2	8	
Sweetanise	1		
Sweetvetch, Utah	5	8	
Yarrow, western	10	10	
Grasses			
Bunchgrasses	8	10	
Sod grasses	10	10	

[a]10 = High percent of establishment can be expected when proper transplanting techniques are used. 1 = Low percent of establishment can be expected, even when proper transplanting techniques are followed.

Figure 2—Three year old wilding transplants of Wyoming big sagebrush in a crested wheatgrass stand.

reinforced tree planter that requires hand placing of the transplants. Rate of planting bareroot stock, using a hand-fed transplanter, depends on soil conditions, species being transplanted, and condition of plants. Rates can vary from 600 to 1,100 per hour (Stevens and others 1981b). Most shrub and many grass and forb transplants cannot be planted successfully using an automatic pickup and planting system found on many modern tree planters. This is because most transplantable shrubs (fig. 1), and many forbs and grasses, have either wide-spreading, multiple branched, fibrous, or fairly long root systems that will tangle in the fingers and chains of the automatic planting device and subsequently are not placed properly in the soil.

A number of totally automatic transplanters have been developed that include the bandoleer concept (Moden and Hansen 1980): the dribbler type (Moden and others 1978a), the steep-slope planter, and the dryland tubling planter (Larson 1980). These systems are designed to automatically transplant container stock grown in specially designed containers.

Figure 3—One year old wildling transplants, planted into an intermediate wheatgrass stand.

Many species of grasses, forbs, and shrubs are available as container-grown stock. Container-grown stock has several advantages over bareroot stock. Roots of container-grown stock are established in a growth medium, and plants are available when needed. Bareroot stock is not usually lifted until the frost is out of the soil, delaying the acquisition of planting stock in some years.

Bareroot stock has several advantages over container-grown stock. Bareroot stock, when properly planted, establishes quicker, generally has a higher rate of survival (Crofts and Parkin 1979), and is more evident because of increased plant size (Monsen 1980b; Stevens 1980a). Bareroot stock is generally older (1 to 3 years) (Stevens 1981) than is container stock (3 to 4 months) (Penrose and Hansen 1981), and has strong woody stems and root systems. Container-grown stock has generally been grown under forced conditions, resulting in young, sometimes weak, spindly plants. Bareroot transplants, especially wildings, are truly hardened, having been grown in the out-of-doors. Lack of bulky packaging and soil makes bareroot stock easier to handle, both on and off the planting site. Initial purchase price, transplant cost, and cost per established plant of container stock is greater than that of bareroot stock (Crofts 1980). Cost of bareroot nursery stock is generally low. The cost of wildings can be especially low; most sagebrushes, rabbitbrushes, winterfat, and some grasses and forbs, are locally abundant and require little expenditure and effort to obtain.

Interseeding

Within the Intermountain West, vast areas have been seeded with, and are dominated by crested and intermediate wheatgrass, and other perennial and annual grasses. Hundreds of thousands of acres are also dominated by unproductive shrub and forb communities.

Interseeding of useful shrubs, forbs, and grasses into less productive and single species communities can provide a means for improving animal habitat, forage production, forage quality, community diversity, and soil stability.

The addition of shrubs and forbs into grass communities can actually improve the nutritional quality of a range, especially during periods when grasses are dry (midsummer, fall, and winter), and crude protein value is generally low (Rumbaugh and others 1981; Van Epps and McKell 1978). A monotypic stand

of any one species is poor habitat for most wildlife. Transplanting and interseeding can increase vegetative diversity. As the diversity of a plant community increases, so does the diversity of bird, mammal, reptile, and insect life it can support (Reynolds 1980).

Interseeding has often been done to improve big game and livestock ranges by introducing shrubs and forbs (fig. 4) (Barnes and Nelson 1950; Monsen 1980a,b; Plummer and others 1968; Stevens and others 1981b) into otherwise less productive communities. Interseeding is an effective means for seeding desirable species into cheatgrass and tarweed stands (Arizona Interagency Range Technical Subcommittee 1969; Giunta and others 1975) and for improving native grass ranges (Derscheid and Rumbaugh 1970; Lang 1962; Nyren and others 1980; Rumbaugh and others 1965). Interseeding can also be a means of reducing forage losses and plant death caused by insects and disease. When erosion hazards are high, when the preparation of a complete seedbed is impractical, or when the purpose of an improvement project is to modify rather than replace the present plant community, interseeding is an alternative to complete community destruction and seedbed preparation (Jordan 1981; Vallentine 1989).

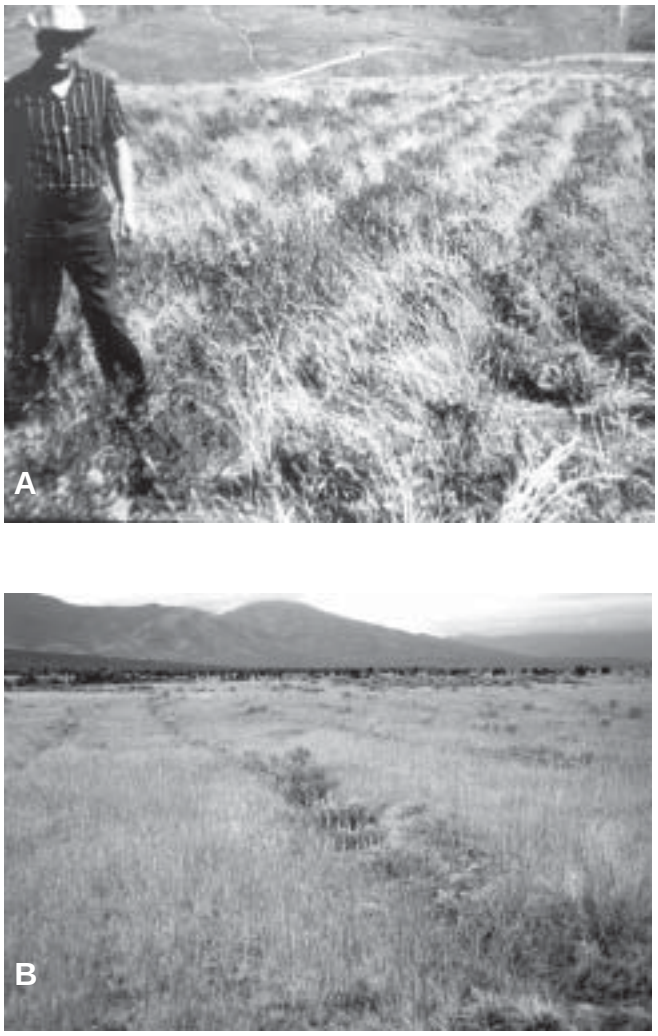


Figure 4—(A) Four year old stand of alfalfa and bitterbrush, interseeded into cheatgrass. (B) Five year old interseeding of big sagebrush, alfalfa, forage kochia, and small burnet into intermediate wheatgrass.

To effectively interseed into existing vegetation, competitive plants within and near the seeding area need to be eliminated. Two effective means to remove competiting vegetation are scalping and herbicides. Removal methods have to: (1) be deep and wide enough to remove or kill all seeds, crowns, and rhizomes of competing vegetation; (2) allow for effective establishment of the seeded species before a reinvasion of competitive vegetation occurs; and (3) be of such a shape and size, when scalping or pitting is used, as to be effective water harvesters (Jordan 1981; Stevens and others 1981b).

Competitive vegetation can be killed in strips or spots with appropriate herbicides (Eckert 1979; Nyren and others 1980; Stevens 1985a). Fall drilling or broadcast seeding can then be done in the sprayed strips or spots. This technique has several advantages. It allows seeding to be done in the most fertile soil, and the litter that is left in place can protect seedlings from frost and heat, provide for retention and detention of surface water, and reduce evaporation.

Mechanical removal of competiting vegetation has been done with various types of pitters and scalpers (Giunta and others 1975; Jordan 1981; Larson 1980; Monsen 1980a; Nyren and others 1978; Schumacher 1964; Stevens 1979; Vallentine 1989; Wright and others 1978) and with rototillers (Smoliak and Feldman 1978).

How wide the scalp or pit needs to be to eliminate competition depends on the vigor and type of existing vegetation, species being interseeded, and type of site being interseeded. Care must be taken to ensure that the most fertile soil is not eliminated by scalping too deep (Stevens 1985a). Drier sites require wider scalps because of increased competition for moisture. In arid areas, summer fallowing may even be required (Bement and others 1965). Scalps made on the contour, with cross dams, can catch and hold additional moisture from snow and rain (Branson and others 1962; Stevens 1978) and can enhance chances of seedling establishment and subsequent plant growth. In planting shrubs in cheatgrass, Giunta and others (1975) found that seedling establishment was superior in 24 inch (61.0 cm) wide scalps as opposed to 4, 8, and 16 inch (10.2, 20.3, and 40.6 cm) wide scalps. In the Northern Great Plains (Derscheid and Rumbaugh 1970) it was found that scalps 6 inches (15.2 cm) wide were sufficient for seeding alfalfa and cool season grasses into native sod. Russian wildrye interseeded

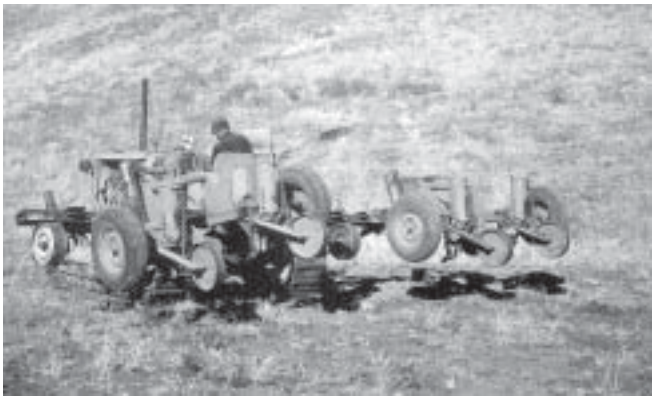


Figure 5—Four Hansen browse seeders being used to establish desirable shrubs and forbs in an annual grass community.

Figure 6—Wyoming big sagebrush seeded in conjunction with crested wheatgrass. Sagebrush was seeded separately through outside seed drops of a rangeland drill.

into native sod in Wyoming did not do well in scalps less than 18 inches (46 cm) wide (Rauzi and others 1965). When seeding native shrubs into crested wheatgrass, Van Epps and McKell (1978) found that the scalps should be at best 40 inches (100 cm) wide, with optimum spacing being 60 inches (150 cm). Seedling establishment varied in three scalp widths in intermediate wheatgrass. The widest scalps (30 inches [76 cm] wide and 9 inches [23 cm] deep) resulted in the most plants per linear foot (30 cm) of scalp. Established plants in the wider scalps were also the largest, and flowered sooner following seeding.

A number of seeding devices have been developed that can be used effectively in conjunction with various types of scalpers. The Hansen browse seeder has been used to establish desirable shrubs and forbs into single species stands (fig. 5). The thimble seeder and the seed dribbler (Larson 1980) are both designed to sow cleaned seed of any size and shape as well as trashy or plumed seed. Seed of selected species can be sown concurrently, yet separately, through various types of drills. This type of seeding reduces interspecies competition and improves establishment (fig. 6).

Nancy L. Shaw

Chapter 29

Production and Use of Planting Stock

Introduction

Vegetation can be rapidly established on disturbed sites by planting stock alone or in combination with direct seedings. Types of planting stock commonly used range from bareroot or containerized seedlings to pads of native vegetation. Inclusion of planting stock in rehabilitation or restoration projects requires careful scheduling, selection of adapted plant species, and use of appropriate propagation, handling, and planting techniques to maximize plant establishment and first-season growth.

Planting stock may be used to advantage in a number of situations.

1. Drastically disturbed areas such as mined sites may be revegetated to quickly provide soil stabilization (Everett 1980; Hungerford 1984; Institute for Land Rehabilitation 1978, 1979) (fig. 1). Rocky or unstable surfaces, steep slopes, and eroding streambanks are inaccessible to most drill seeding equipment and provide poor seedbed conditions if broadcast or aerially seeded. Planting stock can be placed in the most favorable microsites to maximize establishment. Large stock with well developed root systems is used to reduce plant burial or displacement by soil movement.

2. Quantity and quality of cover and forage provided for livestock and big game on critical rangeland sites may be improved and the grazing season lengthened or altered by planting shrubs on seeded grasslands or depleted winter ranges (Medin and Ferguson 1980; Shaw and others 1984; Rumbaugh and others 1981, 1982) (fig. 2).

3. Windbreak, shrub thicket, and conservation plantings are established using planting stock of species with known growth habits or wildlife values. Plants are placed in desired configurations to enhance project objectives (Alcorn and Dodd 1984; Johnson and Anderson 1980; Shaw and others 1984; Snyder 1983).

4. The aesthetics of campgrounds, recreation areas, roadways, and construction sites are enhanced by landscaping with adapted planting stock. Attractive, low-maintenance, native or introduced species may be selected (Stark 1966; Steger and Beck 1973; Tipton and McWilliams 1979; Wilson and others 1984).

5. Severely disturbed range sites such as holding areas, trailing lanes, or powerline corridors may be reclaimed through a combination of seeding and transplanting.

Figure 1—Shrubs planted on phosphate mine spoil to provide erosion control and improve wildlife habitat.

Figure 2—Shrubs planted into a crested wheatgrass monoculture to improve upland game bird cover.

6. Several problems associated with seed procurement, germination, seeding, and seedling establishment may be reduced or avoided by using planting stock:

a. Erratic seed production, low seed quality, and the difficulty of collecting seed from native stands contribute to limited availability and high seed prices of some species (Young and others 1984a; Young and Young 1986). Production of container or bareroot seedlings maximizes the number of plants ultimately obtained from costly seed.
b. Some species are extremely difficult to propagate from seed, but stock can easily be grown from vegetative material.
c. Roundleaf buffaloberry, desert peachbrush, Rocky Mountain maple, and mountain snowberry are valuable species for habitat improvement projects, but develop slowly from direct seeding (Monsen and Plummer 1978). Establishment and development are enhanced when species are planted as seedlings or rooted cuttings and provided with adequate protection from competing vegetation.
d. Problems associated with seeding and early seedling survival, such as soil crusting, rodent predation, late frosts, and cold or drought conditions are reduced by using planting stock.

Planning

Revegetation projects must be carefully planned. Maps and descriptions of the proposed planting site as it will appear following site preparation procedures may be used to subdivide the area into relatively homogenous units based on slope, aspect, soil conditions, and planting goals. This information, along with descriptions of predisturbance vegetation or

vegetation of the surrounding area, particularly sites in earlier successional stages, is used to select suitable plant species for each planting unit.

If a need for planting stock is recognized, the number and size of plants required should be determined. If transplant stock of several species is required, cost, scheduling, and propagation procedures may vary widely. Consequently, planning must be completed well in advance of the proposed planting date to ensure availability of high quality, adapted plant materials. Several factors must be considered in selecting an appropriate propagation technique for each species:

1. **Ease of propagation**. Propagation techniques for many Intermountain shrub species are provided in table 1. Ease of propagation varies widely among species; many are easily and inexpensively grown from seed, but complex seed dormancy and long wet prechilling requirements complicate propagation of others. Species such as willows and poplars are easily propagated from hardwood cuttings, but vegetative propagation of many other species is impractical. Nurserymen or others experienced in plant propagation and available literature should be consulted to determine the best propagation technique for each species and planting situation.

2. **Source of seed or vegetative material**. Scheduling and requirements for adapted material may dictate the choice of propagation technique. "Off the shelf" purchases of container or bareroot stock originating from populations adapted to the planting site are only occasionally available, thus it is frequently necessary to collect the seed or vegetative material required to propagate site-adapted planting stock.

3. **Number of plants required**. Large numbers of plants are most easily and inexpensively obtained from seed, hardwood cuttings, sprigs, or in some cases, wildings. More costly or time consuming methods of vegetative propagation such as layering or root cuttings should be considered only for plants that are difficult to propagate by other means or needed only in small quantities.

4. **Time requirements**. Propagating bareroot or container stock from seed may require 3 months to 3 years from the time of seed collection to outplanting. Seed collection dates range from spring to late fall depending on the species and geographic location. Total production time may be shortened if suitable seed sources can be obtained from seed banks or commercial dealers. Seed banks are particularly valuable when the need for seedlings is not recognized until after the seed crop has matured, as is often the case when planning post-fire revegetation projects. Seed banks are valuable for maintaining supplies of local populations and seeds of species that produce seed crops infrequently.

The best time for collection of vegetative material also varies widely by species. Wildings and hardwood cuttings of easily rooted species may be gathered during the dormant period and transplanted in spring as soon as weather and soil conditions permit. Greenhouse or field propagation of other species may require 2 or 3 years.

5. **Nurseries and facilities**. Federal tree nurseries generally produce seedlings under contract for State and Federal agencies. Seedlings produced by State nurseries may be purchased by government agencies, but are also available to the public, with some restrictions. State and private nurseries produce seedlings on both a speculation and contract basis. Some nurseries produce only selected species or utilize only specific propagation techniques or planting schedules. If there are no local nurseries, shipping distances and costs may become a major factor in selecting the propagation technique and nursery.

Special facilities may be required to hold seedlings in a dormant or hardened condition until they are transplanted. Cold storage areas or snow caches are used to store dormant bareroot seedlings, wildings, or vegetative material until site conditions are suitable for planting. Hardened container seedlings may be held in a shadehouse. If stock is to be used on sites at higher elevations than the nursery site, it may be held in a cooler, outdoors at the planting site, or at a convenient site at the same elevation to prevent it from initiating growth prior to planting. Personnel to care for the plants, a shaded area, and a water supply must be available.

6. **Cost**. Cost of planting stock depends on the cost for procuring seed or vegetative material, the propagation technique, and shipping, holding, and planting costs. Large containerized plants or seedlings are generally the most costly, while wildings and cutting material that do not require nursery propagation are least expensive.

Propagation Methods

Seed

Bareroot and container seedlings of many species can be grown from seed. Seed sources must be carefully selected to provide site-adapted seedlings. Adequate, high-quality seed must be procured to ensure that required numbers of seedlings are produced. Potential seed sources include: (1) purchases made directly from seed collectors, (2) purchases from seed dealers, (3) plants in wildland stands, (4) native stands managed for seed production, and (5) named varieties

Table 1—Propagation methods for selected shrubs and trees adapted to the Intermountain region.

Species	Vegetative propagation							Seed propagation					
	Wildings (W) stem layers (L) rhizomes (R)	Root cuttings (season)[a]	Suckers (season)[a]	Crown divisions (season)[a]	Stem cuttings Type[b]	Season[a]	Facility[c]	Germination pre-treatment	Warm pre-treatment[d]	Wet prechill[e]	Container pro-duction[f]	Bareroot pro-duction	Special considera-tions[g]
									Days				
Alder, thinleaf	L				H	W	G		0	0-90	R, M	1-0	1
Apache plume	W	W			H	ES, F			0	0	R,M	1-0	21
Ash, single-leaf									0	60-120	S	1-0,2-0	1
Aspen, quaking			W	W			G		0	0	R, M	1-0	17
Barberry, Oregon	L				Se H	Su, F W	G G		0-60	30-196	M, S	2-0	3,12
Birch, western paper	L				S	S	G	Immerse in H_2O[e]	0	30-90	R, M	1-0	16
Bitterbrush, antelope	W, L				S H	S, FLD F	G G	48 hour H_2O soak or 1% H_2O_2 soak 5 hrs[e]	0	14-90	M	1-0	6,8,(12)
Bitterbrush, desert	W				S H	S F	G G		0	90	M	1-0	6,8,12
Blackbrush										8		2-0	
Buffaloberry, roundleaf									0	60-90	S	1-0,2-0	3
Buffaloberry, russett		W			X			20-30 min H_2SO_4 soak	0	0-60	M	1-0,2-0	3
Buffaloberry, silver					X				0	0-90	M	1-0,2-0	3
Ceanothus, deerbrush	L	F,W			Se H	Su W	G G	Hot H_2O	0	0-90	R, M	1-0	7,8
Ceanothus, Martin	W,L	F,W			Se H	Su W	G G	Hot H_2O	0	Yes	M	1-0	7,8
Ceanothus, prostrate	W,L	F, W		S	Se H	Su W	G G	Hot H_2O	0	90-115	M	1-0	7,8,12
Ceanothus, redstem	W	F,W			Se H	Su W	G G	Hot H_2O, or 48 hr soak in 100 250 ppm GA[e]	0	60-112	R,M	1-0	7,8
Ceanothus, snowbrush	W, L	F, W			Se H	Su W	G G	Hot H_2O	0	63-90	R, M	1-0	7,8
Ceanothus, wedgeleaf		W	F, W		Se H	Su W	G G	Hot H_2O	0	90	R, M	1-0	7,8,12

(con.)

Table 1—(Con.)

Species	Vegetative propagation							Seed propagation					
	Wildings (W) stem layers (L) rhizomes (R)	Root cuttings (season)[a]	Suckers (season)[a]	Crown divisions (season)[a]	Stem cuttings			Germination pre-treatment	Warm pre-treatment[d]	Wet prechill[e]	Container pro-duction[f]	Bareroot pro-duction	Special considera-tions[g]
					Type[b]	Season[a]	Facility[c]						
									Days				
Cherry, Bessy	W	W			S	LS, ESu	G		0	120	M	1-0	3
Cherry, bitter	W	W			S	LS, ESu	G		0	90-126	R, M	1-0	3
Chokecherry, common western	W,L,R	W			S	LS, ESu	G		0	120-160	R, M	1-0	3
Cinquefoil, bush	W	S			S Se	Su Su	G G		0	0	R, M	1-0	15
Cliffrose, Stansbury	W							48 hr, H_2O soak plus 30 min H_2O_2 soak[e]	0	30	M, S	1-0	12
Cottonwood, narrowleaf	L	W			S H	Su F, W	G, N, U G, N, U		0	0	R, M	1-0	17
Currant, golden	W, L		S		Se H	Su F, W	G G, N		0	60	M	1-0	6,8
Currant, sticky	W, L		S		Se H	Su F, W	G G, N		0	140	M, S	1-0	3
Currant, wax	W, L		S		S H	Su F, W	G G, N		0	120-150	M, S	1-0	3
Cypress, Arizona					H	W	G		0	21-30	M, S	1-0,2-0	1,12
Dogwood, redosier[g]	W, L		S		Se H	Su W	G G		0	60-90	R, M	1-0,2-0	3
Elderberry blue	W	F, S	S	S	Se H	Su W	G G		60-90	30-210	R, M	1-0	4
Ephedra, green											M	1-0	9,12
Ephedra, Nevada											M	1-0	9,12
Ephedra, Torrey	L										R, M	1-0	9,12
Eriogonum, sulfur-flower	W								0	Yes	M	1-0	12
Eriogonum, Wyeth	W										M	1-0	12

(con.)

Table 1—(Con.)

Species	Vegetative propagation							Seed propagation					
	Wildings (W) stem layers (L) rhizomes (R)	Root cuttings (season)[a]	Suckers (season)[a]	Crown divisions (season)[a]	Stem cuttings Type[b]	Season[a]	Facility[c]	Germination pre-treatment	Warm pre-treatment[d]	Wet prechill[e]	Container pro-duction[f]	Bareroot pro-duction	Special considera-tions[g]
									Days				
Greasewood, black									0	0-25	M, S	1-0,2-0	10,11
Hawthorn, river	L				S H	Su W	G G	0.5-3 hr H_2SO_4 soak[d]	90-120	84-112	M, S	1-0,2-0	13
Honeysuckle, Utah	L				Se H	Su W	G G		0	60-90	R, M	1-0	3
Honeysuckle, Tartarian	L				Se H	Su W	G G		0	60-90	R, M	1-0	3
Hopsage, spiny					Se H	Su, F W	G G		0	14-90	M, S	2-0	10,11, 12,19
Juniper, common mountain					Se H	LSu, EF W	G G	30 min H_2SO_4 soak[d]	60-90	90+	S	2-0	1,4, 12,20
Juniper, Rocky Mountain					Se H	LSu, EF W	G G	30 min H_2SO_4 soak[d]	120	120	S	2-0	1,4, 12,20
Juniper, Utah					H Se	W W	G G	30 min H_2SO_4 soak[d]	120	120	S	2-0	1,4, 12,20
Lilac, common	L	W	S	S	S H	ES W	G G		0	0-90	R, M	1-0,1-1	
Locust, black		W	S		H S	W, ES Su	G, N G	Hot H_2O or 10-120 min H_2SO_4 soak	0	0	R, M	1-0	11
Manzanita, bearberry	L	F			SE H	Su F to ES	G G	2-24 hr H_2SO_4 soak[d]	60-120	90-120	M, S	2-0	4,5,12
Maple, bigtooth	W				S	LS	G		180	180	M	1-0,2-0	7,8
Maple, Rocky Mountain	W, L				S	LS	G		180	180	M	1-0,2-0	7,8
Mountain-ash, American	W								0-75	60-150	M	2-0	3
Mountain mahogany, birchleaf									0	30-120	M	1-0	4
Mountain mahogany, curlleaf								10-20 min H_2SO_4 soak	0	30-120	M	1-0	4,12

(con.)

Table 1—(Con.)

Species	Vegetative propagation: Wildings (W) stem layers (L) rhizomes (R)	Root cuttings (season)[a]	Suckers (season)[a]	Crown divisions (season)[a]	Stem cuttings: Type[b]	Season[a]	Facility[c]	Seed propagation: Germination pre-treatment	Warm pre-treatment[d]	Wet prechill[e]	Container production[f]	Bareroot production	Special considerations[g]
									Days				
Mountain mahogany, little-leaf									0	30-120	M	1-0	(12)
Mountain mahogany, true					Se	F	G	48-hr H_2O wash plus 30 min 3% H_2O_2 soak[e]	0	30-120	M, S	1-0	
Ninebark, mallowleaf	W, L		S		S Se H	S, Su Su F, W	G G G		0	30-77	M, S	1-0,2-0	1
Oak, Gambel	W, L										S		22
Olive, autumn	L				S H	Su W	G G		0	10-90	R, M	1-0	3
Peachbrush, Anderson		W			S Se	LS, ESu LSu, F	G G		0	Yes	M, S	1-0	3
Peashrub, Siberian	L	S			Se H	Su, F W	G G	10-12 hr H_2O soak	0	12-60	R, M	1-0	
Penstemon, bush	W, L				S Se	LS, ESu LSu, F	G G		0	Yes	M	1-0	5-12
Plum, American	W	W			S	S	G		0	90-150	R, M	1-0	3
Poplar		W			S H	Su W, F	G, N, U G, N, U				R, M	1-0	
Rabbitbrush, rubber	W						G		0	0	R, M	1-0	21
Raspberry, blackcap	W, L				S	S	G	50-60 min H_2SO_4 soak[d]	60	90	M		
Rock spirea		S			Se	Su	G	6 mo after-ripening	0	126	M	1-0	1
Rose, Woods	L	W	S		S H	Su F, W	G G		0	30	R, M	1-0	4-11
Sage, purple					Se H	Su W	G G				M, S	1-0,2-0	1
Sagebrush, big	W				H	W	G		0	15	R,M	1-0	10-12
Sagebrush, black	W			S	H	S	G		0	10	R, M	1-0	10-12

(con.)

Table 1—(Con.)

Species	Vegetative propagation							Seed propagation					
	Wildings (W) stem layers (L) rhizomes (R)	Root cuttings (season)[a]	Suckers (season)[a]	Crown divisions (season)[a]	Stem cuttings Type[b]	Season[a]	Facility[c]	Germination pre-treatment	Warm pre-treatment[d]	Wet prechill[e]	Container pro-duction[f]	Bareroot pro-duction	Special considera-tions[g]
									Days				
Saltbrush, fourwing					NTSe	Su	G	3-10 mo after-ripening	0	0-50	R,M	1-0	1,4,6, 8,12
Saltbrush, Gardner	W, L				S	S, Su	G	6 mo after-ripening, Leach in H_2O	0	0-21	M	1-0,2-0	12
Saltbush, shadscale	L, R				H Se	W F	G G		0	0-50	R, M, S	2-0	1,4,6, 8,12
Serviceberry, Saskatoon	W, L	W	S	S	S	LS, ESu	G		0-77	90-180+	R, M	1-0	1,4,, 6,8
Serviceberry, Utah	W, L	W	S	S	S	LS,ESu	G			60-180	M	1-0,2-0	2
Snowberry, common	W, L, R		S	S	S H	S F, W	G	4-6 mo after-ripening at 41 °C	90-120	120-180	R, M	1-0,2-0	3,4
Snowberry, longflower	W, L, R		S	S	S Se H	LS, ESu S, F W	G G G	4-6 mo after-ripening at 41 °C	90-120	120-180	M, S	1-0,2-0	3
Snowberry, mountain	W, L, R		S	S	S H	S W	G G	4-6 mo after-ripening at 41 °C	90-120	120-180	M	1-0,2-0	3
Spiraea, Douglas	L	S		S	S H	ES W	G G		0	0	M	1-0	1
Sumac, Rocky Mountain smooth	L	W	W		H	W	G	Hot H_2O	0	0-90	M	1-0	3
Sumac, skunkbush	L	W			H	W	G	Hot H_2O	0	30-90	M, S	1-0	3
Virginsbower, western	W,L			S	S	S,LSu	G		0	60-180	R,M	1-0	1
Willow,					S	S							
coyote	W, L, R	W			H	F, W	G, N, U		0	0	R, M	1-0	14
Willow, purpleosier	W, L, R	W			S H	S F, W	G, N, U		0	0	R, M	1-0	14
Willow, Scouler		W			S H	S F, W	G, N, U G, N, U		0	0	R, M	1-0	14

(con.)

Table 1—(Con.)

Species	Vegetative propagation							Seed propagation					
	Wildings (W) stem layers (L) rhizomes (R)	Root cuttings (season)[a]	Suckers (season)[a]	Crown divisions (season)[a]	Stem cuttings			Germination pre-treatment	Warm pre-treatment[d]	Wet prechill[e]	Container pro-duction[f]	Bareroot pro-duction	Special considera-tions[g]
					Type[b]	Season[a]	Facility[c]						
									Days				
Winterfat, common	W				Se	Fl, Su	G	9-13 wk after-ripening	0	0	R, M	1-0	1,4
Wormwood, old man				S	Se	S, Su	G, N, U						15
Wortleberry, big			S		Se H	S, Su W	G G			30	S	1-0	

[a]Season of collection: EF = Early fall; ES = Early spring; ESu = Early summer; F = Fall; FL = Flowering; FLD = Flowering, leaf development; LS = Late spring; LSu = Late summer; W = Winter.
[b]Stem cutting type: H = Hardwood; NTSe = Nonterminal semihardwood; S = Softwood; Se = Semihardwood.
[c]Facility required for stem cutting propagation: G = Greenhouse; N = Bareroot nursery; U = Plant unrooted.
[d]Pretreatment substitutes for warm pretreatment.
[e]Pretreatment substitutes for wet prechilling.
[f]Container production period (excludes hardening): R = Rapid growth (0 to 3 months); M = Moderate growth (4 to 6 months); S = Slow growth (6 + months).
References:
Ferguson, retired, Provo, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station (personal communication).
Landis and Simonich (1984).
Long, L. Tekoa, WA: Plants of the Wild (personal communication).
Prag, R., Prag, P. Williams, OR: Forest Farm (personal communication).
Wenny, D. Moscow, ID: University of Idaho, Idaho State Nursery (personal communication).
[g]Special Considerations:

(1) Low seed fill common. (2) Seed frequently infested by insects. (3) Remove all pulp from seeds. (4) Seed characteristics vary widely with ecotype or collection. (5) Seedlings susceptible to crown or root rot. (6) Seedlings sensitive to frost. (7) Seedlings sensitive to stem rot. (8) Seedlings sensitive to damping off. (9) Fragile root and stem systems. (10) Bareroot seedlings develop thick taproot. (11) Bareroot seedlings may develop brittle or sharp branches or prickes. (12) Plants evergreen. (13) Store fresh seed at room temperature prior to H_2SO_4 treatment. (14) Seed viability drops within 10 days if stored at room temperature. Viability may be extended to about 1 month if imbibed seed is kept in cold storage in a sealed container. (15) Poor establishment from seed. (16) Seed dried to 1 to 3 percent water content and stored at 36 to 38 °F (2 to 3 °C). (17) Seed viability drops following 2 weeks to 1 month of open storage. Longevity has been increased to at least 4 years by drying seed to a 5 to 8 percent water content and storing it in sealed containers at 36 °F (2 °C). (18) Grows very slowly for first 6 weeks. (19) Sheds all leaves by midsummer. (20) Two years of warm and cold cycles under field conditions may be required to relieve dormancy. (21) Seed difficult to plant. (22) Acorns should be sown immediately, held under cold, damp conditions, or stored dry in sealed containers at 32 to 36 °F (0 to 2 °C). If acorns are attacked by weevils, treat by soaking in water 120 °F (49 °C) for 30 minutes.

[h]References:

Alvarez-Cordero and McKell 1979, Ansley 1983, Bowns and West 1976, Campbell 1984, Doran 1957, Everett and Gautier 1981, Everett and Meeuwig 1975, Everett and others 1978b, Gratkowski 1973, Hartmann and others 1990, Holloway and Zasada 1979, Institute for Land Rehabilitation 1979, Landis and Simonich 1984, Long 1986, Mahlstede and Haber 1957, McArthur and others 1983a, Nord 1959b, Okafo and Hanover 19778, Phipps and others 1983, Plummer 1974b, Schier 1980, Schopmeyer 1974b, Schoenike 1981, SEAM 1976, Shaw 1984, Shaw and Monsen 1984, Sheat 1963, Stark 1966, Toogood 1980, Vories 1981, Wieland and others 1971, Wiesner and Johnson 1977.

Figure 3—Subalpine willow stool block at a nursery.

or selected populations grown in seed fields, seed orchards, or cutting blocks by nurseries or commercial growers (fig. 3).

If seed is purchased from private collectors, the collection date and a site description including elevation, slope, aspect, soil type, and vegetation should be provided. Seed should originate from the vicinity of the planting site or from populations known to be adapted to it. Although seed transfer guidelines have not been established for native Intermountain species, characteristics and site requirements of a number of frequently collected shrub populations have been documented (McArthur and others 1984a; Tiedemann and Johnson 1983; Tiedemann and others 1984b). The range of adaptability varies widely among populations of some species; thus available information must be considered carefully in selecting a seed source.

Named varieties of several important shrub and forb species have been released for commercial seed production following testing by the U.S. Department of Agriculture, Natural Resource Conservation Service, and cooperating agencies (Peterson and Sharp 1994). Description, uses, and range of adaptation of each release are provided in literature available from the Natural Resource Conservation Service. A number of forb varieties have been selected by private growers or seed companies for commercial production. The quality of seed produced under agricultural conditions should exceed that of wildland collections as improved cultural techniques are developed.

Only small quantities of seed are needed to produce container or bareroot orders. Seedlots required for orders can be easily collected during years of average or better seed production (Mirov and Kraebel 1939; Plummer and Jorgensen 1978). One pound of high-quality antelope bitterbrush seed, for example, contains about 15,000 seeds and produces 6,000 to 8,000 bareroot seedlings.

Seed collection must be planned in advance, and seed maturation monitored closely as seed collection dates fluctuate widely from year to year (Swingle 1939; Vories 1981; see table in chapter 24). Adverse weather conditions, insect infestations, or other unexpected events may lead to rapid crop deterioration or failure, necessitating selection of alternative collection sites. Timing of seed collection is critical because some species such as antelope bitterbrush and *Ceanothus* spp. disperse their seed rapidly following maturation (Young and others 1984a; Young and Young 1986).

Commercial seed dealers generally clean seed prior to sale. Most nurseries have conditioning plants and will clean seedlots received for nursery production. The nurseryman should be contacted in advance for scheduling requirements, costs, and recommended seed handling, storage, and shipment procedures. In general, freshly collected seeds should be spread on trays or screens and allowed to air dry. Bulk may be reduced by screening to remove rocks, branches, and twigs (Young and others 1984a). Fumigation may be necessary if insect infestation is a problem. Dried and screened seed may be placed in sealed containers or in cloth or paper bags and stored in a dry area until shipment. Special procedures must be followed to maintain seed viability of willow, birch, oak, and other species (table 1).

Fleshy fruits should be delivered to the seed cleaning facility immediately following harvest. They should not be stored in plastic bags nor allowed to heat excessively prior to drying. Most should be air dried if cleaning is delayed. Some species such as serviceberry and chokecherry are extremely difficult to clean once the pulp is dry. By contrast, some flesh should be left on elderberry and Greene's mountain ash and allowed to decompose slightly to improve germination.

Seedlots must be cleaned carefully to obtain high purity levels and maintain seed quality. High purities are required to maximize uniformity of seed distribution and subsequent seedling development in nursery beds and to simplify seed pretreatment, germination, and planting procedures for container production. Species such as sagebrush and rabbitbrush, that are difficult to process are often marketed at low purities (see table in chapter 24). Additional cleaning to obtain at least 50 or 60 percent purity may be required to produce bareroot or container seedlings of these species (Stein and others 1986).

Long-term seed storage requirements for many Intermountain species are summarized by Hartmann and others (1990), Redente and others (1982), Schopmeyer (1974b), and Vories (1981). Optimum storage methods and the effect of various storage methods on the duration of seed viability have not been examined for most Intermountain plant species.

Although seeds of many species can be stored in a warehouse (see tables in chapters 24 and 26), small lots collected for nursery production should be stored under cold, dry conditions if they must be kept for prolonged periods to maintain seed quality. Seeds should be placed in sealed, moisture-proof containers and stored at 32 to 50 °F (0 to 10 °C) (Copeland and McDonald 1985; Justice and Bass 1978). Below freezing temperatures (0 to 32 °F [–18 to 0 °C]) are effective if the added cost is justified. Optimum water contents for storage of native forb and shrub seeds have not been determined, but maximum safe seed water contents for many tree species is about 9 percent (Hartmann and others 1990; Stein and others 1986). Relative humidity in storage should be less than 70 percent and, if possible, less than 50 percent. Specific storage conditions must be provided for winterfat, rabbitbrush, sagebrush, oak, some maples, willows, cottonwoods, and spiny hopsage to maximize their longevity (Schopmeyer 1974b; Kay and others 1984) (table 1).

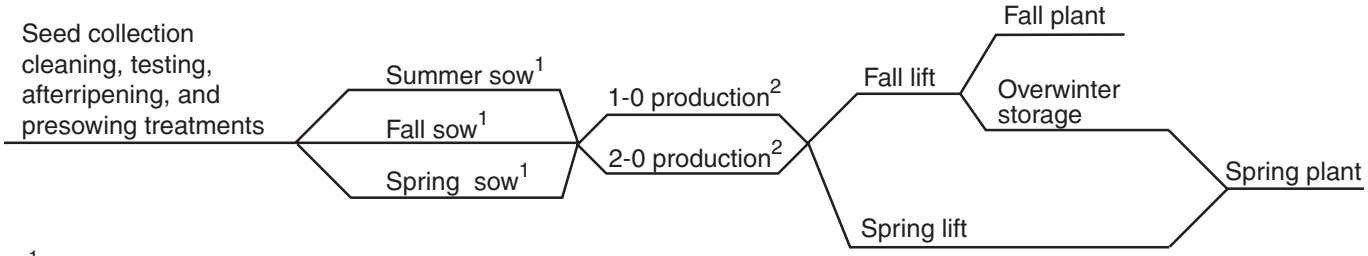
Seed weight and results of recent purity and germination or viability tests are needed to calculate the amount of seed required to produce the requested number of seedlings (Heit 1966). If recent tests have not been conducted, the nursery may test the seed or submit samples to a laboratory for testing. Results of purity, seed weight, and viability tests may be obtained from State or private seed laboratories. Viability is determined by tetrazolium staining (Stein and others 1986). Germination tests may require 2 weeks to 6 months or longer depending on wet prechilling requirements. Germination and tetrazolium test procedures have not been standardized for most native species. Consequently, only a limited number of laboratories will test some species, and results may vary among laboratories. Procedures for sampling seedlots, submitting seed samples for testing, and interpreting test results are provided by Stein and others (1986).

Many native plant species require presowing treatments to overcome seed dormancy (Heit 1971; Schopmeyer 1974b; Vories 1981) (table 1). Acid or mechanical scarification, hot or cold wet pretreatments, hormone application, dry heat, hot water, and various chemical pretreatments are commonly used. The level of treatment required varies with species and seedlot. Treatments are completed by the nursery. Most pretreatments require only 1 or 2 days. Wet prechilling commonly requires 0.5 to 6 months, depending on the species. Required wet prechilling treatments may be completed in the laboratory for container or bareroot production, or by summer or fall seeding for bareroot production.

Production of Bareroot Seedlings

Scheduling sequences for production of bareroot seedlings are outlined in figure 4. Separate schedules should be constructed for each species, illustrating the timing and duration of each step. Seed collection, cleaning, afterripening (if required), testing (purity, seed weight, and germination or viability), and presowing treatments must all be completed prior to the proposed sowing date. The nursery may take responsibility for some or all of these steps, but early planning and coordination with the nursery manager is essential to ensure that all operations are completed in a timely manner.

The quantity of seed required to produce the desired number of seedlings is determined using the formula shown in figure 5 (modified from Williams and Hanks 1976). Predictions of seedling survival and culling rates based on previous production experience with the species or seedlot at the nursery site determine, or in many cases, limit the usefulness of these calculations. Accurate seeding rates are critical to meet production targets and maximize seedling uniformity and density. Achieving desired seedling



[1]Seeding dates:
Summer seed— species requiring both warm and cold germination pretreatments.
Fall seed—species requiring wet prechilling or nondormant species.
Spring seed—nondormant species.

Appropriate laboratory warm or cold pretreatments may substitute for the summer or fall seeding requirements.

[2]Stock grown in nursery beds for one or two growing seasons.

Figure 4—Generalized scheduling alternatives for producing shrub seedlings in a bareroot nursery.

$$\text{Wt (lb)} = \frac{N}{(P)\,(G)\,(n)\,(NSF)\,(1-C)}$$

	Antelope bitterbrush	Fourwing saltbush
N = number of plantable seedlings required	1,000	1,000
P = purity (decimal)	.99	.97
G = germinability (decimal)	.93	.38
n = number of seeds per pound of cleaned seed	15,850	58,145
NSF = nursery survival factor (decimal)	.75	.60
C = culling rate (decimal)	.30	.40
Wt (lb) = weight of seed required to produce N seedlings	.13	.13

Figure 5—Formula for determining the amount of seed required to produce the required number of plantable seedlings. Sample data provided by USDA Forest Service, Lucky Peak Nursery, Boise, ID.

density continues to be a challenge in producing bareroot stock of many native plants.

Nondormant seed may be either fall or spring sown. Species requiring wet prechilling are either fall sown or wet prechilled in the laboratory and spring sown. Species with both warm and cold pretreatment requirements may be field sown in summer to induce germination by the following spring. Alternatively, pretreatments may be completed in the laboratory and the seeds spring sown. As germination requirements become better understood for each species, there is a trend toward increased use of artificial warm and cold pretreatments and spring sowing.

Fall sowing may be preferred for species that germinate in early spring as muddy or frozen nursery beds may make early spring seeding impossible. Consequently, some fall-sown seedlings may attain greater size than spring-sown seedlings after one growing season. However, depending on the nursery site, seedlings emerging early in spring may be exposed to late frosts.

Shrubs are commonly grown using modifications of techniques developed for conifer seedling production (Duryea and Landis 1984) as cultural practices for individual species have not been defined. Seedlings are grown in nursery beds for one or two growing seasons until plants reach adequate size for transplanting (table 1). Seedlings of some species may be root or top pruned to improve uniformity, encourage development of fibrous roots and simplify lifting, handling, and planting (Williams and Hanks 1976). Hardened bareroot seedlings may be lifted in fall or early spring (fig. 6). Shrub seedlings are usually hardened after the first few frosts in fall, the onset of low temperatures, or following leaf fall (Williams and Hanks 1976). The oscilloscope method described by Ferguson and others (1975) has also been used to evaluate seedling dormancy.

Grading criteria have not been established for most native shrub species (fig. 7). Nurseries often market seedlings on the basis of shoot length. Several items should be considered in writing specifications for individual species:

1. All dead, damaged, diseased, and obviously undersized seedlings should be rejected.
2. Experience may indicate size or morphological characteristics that may be correlated with planting success. Carpenter (1983), for example, reported greater survival of antelope bitterbrush seedlings with branched compared to unbranched stems.
3. Large seedlings may be required for dry, rocky, or erodible planting sites.
4. Seedlings with bulky, spreading root and shoot systems are difficult to pack or plant using conventional hand or mechanical planting equipment. Such plants may be root pruned in the nursery during the growing season. Otherwise, bulky seedlings should

Figure 6—Lifting 1-0 shrub seedlings, USDA Forest Service, Lucky Peak Nursery, Boise, ID.

Figure 7—Variation in root and shoot development of 1-0 Saskatoon serviceberry bareroot seedlings grown in a single nursery plot. (Vertical scale in inches.)

be trimmed before packing or, in extreme cases, discarded.

5. Tops may be pruned in the field or after lifting to decrease shoot and root ratios.

Fall lifted seedlings may be field planted immediately if soil water is adequate. These seedlings should be held at ambient temperatures or at the 6 inch (15 cm) soil temperature at the planting site, whichever is lowest, until planting (Dahlgreen 1976). Seedlings that cannot be fall planted may be held in cold storage or "heeled in" at a convenient site for early spring planting. Both techniques are useful for ensuring availability of seedlings for planting low elevation sites in early spring, possibly before weather and soil conditions would permit lifting at the nursery. Cold storage is usually preferable, as conditions are controlled. Seedlings placed in cold storage are stored in cardboard boxes or other containers and held at 28 °F (–2 °C). Temperature of the cooler is gradually raised to about 34 to 36 °F (1 to 2 °C) or higher at the time of spring lifting or prior to outplanting. Spring lifted seedlings may be held in cold storage until remote or high elevation planting sites become accessible in late spring or early summer.

"Heeling in" is a particularly useful technique for species that retain leaves through winter and tend to mold in cold storage if subfreezing temperatures cannot be provided. Seedlings are placed close together in long trenches with the roots vertical, covered with sandy soil to about 1 inch (2.5 cm) above the root collar and thoroughly irrigated to eliminate air pockets around the roots. Trenches are separated to prevent planting or lifting activities in one trench from interfering with seedlings in adjacent trenches. Diseased or damaged seedlings are culled prior to "heeling in," and healthy seedlings are treated with an appropriate fungicide if disease problems are anticipated. Trenches are mulched to preserve soil moisture, decrease frost heaving, and reduce deep freezing of the soil. "Heeled in" seedlings should be lifted for planting prior to bud break in spring (Williams and Hanks 1976). "Heeling in" requires additional handling, and seedlings stored in this manner are exposed to variable and often adverse environmental conditions.

Production of Container Stock

Most container plants are sold as 6 to 18 inch (15 to 46 cm) seedlings. Larger stock may be grown to fill specific needs. Schedules for producing container seedlings of two shrub species are illustrated in figures 8 and 9. Similar schedules should be developed for each species grown. Main areas of consideration for planning are seed procurement, preparation for planting, seedling production, and hardening. Total time required from seed collection to planting may range from 3 months to 2 or 3 years depending on the species and the propagation facilities available. Seed procurement and preparation for planting involve the same steps and considerations as described for bareroot production, namely seed source selection, procurement, cleaning, afterripening, testing, and sowing pretreatments.

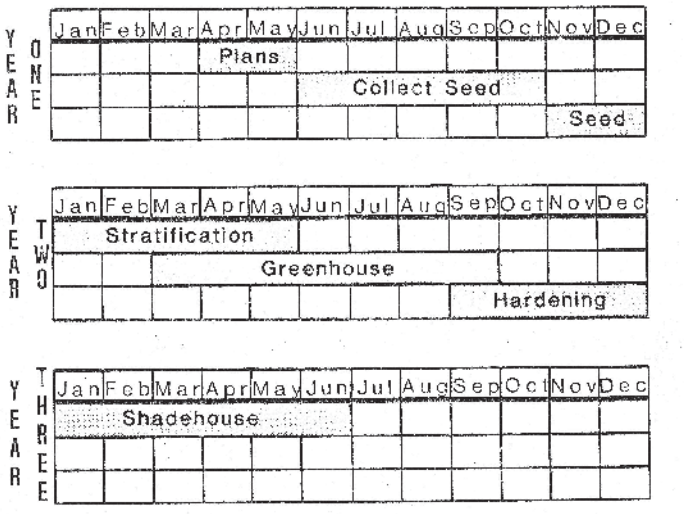


Figure 8—Production schedule for growing native plants in containers: creeping Oregon grape (*Mahonia repens*)—germinants (modified from Landis and Simonich 1984).

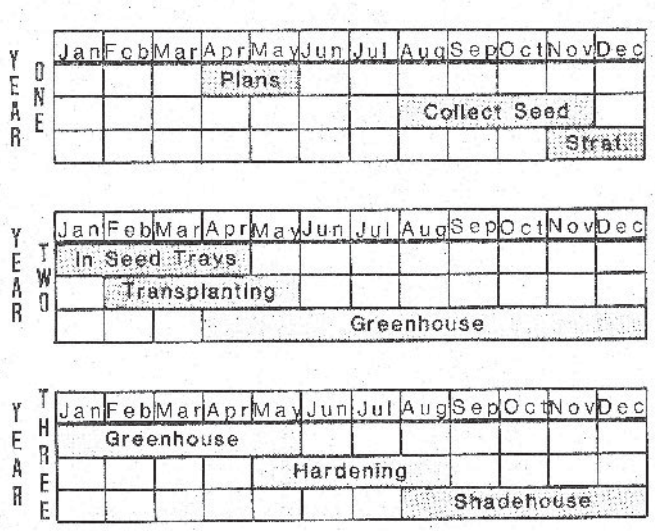


Figure 9—Production schedule for growing native plants in containers: Rocky Mountain juniper (*Juniperus scopulorum*)—transplants (modified from Landis and Simonich 1984).

Several production facilities are used to produce container seedlings. These include a production greenhouse, a coldframe or shadehouse to harden plants, and a shadehouse to hold seedlings until planting. Refrigerated storage is used to maintain dormant stock of conifer seedlings for late spring plantings, but has not received extensive use in the shrub industry (Landis and Simonich 1984). Individual nurseries have adopted cropping schedules compatible with their facilities, propagation systems, geographic location, and markets. Two or three crops of some species may be grown during a year in fully controlled greenhouses. Other greenhouses produce seedlings only during spring and summer.

The selection of appropriate containers for producing native plant seedlings is dependent upon the species' growth rate and habit and expected conditions at the outplanting site. Ray Leach[R] Supercells (fig. 10a), Spencer-Lemaire[R] Book Planters (fig. 10b), and other special containers designed for production of conifer seedlings, are often used (Tinus and McDonald 1979). These containers have vertical internal ribs or grooves to prevent root spiraling. Species with spreading root systems and rapid growth, such as blue elderberry, and planting stock for dry, rocky, or unstable sites should be grown in larger, pot-shaped containers. Additional types of containers have been useful in specialized situations. Tubelings, for example, are seedlings grown in long, narrow containers. This has resulted in improved survival rates for plantings on arid mine spoils (Hodder 1970).

Seeding techniques, potting mixtures, and greenhouse or lathhouse cultural practices for propagation have been reviewed by Aldon (1970a), Augustine and others (1979), Carlson (1976), Ferguson (1980), Ferguson and Monsen (1974), Landis and Simonich (1984), Nelson (1984), and SEAM (1976). Seeding dates are more flexible for container stock than for bareroot stock. However, more extensive production experience and research is still needed to refine the light, irrigation, temperature, nutrient, and other requirements for the production of individual species.

"Hardening" is a critical phase in the production of container stock. This procedure increases the ability of planting stock to survive following outplanting on wildland sites. Plants propagated in the greenhouse under optimum conditions grow rapidly, producing soft, tender branches that are highly sensitive to unfavorable environmental conditions. Hardening is achieved by reducing the plant's growth rate, increasing stored carbohydrates, and heightening tolerance to stress (Penrose and Hansen 1981). It is accomplished by gradually shortening the photoperiod, reducing nighttime temperatures, leaching

Figure 10—Commonly used containers for greenhouse production of shrub seedlings: (a) Spencer-LaMaire[R] book containers; (b) Ray Leach[R] supercells.

excess nitrogen from the planting medium, turning off CO_2 generators, fertilizing with low nitrogen and high phosphorus and potassium fertilizers, and placing the plants under mild drought stress (Landis and Simonich 1984). These conditions somewhat parallel the natural conditions experienced by plants in fall. Hardened plants are inured to stresses encountered in handling and planting as well as to low temperatures of refrigerated storage or outplanting sites. Hardening may be scheduled to meet chilling requirements of some species and provide dormant planting stock for early spring planting. The degree of hardening required depends on the species, proposed outplanting date, and expected weather conditions at the planting site. Time required varies from 1 to 3 months with longer periods needed to prepare plants for early spring or high elevation plantings. Maintenance of plants in an adequately hardened condition prior to outplanting is critical to plant survival and establishment.

Vegetative Propagation

Although many plants are most easily and cheaply grown from seed, there are problems associated with seed propagation of some species or populations: (1) lack of sufficient seed supplies, (2) complex seed dormancy, (3) slow field establishment, (4) maintenance of genetic or gender identity, and (5) cost (Norris 1983).

These problems may be avoided through vegetative propagation. Vegetative material propagated may consist of entire plants (wildings); hardwood, semihardwood, softwood, or herbaceous stem cuttings: or specialized cuttings from runners, stolons, stem layers, suckers, crowns, roots, or rhizomes. Other techniques such as propagation of leaf cuttings, grafting, and tissue or cell culture, have received limited use with Intermountain species, but may become more common in the future, particularly in research.

General techniques for collection and propagation of vegetative materials are described in standard horticultural texts (Chadwick 1954; Doran 1957; Hartmann and others 1990; Mahlstede and Haber 1957; Sheat 1963; Toogood 1980). References describing techniques for propagating individual genera or species are provided in table 1. Many of these techniques were developed for related species and have received only limited use. In addition, propagation success varies with individual collections. Most species can be propagated vegetatively by one or more techniques, but these vary widely in special treatment, equipment, or facilities required. Unrooted cuttings of oldman wormwood, for example, root readily when planted in wet soil (Plummer 1974b), but cuttings of curlleaf mountain mahogany are difficult to root, even in a fully equipped greenhouse (Ferguson and Monsen 1974). Excess material of difficult-to-propagate species should be gathered to cover expected losses. Nursery managers should be consulted when determining the most appropriate technique for propagating each species and developing nursery or greenhouse production schedules.

For species easily propagated from hardwood cuttings or rhizomes, large numbers of plants may be obtained readily and at a reasonable cost. Stock blocks of named shrub varieties or widely adapted populations of commonly requested species have been installed at some nurseries (fig. 11). Bulbs, corms, runners, offsets, root cuttings, and divisions of some forbs are also easily gathered. However, collection of large quantities of root cuttings, stem layers, suckers, and crown divisions of many shrub and tree species is difficult and time consuming. These techniques are useful only when small to moderate quantities of otherwise unavailable material are required.

Wildings

"Wildings" are seedlings or mature plants dug from native stands during the dormant period. They provide sources of inexpensive, readily available, site-adapted planting material and are particularly valuable if small to moderate quantities of one or more species are needed to quickly restore disturbed sites (DeYoe 1983; Everett and Kulla 1976). They also provide a source of planting stock for some species that are difficult to propagate from seed or cuttings, and they are a source of minor species that might otherwise be omitted from plantings. Wildings should not be collected from public lands without permission from the appropriate agency.

Dense natural seedling stands often develop following favorable years for seed germination and seedling establishment. Numerous seedlings of big sagebrush, black sagebrush, rubber rabbitbrush, and fourwing saltbush may be found growing along roadways or in other disturbed areas. Grass and forb seedlings often cover the ground surrounding mature plants. Seedling clusters of bitterbrush and serviceberry

Figure 11—New *Populus* stool beds at a nursery.

develop from rodent caches (Everett and Kulla 1976), while seedlings of snowbrush ceanothus and other species may germinate from seed reserves in the soil following clearcutting or burns (Gratkowski 1973). Most of these seedlings rapidly succumb to competition or other adverse factors. Consequently, minimal disturbance to the community results if small quantities of seedlings are carefully collected.

Wilding collection areas should be selected near the planting site and should be similar in soil type, elevation, slope, aspect, and shading. However, root and shoot growth habits of seedlings growing on steep slopes may not be desirable for transplanting. Wildings should be harvested in early morning when water stress is low. Seedlings may easily be dug from sandy to loamy soils by loosening the soil around root systems with a fork or shovel and pulling the seedlings by hand. A weeder or undercutter may be required to loosen heavy or dry soils. Seedlings must be carefully removed from the soil to minimize root damage. Diseased or damaged seedlings should be discarded. If necessary, tops can be pruned to decrease shoot to root ratios (DeYoe 1983). Harvested seedlings are usually stored in a cooler until used. However, seedlings may also be dug with some native soil remaining on the roots and planted in containers. In either case, the seedlings may be field planted directly or propagated in a nursery or greenhouse to provide larger planting stock.

Temporary nurseries for producing wildings may be established on range or agricultural lands. Seedlings should be grown on readily accessible sites with easily tilled soils. Propagation may simply entail heavy fall seeding and lifting after one or two growing seasons. More ambitious projects may provide minimal maintenance such as protection from grazing or predation, weed control, irrigation, or application of soil amendments. Burning may be used to break seed dormancy of *Ceanothus* and *Arctostaphylos* seeds in soil seed banks. Protection, irrigation, fertilization, and reduction of competition around "mother" plants in native stands provides another approach to production of wildings.

Mature plants or large "pads" of vegetation are sometimes transplanted to rapidly improve aesthetics of disturbed sites and to meet legal requirements for restoration of native plant communities on mining disturbances in arid and semiarid areas (Luke and Monsen 1984). These provide immediate centers for vegetative spread, reproduction from seed, and wildlife cover. Plants or pads of vegetation are sometimes excavated from a site prior to disturbance and held for later replanting. Cultural treatments such as weed or disease control, fertilization, or irrigation may be applied to the vegetation during this period. Mature vegetation may also be obtained from areas adjoining disturbances at the time of revegetation. The Vermeer Tree Spade, capable of excavating and hauling up to eight shrubs or small trees, and the Dryland Sodder, a front-end loader modified to load and unload sod strips without disturbing root systems or soil structure, were cooperatively developed by the USDI Bureau of Land Management and the USDA Forest Service, Missoula Equipment Development Center, to aid in transplanting mature plant materials (Hallman 1982, 1984).

Cuttings

Timing of collection and techniques for handling cuttings should be discussed with a nurseryman or other plant materials specialist. In some cases the nursery may harvest the cuttings. The two major types of cuttings are described.

Hardwood Cuttings—Hardwood cuttings are prepared from previous years' or older growth. They can be gathered quickly in large quantities, transported over long distances, held in cold storage for long periods, and are more durable than other types of cuttings. Many deciduous and some evergreen shrubs and trees are easily and inexpensively propagated from hardwood cuttings (table 1).

Moderately vigorous plants growing in full sunlight should be selected for cutting. Long branches of 2 year old, and in some cases older growth, are harvested. Branches are transported in bundles with the basal ends together, stored in a cool area, and not allowed to dry. Branches are cut into lengths of 4 to 30 inches (10 to 76 cm) or more with a bandsaw. Acceptable diameters generally range from 0.25 to 1 inch (0.6 to 2.5 cm) (Hartmann and others 1990). One cut should be made at an angle to mark either the tops or bases of the cuttings. Shoot apices of branches from evergreen species can be used, but apical growth of deciduous species is usually discarded as it contains low levels of carbohydrates.

Hardwood cuttings can be used in a variety of ways to provide scheduling flexibility and appropriate planting stock for site conditions (Chadwick 1954; Hartmann and others 1990). In areas with mild climates, dormant cuttings may be gathered and planted immediately in fall. Alternatively, bundles of cuttings may be trimmed to desired lengths, packed in moist, well-drained sawdust, sand, or sandy soil and stored underground in an unheated cellar or in a refrigerated room at approximately 40 °F (4 °C) until spring. Bundles may be stored horizontally or vertically, and either upright or inverted. Initiation of root or leaf growth in storage indicates lower storage temperatures are required. Cuttings of willows, hybrid poplars, and other easily rooted species callused in storage may be field planted on moist sites without rooting, or following initiation of rooting (fig. 12a to 12d).

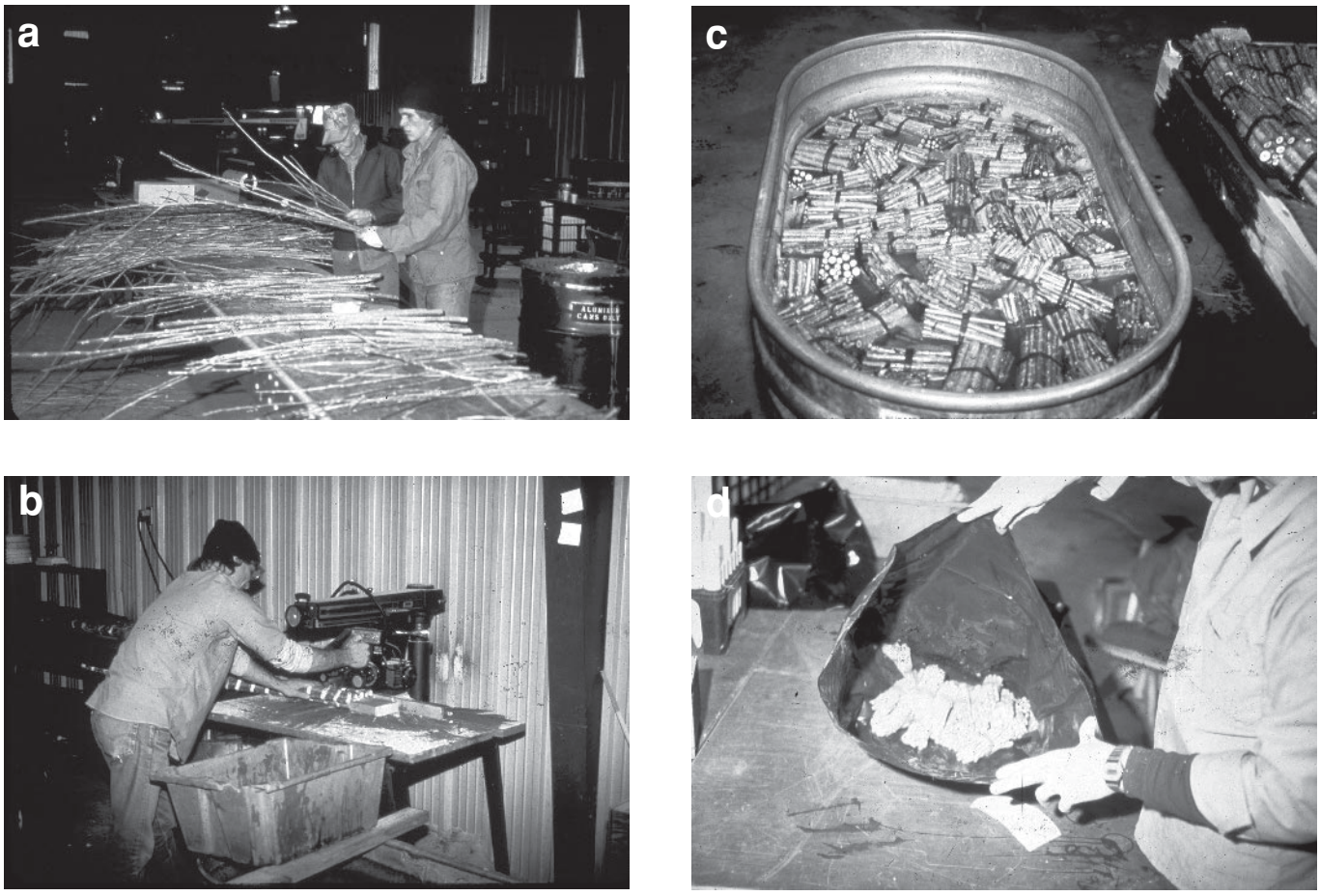


Figure 12—Preparation of cottonwood cuttings: (a) Sorting cottonwood whips by size. (b) Cutting cottonwood whips into sections. (c) Soaking cottonwood cuttings in Captan solution. (d) Placing dried cuttings into bags for storage.

Many willow cuttings can be collected in early spring and stored for short periods or planted immediately while still dormant (Malespin 1985; McCluskey and others 1983). Dipping or soaking bases of cuttings in solutions or powders of root inducing chemicals such as indolebutyic acid, napthalene acetic acid, and indoleacetic acid promotes rooting of some species (Hartmann and others 1990; Williams and Hanks 1976). Soaking cuttings in 3 percent Captan for 10 to 15 minutes, followed by thorough drying, reduces fungal invasion. Tips may be treated with a sealant to reduce desiccation after planting. These treatments may be completed prior to storage or in the field for single-day cutting and planting operations.

Cuttings of easily rooted species may be rooted in a greenhouse or bareroot nursery to produce stock with well developed root systems for outplanting on disturbed sites. Cuttings of species that are difficult to root should be grown in a greenhouse or hot frame until adequate root systems have developed; time required varies from 1 to 16 months (Hartmann and others 1990; Williams and Hanks 1976).

Softwood and Semihardwood Cuttings—A number of native and introduced shrub and tree species can be propagated by one or both of these techniques (table 1). Stock blocks of commonly used windbreak and shelterbelt species maintained at nursery sites provide convenient sources for both types of cuttings.

Softwood and semihardwood cuttings require greater care, more elaborate nursery facilities, and are more costly to propagate than hardwood cuttings (Hartmann and others 1990; Janick 1979). They differ from hardwood cuttings in that they are taken from new, nondormant stems during the growing season. Softwood cuttings are collected from succulent, new spring growth of deciduous or evergreen species that have not begun to lignify. Semihardwood cuttings are collected from partially lignified branches following the first flush of spring growth. Retention of leafy material is essential as these cuttings contain low quantities of stored food materials, necessitating production of food supplies during the rooting period. These cuttings root

rapidly, but use of greenhouses, mist systems, and special techniques are required to promote rooting, maintain high humidity levels, and prevent wilting. Once rooted, cuttings must be carefully hardened prior to outplanting.

Softwood and semihardwood cuttings should be collected from healthy plants growing in full sunlight. Good cuttings can usually be obtained from lateral branches of shrubs. Branches exhibiting average amounts of growth provide the best material. Early spring trimming will usually force growth of numerous lateral shoots from which cuttings can be made. Cuttings should be gathered in the morning when stems are turgid (Norris 1983), wrapped in moist burlap, and stored in coolers out of the sun for delivery to the nursery. Cuttings are trimmed to 3 to 6 inches (8 to 15 cm) for greenhouse planting, slightly longer cuttings are required for field planting in the nursery. The basal cut is usually made just below a node.

The timeframe for collection of softwood cuttings varies among species and can be very narrow (Hartmann and others 1990). Softwood cuttings are highly perishable and must be handled carefully to prevent desiccation. Cuttings of herbaceous plants are made in the same manner as softwood cuttings. Rooting success of softwood and herbaceous cuttings maintained in good condition is generally high and occurs rapidly, generally within 2 to 5 weeks.

Semihardwood cuttings are taken from woody evergreen species and partially matured wood of broadleaved deciduous species. Semihardwood cuttings can usually be collected over a longer period than softwood cuttings. They are slightly less perishable, but generally root more slowly (Hartmann and others 1990; Janick 1979).

Specialized Stems

Layering—Layering, the production of adventitious roots by a stem, is a natural means of vegetative reproduction for some shrubs and many grasses and forbs.

Willows, cottonwoods, currants, and other species have been maintained in stool blocks at nurseries for propagating by layering. The method has potential for other native shrubs, including *Ceanothus* species, serviceberry, some bitterbrush ecotypes, and hawthorn.

Layers are formed by several stem structures:

1. Stem layers are formed when adventitious roots develop from decumbent branches touching the ground. New shoots are generated and the entire branch generally remains attached to the parent plant. Stem layers often develop on prostrate growth forms of antelope bitterbrush and some *Ceanothus* species.

2. Suckers are shoots produced from adventitious buds on roots or the root crown. Shrubs and trees such as mallowleaf ninebark, currant, black locust, raspberry, and Rocky Mountain smooth sumac produce suckers that may be carefully excavated and separated from the parent plant during the dormant season. Suckers frequently root more readily than stem cuttings, but are generally available in smaller quantities.

3. Runners and stolons are specialized stems that grow horizontally, producing new plants at internodes. Offsets are stolons with one internode. Plants producing these structures include wild strawberry, redosier dogwood, and many grasses.

4. Crown divisions are formed when new shoots of many perennial forbs and multistemmed shrubs are produced from the periphery of the crown, gradually adding to its diameter. Small numbers of plants may be obtained by dividing the crowns of these species. The most successful divisions are obtained from the peripheral portions of the crown. Crowns of early flowering herbs are best divided late in the growing period while late flowering herbs should be divided early in spring. Shrubs are divided with a shovel or hatchet during the dormant period. Shoots and roots of divisions are trimmed to a manageable size and outplanted or propagated in a nursery.

Several techniques are available for artificially inducing "layers" as a means of vegetative propagation (Janick 1979). Layered stems may be separated from the parent plant and immediately outplanted or they may be grown in the nursery or greenhouse to produce larger plants with more extensive root systems. Layering is a useful technique for propagating plants that are difficult to grow from cuttings because water and nutrients are provided by the parent plant throughout the rooting period. Although layering techniques are easily mastered, they are somewhat labor intensive, and usually are not suitable for producing large numbers of plants.

Root Cuttings—Root cuttings are infrequently used in propagating native plants as they are generally difficult to harvest. Trees and shrubs such as sumacs, black locust, chokecherries, and lilac that produce suckers can be propagated from root cuttings. The cuttings consist of short sections of young roots. New stems are produced from adventitious buds and roots are generated from the cut ends of the old root or from the base of the developing stem. Root cuttings are gathered during the dormant period when carbohydrate supplies are high (Hartmann and others 1990). Cuttings should be taken from healthy young plants. Small plants may be completely excavated, the cuttings removed, and the plant replaced in the soil. Root systems of larger plants may be partially

excavated and the soil replaced once the cuttings are harvested. Polarity of the cuttings may be maintained by marking the distal ends with a slanting cut. Cuttings are packed in a damp medium such as spaghnum moss, sand, or sawdust, and stored at 36 to 40 °F (2 to 4 °C) until propagated or field planted. Delicate root cuttings of grasses and forbs are cut into sections 1 to 2 inches (3 to 5 cm) long and propagated in flats in a greenhouse or hothouse. As plants begin to develop they are transplanted to other flats or nursery rows for further growth prior to outplanting. Thicker cuttings, 0.25 to 0.5 inches (0.6 to 1.3 cm) in diameter, are packed in bundles with the tops together and stored under cool, moist conditions for several weeks. They are then cut into pieces 2 to 6 inches (5 to 15 cm) long and planted vertically about 2 to 4 inches (5 to 10 cm) apart in a greenhouse or outdoor nursery bed with the top of the cutting at or slightly below the soil surface. These cuttings grow slowly as their regenerative tissues are less active. Successful propagation of root cuttings requires that optimal environmental conditions be provided in terms of light, temperature, humidity, and application of plant growth hormones. Precautions must be taken to avoid conditions conducive to proliferation of diseases.

Rhizomes—Some species (tables 1, 2) produce specialized stems or rhizomes that grow horizontally near or slightly beneath the soil surface. Aerial shoots develop terminally from the rhizome or its branches and roots develop from adventitious buds in nodal areas. Many grasses, forbs, and shrubs used for soil stabilization have been selected for their rhizomatous habit and rapid growth. Rhizomes increase soil stability by spreading through the soil and producing masses of stems, roots, and new rhizome branches.

Rhizomes should be collected in early spring or late fall. They may be handled like root cuttings, but are more susceptible to drying. Rhizomes are easily propagated by dividing them into segments, each containing a nodal area. Rhizome pieces ("sprigs"), particularly those of grasses and forbs, may be treated as bareroot stock and planted immediately, or they may be propagated and sometimes further divided in a nursery or greenhouse before outplanting. If planted at adequate densities on field sites, sprigs grow rapidly and improve vegetative cover and soil stability.

The "sprigger," a modified potato harvester, was developed by the USDI Bureau of Land Management and the USDA Forest Service, Missoula Equipment Development Center to harvest large quantities of sprigs for revegetation of mine sites, roadways, and other disturbances (Hallman 1982, 1984) (fig. 13). Patches of rhizomatous vegetation growing near disturbed areas may be selected to provide site-adapted material. Mowed vegetation is undercut with the sprigger, lifted onto a conveyor system, and offloaded onto a truck. The sprigs may then be broadcast over the disturbance and covered. Nutrients, water, and mulch may be added as part of the operation. This equipment should be used only in authorized areas.

Table 2—Some grass and forb species that can be propagated from rhizomes.

Grasses	Forbs
Alpine timothy	Pacific aster
Bluebunch wheatgrass	Small burnet
Chee reedgrass	Canada goldenrod
Desert saltgrass	Cicer milkvetch
Western wheatgrass	Low penstemon
Streambank wheatgrass	Louisiana sage
Thickspike wheatgrass	Pearly everlasting
	Utah sweetvetch (some accessions)
	Western yarrow

Handling and Planting

Bareroot seedlings are subjected to adverse conditions from lifting to field planting. Exposure to rapid changes in environmental conditions and physical damage incurred during lifting, handling, transfer between storage areas or to the field site, and planting may weaken the seedling, decreasing initial growth and survival. Dahlgreen (1976) lists four critical factors that must be controlled by proper storage and handling practices:

1. **Temperature (long-term storage).** Seedling temperatures must be reduced to 28 to 34 °F (–2 to 1 °C) after packing and held at a constant temperature. At higher temperatures respiration rate increases, food reserves are depleted, plants may break dormancy, and disease becomes a problem. Temperature should be increased gradually prior to planting.

Figure 13—"Sprigger" used to collect rhizomatous planting stock.

2. **Water**. Water is translocated poorly at low temperatures. Consequently, stored seedlings must be maintained at high humidity levels to reduce transpiration and prevent desiccation and decomposition of food reserves. Roots should be kept moist, but not submerged in water. Root tips are most susceptible to drying.

3. **Exposure**. Exposure of seedlings to direct sunlight, high temperatures, frost, or wind during or following planting may result in desiccation and physiological damage.

4. **Environmental change**. Steep humidity and temperature gradients encountered between lifting and planting will stress seedlings. Consequently, handling and exposure must be minimized. Ideally, seedlings should be transported from the nursery in refrigerated trucks, or containers packed with snow and delivered to a snow cache, or storage facility at or near the planting site without intermediate transfers or repacking. Effective snow cache systems have been described by Dahlgreen and others (1974).

Seedlings must be kept in a cool, humid environment at the field planting site (Cleary and DeYoe 1982; DeYoe 1986). Dahlgreen (1976) suggests that approximately 24 to 48 hours before planting, seedlings should be dipped in water, wrapped in wet burlap, and allowed to acclimate. The water dip replaces water lost during shipping and covers roots with a film of water to protect them from drying during planting. Seedling temperature should be allowed to rise to the 8 to 10 inch (20 to 25 cm) soil temperature or the air temperature, whichever is lower. Acclimating plants should be protected from wind, sunlight, and frost.

Careful planning and handling is also essential to maintain the quality of container stock prior to planting. Logistics and labor requirements must be considered because containers are bulky to transport, handle, and store. A holding area is required for container stock that cannot be planted immediately. The area should be well-drained and provide some protection from extreme weather conditions, animals, and mechanical damage. The north side of a building is sometimes adequate. A temporary lathhouse or shaded area may be constructed from shade cloth, snow fence, or strips of canvas. Shipping boxes should be opened when plants arrive and the plants watered as needed. Plants should be checked daily for drying or other potential problems. Dark-colored containers should not be placed in full sunlight, even for a few hours, as soil temperatures on the southwest side of the containers can rise rapidly, causing considerable root damage in a short period of time. Maintenance of an adequate level of hardening can be difficult if stock must be transported long distances without refrigeration or if plants must be held at a lower elevation than the planting site for extended periods.

Fall planting can be successful in areas with mild climates if soil temperatures permit development of new roots before the onset of winter. Fall planting should be attempted only when precipitation has moistened the upper soil layers and the ground is not frozen. Frost heaving is a potential hazard with fall planting. Little root development normally occurs before the ground freezes, thus planted seedlings are poorly anchored.

Spring planting while soil water is high is a common practice in most parts of the Intermountain region. Every effort should be made to hold bareroot and container seedlings in a dormant or hardened condition and to plant before native plants of the same species break dormancy at the planting site. Nondormant stock must be planted after danger of frost has passed, which may not occur until soils have begun to dry. Cool, overcast, humid days with light rain or snow provide optimal planting weather. Penrose and Hansen (1981) recommend planting only when windspeeds are below 20 mi/hr (32 km/hr) and air temperatures are between 32 and 64 °F (0 and 18 °C).

Tools and Equipment

A number of tools may be used for eliminating competing vegetation and handplanting bareroot stock. These include (Larson 1980; Larson and Milodragovich 1982):

1. MacLeod—a combination hoe and rake used for scalping on sites with sandy or loamy soils (fig. 14a).
2. Planting hoes—a group of tools available in styles useful for planting bareroot or container stock. Blades may be mounted to facilitate planting on hillsides or on level ground. The sides and back of the blade are used for scalping.
3. Hoedad—a widely used tool for both planting and scalping. It is useful for sites with heavy or rootbound soils, but difficult to use on compacted soil or rocky ground (fig. 14b).
4. Planting bars are used only for planting, not scalping. They are useful for planting in hard or rocky soils or in confined spaces where the ground is covered with debris. Care must be taken to remove air pockets near the roots when using a planting bar. Compaction of heavy soils with this tool may inhibit root growth and increase frost heaving (fig. 14c).
5. Planting shovels and planting spades are particularly useful for planting large stock and for planting in deep, loose soils (fig. 14d).
6. Dibbles are designed for planting container seedlings (Larson and Milodragovich 1982). They are easy to handle and are particularly useful for sandy or loamy soils and confined spaces. They should not be

used in heavy soils as they tend to compact soil around the planting hole and can contribute to frost heaving. Once the seedling is planted, the root plug must be covered with a layer of native soil to prevent moisture from wicking through the planting medium and to reduce the possibility of frost heaving. Dibble tips matching many container sizes are available. Scalping blades can be attached to some dibbles (fig. 14e).

7. Gas-powered backpack augers may be used to prepare planting holes for a crew of planters. The augered hole must be large enough to accommodate the root system of the bareroot or container seedling. The auger operator should not work too far ahead of the planting crew as the planting hole interiors and soil excavated from them dry quickly on sunny days. Augers are useful in confined areas but are not effective on rocky, sandy, or clay soils or on sites with extensive surface debris. They are difficult to operate safely on steep slopes (Larson 1980; fig. 14f).

Favorable microsites free from large rocks, shallow soils, or drainage problems should be selected for planting each seedling. Roots of bareroot stock should be placed vertically in the planting hole and fanned out against its wall. Care must be taken to keep the plug of soil around the root system of container plants intact. Soils must be carefully compacted around the root system of planted seedlings to obliterate airpockets without crushing the roots (fig. 15, 16). The plant should not be planted too high as the upper portion of the root system will desiccate. Planting too deep must also be avoided. Watering and mulching may be beneficial in dry areas (Long and others 1984). Depressions should be formed around each plant to catch water. Furrows or pits are sometimes constructed to catch water around plants on rangeland sites. Plastic mulch should be used in clump, thicket, or windbreak plantings to direct water toward the plant and reduce weed problems (Snyder 1982).

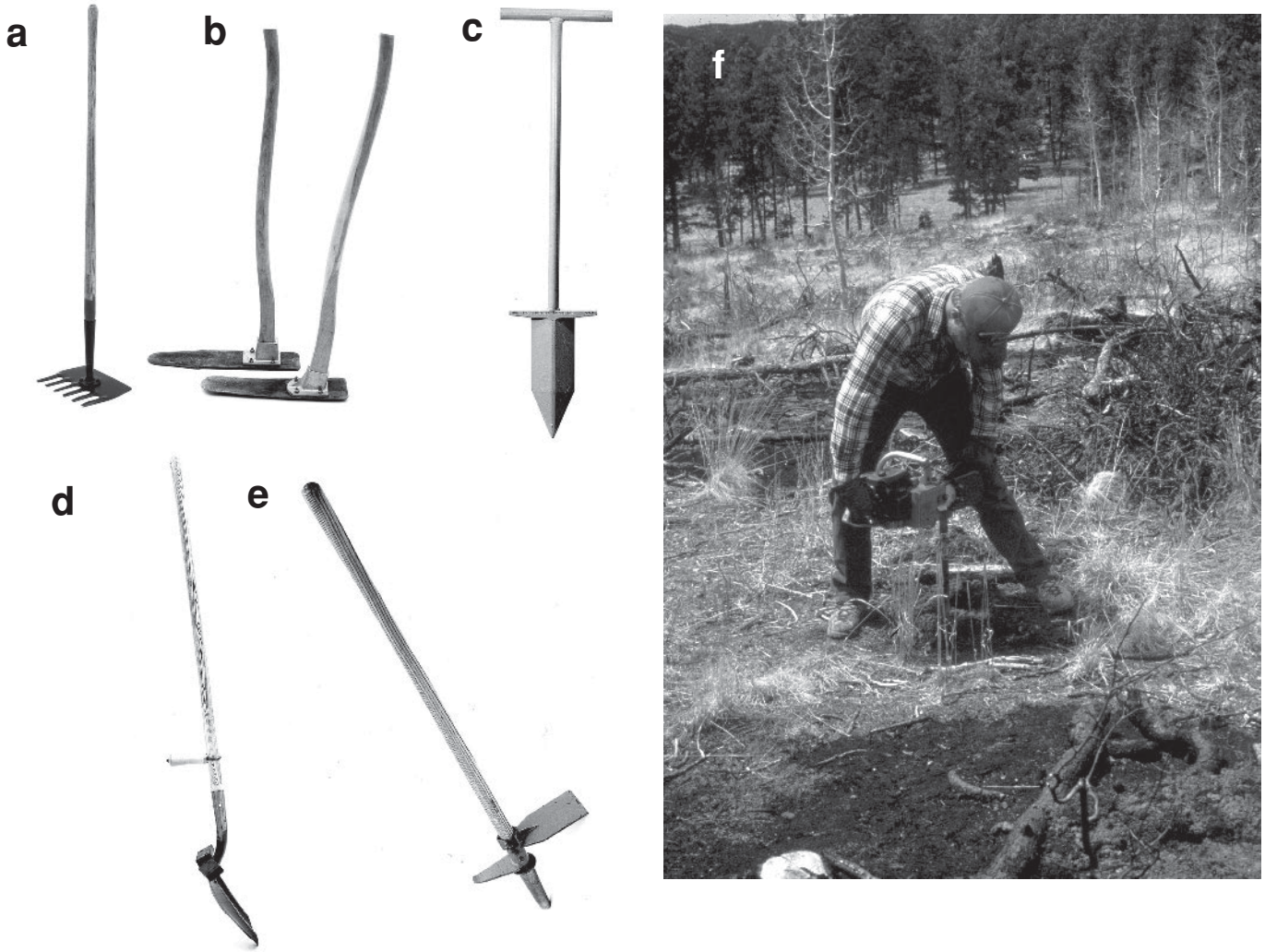
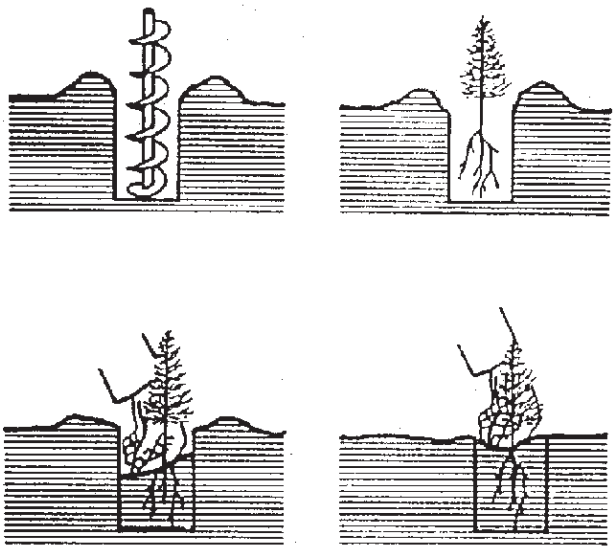
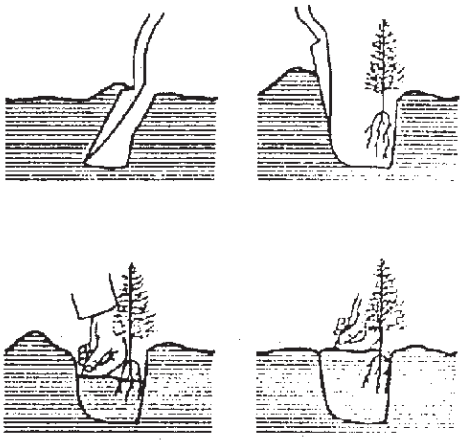


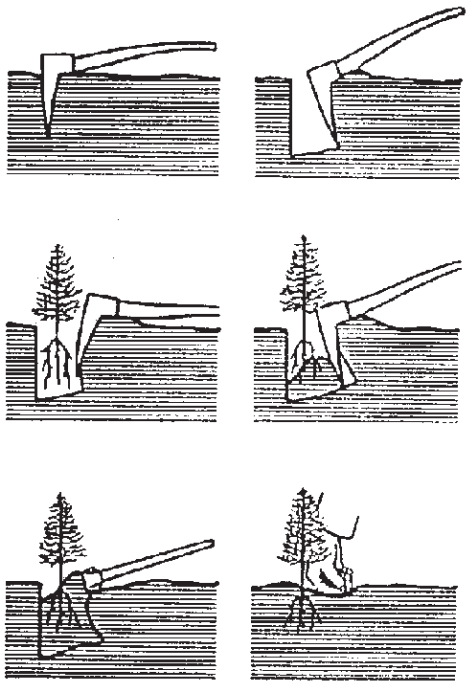
Figure 14—Tools for hand scalping and planting: (a) MacLeod, (b) planting hoe, (c) planting bar, (d) planting shovel, (e) dibble with attached scalper, and (f) auger. (Photographs provided by USDA Forest Service, Missoula Equipment Development Center.)



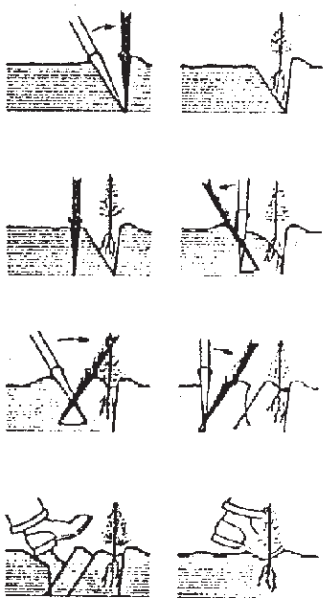
Correct procedure for planting bare-root stock with an auger. Steps: 1. Use auger to dig a vertical hole to desired depth. 2. Insert and hold tree at proper depth in hole. 3. Pack bottom half of hole with soil. 4. Pack soil in top of hole and firm around the seedling. When firming the soil be careful not to scuff the seedling, as it can kill the seedling.



Correct procedure for planting bare-root stock with a shovel or tiling spade. Steps: 1. Insert shovel into soil vertically, with the blade reversed. Push handle forward. Pull soil back and out of hole. 2. Straighten back of hole. Insert tree at proper depth. 3. Pack soil at bottom of hole. 4. Pack soil at top of hole and firm soil around seedling. When firming soil be careful not to scuff the seedling, as it can kill the seedling.



Correct procedure for planting bare-root stock with a planting hoe. Steps: 1. Swing hoe to get full vertical penetration; hoe blade must be vertical, not slanted. 2. Lift handle and pull to widen hole. 3. Place seedling in hole at proper depth while using hoe to hold back soil. 4. Pack soil at bottom of hole. 5. Pack soil at top of hole. 6. Firm soil around seedling. When firming the soil be careful not to scuff the seedling, as it can kill the seedling.



Correct procedure for planting bare-root stock with a planting bar. Steps: 1. Insert bar at angle shown and push forward to upright position. 2. Remove bar and place seedling at the proper depth. 3. Insert bar vertically about 2 inches toward the planter from the seedling. 4. Pull bar handle toward planter to firm soil at bottom of roots. 5. Push bar handle forward to firm soil at top of roots. 6. Insert bar vertically about 2 inches from last hole. 7. Push forward then pull backward to fill hole. 8. Fill in last hole by stamping with heel. 9. Firm soil around seedling. When firming soil be careful not to scuff the seedling, as it can kill the seedling.

Figure 15—Techniques for planting bareroot stock with standard hand-planting tools (Greaves and Hermann 1978).

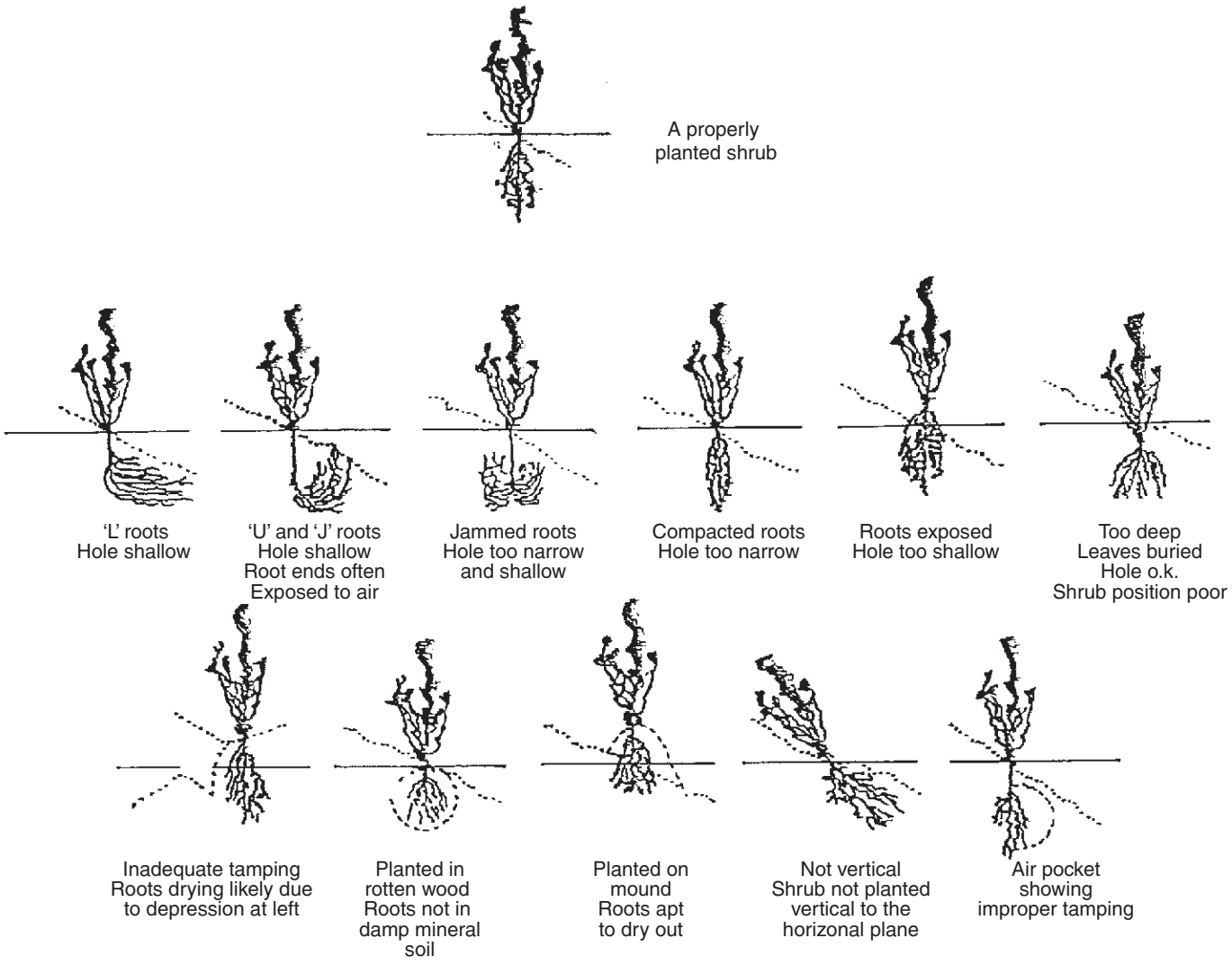


Figure 16—Proper planting of bareroot seedlings and common planting errors (Weadick 1976).

Transplant spacing depends on project objectives, characteristics of the site being planted, and expected mortality rates. Seedlings may be planted in a random pattern or in clusters using mixtures of species to create natural-appearing stands. Most shrub seedlings are slow-growing. If planted with seeded grasses or amid competing weedy species, survival rates may be low and time to maturity may increase substantially (Van Epps and McKell 1983). This problem may be alleviated by planting seedlings in scalps from which herbaceous competition has been removed (Geist and Edgerton 1984; Stevens and others 1981b). Organic or plastic mulches may be used to control competition in windbreak or cluster plantings (Snyder 1982).

Labor requirements and costs for hand planting are high compared to standard seeding methods. Individual crew members may plant 300 to 1,200 seedlings per day, depending on their experience, and on the terrain, soil conditions, and seedling size. Handplanting permits the selection of the most favorable sites for planting and is the only means of planting on steep, rocky sites. Mechanical planters may be used to plant on moderate or level terrain.

Seedling Protection

Seedling survival and growth are enhanced by protection from adverse climatic conditions, insects, disease, and predation by birds and mammals. Such protection may be afforded through care in site selection, site preparation practices, and seedling or site treatments during the establishment period. A few examples of protection approaches are provided (DeYoe and others 1985; Penrose and Hansen 1981; Stoszek 1976).

Physical Site Factors

1. Use species and accessions adapted to site conditions. On severely disturbed sites early seral species may be more appropriate than late seral or climax species present in predisturbance vegetation.

2. Use furrows, pits, and mulches to collect and retain water in arid areas.

3. Provide supplemental water to establish seedlings on very arid sites or to maintain seedlings during unusually dry seasons on any site.

4. Use erosion control structures or place materials on the soil surface to reduce soil and water erosion. Larger planting stock is less likely to be uprooted in such situations.

5. Select protected microsites. If high soil surface temperatures are expected, use planting stock with large stem caliper and good root to shoot ratios. Temperatures greater than 130 °F (55 °C) near the soil surface can be lethal to phloem and cambial cells. Retain shade (taller weeds and shrubs) during site preparation, but plant seedlings on microsites from which vegetation has been removed.

6. Frost heaving is minimized by planting larger seedlings, covering the soil plug of container seedlings with native soil, and providing a cover of sod, litter, and debris.

7. Damage resulting from late frosts may be decreased by: avoiding frost prone sites, planting strips of frost tolerant species as cover crops to protect developing species, or avoiding destruction of heat-insulating ground cover material.

Animals

1. Gophers feed in the root zone and prefer broadleafed forbs. Their activities are controlled by baiting or trapping. Treatments must be reapplied as needed for one or more growing seasons. Federal registration and regulations concerning use of rodenticides should be checked prior to use.

2. Big game control methods include:

Repellents—A number of chemicals are available for repelling deer and other animals from conifer seedlings and other plants (DeYoe and Schaap 1987; DeYoe and others 1985). Effectiveness of these substances has been highly variable

Plants with low palatability—Such plants should be selected when it is desirable to reduce big game use of sites such as highway right-of-ways.

Fencing—This is generally not economical, but may be an option on small, critical sites. Solar-powered, electrical, and other temporary fencing is used for this purpose.

Insects and Diseases

Use of adapted species is the best approach for reducing insect and disease problems. Other forms of control are generally reserved for extreme situations.

Competing Vegetation

A variety of chemical and mechanical treatments are available for reducing competition with native and exotic species (Vallentine 1980). Depending on the site and species present, consideration should be given to retention of some original vegetation to provide shade, frost protection, insect predators, or an alternate forage source for livestock or big game.

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Appendices

Appendix 1: Scientific and Common Names

Scientific name	Common name
A. Plants	
Abies	fir
Abies concolor	fir, white
Abies grandis	fir, grand
Abies lasiocarpa	fir, subalpine
Abies magnifica	fir, California red
Acer	maple
Acer glabrum	maple, Rocky Mountain
Acer grandidentatum	maple, bigtooth
Acer negundo	boxelder
Achillea millefolium alpicola	yarrow, timberline
Achillea millefolium lanulosa	yarrow, western
Achillea millefolium millefolium	yarrow, European*
Achnatherum hymenoides	ricegrass, Indian
Achnatherum thurberianum	needlegrass, Thurber
Adenostema	chamise
Agastache urticifolia	giant hyssop, nettleleaf
Agoseris	agoseris
Agropyron	wheatgrass
Agropyron spp.	wheatgrass, crested*
Agropyron albicans	wheatgrass, Montana
Agropyron cristatum	wheatgrass, fairway crested*
Agropyron dasystachyum	wheatgrass, streambank
Agropyron dasystachyum	wheatgrass, thickspike
Agropyron desertorum	wheatgrass, desert*
Agropyron desertorum	wheatgrass, standard crested (desert)*
Agropyron elongatum	wheatgrass, tall*
Agropyron fragile	wheatgrass, Siberian*
Agropyron intermedium	wheatgrass, intermediate*
Agropyron junceum	wheatgrass, rushleaf*
Agropyron repens	quackgrass*

Scientific name	Common name
Agropyron repens x A. spicatum	wheatgrass, NewHy*
Agropyron scribneri	wheatgrass, Scribner
Agropyron sibiricum	wheatgrass, Siberian*
Agropyron smithii	wheatgrass, bluestem
Agropyron smithii	wheatgrass, western
Agropyron spicatum	wheatgrass, bluebunch
Agropyron spicatum	wheatgrass, Snake River
Agropyron subsecundum	wheatgrass, bearded*
Agropyron trachycaulum	wheatgrass, slender
Agropyron trichophorum	wheatgrass, pubescent*
Agrostis stolonifera	bentgrass, carpet
Agrostis stolonifera	bentgrass, redtop
Agrostis stolonifera	redtop*
Allenrolfea	iodine bush
Alnus	alder
Alnus incana	alder, speckled
Alnus tenuifolia	alder, thinleaf
Alopecurus arundinaceus	foxtail, creeping (foxtail, reed)*
Alopecurus pratensis	foxtail, meadow*
Ambrosia	ragweed
Amelanchier	serviceberry
Amelanchier alnifolia	serviceberry, Saskatoon
Amelanchier pumila	serviceberry, dwarf Saskatoon
Amelanchier utahensis	serviceberry, Utah
Amorpha canescens	amorpha, leadplant
Amsinckia	fiddleneck
Anaphalis margaritacea	pearly everlasting
Andropogon gerardii	bluestem, big
Angelica pinnata	angelica, small leaf
Aquilegia coerulea	columbine, Colorado
Arceuthobium	mistletoe, dwarf
Arctostaphylos	manzanita
Arctostaphylos patula	manzanita, greenleaf
Arctostaphylos uva-ursi	manzanita, bearberry
Aristida	three-awn
Aristida purpurea	three-awn, purple
Aristida purpurea longiseta	three-awn, Fendler
Aristida purpurea longiseta	three-awn, red
Arnica	arnica
Arrhenatherum elatius	oatgrass, tall*
Artemisia	sagebrush
Artemisia abrotanum	wormwood, oldman*
Artemisia abrotanum nana	wormwood, dwarf*
Artemisia absinthium	wormwood, common*
Artemisia arbuscula	sagebrush, low

Scientific name	Common name
Artemisia arbuscula thermopola	sagebrush, hotsprings (cleft-leaf)
Artemisia argillosa	sagebrush, coaltown
Artemisia bigelovii	sagebrush, Bigelow (flat)
Artemisia cana	sagebrush, silver
Artemisia cana bolanderi	sagebrush, Bolander silver
Artemisia cana cana	sagebrush, plains silver
Artemisia cana viscidula	sagebrush, mountain silver
Artemisia dracunculus	sage, tarragon
Artemisia filifolia	sage, sand
Artemisia frigida	sagebrush, fringed
Artemisia longifolia	sagebrush, longleaf
Artemisia longiloba	sagebrush, alkali (early)
Artemisia ludoviciana	sagewort, Louisiana
Artemisia ludoviciana	sage, Louisiana (wormwood)
Artemisia nova	sagebrush, black
Artemisia pedatifida	sagebrush, birdsfoot
Artemisia pygmaea	sagebrush, pygmy
Artemisia rigida	sagebrush, stiff (scabland)
Artemisia rothrockii	sagebrush, rothrock
Artemisia spinescens	budsage
Artemisia spinescens	sagebrush, bud
Artemisia tridentata	sagebrush, big
Artemisia tridentata spiciformis	sagebrush, subalpine big (snowbank, timberline, or spicate big)
Artemisia tridentata tridentata	sagebrush, basin big
Artemisia tridentata vaseyana	sagebrush, mountain big
Artemisia tridentata wyomingensis	sagebrush, Wyoming big
Artemisia tridentata xericensis	sagebrush, foothills big (xeric big)
Artemisia tripartita	sagebrush, threetip
Artemisia tripartita rupicola	sagebrush, Wyoming threetip
Artemisia tripartita tripartita	sagebrush, tall threetip
Asclepias subverticillata	milkweed, whorled
Aster	aster
Aster chilensis	aster, Pacific
Aster engelmannii	aster, Engelmann
Aster foliaceus	aster, alpine leafybract
Aster glaucodes	aster, blueleaf
Aster laevis	aster, smooth
Astragalus	locoweed
Astragalus	milkvetch
Astragalus canadensis	milkvetch, Canadian
Astragalus cicer	milkvetch, cicer*
Astragalus filipes	milkvetch, Snake River (milkvetch, basalt)
Astragalus galegiformis	astragalus, giant
Atriplex	saltbush

Scientific name	Common name
Atriplex aptera	saltbush, wingless
Atriplex bonnevillensis	saltbush, Bonneville
Atriplex buxifolia	saltbush, Gardner
Atriplex canescens	saltbush, fourwing
Atriplex confertifolia	saltbush, shadscale
Atriplex confertifolia	shadscale
Atriplex corrugata	saltbush, mat
Atriplex cuneata	saltbush, Castle Valley clover
Atriplex cuneata	saltbush, cuneate
Atriplex falcata	saltbush, falcate
Atriplex gardneri	saltbush, Gardner
Atriplex garrettii	saltbush, Garrett
Atriplex hymenelytra	saltbush, desert holly
Atriplex lentiformis	saltbush, big (quailbush)
Atriplex navajoensis	saltbush, Navajo
Atriplex nuttallii	saltbush, Nuttall's
Atriplex obovata	saltbush, broadscale
Atriplex polycarpa	quailbush
Atriplex polycarpa	saltbush, allscale
Atriplex polycarpa	saltbush, cattle
Atriplex polycarpa	saltbush, quail
Atriplex robusta	saltbush, robust*
Atriplex semibaccata	saltbush, Australian*
Atriplex torreyi	saltbush, Torrey
Atriplex tridentata	saltbush, trident
Avena elatior	oatgrass, tall*
Balsamorhiza	balsamroot
Balsamorhiza hookeri	balsamroot, hairy
Balsamorhiza macrophylla	balsamroot, cutleaf
Balsamorhiza sagittata	balsamroot, arrowleaf
Bassia hyssopifolia	bassia, fivehook
Betula	birch
Betula glandulosa	birch, bog
Betula occidentalis	birch, water
Betula papyrifera	birch, paper
Betula pendula	birch, European white
Betula pubescens	birch, downy*
Bouteloua	grama
Bouteloua curtipendula	grama, sideoats
Bouteloua eriopoda	grama, black
Bouteloua gracilis	grama, blue
Bromus	bromegrass
Bromus anomalus	brome, nodding
Bromus biebersteinii	brome, meadow*
Bromus carinatus	brome, California

Scientific name	Common name
Bromus carinatus	brome, mountain
Bromus ciliatus	brome, fringed
Bromus erectus	brome, meadow*
Bromus inermis	brome, Hungarian*
Bromus inermis	brome, smooth*
Bromus japonicus	brome, Japanese*
Bromus pumpellianus	brome, Pumpelly's
Bromus rigidus	brome, ripgut*
Bromus riparius	brome, meadow*
Bromus rubens	brome, red*
Bromus tectorum	brome, downy
Bromus tectorum	cheatgrass*
Bromus tomentellus	brome, subalpine
Buchloe dactyloides	buffalograss
Calamagrostis	reedgrass
Calamagrostis canadensis	reedgrass, bluejoint
Calamagrostis epigeios	reedgrass, chee*
Calamagrostis montanensis	reedgrass, plains
Calamagrostis rubescens	pinegrass
Camphorosoma monspeliaca	camphorfume, Mediterranean*
Caragana arborescens	peashrub, Siberian*
Caragana arborescens pygmaea	peashrub, pygmy*
Cardaria draba	whitetop*
Carduus nutans	thistle, musk*
Carex	sedge
Carex aquatilis	sedge, water
Carex aurea	sedge, golden
Carex disperma	sedge, softleaved
Carex douglasii	sedge, Douglas
Carex elynoides	sedge, blackroot
Carex festivella	sedge, ovalhead
Carex hoodii	sedge, hood
Carex lanuginosa	sedge, woolly
Carex lenticularis lipocarpa	sedge, Kellogg
Carex microptera	sedge, smallwing
Carex nardina	sedge, Hepburn
Carex nebrascensis	sedge, Nebraska
Carex nigricans	sedge, black alpine
Carex praegracilis	sedge, slim
Carex rostrata	sedge, beaked
Carex rupestris	sedge, rock (curly)
Carex saxatilis	sedge, russet
Carex scirpoidea	sedge, downy
Carex simulata	sedge, analogue
Carex vallicola	sedge, valley

Scientific name	Common name
Castilleja hispida	painted cup, sulphur
Ceanothus	buckbrush
Ceanothus	ceanothus, buckbrush
Ceanothus cuneatus	ceanothus, wedgeleaf
Ceanothus fendleri	ceanothus, Fendler
Ceanothus greggii	ceanothus, desert
Ceanothus integerrimus	ceanothus, deerbrush
Ceanothus lemmonii	ceanothus, Lemmon
Ceanothus martinii	ceanothus, Martin
Ceanothus prostrata	ceanothus, prostrate
Ceanothus sanguineus	ceanothus, redstem
Ceanothus velutinus	ceanothus, snowbrush
Celtis reticulata	hackberry, netleaf
Centaurea biebersteinii	knapweed, spotted*
Centaurea repens	knapweed, Russian*
Centaurea solstitialis	starthistle, yellow
Centaurium venustum	centaury, charming
Ceratoides lanata	winterfat
Ceratoides lanata ruinina	winterfat, big
Ceratoides lanata subspinosa	winterfat, foothills
Ceratoides latens	winterfat, Pamirian*
Cercocarpus	mountain mahogany
Cerocarpus betuloides	mountain mahogany, birchleaf
Cerocarpus intricatus	mountain mahogany, littleleaf
Cerocarpus ledifolius	mountain mahogany, curlleaf
Cerocarpus ledifolius intermontanus	mountain mahogany, intermountain curlleaf
Cerocarpus montanus	mountain mahogany, true
Chondrilla juncea	skeletonweed, rush*
Chorispora tenella	mustard, blue
Chrysanthemum leucanthemum	daisy, oxeye*
Chrysothamnus	rabbitbrush
Chrysothamnus albidus	rabbitbrush, alkali
Chrysothamnus depressus	rabbitbrush, dwarf
Chrysothamnus eremobius	rabbitbrush, Pintwater
Chrysothamnus gramineus	goldenrod, Panamint rock
Chrysothamnus greenei	rabbitbrush, Greene's
Chrysothamnus humilis	rabbitbrush, Truckee
Chrysothamnus linifolius	rabbitbrush, spreading
Chrysothamnus molestus	rabbitbrush, Arizona
Chrysothamnus nauseosus	rabbitbrush, rubber
Chrysothamnus nauseosus albicaulis	rabbitbrush, mountain whitestem rubber
Chrysothamnus nauseosus consimilis	rabbitbrush, threadleaf rubber
Chrysothamnus nauseosus hololeucus	rabbitbrush, basin whitestem rubber
Chrysothamnus nauseosus hololeucus	rabbitbrush, whitestem rubber
Chrysothamnus nauseosus leiospermus	rabbitbrush, leiospermus rubber

Scientific name	Common name
Chrysothamnus nauseosus mohavensis	rabbitbrush, Mohave rubber
Chrysothamnus nauseosus nauseosus	rabbitbrush, green rubber
Chrysothamnus nauseosus salicifolius	rabbitbrush, mountain rubber
Chrysothamnus nauseosus turbinatus	rabbitbrush, turbinate rubber
Chrysothamnus nauseosus utahensis	rabbitbrush, Utah green rubber
Chrysothamnus paniculatus	rabbitbrush, Mojave
Chrysothamnus parryi	rabbitbrush, Parry
Chrysothamnus parryi nevadensis	rabbitbrush, Nevada
Chrysothamnus pulchellus	rabbitbrush, southwestern
Chrysothamnus vaseyi	rabbitbrush, Vasey
Chrysothamnus viscidiflorus	rabbitbrush, low (yellow)
Chrysothamnus viscidiflorus	yellowbrush
Chrysothamnus viscidiflorus lanceolatus	rabbitbrush, mountain low
Chrysothamnus viscidiflorus puberulus	rabbitbrush, hairy low
Chrysothamnus viscidiflorus stenophyllus	rabbitbrush, narrowleaf low
Chrysothamnus viscidiflorus viscidiflorus	rabbitbrush, stickyleaf low (Douglas)
Cirsium arvense	thistle, Canada*
Clematis ligusticifolia	virginsbower, western
Coleogyne ramosissima	blackbrush
Collomia linearis	collomia, slenderleaf
Colutea arborescens	bladdersenna, common*
Cornus	dogwood
Cornus stolonifera	dogwood, redosier
Coronilla varia	crownvetch*
Cotoneaster acutifolia	cotoneaster, Peking*
Cowania	cliffrose
Cowania stansburiana	cliffrose, Stansbury
Crataegus	hawthorn
Crataegus columbiana	hawthorn, Columbia
Crataegus douglasii	hawthorn, Douglas
Crataegus rivularis	hawthorn, river
Crataegus succulenta	hawthorn, yellow*
Cupressus arizonica	cypress, Arizona
Cynosurus echinatus	dogtail*
Dactylis glomerata	orchardgrass*
Delphinium nuttallianum	larkspur, low
Delphinium occidentale	larkspur, tall
Deschampsia caespitosa	hairgrass, tufted
Descurainia	mustard, tansy
Descurainia	tansymustard
Descurainia pinnata	tansymustard
Descurainia sophia	tansymustard, flixweed*
Digitaria californica	cottontop, Arizona
Distichlis	saltgrass
Distichlis spicata	saltgrass, inland

Scientific name	Common name
Dryas	dryas
Elaeagnus angustifolia	Russianolive*
Elaeagnus commutata	silverberry
Elaeagnus umbellata	autumn eleagnus (autumn olive)
Elaeagnus umbellatum	olive, autumn*
Eleocharis palustris	spikerush, common
Elymus	wildrye
Elymus angustus	wildrye, Altai*
Elymus aristatus	wildrye, purple
Elymus canadensis	wildrye, Canada
Elymus cinereus	wildrye, Great Basin
Elymus dahuricus	wildrye, Dahurian*
Elymus elymoides	squirreltail, bottlebrush
Elymus flavescens	wildrye, yellow
Elymus giganteus	wildrye, mammoth*
Elymus glaucus	wildrye, blue
Elymus junceus	wildrye, Russian*
Elymus lanceolatus lanceolatus	wheatgrass, thickspike
Elymus macrourus	wheatgrass, thickspike
Elymus multisetus	squirreltail, big
Elymus salinus	wildrye, Salina
Elymus simplex	wildrye, low creeping (alkali)
Elymus trachycaulus	wheatgrass, slender
Elymus triticoides	wildrye, beardless (creeping)
Elymus wawawaiensis	wheatgrass, Snake River
Elytrigia smithii	wheatgrass, western
Ephedra	ephedra, jointfir
Ephedra nevadensis	ephedra, Nevada
Ephedra torreyana	ephedra, Torrey
Ephedra viridis	ephedra, green
Epilobium angustifolia	fireweed
Equisetum	horsetail
Erigeron speciosus	fleabane, Oregon
Erigeron ursinus	fleabane, Bear River
Eriogonum	buckwheat
Eriogonum fasciculatum	buckwheat, wild California flattop
Eriogonum heracleoides	buckwheat, Wyeth
Eriogonum heracleoides	eriogonum, Wyeth
Eriogonum niveum	eriogonum, snow
Eriogonum ovalifolium	eriogonum, cushion
Eriogonum umbellatum	buckwheat, sulfur
Eriogonum umbellatum	eriogonum, sulfur
Eriogonum wrightii	buckwheat, Wright
Eriogonum wrightii	eriogonum, Wright
Erodium cicutarium	alfileria (filaree)*

Scientific name	Common name
Euphorbia esula	spurge, leafy*
Eurotia lanata	winterfat
Fallugia paradoxa	Apache plume
Festuca	fescue
Festuca arizonica	fescue, Arizona
Festuca arundinacea	fescue, tall (fescue, alta or reed) *
Festuca elatior	fescue, meadow*
Festuca idahoensis	fescue, Idaho
Festuca ovina duriuscula	fescue, hard
Festuca ovina duriuscula	fescue, hard sheep*
Festuca ovina ovina	fescue, sheep (fescue, alpine)
Festuca ovina sulcata	fescue, sulcata sheep
Festuca rubra	fescue, red*
Festuca thurberi	fescue, Thurber
Forestiera neomexicana	forestiera, New Mexico
Fragaria	strawberry, wild
Fraxinus anomala	ash, singleleaf
Fraxinus pennsylvanica	ash, green
Geranium	geranium
Geranium richardsonii	geranium, Richardson
Geranium viscosissimum	geranium, sticky
Gleditsia triacanthos	honeylocust
Grayia brandegei	hopsage, spineless
Grayia spinosa	hopsage, spiny
Gutierrezia	matchbrush
Gutierrezia (Xanthocephalum)	snakeweed
Gutierrezia microcephala	matchbrush, small head
Gutierrezia microcephala	snakeweed, threadleaf
Gutierrezia petradoria	snakeweed, goldenrod
Gutierrezia pomariensis	snakeweed, orchard
Gutierrezia sarothrae	snakeweed, broom
Gutierrezia sphaerocephala	snakeweed, roundleaf
Halimodendron halodendron	salt-tree, Siberian*
Halogeton glomeratus	halogeton*
Haplopappus	goldenweed
Haplopappus bloomeri	goldenweed, rabbitbrush
Haplopappus carthamoides	goldenweed, largeflowered
Haplopappus greenei	goldenweed, Greene's
Haplopappus macronema	goldenweed, whitestem
Haplopappus resinosus	goldenweed, Columbia
Haplopappus suffruticosus	goldenweed, shrubby
Hedysarum boreale boreale	sweetvetch, Uinta (northern)
Hedysarum boreale gremiale	sweetvetch, Utah
Hedysarum boreale utahense	sweetvetch, Utah
Hedysarum coronarium	sweetvetch, sulla

Scientific name	Common name
Helianthella uniflora	helianthella, oneflower
Helianthus annuus	sunflower
Heracleum lanatum	cowparsnip
Hesperochloa kingii	fescue, spike
Hilaria jamesii	curly grass
Hilaria jamesii	galleta
Holodiscus	oceanspray
Holodiscus discolor	oceanspray, creambush
Holodiscus dumosus	oceanspray, bush
Holodiscus dumosus	oceanspray, rock
Holodiscus dumosus	rockspirea
Hordeum	barley
Hordeum brachyantherum	barley, meadow
Hordeum bulbosum	barley, bulbous*
Hordeum jubatum	barley, foxtail
Hordeum vulgare	barley, beardless*
Iris germanica	iris, German*
Iva axillaris	povertyweed
Ivesia gordonii	ivesia, Gordon
Juncus	rush
Juncus arcticus balticus	rush, Baltic
Juncus drummondii	rush, Drummond
Juncus ensifolius	rush, swordleaf
Juncus longistylis	rush, longstyle
Juncus torreyi	rush, Torrey
Juniperus	juniper
Juniperus ashei	juniper, Ashe
Juniperus communis montana	juniper, mountain
Juniperus horizontalis	juniper, creeping
Juniperus occidentalis	juniper, western
Juniperus osteosperma	juniper, Utah
Juniperus scopulorum	juniper, Rocky Mountain
Kochia americana	molly, gray (green)
Kochia prostrata	kochia, forage*
Kochia scoparia	kochia, Belvedere
Kochia scoparia	summercypress, Belvedere*
Koeleria macrantha	junegrass, prairie
Krascheninnikovia lanata	winterfat
Lactuca serriola	lettuce, prickly*
Larrea tridentata	creosotebush
Lathyrus lanszwertii	peavine, thickleaf
Lathyrus latifolium	peavine, perennial*
Lathyrus sylvestris	peavine, flat
Lathyrus zionis	peavine, Utah
Lepidium	pepperweed

Scientific name	Common name
Lepidospartum latisquamatum	scalebroom
Leymus angustus	wildrye, Altai*
Leymus cinereus	wildrye, Great Basin
Leymus racemosus	wildrye, mammoth*
Leymus triticoides	wildrye, beardless (creeping)
Ligusticum porteri	ligusticum, Porter
Ligusticum tenuifolium	ligusticum, narrowleaf
Linum perenne lewisii	flax, Lewis
Lolium multiflorum	rye, annual
Lolium multiflorum	ryegrass, Italian*
Lolium perenne	ryegrass, perennial*
Lolium pratense	rye, meadow
Lomatium dissectum	lomatium, carrotleaf
Lomatium graveolens	lomatium, stinking
Lomatium nuttallii (kingii)	lomatium, Nuttall
Lomatium triternatum	lomatium, nineleaf (narrowleaf)
Lonicera	honeysuckle
Lonicera ciliosa	honeysuckle, western trumpet (honeysuckle, orange)*
Lonicera involucrata	honeysuckle, bearberry
Lonicera tatarica	honeysuckle, Tatarian*
Lonicera utahensis	honeysuckle, Utah
Lotus corniculatus	deervetch, birdfoot
Lotus corniculatus	trefoil, birdsfoot*
Lupinus	lupine
Lupinus alpestris	lupine, mountain
Lupinus argenteus	lupine, silvery
Lupinus nevadensis	lupine, Nevada
Lupinus sericeus	lupine, silky
Lycium barbarum	matrimony vine*
Madia	madia; tarweed
Madia glomerata	tarweed, cluster
Mahonia	barberry; Oregon grape
Mahonia aquifolium	barberry, shining
Mahonia fremontii	barberry, Fremont
Mahonia repens	barberry, creeping
Malcomia africana	mustard, African*
Medicago	alfalfa
Medicago falcata	alfalfa, sicklepod*
Medicago lupulina	medick, black*
Medicago sativa	alfalfa*
Melica bulbosa	oniongrass
Melilotus	clover, sweet
Melilotus alba	sweetclover, white*
Melilotus officinalis	sweetclover, yellow*
Mertensia arizonica	bluebell, tall

Scientific name	Common name
Mertensia	bluebell
Muhlenbergia asperifolia	muhly, alkali
Muhlenbergia richardsonis	muhly, mat
Muhlenbergia wrightii	muhly, spike
Onobrychis viciaefolia	sainfoin*
Orobanche	broomrape
Oryzopsis hymenoides	ricegrass, Indian
Osmorhiza chilensis	sweetroot, spreading
Osmorhiza occidentalis	sweetanise
Pachistima myrsinites	mountain lover
Panicum	millet*
Panicum capillare	witchgrass
Pascopyrum smithii	wheatgrass, western
Penstemon	penstemon
Penstemon cyananthus	penstemon, Wasatch
Penstemon eatonii	penstemon, Eaton (firecracker)
Penstemon fruticosus	penstemon, bush
Penstemon humilis	penstemon, low
Penstemon linarioides	penstemon, toadflax
Penstemon pachyphyllus	penstemon, thickleaf
Penstemon palmeri	penstemon, Palmer
Penstemon platyphyllus	penstemon, sidehill
Penstemon rydbergii	penstemon, Rydberg
Penstemon sepalulus	penstemon, littlecup
Penstemon spectabilis	penstemon, showy
Penstemon strictus	penstemon, Rocky Mountain
Peraphyllum ramosissimum	Indian apple
Petradoria	rockgoldenrod
Phalaris arundinacea	canarygrass, reed*
Philadelphus	syringa
Philadelphus lewisii	mockorange, Lewis
Philadelphus microphyllus	mockorange, littleleaf
Phleum alpinum	timothy, alpine (mountain)
Phleum pratense	timothy*
Physocarpus alternans	ninebark, dwarf
Physocarpus capitatus	ninebark, Pacific
Physocarpus malvaceus	ninebark, mallow
Physocarpus monogynus	ninebark, mountain
Picea	spruce
Picea engelmannii	spruce, Engelmann
Picea pungens	spruce, blue
Pinus	pinyon
Pinus albicaulis	pine, whitebark
Pinus aristata	pine, bristlecone
Pinus contorta	pine, lodgepole

Scientific name	Common name
Pinus edulis	pinyon
Pinus flexilis	pine, limber
Pinus jeffreyi	pine, Jeffrey
Pinus longaeva	pine, bristlecone
Pinus monophylla	pinyon, singleleaf
Pinus monticola	pine, western white
Pinus palustris	pine, longleaf
Pinus ponderosa	pine, ponderosa
Poa	bluegrass
Poa alpina	bluegrass, alpine
Poa ampla	bluegrass, big
Poa bulbosa	bluegrass, bulbous*
Poa canbyi	bluegrass, Canby
Poa compressa	bluegrass, Canada*
Poa cusickii	bluegrass, Cusick's
Poa fendleriana	bluegrass, mutton (bluegrass, longtongue)
Poa fendleriana	muttongrass
Poa longiligula	muttongrass, longtongue (longtongue bluegrass)
Poa nevadensis	bluegrass, Nevada
Poa pratensis	bluegrass, Kentucky*
Poa reflexa	bluegrass, nodding
Poa scabrella	bluegrass, pine
Poa secunda	bluegrass, Sandberg
Polygonum	knotweed
Polygonum douglasii	knotweed, Douglas
Populus	cottonwood; poplar
Populus angustifolia	cottonwood, narrowleaf
Populus balsamifera	poplar, balsam
Populus deltoides	cottonwood, eastern
Populus fremontii	cottonwood, Fremont
Populus tremuloides	aspen, quaking
Populus trichocarpa	cottonwood, black
Potentilla	cinquefoil
Potentilla fruticosa	cinquefoil, shrubby (cinquefoil, bush)
Potentilla glandulosa	cinquefoil, gland
Prosopis	mesquite
Prosopis glandulosa	mesquite, honey
Prunus americana	plum, American
Prunus andersonii	Anderson peachbrush
Prunus andersonii	desert almond
Prunus andersonii	peachbrush, Anderson
Prunus besseyi	cherry, Bessey*
Prunus emarginata	cherry, bitter
Prunus fasciculata	peachbrush, desert
Prunus spinosa	blackthorn*

Scientific name	Common name
Prunus tomentosa	cherry, Nanking*
Prunus virginiana	chokecherrry, common
Prunus virginiana demissa	chokecherry, western
Prunus virginiana melanocarpa	chokecherry, black
Psathyrostachys juncea	wildrye, Russian*
Pseudoroegneria spicata	wheatgrass, bluebunch
Pseudoroegneria spicata inerme	wheatgrass, beardless bluebunch
Pseudotsuga menziesii	Douglas-fir
Puccinellia airoides	alkaligrass, Nuttall
Purshia	bitterbrush
Purshia glandulosa	bitterbrush, desert
Purshia tridentata	bitterbrush, antelope
Quercus	oak
Quercus gambelii	oak, Gambel
Quercus undulata	oak, wavyleaf
Ranunculus testiculatus	buttercup, bur*
Rhamnus purshiana	buckthorn, cascara*
Rhus	sumac
Rhus aromatica (trilobata)	sumac, skunkbush
Rhus glabra	sumac, Rocky Mountain smooth
Ribes	currant; gooseberry
Ribes aureum	currant, golden
Ribes cereum	currant, wax
Ribes viscosissimum	currant, sticky
Robinia pseudoacacia	locust, black*
Rosa	wildrose
Rosa acicularis	rose, prickly
Rosa gymnocarpa	rose, baldhip
Rosa nutkana	rose, Nootka
Rosa woodsii	rose, Woods
Rubus	blackberry, blackcap
Rubus leucodermis	raspberry, black (blackcap)
Rubus parviflorus	thimbleberry
Salicornia	glasswort
Salix	willow
Salix amygdaloides	willow, peachleaf
Salix bebbiana	willow, Bebb (beaked)
Salix boothii	willow, Booth
Salix brachycarpa	willow, barrenground
Salix drummondiana	willow, Drummond (beautiful)
Salix exigua	willow, coyote (sandbar)
Salix geyeriana	willow, Geyer
Salix glauca	willow, grayleaf (glaucous)
Salix lasiandra	willow, whiplash (Pacific)
Salix lasiolepis	willow, arroyo

Scientific name	Common name
Salix lutea	willow, yellow (shining)
Salix planifolia	willow, plainleaf (tealeaf)
Salix purpurea	willow, purpleosier*
Salix scouleriana	willow, Scouler (mountain)
Salix wolfii	willow, Wolf
Salsola iberica	thistle, Russian*
Salvia dorrii	purple sage
Sambucus	elderberry
Sambucus cerulea	elderberry, blue
Sambucus racemosa	elderberry, red
Sambucus racemosa melanocarpa	elderberry, black
Sanguisorba minor	burnet, small*
Sanguisorba muricata	burnet, small*
Sanguisorba occidentalis	burnet, western
Sanguisorba sitchensis	burnet, Alaskan
Saponaria officinalis	bouncing-bet*
Sarcobatus	greasewood
Sarcobatus baileyi	greasewood, Bailey
Sarcobatus vermiculatus	greasewood, black
Scirpus acutus	bulrush, tule
Scirpus maritimus	bulrush, saltmarsh
Secale cereale	rye, winter*
Secale montanum	rye, mountain*
Senecio serra	groundsel, butterweed
Shepherdia	buffaloberry
Shepherdia argentea	buffaloberry, silver
Shepherdia canadensis	buffaloberry, russet
Shepherdia canadensis	soapberry
Shepherdia rotundifolia	buffaloberry, roundleaf
Sidalcea oregana	checker-mallow, Oregon
Sisymbrium altissimum	mustard, tumble*
Sitanion hystrix	squirreltail, bottlebrush
Sitanion jubatum	squirreltail, big
Smilacina	Solomon-plume, fat
Smilacina racemosa	Solomon-seal, western
Solidago	goldenrod
Solidago canadensis	goldenrod, Canada
Solidago multiradiata	goldenrod, low
Solidago parryi	goldenrod, Parry
Sorbus americana	mountain ash, American
Sorbus scopulina	mountain ash, Greene's
Sorbus sitchensis	mountain ash, Sitka*
Sphaeralcea	globemallow
Sphaeralcea coccinea	globemallow, scarlet
Sphaeralcea grossulariifolia	globemallow, gooseberryleaf

Scientific name	Common name
Sphaeralcea munroana	globemallow, munro
Sphaeralcea rivularis	globemallow, stream
Spiraea betulifolia	spiraea, bridal wreath (birchleaf)
Spiraea densiflora	spiraea, subalpine
Sporobolus	dropseeds
Sporobolus airoides	sacaton, alkali
Sporobolus cryptandrus	dropseed, sand
Stellaria	starwort
Stipa	needlegrass
Stipa columbiana	needlegrass, Columbia
Stipa columbiana	needlegrass, subalpine
Stipa comata	needle-and-thread
Stipa lettermanii	needlegrass, Letterman
Stipa thurberiana	needlegrass, Thurber
Stipa viridula	needlegrass, green
Suaeda	seepweed
Suaeda suffrutescens	sumpbush, desert
Suaeda torreyana	seepweed, desert
Symphoricarpos	snowberry
Symphoricarpos albus	snowberry, common (white)
Symphoricarpos longiflorus	snowberry, desert (longflower)
Symphoricarpos occidentalis	snowberry, western
Symphoricarpos occidentalis	wolfberry
Symphoricarpos oreophilus	snowberry, mountain
Syringa villosa	lilac, late*
Syringa vulgaris	lilac, common*
Taeniatherum caput-medusae	medusahead*
Tamarix ramosissima	cedar, salt*
Taraxacum	dandelion*
Tetradymia	horsebrush (cottonthorn)
Tetradymia argyraea	horsebrush, striped
Tetradymia axillaris	horsebrush, longspine
Tetradymia canescens	horsebrush, gray
Tetradymia comosa	horsebrush, hairy
Tetradymia filifolia	horsebrush, threadleaf
Tetradymia glabrata	horsebrush, littleleaf
Tetradymia nuttallii	horsebrush, Nuttall
Tetradymia spinosa	horsebrush, spiny
Tetradymia stenolepis	horsebrush, Mohave
Tetradymia tetrameres	horsebrush, fourpart
Thalictrum	meadowrue
Thalictrum fendleri	meadowrue, Fendler
Thamnosma montana	bush, turpentine
Thinopyrum intermedium	wheatgrass, intermediate*
Thinopyrum intermedium	wheatgrass, pubescent*

Scientific name	Common name
Thinopyrum ponticum	wheatgrass, tall*
Toxicodendron rydbergii	ivy, poison
Tragopogon dubius	salsify, vegetable-oyster (goat's beard)*
Trifolium	clover
Trifolium fragiferum	clover, strawberry*
Trifolium hybridum	clover, alsike*
Trifolium pratense	clover, red*
Trifolium repens	clover, white*
Trisetum spicatum	trisetum, spike
Triticum aestivum x Secale cereale	triticale*
Tsuga heterophylla	hemlock, western
Tsuga mertensiana	hemlock, mountain
Typha	cattail
Ulmus pumila	elm, Siberian*
Vaccinium	blueberry; whortleberry
Vaccinium membranaceum	huckleberry, mountain
Valeriana, edulis	valerian, edible
Veratrum californicum	skunk cabbage
Vicia americana	vetch, American
Vicia cracca	vetch, bramble
Viguiera multiflora	goldeneye, showy
Viguieria	goldeneye
Viguieria multiflora nevadensis	goldeneye, Nevada
Viola nuttallii	violet, Nuttall's
Viola purpurea	violet, goosefoot
Vulpia microstachys	fescue, desert
Wyethia	mule-ears
Yucca	yucca
Yucca brevifolia	Joshua tree
Zuckia arizonica	zuckia, Arizona
Zuckia arizonica	siltbush
Zuckia brandegei	hopsage, spineless

B. Mammals

Alces alces	moose
Alces alces shiras	moose, Shiras
Antilocarpa americana	pronghorn (antelope)
Bos taurus	cattle, domestic*
Canis latrans	coyote
Capra hircus	goat, domestic*
Castor canadensis	beaver, American
Cervus elaphus	elk
Cynomys	prairie dog
Dipodomys	kangaroo rat
Equus asinus	burro, domestic or feral*

Scientific name	Common name
Equus caballus	horse, domestic or feral*
Erethizon dorsatum	porcupine
Lepus	jack rabbit
Lepus americanus	hare, snowshoe
Lepus californicus	jack rabbit, black-tailed
Lynx rufus	bobcat
Marmota	marmot
Microdipodops	kangaroo mouse
Microtus	vole
Mustela	weasel
Neotoma	woodrat
Odocoileus hemionus columbianus	deer, black-tailed
Odocoileus hemionus hemionus	deer, mule
Odocoileus virginianus	deer, white-tailed
Onychomys	grasshopper mouse
Oreamnos americanus	mountain goat
Ovis aries	sheep, domestic*
Ovis canadensis	sheep, bighorn
Ovis canadensis canadensis	sheep, Rocky Mountain bighorn
Ovis canadensis nelsoni	sheep, desert bighorn
Pecari tajacu	javelina
Perognathus	pocket mouse
Peromyscus	deer mouse
Rangifer tarandus caribou	caribou, woodland
Rangifer tarandus groenlandicus	caribou, barren ground
Spermophilus townsendii	ground squirrel, Townsend's
Spilogale and *Mephitis*	skunk
Sus domesticus	hog, domestic or feral*
Sylvilagus	cottontail
Sylvilagus nuttalli	cottontail, mountain
Tamias	chipmunk
Taxidea taxus	badger, American
Thomomys, *Geomys*, *Papogeomys*	pocket gopher
Ursus americanus	bear, black
Ursus arctos horribilis	bear, grizzly
Vulpes and *Urocyon*	fox

C. Birds

Alectoris chukar	chukar*
Bonasa umbellus	grouse, ruffed
Branta canadensis	goose, Canada
Callipepla californicus	quail, California
Callipepla gambelii	quail, Gambel's
Carduelis	redpoll
Carduelis pinus	siskin, pine

Scientific name	Common name
Catharus ustulatus	thrush, Swainson's
Centrocercus urophasianus	sage-grouse
Colinus viginianus	bobwhite
Columba fasciata	pigeon, band-tailed
Cyrtonyx montezumae	quail, Mearn's
Cyrtonyx montezumae	quail, Montezuma
Dendragapus canadensis	grouse, spruce
Dendragapus obscurus	grouse, blue
Dryocopus pileatus	woodpecker, pileated
Meleagris gallapavo	turkey, wild
Meleagris gallapavo merriami	turkey, Merriam's
Parus gambeli	chickadee, mountain
Pedioecetes phasianellus	grouse, sharp-tailed
Perdix perdix	partridge, gray*
Phasianus colchicus	pheasant, ring-necked*
Regulus calendula	kinglet, ruby-crowned
Selasphorus platycercus	hummingbird, broad-tailed
Sphyrapicus nuchalis	sapsucker, red-naped
Sphyrapicus thyroideus	sapsucker, Williamson's
Sphyrapicus varius	sapsucker, yellow-bellied
Tympanuchus	prairie-chicken
Zenaida macroura	dove, mourning

D. Insects

Apoidea	bee
Aroga websteri	moth, sagebrush defoliator
Caelifera and Ensifera	grasshopper
Coleophoridae	moth, case-bearing
Coleoptera	beetle
Diptera	fly
Elateridae	wireworm
Formicidae	ant
Gryllidae	cricket
Hymenoptera	wasp
Lygus	lygus bug (leaf bug)
Malacosoma	caterpillar, tent
Noctuidae	cutworm
Tephritidae	tephritid fly (fruit fly)
Vespinae	hornet

E. Bacteria and Fungi

Acremonium coenophialum	endophytic fungus of tall fescue
Claviceps purpurea	ergot (fungus of wildrye)
Frankia	frankia (nitrogen-fixing bacteria)
Gymnosporangium	rust (several fungi of serviceberry)

Appendix 2: Common and Scientific Names

Common name	Scientific name
A. Plants	
agoseris	*Agoseris*
alder	*Alnus*
alder, speckled	*Alnus incana*
alder, thinleaf	*Alnus tenuifolia*
alfalfa	*Medicago*
alfalfa*	*Medicago sativa*
alfalfa, sicklepod*	*Medicago falcata*
alfileria (filaree)*	*Erodium cicutarium*
alkaligrass, Nuttall	*Puccinellia airoides*
amorpha, leadplant	*Amorpha canescens*
Anderson peachbrush	*Prunus andersonii*
angelica, small leaf	*Angelica pinnata*
Apache plume	*Fallugia paradoxa*
arnica	*Arnica*
ash, green	*Fraxinus pennsylvanica*
ash, singleleaf	*Fraxinus anomala*
aspen, quaking	*Populus tremuloides*
aster	*Aster*
aster, alpine leafybract	*Aster foliaceus*
aster, blueleaf	*Aster glaucodes*
aster, Engelmann	*Aster engelmannii*
aster, Pacific	*Aster chilensis*
aster, smooth	*Aster laevis*
astragalus, giant	*Astragalus galegiformis*
autumn eleagnus (autumn olive)	*Elaeagnus umbellata*
balsamroot	*Balsamorhiza*
balsamroot, arrowleaf	*Balsamorhiza sagittata*
balsamroot, cutleaf	*Balsamorhiza macrophylla*
balsamroot, hairy	*Balsamorhiza hookeri*
barberry	*Mahonia*
barberry, creeping	*Mahonia repens*
barberry, Fremont	*Mahonia fremontii*
barberry, shining	*Mahonia aquifolium*
barley	*Hordeum*
barley, beardless*	*Hordeum vulgare*
barley, bulbous*	*Hordeum bulbosum*
barley, foxtail	*Hordeum jubatum*
barley, meadow	*Hordeum brachyantherum*
bassia, fivehook	*Bassia hyssopifolia*
bentgrass, carpet	*Agrostis stolonifera*
bentgrass, redtop	*Agrostis stolonifera*
birch	*Betula*

Common name	Scientific name
birch, bog	*Betula glandulosa*
birch, downy*	*Betula pubescens*
birch, European white	*Betula pendula*
birch, paper	*Betula papyrifera*
birch, water	*Betula occidentalis*
bitterbrush	*Purshia*
bitterbrush, antelope	*Purshia tridentata*
bitterbrush, desert	*Purshia glandulosa*
blackberry, blackcap	*Rubus*
blackbrush	*Coleogyne ramosissima*
blackthorn*	*Prunus spinosa*
bladdersenna, common*	*Colutea arborescens*
bluebell	*Mertensia*
bluebell, tall	*Mertensia arizonica*
blueberry	*Vaccinium*
bluegrass	*Poa*
bluegrass, alpine	*Poa alpina*
bluegrass, big	*Poa ampla*
bluegrass, bulbous*	*Poa bulbosa*
bluegrass, Canada*	*Poa compressa*
bluegrass, Canby	*Poa canbyi*
bluegrass, Cusick's	*Poa cusickii*
bluegrass, Kentucky*	*Poa pratensis*
bluegrass, mutton (bluegrass, longtongue)	*Poa fendleriana*
bluegrass, Nevada	*Poa nevadensis*
bluegrass, nodding	*Poa reflexa*
bluegrass, pine	*Poa scabrella*
bluegrass, Sandberg	*Poa secunda*
bluestem, big	*Andropogon gerardii*
bouncing-bet*	*Saponaria officinalis*
boxelder	*Acer negundo*
bromegrass	*Bromus*
brome, California	*Bromus carinatus*
brome, downy	*Bromus tectorum*
brome, fringed	*Bromus ciliatus*
brome, Hungarian*	*Bromus inermis*
brome, Japanese*	*Bromus japonicus*
brome, meadow*	*Bromus biebersteinii*
brome, meadow*	*Bromus erectus*
brome, meadow*	*Bromus riparius*
brome, mountain	*Bromus carinatus*
brome, nodding	*Bromus anomalus*
brome, Pumpelly's	*Bromus pumpellianus*
brome, red*	*Bromus rubens*
brome, ripgut*	*Bromus rigidus*

Common name	Scientific name
brome, smooth*	*Bromus inermis*
brome, subalpine	*Bromus tomentellus*
broomrape	*Orobanche*
buckbrush	*Ceanothus*
buckthorn, cascara*	*Rhamnus purshiana*
buckwheat	*Eriogonum*
buckwheat, sulfur	*Eriogonum umbellatum*
buckwheat, wild California flattop	*Eriogonum fasciculatum*
buckwheat, Wright	*Eriogonum wrightii*
buckwheat, Wyeth	*Eriogonum heracleoides*
budsage	*Artemisia spinescens*
buffaloberry	*Shepherdia*
buffaloberry, roundleaf	*Shepherdia rotundifolia*
buffaloberry, russet	*Shepherdia canadensis*
buffaloberry, silver	*Shepherdia argentea*
buffalograss	*Buchloe dactyloides*
bulrush, saltmarsh	*Scirpus maritimus*
bulrush, tule	*Scirpus acutus*
burnet, Alaskan	*Sanguisorba sitchensis*
burnet, small*	*Sanguisorba minor*
burnet, small*	*Sanguisorba muricata*
burnet, western	*Sanguisorba occidentalis*
bush, turpentine	*Thamnosma montana*
buttercup, bur*	*Ranunculus testiculatus*
camphorfume, Mediterranean*	*Camphorosoma monspeliaca*
canarygrass, reed*	*Phalaris arundinacea*
cattail	*Typha*
ceanothus, buckbrush	*Ceanothus*
ceanothus, deerbrush	*Ceanothus integerrimus*
ceanothus, desert	*Ceanothus greggii*
ceanothus, Fendler	*Ceanothus fendleri*
ceanothus, Lemmon	*Ceanothus lemmonii*
ceanothus, Martin	*Ceanothus martinii*
ceanothus, prostrate	*Ceanothus prostrata*
ceanothus, redstem	*Ceanothus sanguineus*
ceanothus, snowbrush	*Ceanothus velutinus*
ceanothus, wedgeleaf	*Ceanothus cuneatus*
cedar, salt*	*Tamarix ramosissima*
centaury, charming	*Centaurium venustum*
chamise	*Adenostema*
cheatgrass*	*Bromus tectorum*
checker-mallow, Oregon	*Sidalcea oregana*
cherry, Bessey*	*Prunus besseyi*
cherry, bitter	*Prunus emarginata*
cherry, Nanking*	*Prunus tomentosa*

Common name	Scientific name
chokecherrry, common	*Prunus virginiana*
chokecherry, black	*Prunus virginiana melanocarpa*
chokecherry, western	*Prunus virginiana demissa*
cinquefoil	*Potentilla*
cinquefoil, gland	*Potentilla glandulosa*
cinquefoil, shrubby (cinquefoil, bush)	*Potentilla fruticosa*
cliffrose	*Cowania*
cliffrose, Stansbury	*Cowania stansburiana*
clover	*Trifolium*
clover, alsike*	*Trifolium hybridum*
clover, red*	*Trifolium pratense*
clover, strawberry*	*Trifolium fragiferum*
clover, sweet	*Melilotus*
clover, white*	*Trifolium repens*
collomia, slenderleaf	*Collomia linearis*
columbine, Colorado	*Aquilegia coerulea*
cotoneaster, Peking*	*Cotoneaster acutifolia*
cottonthorn (horsebrush)	*Tetradymia*
cottontop, Arizona	*Digitaria californica*
cottonwood	*Populus*
cottonwood, black	*Populus trichocarpa*
cottonwood, eastern	*Populus deltoides*
cottonwood, Fremont	*Populus fremontii*
cottonwood, narrowleaf	*Populus angustifolia*
cowparsnip	*Heracleum lanatum*
creosotebush	*Larrea tridentata*
crownvetch*	*Coronilla varia*
curly grass	*Hilaria jamesii*
currant	*Ribes*
currant, golden	*Ribes aureum*
currant, sticky	*Ribes viscosissimum*
currant, wax	*Ribes cereum*
cypress, Arizona	*Cupressus arizonica*
daisy, oxeye*	*Chrysanthemum leucanthemum*
dandelion*	*Taraxacum*
deervetch, birdfoot	*Lotus corniculatus*
desert almond	*Prunus andersonii*
dogtail*	*Cynosurus echinatus*
dogwood	*Cornus*
dogwood, redosier	*Cornus stolonifera*
Douglasfir	*Pseudotsuga menziesii*
dropseed, sand	*Sporobolus cryptandrus*
dropseeds	*Sporobolus*
dryas	*Dryas*
elderberry	*Sambucus*

Common name	Scientific name
elderberry, black	*Sambucus racemosa melanocarpa*
elderberry, blue	*Sambucus cerulea*
elderberry, red	*Sambucus racemosa*
elm, Siberian*	*Ulmus pumila*
ephedra	*Ephedra*
ephedra, green	*Ephedra viridis*
ephedra, Nevada	*Ephedra nevadensis*
ephedra, Torrey	*Ephedra torreyana*
eriogonum, cushion	*Eriogonum ovalifolium*
eriogonum, snow	*Eriogonum niveum*
eriogonum, sulfur	*Eriogonum umbellatum*
eriogonum, Wright	*Eriogonum wrightii*
eriogonum, Wyeth	*Eriogonum heracleoides*
fescue	*Festuca*
fescue, Arizona	*Festuca arizonica*
fescue, desert	*Vulpia microstachys*
fescue, hard	*Festuca ovina duriuscula*
fescue, hard sheep*	*Festuca ovina duriuscula*
fescue, Idaho	*Festuca idahoensis*
fescue, meadow*	*Festuca elatior*
fescue, red*	*Festuca rubra*
fescue, sheep (fescue, alpine)	*Festuca ovina ovina*
fescue, spike	*Hesperochloa kingii*
fescue, sulcata sheep	*Festuca ovina sulcata*
fescue, tall (fescue, alta or reed)*	*Festuca arundinacea*
fescue, Thurber	*Festuca thurberi*
fiddleneck	*Amsinckia*
filaree	*Erodium cicutarium*
fir	*Abies*
fir, California red	*Abies magnifica*
fir, grand	*Abies grandis*
fir, subalpine	*Abies lasiocarpa*
fir, white	*Abies concolor*
fireweed	*Epilobium angustifolia*
flax, Lewis	*Linum perenne lewisii*
fleabane, Bear River	*Erigeron ursinus*
fleabane, Oregon	*Erigeron speciosus*
forestiera, New Mexico	*Forestiera neomexicana*
foxtail, creeping (foxtail, reed)*	*Alopecurus arundinaceus*
foxtail, meadow*	*Alopecurus pratensis*
galleta	*Hilaria jamesii*
geranium	*Geranium*
geranium, Richardson	*Geranium richardsonii*
geranium, sticky	*Geranium viscosissimum*
giant hyssop, nettleleaf	*Agastache urticifolia*

Common name	Scientific name
glasswort	*Salicornia*
globemallow	*Sphaeralcea*
globemallow, gooseberryleaf	*Sphaeralcea grossulariifolia*
globemallow, munro	*Sphaeralcea munroana*
globemallow, scarlet	*Sphaeralcea coccinea*
globemallow, stream	*Sphaeralcea rivularis*
goldeneye	*Viguieria*
goldeneye, Nevada	*Viguieria multiflora nevadensis*
goldeneye, showy	*Viguiera multiflora*
goldenrod	*Solidago*
goldenrod, Canada	*Solidago canadensis*
goldenrod, low	*Solidago multiradiata*
goldenrod, Panamint rock	*Chrysothamnus gramineus*
goldenrod, Parry	*Solidago parryi*
goldenweed	*Haplopappus*
goldenweed, Columbia	*Haplopappus resinosus*
goldenweed, Greene's	*Haplopappus greenei*
goldenweed, largeflowered	*Haplopappus carthamoides*
goldenweed, rabbitbrush	*Haplopappus bloomeri*
goldenweed, shrubby	*Haplopappus suffruticosus*
goldenweed, whitestem	*Haplopappus macronema*
gooseberry	*Ribes*
grama	*Bouteloua*
grama, black	*Bouteloua eriopoda*
grama, blue	*Bouteloua gracilis*
grama, sideoats	*Bouteloua curtipendula*
greasewood	*Sarcobatus*
greasewood, Bailey	*Sarcobatus baileyi*
greasewood, black	*Sarcobatus vermiculatus*
groundsel, butterweed	*Senecio serra*
hackberry, netleaf	*Celtis reticulata*
hairgrass, tufted	*Deschampsia caespitosa*
halogeton*	*Halogeton glomeratus*
hawthorn	*Crataegus*
hawthorn, Columbia	*Crataegus columbiana*
hawthorn, Douglas	*Crataegus douglasii*
hawthorn, river	*Crataegus rivularis*
hawthorn, yellow*	*Crataegus succulenta*
helianthella, oneflower	*Helianthella uniflora*
hemlock, mountain	*Tsuga mertensiana*
hemlock, western	*Tsuga heterophylla*
honeylocust	*Gleditsia triacanthos*
honeysuckle	*Lonicera*
honeysuckle, bearberry	*Lonicera involucrata*
honeysuckle, Tatarian*	*Lonicera tatarica*

Common name	Scientific name
honeysuckle, Utah	*Lonicera utahensis*
honeysuckle, western trumpet (honeysuckle, orange)*	*Lonicera ciliosa*
hopsage, spineless	*Grayia brandegei*
hopsage, spineless	*Zuckia brandegei*
hopsage, spiny	*Grayia spinosa*
horsebrush (cottonthorn)	*Tetradymia*
horsebrush, fourpart	*Tetradymia tetrameres*
horsebrush, gray	*Tetradymia canescens*
horsebrush, hairy	*Tetradymia comosa*
horsebrush, littleleaf	*Tetradymia glabrata*
horsebrush, longspine	*Tetradymia axillaris*
horsebrush, Mohave	*Tetradymia stenolepis*
horsebrush, Nuttall	*Tetradymia nuttallii*
horsebrush, spiny	*Tetradymia spinosa*
horsebrush, striped	*Tetradymia argyraea*
horsebrush, threadleaf	*Tetradymia filifolia*
horsetail	*Equisetum*
huckleberry, mountain	*Vaccinium membranaceum*
Indian apple	*Peraphyllum ramosissimum*
iodine bush	*Allenrolfea*
iris, German*	*Iris germanica*
ivesia, Gordon	*Ivesia gordonii*
ivy, poison	*Toxicodendron rydbergii*
jointfir	*Ephedra*
Joshua tree	*Yucca brevifolia*
junegrass, prairie	*Koeleria macrantha*
juniper	*Juniperus*
juniper, Ashe	*Juniperus ashei*
juniper, creeping	*Juniperus horizontalis*
juniper, mountain	*Juniperus communis montana*
juniper, Rocky Mountain	*Juniperus scopulorum*
juniper, Utah	*Juniperus osteosperma*
juniper, western	*Juniperus occidentalis*
knapweed, Russian*	*Centaurea repens*
knapweed, spotted*	*Centaurea biebersteinii*
knotweed	*Polygonum*
knotweed, Douglas	*Polygonum douglasii*
kochia, Belvedere	*Kochia scoparia*
kochia, forage*	*Kochia prostrata*
larkspur, low	*Delphinium nuttallianum*
larkspur, tall	*Delphinium occidentale*
lettuce, prickly*	*Lactuca serriola*
ligusticum, narrowleaf	*Ligusticum tenuifolium*
ligusticum, Porter	*Ligusticum porteri*

Common name	Scientific name
lilac, common*	*Syringa vulgaris*
lilac, late*	*Syringa villosa*
locoweed	*Astragalus*
locust, black*	*Robinia pseudoacacia*
lomatium, carrotleaf	*Lomatium dissectum*
lomatium, nineleaf (narrowleaf)	*Lomatium triternatum*
lomatium, Nuttall	*Lomatium nuttallii (kingii)*
lomatium, stinking	*Lomatium graveolens*
lupine	*Lupinus*
lupine, mountain	*Lupinus alpestris*
lupine, Nevada	*Lupinus nevadensis*
lupine, silky	*Lupinus sericeus*
lupine, silvery	*Lupinus argenteus*
madia	*Madia*
manzanita	*Arctostaphylos*
manzanita, bearberry	*Arctostaphylos uvaursi*
manzanita, greenleaf	*Arctostaphylos patula*
maple	*Acer*
maple, bigtooth	*Acer grandidentatum*
maple, Rocky Mountain	*Acer glabrum*
matchbrush	*Gutierrezia*
matchbrush, small head	*Gutierrezia microcephala*
matrimony vine*	*Lycium barbarum*
meadowrue	*Thalictrum*
meadowrue, Fendler	*Thalictrum fendleri*
medick, black*	*Medicago lupulina*
medusahead*	*Taeniatherum caput-medusae*
mesquite	*Prosopis*
mesquite, honey	*Prosopis glandulosa*
milkweed, whorled	*Asclepias subverticillata*
milkvetch	*Astragalus*
milkvetch, Canadian	*Astragalus canadensis*
milkvetch, cicer*	*Astragalus cicer*
milkvetch, Snake River (milkvetch, basalt)	*Astragalus filipes*
millet*	*Panicum*
mistletoe, dwarf	*Arceuthobium*
mockorange, Lewis	*Philadelphus lewisii*
mockorange, littleleaf	*Philadelphus microphyllus*
molly, gray (green)	*Kochia americana*
mountain ash, American	*Sorbus americana*
mountain ash, Greene's	*Sorbus scopulina*
mountain ash, Sitka*	*Sorbus sitchensis*
mountain lover	*Pachistima myrsinites*
mountain mahogany	*Cercocarpus*
mountain mahogany, birchleaf	*Cerocarpus betuloides*

Common name	Scientific name
mountain mahogany, curlleaf	*Cerocarpus ledifolius*
mountain mahogany, intermountain curlleaf	*Cerocarpus ledifolius intermontanus*
mountain mahogany, littleleaf	*Cerocarpus intricatus*
mountain mahogany, true	*Cerocarpus montanus*
muhly, alkali	*Muhlenbergia asperifolia*
muhly, mat	*Muhlenbergia richardsonis*
muhly, spike	*Muhlenbergia wrightii*
mule-ears	*Wyethia*
mustard, African*	*Malcomia africana*
mustard, blue	*Chorispora tenella*
mustard, tansy	*Descurainia*
mustard, tumble*	*Sisymbrium altissimum*
muttongrass	*Poa fendleriana*
muttongrass, longtongue (longtongue bluegrass)	*Poa longiligula*
needle-and-thread	*Stipa comata*
needlegrass	*Stipa*
needlegrass, Columbia	*Stipa columbiana*
needlegrass, green	*Stipa viridula*
needlegrass, Letterman	*Stipa lettermanii*
needlegrass, subalpine	*Stipa columbiana*
needlegrass, Thurber	*Achnatherum thurberianum*
needlegrass, Thurber	*Stipa thurberiana*
ninebark, dwarf	*Physocarpus alternans*
ninebark, mallow	*Physocarpus malvaceus*
ninebark, mountain	*Physocarpus monogynus*
ninebark, Pacific	*Physocarpus capitatus*
oak	*Quercus*
oak, Gambel	*Quercus gambelii*
oak, wavyleaf	*Quercus undulata*
oatgrass, tall*	*Arrhenatherum elatius*
oatgrass, tall*	*Avena elatior*
oceanspray	*Holodiscus*
oceanspray, bush	*Holodiscus dumosus*
oceanspray, creambush	*Holodiscus discolor*
oceanspray, rock	*Holodiscus dumosus*
olive, autumn*	*Elaeagnus umbellatum*
oniongrass	*Melica bulbosa*
orchardgrass*	*Dactylis glomerata*
Oregon grape	*Mahonia*
painted cup, sulphur	*Castilleja hispida*
peachbrush, Anderson	*Prunus andersonii*
peachbrush, desert	*Prunus fasciculata*
pearly everlasting	*Anaphalis margaritacea*
peashrub, pygmy*	*Caragana arborescens pygmaea*
peashrub, Siberian*	*Caragana arborescens*

Common name	Scientific name
peavine, flat	*Lathyrus sylvestris*
peavine, perennial*	*Lathyrus latifolium*
peavine, thickleaf	*Lathyrus lanszwertii*
peavine, Utah	*Lathyrus zionis*
penstemon	*Penstemon*
penstemon, bush	*Penstemon fruticosus*
penstemon, Eaton (firecracker)	*Penstemon eatonii*
penstemon, littlecup	*Penstemon sepalulus*
penstemon, low	*Penstemon humilis*
penstemon, Palmer	*Penstemon palmeri*
penstemon, Rocky Mountain	*Penstemon strictus*
penstemon, Rydberg	*Penstemon rydbergii*
penstemon, showy	*Penstemon spectabilis*
penstemon, sidehill	*Penstemon platyphyllus*
penstemon, thickleaf	*Penstemon pachyphyllus*
penstemon, toadflax	*Penstemon linarioides*
penstemon, Wasatch	*Penstemon cyananthus*
pepperweed	*Lepidium*
pine, bristlecone	*Pinus aristata*
pine, bristlecone	*Pinus longaeva*
pine, Jeffrey	*Pinus jeffreyi*
pine, limber	*Pinus flexilis*
pine, lodgepole	*Pinus contorta*
pine, longleaf	*Pinus palustris*
pine, ponderosa	*Pinus ponderosa*
pine, western white	*Pinus monticola*
pine, whitebark	*Pinus albicaulis*
pinegrass	*Calamagrostis rubescens*
pinyon	*Pinus*
pinyon	*Pinus edulis*
pinyon, singleleaf	*Pinus monophylla*
plum, American	*Prunus americana*
poplar	*Populus*
poplar, balsam	*Populus balsamifera*
povertyweed	*Iva axillaris*
purple sage	*Salvia dorrii*
quackgrass*	*Agropyron repens*
quailbush	*Atriplex polycarpa*
rabbitbrush	*Chrysothamnus*
rabbitbrush, alkali	*Chrysothamnus albidus*
rabbitbrush, Arizona	*Chrysothamnus molestus*
rabbitbrush, dwarf	*Chrysothamnus depressus*
rabbitbrush, Greene's	*Chrysothamnus greenei*
rabbitbrush, low (yellow)	*Chrysothamnus viscidiflorus*
rabbitbrush, hairy low	*Chrysothamnus viscidiflorus puberulus*

Common name	Scientific name
rabbitbrush, mountain low	*Chrysothamnus viscidiflorus lanceolatus*
rabbitbrush, narrowleaf low	*Chrysothamnus viscidiflorus stenophyllus*
rabbitbrush, stickyleaf low (Douglas)	*Chrysothamnus viscidiflorus viscidiflorus*
rabbitbrush, Mojave	*Chrysothamnus paniculatus*
rabbitbrush, Nevada	*Chrysothamnus parryi nevadensis*
rabbitbrush, Parry	*Chrysothamnus parryi*
rabbitbrush, Pintwater	*Chrysothamnus eremobius*
rabbitbrush, rubber	*Chrysothamnus nauseosus*
rabbitbrush, basin whitestem rubber	*Chrysothamnus nauseosus hololeucus*
rabbitbrush, green rubber	*Chrysothamnus nauseosus nauseosus*
rabbitbrush, leiospermus rubber	*Chrysothamnus nauseosus leiospermus*
rabbitbrush, Mohave rubber	*Chrysothamnus nauseosus mohavensis*
rabbitbrush, mountain rubber	*Chrysothamnus nauseosus salicifolius*
rabbitbrush, mountain whitestem rubber	*Chrysothamnus nauseosus albicaulis*
rabbitbrush, threadleaf rubber	*Chrysothamnus nauseosus consimilis*
rabbitbrush, turbinate rubber	*Chrysothamnus nauseosus turbinatus*
rabbitbrush, Utah green rubber	*Chrysothamnus nauseosus utahensis*
rabbitbrush, whitestem rubber	*Chrysothamnus nauseosus hololeucus*
rabbitbrush, southwestern	*Chrysothamnus pulchellus*
rabbitbrush, spreading	*Chrysothamnus linifolius*
rabbitbrush, Truckee	*Chrysothamnus humilis*
rabbitbrush, Vasey	*Chrysothamnus vaseyi*
ragweed	*Ambrosia*
raspberry, black (blackcap)	*Rubus leucodermis*
redtop*	*Agrostis stolonifera*
reedgrass	*Calamagrostis*
reedgrass, bluejoint	*Calamagrostis canadensis*
reedgrass, chee*	*Calamagrostis epigeios*
reedgrass, plains	*Calamagrostis montanensis*
ricegrass, Indian	*Achnatherum hymenoides*
ricegrass, Indian	*Oryzopsis hymenoides*
rockspirea	*Holodiscus dumosus*
rockgoldenrod	*Petradoria*
rose, baldhip	*Rosa gymnocarpa*
rose, Nootka	*Rosa nutkana*
rose, prickly	*Rosa acicularis*
rose, Woods	*Rosa woodsii*
rush	*Juncus*
rush, Baltic	*Juncus arcticus balticus*
rush, Drummond	*Juncus drummondii*
rush, longstyle	*Juncus longistylis*
rush, swordleaf	*Juncus ensifolius*
rush, Torrey	*Juncus torreyi*
Russianolive*	*Elaeagnus angustifolia*
rye, annual	*Lolium multiflorum*

Common name	Scientific name
rye, meadow	*Lolium pratense*
rye, mountain*	*Secale montanum*
rye, winter*	*Secale cereale*
ryegrass, Italian*	*Lolium multiflorum*
ryegrass, perennial*	*Lolium perenne*
sacaton, alkali	*Sporobolus airoides*
sage, Louisiana (wormwood)	*Artemisia ludoviciana*
sage, purple	*Salvia dorrii*
sage, sand	*Artemisia filifolia*
sage, tarragon	*Artemisia dracunculus*
sagebrush	*Artemisia*
sagebrush, alkali (early)	*Artemisia longiloba*
sagebrush, big	*Artemisia tridentata*
sagebrush, basin big	*Artemisia tridentata tridentata*
sagebrush, foothills big (xeric big)	*Artemisia tridentata xericensis*
sagebrush, mountain big	*Artemisia tridentata vaseyana*
sagebrush, subalpine big (snowbank, timberline, or spicate big)	*Artemisia tridentata spiciformis*
sagebrush, Wyoming big	*Artemisia tridentata wyomingensis*
sagebrush, Bigelow (flat)	*Artemisia bigelovii*
sagebrush, birdsfoot	*Artemisia pedatifida*
sagebrush, black	*Artemisia nova*
sagebrush, bud	*Artemisia spinescens*
sagebrush, coaltown	*Artemisia argillosa*
sagebrush, fringed	*Artemisia frigida*
sagebrush, hotsprings (cleftleaf)	*Artemisia arbuscula thermopola*
sagebrush, longleaf	*Artemisia longifolia*
sagebrush, low	*Artemisia arbuscula*
sagebrush, pygmy	*Artemisia pygmaea*
sagebrush, rothrock	*Artemisia rothrockii*
sagebrush, silver	*Artemisia cana*
sagebrush, Bolander silver	*Artemisia cana bolanderi*
sagebrush, mountain silver	*Artemisia cana viscidula*
sagebrush, plains silver	*Artemisia cana cana*
sagebrush, stiff (scabland)	*Artemisia rigida*
sagebrush, threetip	*Artemisia tripartita*
sagebrush, tall threetip	*Artemisia tripartita tripartita*
sagebrush, Wyoming threetip	*Artemisia tripartita rupicola*
sagewort, Louisiana	*Artemisia ludoviciana*
sainfoin*	*Onobrychis viciaefolia*
salsify, vegetable-oyster (goat's beard)*	*Tragopogon dubius*
saltbush	*Atriplex*
saltbush, allscale	*Atriplex polycarpa*
saltbush, Australian*	*Atriplex semibaccata*
saltbush, big (quailbush)	*Atriplex lentiformis*

Common name	Scientific name
saltbush, Bonneville	*Atriplex bonnevillensis*
saltbush, broadscale	*Atriplex obovata*
saltbush, Castle Valley clover	*Atriplex cuneata*
saltbush, cattle	*Atriplex polycarpa*
saltbush, cuneate	*Atriplex cuneata*
saltbush, desert holly	*Atriplex hymenelytra*
saltbush, falcate	*Atriplex falcata*
saltbush, fourwing	*Atriplex canescens*
saltbush, Gardner	*Atriplex buxifolia*
saltbush, Gardner	*Atriplex gardneri*
saltbush, Garrett	*Atriplex garrettii*
saltbush, mat	*Atriplex corrugata*
saltbush, Navajo	*Atriplex navajoensis*
saltbush, Nuttall's	*Atriplex nuttallii*
saltbush, quail	*Atriplex polycarpa*
saltbush, robust*	*Atriplex robusta*
saltbush, shadscale	*Atriplex confertifolia*
saltbush, Torrey	*Atriplex torreyi*
saltbush, trident	*Atriplex tridentata*
saltbush, wingless	*Atriplex aptera*
saltgrass	*Distichlis*
saltgrass, inland	*Distichlis spicata*
salt-tree, Siberian*	*Halimodendron halodendron*
scalebroom	*Lepidospartum latisquamatum*
sedge	*Carex*
sedge, analogue	*Carex simulata*
sedge, beaked	*Carex rostrata*
sedge, black alpine	*Carex nigricans*
sedge, blackroot	*Carex elynoides*
sedge, Douglas	*Carex douglasii*
sedge, downy	*Carex scirpoidea*
sedge, golden	*Carex aurea*
sedge, Hepburn	*Carex nardina*
sedge, hood	*Carex hoodii*
sedge, Kellogg	*Carex lenticularis lipocarpa*
sedge, Nebraska	*Carex nebrascensis*
sedge, ovalhead	*Carex festivella*
sedge, rock (curly)	*Carex rupestris*
sedge, russet	*Carex saxatilis*
sedge, slim	*Carex praegracilis*
sedge, smallwing	*Carex microptera*
sedge, softleaved	*Carex disperma*
sedge, valley	*Carex vallicola*
sedge, water	*Carex aquatilis*
sedge, woolly	*Carex lanuginosa*

Common name	Scientific name
seepweed	*Suaeda*
seepweed, desert	*Suaeda torreyana*
serviceberry	*Amelanchier*
serviceberry, dwarf Saskatoon	*Amelanchier pumila*
serviceberry, Saskatoon	*Amelanchier alnifolia*
serviceberry, Utah	*Amelanchier utahensis*
shadscale	*Atriplex confertifolia*
siltbush	*Zuckia arizonica*
silverberry	*Elaeagnus commutata*
skeletonweed, rush*	*Chondrilla juncea*
skunk cabbage	*Veratrum californicum*
snakeweed	*Gutierrezia (Xanthocephalum)*
snakeweed, broom	*Gutierrezia sarothrae*
snakeweed, goldenrod	*Gutierrezia petradoria*
snakeweed, orchard	*Gutierrezia pomariensis*
snakeweed, roundleaf	*Gutierrezia sphaerocephala*
snakeweed, threadleaf	*Gutierrezia microcephala*
snowberry	*Symphoricarpos*
snowberry, common (white)	*Symphoricarpos albus*
snowberry, desert (longflower)	*Symphoricarpos longiflorus*
snowberry, mountain	*Symphoricarpos oreophilus*
snowberry, western	*Symphoricarpos occidentalis*
soapberry	*Shepherdia canadensis*
Solomonplume, fat	*Smilacina*
Solomon-seal, western	*Smilacina racemosa*
spikerush, common	*Eleocharis palustris*
spirea, rock	*Holodiscus dumosus*
spiraea, bridal wreath (birchleaf)	*Spiraea betulifolia*
spiraea, subalpine	*Spiraea densiflora*
spruce	*Picea*
spruce, blue	*Picea pungens*
spruce, Engelmann	*Picea engelmannii*
spurge, leafy*	*Euphorbia esula*
squirreltail, big	*Elymus multisetus*
squirreltail, big	*Sitanion jubatum*
squirreltail, bottlebrush	*Elymus elymoides*
squirreltail, bottlebrush	*Sitanion hystrix*
starthistle, yellow	*Centaurea solstitialis*
starwort	*Stellaria*
strawberry, wild	*Fragaria*
sumac	*Rhus*
sumac, Rocky Mountain smooth	*Rhus glabra*
sumac, skunkbush	*Rhus aromatica (trilobata)*
summercypress, Belvedere*	*Kochia scoparia*
sumpbush, desert	*Suaeda suffrutescens*

Common name	Scientific name
sunflower	*Helianthus annuus*
sweetanise	*Osmorhiza occidentalis*
sweetclover	*Melilotus*
sweetclover, white*	*Melilotus alba*
sweetclover, yellow*	*Melilotus officinalis*
sweetroot, spreading	*Osmorhiza chilensis*
sweetvetch, sulla	*Hedysarum coronarium*
sweetvetch, Uinta (northern)	*Hedysarum boreale boreale*
sweetvetch, Utah	*Hedysarum boreale gremiale*
sweetvetch, Utah	*Hedysarum boreale utahense*
syringa	*Philadelphus*
tansymustard	*Descurainia*
tansymustard	*Descurainia pinnata*
tansymustard, flixweed*	*Descurainia sophia*
tarweed	*Madia*
tarweed, cluster	*Madia glomerata*
thimbleberry	*Rubus parviflorus*
thistle, Canada*	*Cirsium arvense*
thistle, musk*	*Carduus nutans*
thistle, Russian*	*Salsola iberica*
threeawn	*Aristida*
threeawn, Fendler	*Aristida purpurea longiseta*
three-awn, purple	*Aristida purpurea*
threeawn, red	*Aristida purpurea longiseta*
timothy*	*Phleum pratense*
timothy, alpine (mountain)	*Phleum alpinum*
trefoil, birdsfoot*	*Lotus corniculatus*
trisetum, spike	*Trisetum spicatum*
triticale*	*Triticum aestivum* x *Secale cereale*
valerian, edible	*Valeriana, edulis*
vetch, American	*Vicia americana*
vetch, bramble	*Vicia cracca*
violet, goosefoot	*Viola purpurea*
violet, Nuttall's	*Viola nuttallii*
virginsbower, western	*Clematis ligusticifolia*
wheatgrass	*Agropyron*
wheatgrass, bearded*	*Agropyron subsecundum*
wheatgrass, beardless bluebunch	*Pseudoroegneria spicata inerme*
wheatgrass, bluebunch	*Agropyron spicatum*
wheatgrass, bluebunch	*Pseudoroegneria spicata*
wheatgrass, bluestem	*Agropyron smithii*
wheatgrass, crested*	*Agropyron* spp.
wheatgrass, desert*	*Agropyron desertorum*
wheatgrass, fairway crested*	*Agropyron cristatum*
wheatgrass, intermediate*	*Agropyron intermedium*
wheatgrass, intermediate*	*Thinopyrum intermedium*

Common name	Scientific name
wheatgrass, Montana	*Agropyron albicans*
wheatgrass, NewHy*	*Agropyron repens* x *A. spicatum*
wheatgrass, pubescent*	*Agropyron trichophorum*
wheatgrass, pubescent*	*Thinopyrum intermedium*
wheatgrass, rushleaf*	*Agropyron junceum*
wheatgrass, Scribner	*Agropyron scribneri*
wheatgrass, Siberian*	*Agropyron fragile*
wheatgrass, Siberian*	*Agropyron sibiricum*
wheatgrass, slender	*Agropyron trachycaulum*
wheatgrass, slender	*Elymus trachycaulus*
wheatgrass, Snake River	*Agropyron spicatum*
wheatgrass, Snake River	*Elymus wawawaiensis*
wheatgrass, standard crested (desert)*	*Agropyron desertorum*
wheatgrass, streambank	*Agropyron dasystachyum*
wheatgrass, tall*	*Agropyron elongatum*
wheatgrass, tall*	*Thinopyrum ponticum*
wheatgrass, thickspike	*Agropyron dasystachyum*
wheatgrass, thickspike	*Elymus macrourus*
wheatgrass, thickspike	*Elymus lanceolatus lanceolatus*
wheatgrass, western	*Agropyron smithii*
wheatgrass, western	*Elytrigia smithii*
wheatgrass, western	*Pascopyrum smithii*
whitetop*	*Cardaria draba*
whortleberry	*Vaccinium*
wildrose	*Rosa*
wildrye	*Elymus*
wildrye, Altai*	*Elymus angustus*
wildrye, Altai*	*Leymus angustus*
wildrye, beardless (creeping)	*Elymus triticoides*
wildrye, beardless (creeping)	*Leymus triticoides*
wildrye, blue	*Elymus glaucus*
wildrye, Canada	*Elymus canadensis*
wildrye, Dahurian*	*Elymus dahuricus*
wildrye, Great Basin	*Elymus cinereus*
wildrye, Great Basin	*Leymus cinereus*
wildrye, low creeping/alkali	*Elymus simplex*
wildrye, mammoth*	*Elymus giganteus*
wildrye, mammoth*	*Leymus racemosus*
wildrye, purple	*Elymus aristatus*
wildrye, Russian*	*Elymus junceus*
wildrye, Russian*	*Psathyrostachys juncea*
wildrye, Salina	*Elymus salinus*
wildrye, yellow	*Elymus flavescens*
willow	*Salix*
willow, arroyo	*Salix lasiolepis*
willow, barrenground	*Salix brachycarpa*

Common name	Scientific name
willow, Bebb (beaked)	*Salix bebbiana*
willow, Booth	*Salix boothii*
willow, coyote (sandbar)	*Salix exigua*
willow, Drummond (beautiful)	*Salix drummondiana*
willow, Geyer	*Salix geyeriana*
willow, grayleaf (glaucous)	*Salix glauca*
willow, peachleaf	*Salix amygdaloides*
willow, purpleosier*	*Salix purpurea*
willow, Scouler (mountain)	*Salix scouleriana*
willow, plainleaf (tealeaf)	*Salix planifolia*
willow, whiplash (Pacific)	*Salix lasiandra*
willow, Wolf	*Salix wolfii*
willow, yellow (shining)	*Salix lutea*
winterfat	*Ceratoides lanata*
winterfat	*Eurotia lanata*
winterfat	*Krascheninnikovia lanata*
winterfat, big	*Ceratoides lanata ruinina*
winterfat, foothills	*Ceratoides lanata subspinosa*
winterfat, Pamirian*	*Ceratoides latens*
witchgrass	*Panicum capillare*
wolfberry	*Symphoricarpos occidentalis*
wormwood, common*	*Artemisia absinthium*
wormwood, dwarf*	*Artemisia abrotanum nana*
wormwood, oldman*	*Artemisia abrotanum*
yarrow, European*	*Achillea millefolium millefolium*
yarrow, timberline	*Achillea millefolium alpicola*
yarrow, western	*Achillea millefolium lanulosa*
yellowbrush	*Chrysothamnus viscidiflorus*
yucca	*Yucca*
zuckia, Arizona	*Zuckia arizonica*

B. Mammals

badger, American	*Taxidea taxus*
bear, black	*Ursus americanus*
bear, grizzly	*Ursus arctos horribilis*
beaver, American	*Castor canadensis*
bobcat	*Lynx rufus*
burro, domestic or feral*	*Equus asinus*
caribou, barren ground	*Rangifer tarandus groenlandicus*
caribou, woodland	*Rangifer tarandus caribou*
chipmunk	*Tamias*
cattle, domestic*	*Bos taurus*
cottontail	*Sylvilagus*
cottontail, mountain	*Sylvilagus nuttalli*
coyote	*Canis latrans*

Common name	Scientific name
deer, black-tailed	*Odocoileus hemionus columbianus*
deer, mule	*Odocoileus hemionus hemionus*
deer, white-tailed	*Odocoileus virginianus*
deer mouse	*Peromyscus*
elk	*Cervus elaphus*
fox	*Vulpes* and *Urocyon* .
goat, domestic*	*Capra hircus*
grasshopper mouse	*Onychomys*
ground squirrel, Townsend's	*Spermophilus townsendii*
hare, snowshoe	*Lepus americanus*
hog, domestic or feral*	*Sus domesticus*
horse, domestic or feral*	*Equus caballus*
jack rabbit	*Lepus*
jack rabbit, black-tailed	*Lepus californicus*
javelina	*Pecari tajacu*
kangaroo mouse	*Microdipodops*
kangaroo rat	*Dipodomys*
marmot	*Marmota*
moose	*Alces alces*
moose, Shiras	*Alces alces shiras*
mountain goat	*Oreamnos americanus*
pocket gopher	*Thomomys*, *Geomys*, *Papogeomys*
pocket mouse	*Perognathus*
porcupine	*Erethizon dorsatum*
prairie dog	*Cynomys*
pronghorn (antelope)	*Antilocarpa americana*
sheep, domestic*	*Ovis aries*
sheep, bighorn	*Ovis canadensis*
sheep, desert bighorn	*Ovis canadensis nelsoni*
sheep, Rocky Mountain bighorn	*Ovis canadensis canadensis*
skunk	*Spilogale* and *Mephitis*
vole	*Microtus*
weasel	*Mustela*
woodrat	*Neotoma*

C. Birds

chickadee, mountain	*Parus gambeli*
prairie-chicken	*Tympanuchus*
chukar*	*Alectoris chukar*
dove, mourning	*Zenaida macroura*
goose, Canada	*Branta canadensis*
grouse, blue	*Dendragapus obscurus*
grouse, sharp-tailed	*Pedioecetes phasianellus*
grouse, ruffed	*Bonasa umbellus*
grouse, spruce	*Dendragapus canadensis*

Common name	Scientific name
hummingbird, broad-tailed	*Selasphorus platycercus*
kinglet, ruby-crowned	*Regulus calendula*
partridge, gray*	*Perdix perdix*
pheasant, ring-necked*	*Phasianus colchicus*
pigeon, band-tailed	*Columba fasciata*
bobwhite	*Colinus viginianus*
quail, California	*Callipepla californicus*
quail, Gambel's	*Callipepla gambelii*
quail, Mearn's	*Cyrtonyx montezumae*
quail, Montezuma	*Cyrtonyx montezumae*
redpoll	*Carduelis*
sage-grouse	*Centrocercus urophasianus*
sapsucker, red-naped	*Sphyrapicus nuchalis*
sapsucker, Williamson's	*Sphyrapicus thyroideus*
sapsucker, yellow-bellied	*Sphyrapicus varius*
siskin, pine	*Carduelis pinus*
thrush, Swainson's	*Catharus ustulatus*
turkey, Merriam's	*Meleagris gallapavo merriami*
turkey, wild	*Meleagris gallapavo*
woodpecker, pileated	*Dryocopus pileatus*

D. Insects

ant	Formicidae
bee	Apoidea
beetle	Coleoptera
caterpillar, tent	*Malacosoma*
cricket	Gryllidae
cutworm	Noctuidae
fly	Diptera
grasshopper	Caelifera and Ensifera
hornet	Vespinae
lygus bug (leaf bug)	*Lygus*
moth, case-bearing	Coleophoridae
moth, sagebrush defoliator	*Aroga websteri*
tephritid fly (fruit fly)	Tephritidae
wasp	Hymenoptera
wireworm	Elateridae

E. Bacteria and Fungi

ergot (fungus of wildrye)	*Claviceps purpurea*
endophytic fungus of tall fescue	*Acremonium coenophialum*
frankia (nitrogen-fixing bacteria)	*Frankia*
rust (several fungi of serviceberry)	*Gymnosporangium*

*Species introduced to North America

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