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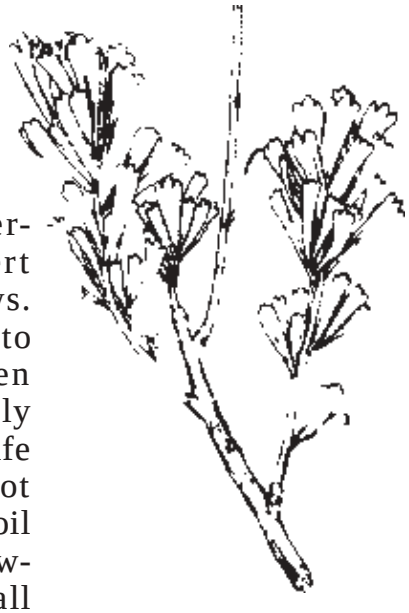
Chapter 22

Rosaceous Shrubs



Important shrubs of the Rose Family (Rosaceae) in the Intermountain region are distributed from blackbrush and salt desert shrub communities through high elevation forests and meadows. Growth habits of this group vary from trailing brambles to upright shrubs and small trees. Some species are evergreen while others are deciduous. Many of these species are highly valued for the cover, fruits, and forage they provide for wildlife and livestock. Rosaceous species that develop spreading root systems, root suckers, rhizomes, or stem layers provide soil stabilization. Several species are capable of regenerating following fire. Those that produce fragrant flowers or colorful fall foliage are prized for their ornamental value.

Because of their browse value, antelope bitterbrush and several other rosaceous shrubs were among the first species to be used in wildlife habitat improvement efforts. Members of the bitterbrush-cliffrose complex as well as serviceberries, chokecherries, and the mountain mahoganies lend themselves to artificial seeding; their seed are fairly large and relatively easy to collect, clean, store, and plant. Additional species of this family are seeing increased use in response to the growing emphasis on use of native species for wildland revegetation and low maintenance landscaping, community restoration issues, mitigation for endangered species, and a general shift to employ revegetation when deemed necessary to conserve or restore ecosystem diversity and functionality.

Chapter Contents by Species

Use of rosaceous species often presents challenges to those involved in revegetation efforts. Size and quality of seed crops vary considerably from year to year. Complex germination requirements, low initial growth rates, sensitivity to competition, and rodent and bird preference for seed and seedlings of some species hinder their establishment and reduce survival. Appropriate planting practices and management of young seedlings or plants are required to minimize these problems. Control of browsing by livestock and wildlife during the first 2 to 3 years is often essential to improve establishment and early growth.

Bareroot or containerized planting stock is commonly used to shorten the period of seedling vulnerability. Seedlings of native or introduced species of *Prunus* and *Rosa* are traditionally grown by many nurseries for conservation plantings. Antelope bitterbrush, Saskatoon serviceberry, and curlleaf mountain mahogany or true mountain mahogany seedlings are commonly grown for wildlife habitat improvement. Seedlings of specific ecotypes and most other species must generally be obtained through contract production.

Characteristics of the site of origin of seed or planting stock should be matched to those of the planting site as closely as possible; ecotypes of individual species vary considerably in range of adaptability. Although few rosaceous shrub cultivars have been selected and released for commercial production of seed

and planting stock by the USDA Soil Conservation Service (Hassell 1988), a number of others are under study. Site requirements and characteristics of released cultivars have been extensively studied and documented. Publications are available describing the attributes and site requirements of commonly collected antelope bitterbrush populations (Tiedemann and Johnson 1983). Verification of seed origin of wildland collections may be accomplished by monitoring contract seed collections from designated native sites or plantings. Seed certifying agencies have developed a "source identified" classification for wildland seed certification that provides verification of site of origin as well as compliance with minimum seed quality standards (Young 1995).

Seeding recommendations for major vegetative types and conditions are discussed in chapter 17. Rosaceous shrubs adapted to these vegetative types and conditions are included in the seeding recommendations. Seed characteristics are found in chapter 24.

The following sections include a brief species description and discussions of ecological relationships, distribution, culture requirements, use, improved varieties, and management for each of these Rosaceae species.

Amelanchier alnifolia

Saskatoon Serviceberry

Saskatoon serviceberry is a deciduous shrub or small tree 1 to 20 ft (0.3 to 6 m) or more in height (fig. 1). The root system varies from a strong taproot to a branching lateral root system. New shoots develop from rhizomes extending up to 5 ft (1.5 m) from the parent plant (Hemmer 1975). Branches are reddish brown and pubescent when young, but later became glabrous. Leaf shape is extremely variable. They are approximately 1 inch (2.5 cm) long and oval to suborbicular with serrate or dentate margins to the middle or below. Perfect flowers with five showy white petals appear in large terminal clusters. Mature pomes are purple to black and 0.4 to 0.6 inch (1.0 to 1.5 cm) in diameter. Each pome contains 10 locules, each with one seed; one third to one half are commonly abortive (Blauer and others 1975; Brinkman 1974a; Harrington 1964). Seed are dark purplish-brown with a leathery seed coat (Belcher 1985). Flowers bloom from May through June and fruits ripen in July and August (Dittberner and Olson 1983).

Ecological Relationships and Distribution

Three species of serviceberry are distributed through the western United States. Saskatoon serviceberry, dwarf Saskatoon serviceberry, and Utah serviceberry. Although different geographic races have not been identified, they are expected to occur within these widely distributed species (Brinkman 1974a). In addition, several hybrids have been reported (Cruise 1964).

Saskatoon serviceberry is distributed from Alaska and the Yukon east to Hudson's Bay and south to California, New Mexico, and Nebraska (Harrington 1964; Welsh and others 1987). Plants occur from near sea level to over 9,000 ft (2,770 m) in the Rocky Mountains in areas with an annual precipitation of 12 to 25 inches (30 to 64 cm) or more (Jones 1946). Saskatoon serviceberry grows on sites ranging from dry, rocky, exposed slopes to riparian areas with deep moist soils. At the lower edge of its range, plants are often intermixed with mountain big sagebrush/grass and to a lesser extent with Wyoming big sagebrush/grass communities (Tisdale and Hironaka 1981). Saskatoon serviceberry also occurs in mountain brush, upper pinyon-juniper, and ponderosa pine communities (Blauer and others 1975). It sometimes grows in nearly pure stands, dominating other shrubs, but supporting a productive understory.

Plant Culture

A few small nurseries or conservation plantings of Saskatoon serviceberry are managed to furnish seed for planting stock production. Most seed currently used in artificial revegetation is harvested from wildland stands. Large quantities of seed can be harvested at reasonable costs during good production years. Some stands produce consistently good seed crops, but harvestable yields usually occur at intervals ranging from 1 to 5 years, depending on the site. Plants usually produce numerous flowers each year, but

Figure 1—Saskatoon serviceberry occurs as single plants, thickets, and nearly pure stands on sites ranging from riparian areas to dry, rocky slopes.

spring frosts, rust infestations, and insect damage often diminish seed production (Blauer and others 1975). Seed is disseminated by gravity and by birds and other animals that pass the seed through their digestive tracts (Hemmer 1975).

Pomes are fleshy when mature and dry slowly on the shrub. They are normally collected by hand picking or by beating the shrub to dislodge them. Seed can easily be separated from the fresh pomes. However, once the fruits dry, the pericarp remains closely attached to the seed. Dry pomes are macerated in a blender or Dybvig to separate the seed from the dried pulp. Dried material is then extracted from the seed by screening. For seed purchases recommended purity is 95 percent and germination 85 percent. There are about 45,395 seed per lb (100,078 per kg) at 100 percent purity (see chapter 24). Seeds have varying degrees of embryo dormancy that can sometimes be overcome by wet prechilling (Brinkman 1974a). Seed prechilled at 34 to 41 °F (1 to 5 °C) for 3 to 20 months germinated from 84 to 100 percent; the time requirement varied considerably among seedlots (Hargrave 1937; Heit 1968b; McKeever 1938). The seed coats of some serviceberry species also prevent germination (Young and Young 1986). Weber and others (1982) found acid scarification for 30 minutes and imbibition in a mixture of thiourea and benzyladenine released this form of dormancy. These authors found no differences in germination among different sized seed. Some selections from central Montana appear less dormant than many other populations.

Saskatoon serviceberry should be seeded separately from rapidly growing herbs. Plantings should be made in strips or scalps at least 25 to 30 inches (63 to 76 cm) wide. Seed may be drilled or broadcast seeded in a firm, prepared seedbed and should be covered with 0.25 to 0.50 inch (0.64 to 1.25 cm) of soil. Broadcast seeding without soil coverage is not recommended. Rodents quickly gather seed, even those placed in soil. Consequently, seeding in late fall or early winter after rodent activity has diminished is advised (Brinkman 1974a; Plummer and others 1968)

Seedling growth is dramatically affected by available soil water. Survival may be low if seedlings are subjected to drought during the first few months of growth. Stressed plants are often stunted, and although they may persist through one or more growing seasons, they usually do not recover. In contrast, healthy seedlings that survive the first growing season are usually very tenacious.

Saskatoon serviceberry can be grown and field planted as bareroot or container stock. Bareroot seedlings reach adequate size for outplanting in one season, developing a heavy taproot (Shaw 1984). Container seedlings are propagated from seed, germinants, or small transplants and require a 3 to 4 month cropping period (Landis and Simonich 1984). The shrub is not easily propagated from cuttings (Doran 1957). Komissarov (1938) found rooting occurred in 25 percent of all softwood cuttings taken in midsummer following treatment with 50 mg/L indole-3-acetic acid (IAA) for 24 hours. Untreated cuttings did not root. Field survival of planting stock depends on use of healthy dormant or properly hardened stock and reduction of competition on the planting site.

Uses and Management

Saskatoon serviceberry is an important browse plant for game and livestock due to its fair to high palatability (Blauer and others 1975). It is capable of persisting with a diverse and productive understory that is important for summer grazing. Saskatoon serviceberry is used by livestock, particularly sheep, in midsummer after full leaf development and after more palatable species have been browsed (Blauer and others 1975).

Big game animals make considerable use of the shrub (Kufeld 1973; Kufeld and others 1973). Tueller (1979) found serviceberry was utilized by deer during the entire year, but it was most important during the midsummer and fall months. New shoots are particularly palatable, but deer consuming large quantities of new serviceberry growth in spring can be poisoned by it. Problems also occur if Saskatoon serviceberry comprises more than 35 percent of the fall or winter diet of stressed deer (Quinton 1985). Birds utilize the bark, fruits, and leaves. The fruit is a key grizzly bear food (Mace and Bissell 1986; Zager 1980). Seed are used by rodents and small birds (Blauer and others 1975). Saskatoon serviceberry is particularly valuable as a minor species in sagebrush communities on open hillsides and ridges. Use should not be allowed to reduce plant productivity at these locations.

Saskatoon serviceberry is a useful shrub for landscape plantings in recreation areas, roadways, and other low maintenance areas. It persists in areas that receive heavy traffic and can withstand wind and severe storms. It can also be used as a background screen or for focal plantings.

Saskatoon serviceberry should not be planted off site. Sources from mountain brush communities are not well suited to lower elevations. The species has not performed well on road or mine disturbances. Developing seedlings do not survive if heavily grazed or subjected to drought stress. However, established plants, those 5 or more years of age, can withstand rather heavy use, particularly winter browsing. In fact, mature plants may be stimulated by some grazing. Plant vigor can be maintained with 60 percent fall or winter use or 40 to 50 percent spring use (Young and Payne 1948).

Saskatoon serviceberry seedlings develop slower than antelope bitterbrush seedlings. Young seedlings are seriously affected by grazing, and, unfortunately,

game animals tend to seek these plants. If not heavily grazed, 4- to 5-year-old plants often begin to grow relatively rapidly. Such plants usually require 8 to 12 years to reach mature size, but some plantings of adapted ecotypes established on dry sagebrush sites have taken as much as 20 years to mature. Production of good seedcrops may not occur until shrubs reach full size. Moderate grazing of established plants may keep bushes hedged, but this usually does not cause mortality.

Mature plants tend to persist for long periods. Hemmer (1975) reported ages of 50 to 85 years for serviceberry growing in climax brush fields. Saskatoon serviceberry can remain suppressed in closed conifers stands for long time periods. Reducing canopy cover stimulates resprouting (Wright and others 1979). Regeneration from seed is normally rare (Noste and Bushey 1987).

Saskatoon serviceberry is most vigorous in seral communities. Productivity may increase following burning or mechanical control in such situations. However, where density is low or succession far advanced, such efforts may be counterproductive (Hemmer 1975; Howard 1997). Plants recover well following fires and survive even severe burns if the soil is moist at the time of burning (Fischer and Clayton 1983). Tops may be killed, but plants can resprout from rhizomes (Frischknecht and Plummer 1955). Those rhizome buds located immediately below the burned tissue sprout most readily (Bradley 1984).

Varieties and Ecotypes

Selection work has focused on comparing seed germination characteristics and site requirements of selected ecotypes. To date, studies have not resulted in identification of ecotypes unusually well suited to restoration and revegetation work, although some populations seem to produce consistently higher seed fill. For this reason, use of local material on sites previously occupied by Saskatoon serviceberry is recommended.

Amelanchier utahensis

Utah Serviceberry

Utah serviceberry is similar in growth habit to Saskatoon serviceberry. Plants vary from large upright shrubs to small trees 4 to 15 ft (1.2 to 4.6 m) tall (fig. 2). Twigs are unarmed. The alternate deciduous leaves are simple, about 0.8 to 2.0 inches (2 to 5 cm) long, and are borne on a short petiole (Harrington 1964). Leaves are suborbicular, oval, ovate or obovate with coarsely serrate-dentate margins to the middle or below. Flowers are clustered on racemes borne on short leafy branchlets. They are perfect and regular with five white petals. The stamens are numerous and inserted on the rim of the calyx tube. The ovary is inferior with three or four styles. Each locule contains two ovules. Fruits are purple to black pomes 0.2 to 0.4 inch (6 to 10 mm) in diameter (Harrington 1964; Welsh and others 1987).

Utah serviceberry differs from Saskatoon serviceberry in having a somewhat smaller stature, smaller leaves that are pubescent at least on the lower surface, three to four styles compared to four or five, and a hard, dry fruit. Davis (1952) considered Utah serviceberry a subspecies of Saskatoon serviceberry, but Jones (1946), Blauer and others (1975), and Welsh and others (1987) considered differences in fruiting and growth habits sufficient to warrant species status.

Ecological Relationships and Distribution

Utah serviceberry occurs at scattered sites from eastern Oregon to Montana and south to Texas, California, Baja California and Sonora (Blauer and others 1975; Welsh and others 1987). It is generally found on drier sites than Saskatoon serviceberry. It occurs on foothill sites at elevations from 2,000 to 7,000 ft (600 to 2,600 m) where it grows on dry, rocky outcrops and on shallow soils. It is associated with a wide number of plant communities including aspen, ponderosa pine, pinyon-juniper, mountain brush, and big sagebrush. Although it may occur in dense stands, plants are usually scattered and intermixed with other woody species.

Figure 2—Utah serviceberry is a highly variable species that usually occurs on drier sites than Saskatoon serviceberry.

Plant Culture

Fruits of Utah serviceberry ripen in late summer, but may remain on the bush for up to 2 years. Utah serviceberry plants generally produce fewer fruits than Saskatoon serviceberries; this may be due to its occurrence on drier sites. However, some stands in southern Utah's Iron County often yield extremely heavy crops. Seed are dispersed by birds and small mammals (Brinkman 1974a).

The pomes are somewhat more difficult to dislodge than those of Saskatoon serviceberry but can be collected in fairly large quantities during years of good production. To obtain seed, the dry pomes are usually placed in a blender or a Dybvig with water and macerated to separate the seed from the dry pulp. Seeds are smaller and often have lower fill than those of Saskatoon serviceberry, but germination characteristics are quite similar. For seed pruchases, recommended purity is 85 percent and germination 95 percent. There are about 25,800 seeds per lb (56,900 per kg) at 100 percent purity (see chapter 24).

Utah serviceberry is best established by drill seeding. Seed should be planted at a depth of 0.5 inch (1.3 cm) in a weed-free seedbed. Hand seeding disturbed sites or seeding with interseeders or similar implements that can selectively place seed in the soil are also effective. Seeding at rates of 2 to 4 lb per acre (2.2 to 4.4 kg per ha) is required to produce acceptable stands. Seedlings establish slowly and are sensitive to herbaceous competition. Bareroot or container seedlings are reasonably easy to produce, but they are also highly sensitive to competition.

Uses and Management

Utah serviceberry is adapted to low foothill sites, and may be used to improve diversity in sagebrush communities. Selections of Utah serviceberry have been seeded in relatively arid situations such as pinyon-juniper and big sagebrush communities where serviceberry is not native, in expectation that it may successfully establish and improve wildlife cover. Successful plantings in such areas have persisted for approximately 30 years to date, but natural recruitment has not occurred. Saskatoon serviceberry has failed to persist in such situations. Utah serviceberry is resistant to rust (*Gymnosporangium* spp.) diseases that often attack Saskatoon serviceberry (Krebill 1972; Plummer and others 1968) and is occasionally selected for planting where the rust is prevalent.

Slow establishment and poor survival have somewhat limited the use of both serviceberry species, but Utah serviceberry establishes and grows faster than Saskatoon serviceberry (Plummer and others 1968). Seedlings fail to establish when seeded in poorly prepared, weedy seedbeds. Young seedlings require protection from grazing until plants have fully established, but mature shrubs withstand considerable browsing. Some early plantings have been productive for 40 years, although little spread has been noted (Monsen n.d.). Neither serviceberry species establishes or grows well on highly disturbed sites such as roadways or mine spoils.

Utah serviceberry provides good forage for cattle and good to excellent browse for sheep and goats in early spring. Deer browse it year long, but use is particularly heavy in winter. Birds and small mammals use the berries in winter and spring (Blauer and others 1975). Plants survive fires and regenerate by sprouting (Tisdale and Hironaka 1981; Wright and others 1979).

Varieties and Ecotypes

There are no releases. Local ecotypes are recommended for on-site planting.

Cercocarpus betuloides

Birchleaf Mountain Mahogany

Birchleaf mountain mahogany is an open, erect shrub or small tree varying in height from 6 to 23 ft (2 to 7 m). Although evergreen, it is similar in other respects to true mountain mahogany (Welsh and others 1987) (fig. 3). It occupies dry slopes and washes below 6,000 ft (1,846 m) from central California to southwestern Oregon (Munz and Keck 1959).

Figure 3—Birchleaf mountain mahogany stem with new leaves and flowers, just after petal fall.

Collections of birchleaf mountain mahogany from central California have been planted within the Intermountain region on game and livestock ranges because of their evergreen growth habit, seedling vigor, and drought tolerance. Healthy birchleaf mountain mahogany seedlings that survive the first growing season are usually very tenacious. However, young plants are often stunted when stressed and although they may persist for 1 or more years, they usually do not recover. The seedlings and young plants grow slightly faster than most selections of true mountain mahogany for about the first 5 or 6 years. After this time, growth rates and growth habits of the two species are quite similar.

Cercocarpus intricatus

Littleleaf Mountain Mahogany

Littleleaf mountain mahogany is an intricately branched shrub usually less than 8 ft (2.4 m) tall (fig. 4), with strongly revolute linear leaves (Blauer and others 1975). It occurs primarily in Utah, Nevada, and southern Arizona, occupying harsh rocky sites, particularly areas with high summer temperatures and infrequent rain storms. There are low-growing forms of littleleaf mountain mahogany in Oregon and Washington (Hitchcock and others 1961). Stutz (1974) suggests that littleleaf mountain mahogany is a segregant of curlleaf mountain mahogany that tends to be associated with more xeric sites. Seed germination and cultural requirements for littleleaf mountain mahogany and other mountain mahogany species are quite similar.

Littleleaf mountain mahogany is productive and evergreen with a low shrubby growth habit. It hybridizes with both curlleaf and true mountain mahogany (Blauer and others 1975; Stutz 1974).

Figure 4—Littleleaf mountain mahogany is evergreen, low-growing, and generally very palatable.

Cercocarpus ledifolius

Curlleaf Mountain Mahogany

Curlleaf mountain mahogany is an erect shrub or small tree sometimes attaining heights of 22 to 26 ft (7 to 8 m) (fig. 5) (Harrington 1964; Munz and Keck 1959). It has a rather deep, well developed root system (Noste and Bushey 1987) and one to several main trunks up to 7 inches (18 cm) in diameter with deeply furrowed reddish-brown bark. The shiny leaves are thick and evergreen, 0.4 to 1.2 inches (1 to 3 cm) long and 0.2 to 0.4 inch (0.5 to 1 cm) wide. Leaves are resinous and aromatic, entire, lanceolate, usually glabrous above and white tomentose below. Leaf margins are highly revolute, hence the name curlleaf. Flowers are solitary or in twos or threes with white to greenish-yellow sepals and no petals. The fruit is an achene 0.3 to 0.4 inch (0.8 to 1.0 cm) long with an attached plumose style elongating to 1.6 to 2.8 inches (4 to 7 cm) at maturity. The flowering period extends from May to June; fruits ripen from May to August (Blauer and others 1975; Harrington 1964; Munz and Keck 1959).

Figure 5—Curlleaf mountain mahogany, note high-lining by deer.

Ecological Relationships and Distribution

Curlleaf mountain mahogany is distributed east of the Cascades and Sierra Nevadas from Washington to Baja California and east to Montana, Colorado, and Arizona. Curlleaf mountain mahogany occurs at elevations from 2,000 to 9,000 ft (615 to 2,770 m) (Harrington 1964; USDA Forest Service 1937).

Curlleaf mountain mahogany is usually found on warm, dry, rocky ridges on southern or western slopes but may occur on all exposures (Brayton and Mooney 1966; Martin 1950; Miller 1964; Tidestrom 1925). At lower elevations in the Great Basin, it often grows on limestone, decomposed granite, or other coarse-textured soils on steep north slopes and among cliffs and ledges (Dayton 1931). Plants may be nodulated by the nitrogen-fixing endophyte *Frankia* (Lepper and Fleschmen 1977).

Curlleaf mountain mahogany characteristically grows in isolated patches that are nearly pure stands. These sometimes cover considerable acreages and often form a band between conifer forests and sagebrush or other shrub communities. Curlleaf mountain mahogany is not reported as a dominant or associated species of principal forest habitat types in Montana (Pfister and others 1977), northern Idaho, or Washington (Daubenmire and Daubenmire 1968). However, the plant is a codominant with Douglas-fir in some drier forested areas in Idaho (Steele and others 1981). Dealy and others (1981) described five communities dominated by curlleaf mountain mahogany in southeastern Oregon. These include curlleaf mountain mahogany/mountain big sagebrush/bunchgrass, curlleaf mountain mahogany/mountain snowberry/grass, curlleaf mountain mahogany/Idaho fescue, curlleaf mountain mahogany/bearded bluebunch wheatgrass, and curlleaf mountain mahogany/pinegrass. Johnson and Simon (1987) described a curlleaf mountain mahogany plant community type for the Wallowa-Snake Province of northeastern Oregon. Curlleaf mountain mahogany is the dominant understory in some limber pine, white fir, and juniper series (Dealy and others 1981; Hironaka and others 1983; Steele and others 1981; Youngblood and Mauk 1985). It also grows in association with other woody species such as pinyon, oak, serviceberry, bitterbrush, or gooseberry (USDA Forest Service 1937). Curlleaf mountain mahogany occasionally occurs with ponderosa pine where both species overlap, but these sites generally do not form large or distinct communities. Extremely tall curlleaf mountain mahogany plants occur with Douglas-fir and Rocky Mountain maple in canyon bottoms and narrow draws or drainages in central and southern Utah. These small communities provide important habitat for big game and livestock.

In most situations where curlleaf mountain mahogany dominates, its crown cover ranges from 35 to 60 percent. Dealy and others (1981) counted 300 to 800 stems per acre (120 to 325 per ha) with an average of 500 per acre (200 per ha) in eastern Oregon. Somewhat higher numbers were reported from Montana, the average figure being 1,375 stems per acre (550 per ha) (Duncan 1975). In Idaho, Scheldt (1969) reported a mean of 207 shrubs per acre (84 per ha).

Three principal species of mountain mahogany (*Cercocarpus ledifolius*, *C. intricatus*, and *C. montanus*) occur in the Intermountain region (Harrington 1964; Welsh 1982). Holmgren (1987) divided *C. ledifolius* into two taxa: *C. ledifolius* var. *ledifolius* and var. *intermontanus* (Intermountain curlleaf mountain mahogany). Intermountain curlleaf mountain mahogany is distinguished from variety *ledifolius* by its broader leaves that are less densely pubescent ventrally, its usually longer petioles and hypanthium tubes, and more treelike habit. Stutz (1990) concurred with Holmgren's revision, concluding that the taxa growing in the Intermountain West apparently arrived from different origins. The evolutionary processes that produced the existing species, particularly littleleaf mountain mahogany are still proceeding. All three hybridize in areas where they overlap (Blauer and others 1975; Plummer and others 1957; Pyrah 1964; Stutz 1974). The resulting hybrid populations are frequently important components of local vegetation.

Intermountain curlleaf mountain mahogany occurs in southeastern Washington, eastern Oregon, northern, eastern, and southern California, central and southern Idaho, western Wyoming, Utah, and adjacent parts of Colorado and Arizona (Holmgren 1987). It often exists in pure stands surrounded by open sagebrush or mixed with Gambel oak, bigtooth maple, pinyon-juniper, ponderosa pine, Douglas-fir, or white pine at elevations of 4,300 to 9,800 ft (1,300 to 3,000 m). Variety *ledifolius* occurs in eastern Oregon, central and southern Idaho, southwestern Montana, north-central Wyoming, and northern Utah (Holmgren 1987). It grows on talus slides, rock outcrops and rocky slopes at elevations from 1,300 to 6,900 ft (400 to 2,100 m).

Plant Culture

Stands of curlleaf mountain mahogany produce good seed crops about in 2 of every 5 years. Few years occur when little or no seed develops. However, to be profitable for hand harvesting, a heavy seed crop with good viability must be produced; seed must ripen fairly uniformly; and most seed must remain on the bush for a period of time to permit a collection period.

Elevational range and aspect affect the period of flowering and seed development. Seed are sometimes dispersed rapidly by stormy weather conditions. Consequently, ripening seed should be checked periodically if possible, and harvested immediately when mature. Ripe seed are normally wind dispersed and can be carried some distance from the parent plant (Deitschman and others 1974a). Once the achenes fall

to the ground, rodents begin gathering them; a high percent of all viable seed may be removed within 1 or 2 days. Field mice remove embryos from the achenes. Consequently, fallen achenes should be carefully examined before they are collected. Twisting of the plume in response to changes in water content plants the seed by drilling it into the ground (Dealy 1978).

Seed are harvested by beating the shrub to dislodge the achenes and catching them in lightweight tarps or netting placed down wind. Plumes can be removed with a Dybvig or barley debearder. The material is then screened with a fanning mill to separate the seed from the remaining debris. If harvested lots contain numerous small twigs, they must be separated over a gravity table to improve purity. Seeds are not removed from the achenes. The ripened seed are hard and brittle and can be fractured or broken by improper cleaning procedures, thus hammermilling should be avoided. Purity of at least 90 percent and germination of at least 80 percent are recommended for seed purchases. There are about 51,865 seeds per lb (114,342 per kg) at 100 percent purity (see chapter 24). Curlleaf mountain mahogany seeds remain viable for extended periods in storage. Stevens and others (1981a) found little loss of viability after 7 years of warehouse storage. Nearly 85 percent of seeds stored for 15 years germinated.

Freshly harvested seed is dormant and requires wet prechilling (Dealy 1975; Deitschman and others 1974a). Dealy (1975) found seed prechilled at 39 °F (4 °C) for 170 or 270 days germinated to 98 and 100 percent, respectively. He concluded that the membrane surrounding the embryo may block gas diffusion and be a principal factor in controlling dormancy. Young and others (1978) found that soaking seed at 41 °F (5 °C) for 21 days in an aerated solution of potassium nitrate and gibberellin improved germination over a range of temperatures. Drying the seed narrowed the temperature range permitting germination, but increased germinability was retained at these temperatures.

Curlleaf mountain mahogany fruit size varies among ecotypes and collection sites. To date, seed size has not been closely correlated with site conditions. Differences may be due, in part, to genetic traits; sources producing large fruits tend to perpetuate this trait when planted on different sites.

The oblong achenes of curlleaf mountain mahogany are large enough that they are easily handled and planted alone or in mixtures with other shrub seed using conventional drills. They may also be hand seeded in selected spots. Curlleaf mountain mahogany establishes best from fall seeding because of its wet prechilling requirement and ability to germinate at low temperatures (Dealy 1975; Plummer and others 1968). In addition, late fall or early winter seeding, when rodents are less active, reduces seed predation. Concentrating seedings in areas with low rodent populations can greatly enhance seeding success.

Curlleaf mountain mahogany seedlings are not competitive with exotic annuals, particularly cheatgrass. Attempts to plant curlleaf mountain mahogany at lower elevations of mountain brush and big sagebrush communities infested with these weeds have generally not been successful. Proper seedbed preparation and control of competing herbs are essential for shrub establishment. Phillips (1970) reported high seed germination occurred on mineral soils cleared of litter and plant competition.

Seedlings emerge early in spring following ground thaw when soil water is likely to be favorable. However, seedlings are sensitive to late frosts. Dealy (1975) found new seedlings exhibit rapid root growth in relation to top growth, providing some resistance to drought and codeveloping competition. However, Scheldt and Tisdale (1970) did find heavy seedling mortality occurred during the first summer of establishment, often resulting from drought and predation by rodents and rabbits.

Curlleaf mountain mahogany can be propagated and field planted as bareroot or container stock (Butterfield and Tueller 1980; Landis and Simonich 1984; Shaw 1984). Seedlings develop rapidly in bareroot nurseries. They must be lifted when dormant. Evergreen plants are particularly sensitive to lifting and handling once growth has begun. Damage to the taproot should be avoided during lifting. Container stock is easier to handle and often provides better establishment (Ferguson 1983; Landis and Simonich 1984). Propagation of curlleaf mountain mahogany from stem cuttings is difficult (Everett and others 1978).

Uses and Management

Because of its evergreen habit and occurrence between forest and shrub communities, curlleaf mountain mahogany provides important cover and forage for a wide variety of wildlife species. Curlleaf mountain mahogany produces highly palatable winter browse and thermal and hiding cover for elk, deer and other big game (Dealy 1971, 1975; Kufeld and others 1973; Mueggler and Stewart 1980; Smith 1952). Tueller (1979) reported curlleaf mountain mahogany was one of six shrub species that comprised the largest single fraction of deer diets on winter ranges in Nevada. It is also ranked as a principal winter browse for big game in Utah (Richens 1967), Oregon, and Washington (Mitchell 1951). Curlleaf mountain mahogany provides food, hiding cover, and nesting sites for many birds (Dealy and others 1981).

Blauer and others (1975), Duncan (1975) and Mueggler and Stewart (1980) reported livestock make light use of mature curlleaf mountain mahogany shrubs. However, seedlings and young stands can be

heavily browsed. Many healthy stands support a diverse herbaceous understory that provides good summer forage for sheep and cattle (Dealy and others 1981), but they are often inaccessible to livestock in winter. Curlleaf mountain mahogany has good nutritive value (5.9 percent digestible protein) and digestibility (64.8 percent) in winter (Bissell and Strong 1955; Smith 1952; Welch 1981). It is one of only a few shrubs to exceed the protein requirements of wintering mule deer; its leaves are evergreen and retain high protein levels throughout the winter (Welch and McArthur 1979b). Winter phosphorus level (0.18 percent) exceeds the lower range of phosphorus required for wintering mule deer (Trout and Thiessen 1973; Tueller 1979).

Curlleaf mountain mahogany is a useful species for revegetating roadway and mine disturbances (Hungerford 1984; Stark 1966) and it is an excellent ornamental. It requires little maintenance, the leaves are attractive and evergreen, and it withstands considerable traffic and browsing. Compared to other wildland shrubs, it responds well to supplemental watering. Curlleaf mountain mahogany wood is extremely dense as a result of its low growth rate. It has been used for charcoal, fenceposts, and wood carving (Blauer and others 1975). Stands are occasionally logged for firewood.

Curlleaf mountain mahogany exhibits three characteristics that should be recognized and understood if the species is to be used in revegetation projects. First, seedlings can perform well on exposed sites if protected from competition. Second, young plants can persist and furnish considerable high quality forage even when moderately to heavily grazed. Under such conditions plants will not reach mature stature and could be weakened or killed if subjected to other forms of stress. Third, although seedlings are not compatible with herbaceous competition, established plants do very well in conjunction with some highly productive herbs. Curlleaf mountain mahogany could be more widely planted with some herbaceous species to improve total and seasonal forage production if the shrubs were planted in separate strips or spots from the herbaceous species.

Many stands of curlleaf mountain mahogany exist with little herbaceous understory. Shrub/grass plantings established with intermediate wheatgrass and other introduced herbs can be very productive. However, the ability of the shrub to regenerate naturally under such conditions is reduced, particularly on deep, productive soils. On shallow, rocky soils, where weedy grasses and herbs have not gained dominance, native forbs can usually be seeded along with the shrubs.

Curlleaf mountain mahogany requires a longer period to attain mature stature than most other shrubs. Plantings and stand rejuvenation treatments should be extensive to reduce the impact of browsing during establishment or recovery (Gruell and others 1985). Plantings established in south central Idaho and protected from livestock and deer use grew relatively slowly for about 6 years, but then grew dramatically during the next 4 to 6 years. This growth pattern has been noted in other protected study locations (Monsen n.d.). Because the species is highly palatable (Mueggler and Stewart 1980; Smith 1952), the naturally slow-growing plants are continually browsed and, if not protected, remain in a stunted condition, assuming a rounded, hedged form (Blauer and others 1975; Garrison 1953). Plantings established in central Utah in 1950, for example, have survived continuous heavy browsing, and the shrubs have remained quite small. Once released from grazing, hedged plants can recover quickly. Ferguson (1983) recommended browsing be limited to 50 to 60 percent of current annual growth to maintain productivity and a vigorous, shrubby growth habit.

Many extensive stands of curlleaf mountain mahogany have been highlined. Most plants are mature to decadent. New growth is out of reach of browsing animals. Growth from lower branches diminishes as a result of hedging and shading. Little or no reproduction occurs in these closed stands (Phillips 1970). Various treatments have been investigated to regenerate them. Stands with live branches within reach of browsing animals have been treated by top pruning in Utah and Montana. Pruning in spring or early fall prompted regrowth and increased forage availability (Austin and Urness 1980; Garrison 1953; Ormiston 1978; Thompson 1970), but such treatments are expensive. Chaining or bulldozing kills most older or highlined, single stemmed plants (Christensen and others 1966; Dealy 1971), but can be used to open areas within closed stands for natural regeneration or planting.

Plants growing on shallow soils and exposed sites, usually midwinter ranges for game, are difficult to manage. Curlleaf mountain mahogany growing in monotypic stands or in mixed stands with other shrubs such as antelope bitterbrush, skunkbush sumac, and green ephedra often receives heavy browsing year after year. Most of these species are capable of withstanding considerable use, but may be weakened and killed over time. Natural recovery is slow and often prevented by continued use. Artificial revegetation is also very difficult on these sites.

Curlleaf mountain mahogany plants are not highly fire tolerant. The plants and onsite seed banks can be killed by high intensity burns (Noste and Bushey 1987; Wright and others 1979). The thick lower bark protects plants from low-intensity fires and although the species is a weak sprouter, some surviving plants

can resprout from stem buds. In addition, new seedlings may emerge from unburned seed (Bushey and Noste 1987; Gruell and others 1985). Some stands are now restricted to rocky slopes due to high wildfire frequency. In other areas, intense fire suppression and understory reduction with grazing have permitted curlleaf mountain mahogany to invade sites with deeper soils (Dealy 1975; Gruell and others 1985).

Low intensity fires can be used to stimulate communities with low vigor or maintain curlleaf mountain mahogany where it occurs as a seral species with conifers (Gruell and others 1985). Burning can also improve age class structure of curlleaf mountain mahogany stands. Natural recovery can occur following prescribed fires, but it is often significantly enhanced by mechanical site preparation that reduces herbaceous competition and creates a weed free seedbed (Phillips 1970). Stands may also be rejuvenated by thinning them to 40 to 60 clumps per acre (99 to 148 per ha) and mechanically clearing seedbed areas within the stand. Protection of stands less than 50 years of age from fire is recommended if curlleaf mountain mahogany is the climax species. Reduction of browse use is essential for all stand improvement projects.

The mountain mahoganies are relatively free from infestation by insects and disease (Ferguson 1983). However, serious outbreaks have destroyed sizeable stands in southwestern Idaho. Furniss and Barr (1967) reported the looper destroyed 46 percent of a 5,900 acre (14,580 ha) stand of curlleaf mountain mahogany over 3 years. Tent caterpillars have been responsible for severe defoliation in the Great Basin (Furniss and Barr 1967).

Varieties and Ecotypes

Numerous accessions of curlleaf mountain mahogany have been collected and evaluated for forage value, seedling establishment, and vegetative growth characteristics. Attempts have been made to select and develop ecotypes with improved seedling vigor and high growth rates, but to date no major improvements have been achieved. In general, selections appear universally adapted to all areas where the species occurs. However, it is possible that differences exist, but have not yet been fully recognized.

Differentiation of the ancestral mountain mahogany may have resulted in the appearance of some important traits. Stutz (1974) proposed that the highly plastic true mountain mahogany, a plant better adapted to mesic conditions, may have evolved from curlleaf mountain mahogany. In contrast, the smaller, narrower leaves of littleleaf mountain mahogany may have evolved as a response of curlleaf mountain mahogany to more xeric circumstances. Because the three species are closely related, each with chromosome number 2n = 18 (McArthur and Sandersen 1985), artificial hybridization is possible and could be employed to incorporate specific traits into selected populations.

Natural hybrids between Intermountain mountain mahogany and true mountain mahogany and later generation backcrosses are quite common where both parents are found growing together (Blauer and others 1975; Plummer and others 1957). Hybrids are somewhat fire tolerant, a characteristic of true mountain mahogany. They often have a wider area of adaptation than curlleaf mountain mahogany. Hybrids are easy to recognize; they are tall and treelike with evergreen leaves and always occur in stands of true mountain mahogany where true mountain mahogany is the female parent (Stutz 1990). These hybrids rarely reproduce. Few hybrids of *C. ledifolius* var. *ledifolius* and true mountain mahogany have been reported. This is perhaps due to the fact that these taxa occur together only infrequently and hybrids are less easily recognized. They are highly fertile. Hybrids between littleleaf mountain mahogany and true mountain mahogany are rare (Pyrah 1964), perhaps due to reproductive barriers (Stutz 1990). They are usually sterile. Hybrids between littleleaf mountain mahogany and Intermountain mountain mahogany are common in some areas where the species overlap (Blauer and others 1975; Plummer and others 1957; Stutz 1990).

Cercocarpus ledifolius var. *ledifolius* is a small shrub or tree occurring in the northern part of the Intermountain region, and is most common in Wyoming and Montana (Cary 1917; Miller 1964). It also occurs in Oregon, Idaho, California, Nevada, Utah, Colorado, and Arizona. It is taller in stature than littleleaf mountain mahogany with larger leaves and flowers. Hybridization with curlleaf mountain mahogany is common.

Some *C. ledifolius* var. *ledifolius* populations express unique features of value in range and wildlife habitat improvement. Ecotypes occurring in eastern Wyoming and western Montana include low decumbent and semi-erect forms (Miller 1964). They are evergreen, propagate by stem layering, and produce profusely branching root systems (Miller 1964). Some plants are also capable of resprouting, a feature uncommon in curlleaf mountain mahogany. The decumbent ecotypes exist primarily on shallow soils developed from a fractured limestone substrate.

Members of these ecotypes vary in stature and growth form. Most develop multiple stems and are semi-erect with leaves of varying sizes. The decumbent growth form and the hybrids provide an extremely valuable base for future plantings. If adapted to typical curlleaf mountain mahogany sites, the

hybrids could be used to decrease the size of the tree-like curlleaf mountain mahogany growth forms. In addition, the stem layering and root sprouting features could enhance the fire tolerance and soil stabilization values of this important shrub.

Cercocarpus montanus

True Mountain Mahogany

True mountain mahogany also known as blackbrush, deerbrush, alder, sweetbriar, and tallow brush, is an erect shrub or small tree 2 to 13 ft (0.6 to 4 m) in height. Stems of main branches have smooth, grayish-brown bark (fig. 6). Young twigs are often villous. The short petiolate leaves are oval to broadly ovate, serrate above the middle, 0.4 to 2.0 inches (1 to 5 cm) long, and 0.4 to 1 inch (1 to 2.5 cm) wide. Leaves are deciduous to semi-evergreen, dark green and glabrous above with prominent veins and a fine whitish tomentum beneath. Flowers are perfect and regular, borne in small clusters in the axils of short spurs. There are five sepals extending from a trumpetlike hypanthium, no petals, 25 to 40 stamens in two to three whorls, and a single pistil. The fruit is an elongate achene with a plumose style, 2.4 to 3.9 inches (6 to 10 cm) long at maturity. Flowering occurs from mid-May to late June. Fruits mature from July into September depending on elevation. They are wind dispersed (Harrington 1964; Hitchcock and others 1961; Welsh and others 1987).

Chromosome number of true mountain mahogany is n = 9 (McArthur and Sanderson 1985). Natural hybridization between species of mountain mahogany in Utah has been observed in areas of overlapping ranges. Curlleaf mountain mahogany x littleleaf mountain mahogany hybrids are most abundant because of their overlapping flowering periods. True mountain mahogany x curlleaf mountain mahogany hybrids are less common, and true mountain mahogany x littleleaf mountain mahogany hybrids are rare (Pyrah 1964).

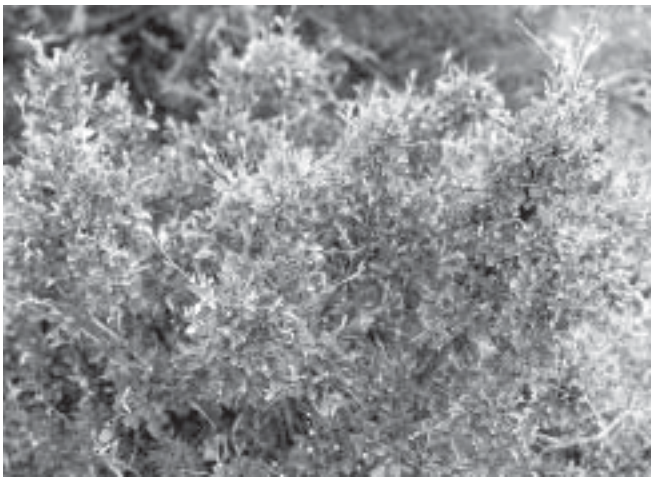


Figure 6—True mountain mahogany post-flowering, but prior to development of the elongate plumose styles.

Ecological Relationships and Distribution

The range of true mountain mahogany extends from Montana to South Dakota and south to New Mexico, Arizona, and Colorado (Harrington 1964; Martin 1950) in areas receiving 10 to 23 inches (25 to 58 cm) of annual precipitation. It occupies bluffs, mountain slopes, and foothills from 3,500 to 10,000 ft (1,070 to 3,050 m) in elevation. It commonly grows on rocky or well-drained soils on all exposures. It is also common on moist fertile sites, canyon bottoms, and north and east slopes. It usually grows in association with other shrubs and trees including ponderosa pine, Gambel oak, Utah juniper, pinyon, and other woody species of mountain brush communities (Blauer and others 1975). It frequently grows with mountain big sagebrush. Pure stands do exist, but are limited in extent.

In Utah the species is widespread, occupying diverse situations, but most commonly occurring on shallow soils and slickrock sites (Greenwood and Brotherson 1978). In Colorado, Medin (1960) found soil depth to be the most important factor influencing true mountain mahogany production on both shale and sandstone-derived soils. Clay content of the A horizon was very important in sandstone-derived soils; greater clay content was beneficial. Factors influencing water availability to the plant were key in influencing production. Brotherson and others (1984) also found factors affecting water availability had a significant impact on the development of true mountain mahogany communities. In Utah, Anderson (1974) reported a combination of site factors including soil texture, percent litter, soil pH, and exposed rock influenced the distribution of the shrub. However, no specific combinations of factors could be used to predict its occurrence. Stands on north-facing slopes of central Utah study sites were transitional in succession to other mountain brush types (Christensen 1964). Succession progressed much more slowly on more xeric southerly sites, and perhaps would never progress beyond the true mountain mahogany stage (Brotherson and others 1984).

Plant Culture

Reproductive phenology of true mountain mahogany is related to aspect and elevation (Blauer and others 1975). Stands of true mountain mahogany growing on fertile sites usually produce an abundant seed crop. Seeds are more easily harvested than those of curlleaf mountain mahogany; plants are smaller in stature.

Seed is usually hand collected from wildland stands; no commercial nurseries are being maintained. Plumes are removed with a Dybvig or barley debearder, followed by screening. Piatt (1973) reported that the larger seed of true mountain mahogany germinate better than small seed, but relative size may not be a reliable index of differences in source germinability. Seed may be stored for up to 7 years in an open warehouse without a major decrease in viability (Stevens and others 1981a). Purity of 90 percent and germination of 80 percent are recommended for seed purchases. There are approximately 59,030 seeds per lb (130,138 per kg) at 100 percent purity (see chapter 24).

Ecotypes of this species appear much more sensitive to site conditions than do collections of curlleaf mountain mahogany. Utilization of ecotypes acquired near the proposed planting site or from similar sites is recommended.

Seed must be fall sown at a depth of approximately 0.5 inch (1.25 cm). Surface plantings are not successful and should be avoided. Growth of emerging seedlings is seriously depressed if they are subjected to competition from herbs. Consequently, the shrub should be seeded in strips or plots separate from grasses. Seeding this species with a Hansen seed dribbler attached to a caterpillar tractor has been very successful on pinyon-juniper chainings. This method also serves to prevent development of such a dense shrub overstory that herbaceous species are eliminated. Interseeding the shrub into established stands of perennial grasses can be successful if strips or patches of understory vegetation are first removed.

True mountain mahogany is frequently scattered among the upper big sagebrush communities. In those situations it has sometimes been eliminated or seriously reduced by browsing. Natural recovery is slow, and artificial seedings are difficult to establish if the sites are infested with weedy annuals. If populations of exotic annuals are low, natural and artificial seedings are quite successful.

Germination requirements are similar to those of curlleaf mountain mahogany; seeds require afterripening and wet prechilling (Deitschman and others 1974a). Seedlings emerge shortly after the ground thaws. Many of the small seedlings are lost to drought and early spring frost (Plummer and others 1968). Mortality also results from severe browsing by rodents, rabbits, and big game. Consequently, seedings should be protected from browsing for 3 years or more.

Seedlings are easily grown as either container or bareroot stock. Planting stock must be dormant or properly hardened to ensure success. Bareroot seedlings should not be root pruned during lifting or outplanting. Transplants should be planted in strips or scalps cleared of competing vegetation. Field survival of container or nursery grown transplants of all mahogany species is only fair to good. However, true mountain mahogany usually transplants better than curlleaf mountain mahogany.

Uses and Management

Medin and Anderson (1979) and Tueller (1979) reported true mountain mahogany is one of the principal browse species used by wintering deer within its range. The widespread occurrence, nutritive value, and high palatability of this species ensure its rank as a valuable shrub for big game habitat (Plummer and others 1968; Young and Bailey 1975). The plant also receives considerable spring and summer use by big game and livestock and provides cover for numerous wildlife species. Compared to curlleaf mountain mahogany it is a superior browse for livestock, particularly sheep (Ferguson 1983). True mountain mahogany is fairly tolerant of browsing. A Colorado clipping study indicated plants can withstand 60 to 80 percent browsing (Shepherd 1971). However, Brotherson and others (1984) found that about one-half of the true mountain mahogany in central Utah stands was highlined and out of reach of browsing animals. Some stands have been severely reduced by heavy browsing (Ream 1964).

Nutrient value of true mountain mahogany in winter is not as high as that of curlleaf mountain mahogany. Digestibility of true mountain mahogany has been reported as 48.4 percent. Digestible protein is 3.4 percent (Smith 1957; Urness and others 1977; Welch 1981); adequate winter digestible protein content is 5.2 percent for wintering deer.

True mountain mahogany also has value as an ornamental. Plants are used for landscaping along the West coast. In inland areas they are very hardy, requiring low maintenance. Its semi-evergreen habit, shiny plumose fruits, and growth habit are unique and attractive. It grows rapidly with limited irrigation.

Burning is a good technique for rejuvenating stands and increasing plant vigor. True mountain mahogany can resprout vigorously from surviving root crowns following burning. Recovery may be rapid even following rather intense burns (Blauer and others 1975; Wright and others 1979). Survival after burning may be high at all seasons, but response is greater following dormant season burns in Colorado (Young 1983). Current annual growth measured in late winter was 475 to 650 percent greater on burns than on controls. Production was greater on low intensity than on high intensity burns. Seed dispersed long distances by winds from unburned sites also contributes to recovery of burned or otherwise disturbed sites.

True mountain mahogany has been established from direct seedings on mine disturbances in Utah and Idaho (Ferguson and Frischknecht 1985). Seedlings

survive on infertile soils; on spoil wastes they appear to benefit by the addition of even small amounts of topsoil. Plants may be nodulated by the nitrogen-fixing endophyte *Frankia* (Hoeppel and Wollum 1971). Transplants grow slowly and are sensitive to competition.

Varieties and Ecotypes; Other Species

Attempts have been made to enhance seed germination, seedling vigor, and growth rate of true mountain mahogany by selection of ecotypes. A selection referred to as "Montane" was released by the U.S. Department of Agriculture, Natural Resource Conservation Service, Los Lunas Plant Materials Center (Thornburg 1982). This cultivar, collected on the Santa Fe National Forest near Coyote, NM, has nondormant seed and excellent seedling vigor. Its adaptation to sites outside its area of collection has not been fully documented.

Coleogyne ramosissima

Blackbrush

Blackbrush, the only member of its genus, is a long-lived densely branched shrub usually about 3 ft (0.9 m) in height, but sometimes reaching 6 ft (1.8 m) or more (fig. 7). The root system is shallow and spreading with most roots less then 16 inches (40 cm) deep. Roots are associated with the nitrogen fixing actinomycete *Frankia* (Bowns and West 1976; Dittberner and Olsen 1983). The tangled ash-gray branches give the shrub a dark appearance, particularly when wet; hence the name blackbrush (Benson and Darrow 1945). Main stems proliferate by stem splitting. The short branches die back from the apex after a few years of growth leaving a spiny tip. Lateral branches then develop producing a rounded shrub (Bowns and West 1976). The small persistent leaves are clustered along the branches. They are simple, leathery, about 0.2 to 0.6 inch (5 to 15 mm) long, and 0.04 to 0.12 inch (1 to 1.5 mm) wide. The flowers are terminal on new branchlets. They have four yellow to brownish sepals and are usually apetalous. Numerous stamens are inserted at the base of the disk that encircles the ovary. The fruit is a glabrous, brown achene 0.2 to 0.3 inch (5 and 8 mm) in length (Harrington 1964; Munz and Keck 1959; Welsh and others 1987). Plants normally flower as early as March at lower elevations (McMinn 1951) and as late as June at higher elevations (Munz and Keck 1959). Seeds mature in midsummer. Blackbrush has n = 8 chromosomes, which is unusual for the subfamily Rosoideae (McArthur and Sanderson 1985). The 4-merous apetalous flowers and opposite leaves are also unusual for the Rosaceae.

New growth and flowering are dependent on the quantity and distribution of precipitation. In the absence of adequate fall or winter/spring rain, vegetative and reproductive growth are curtailed (Ackerman and others 1980). Blackbrush enters a period of summer inactivity in response to low soil moisture. Flowering occurs from April to August depending on location. Fruits ripen from April to June and are dispersed shortly thereafter (Ackerman and others 1980).

Figure 7—Blackbrush community in southwestern Utah.

Ecological Relationships and Disribution

Considered a relict endemic species of arid and semiarid areas of western North America (Stebbins 1972), blackbrush's present distribution is thought to represent a restriction of a once more extensive range (Stebbins and Major 1965). Blackbrush is distributed from southern California, east through southern Nevada, northern Arizona, southeastern Utah and southwestern Colorado in areas with annual precipitation in the 6 to 12 inch (150 to 300 mm) range (Harrington 1964; Munz and Keck 1959; Turner 1982; USDA Soil Conservation Service and USDI Bureau of Land Management 1981; Welsh and others 1987). Blackbrush occurs as a dominant species over extensive areas and is particularly common in the southwestern Great Basin Desert along the Colorado River drainage system (Turner 1982). Blackbrush is a major shrub along the Transition Zone between the Great Basin and Mojave Deserts (Tidestrom 1925). Monotypic stands within this Zone intergrade into mixed communities of Mojave Desert, Colorado Plateau, and Great Basin vegetation.

Monotypic stands of blackbrush are characterized by low understory species diversity and greater total

cover than most desert shrub communities. Plants are long-lived and slow growing; their communities are highly stable. Blackbrush often replaces itself following disturbances, but reestablishment of shrub cover occurs very slowly due to extremely erratic seedling establishment and low growth rates (Webb and others 1987). In southern Nevada, Beatley (1974) characterized blackbrush as requiring Great Basin precipitation and Mojave Desert temperatures and existing primarily between creosotebush and pinyon-juniper or sagebrush communities (Wells and Jorgensen 1964). In Arizona, blackbrush occurs in areas having a mean annual soil temperature of 59 °F (15 °C) (USDA Soil Conservation Service and USDI Bureau of Land Management 1981).

In general, blackbrush stands occur on upland sites, broad terraces, and gently rolling hills (USDA Forest Service and USDI Bureau of Land Management 1981). Soils are usually shallow, calcareous, and coarse textured, ranging from gravelly to cobbly loam or gravelly clay loam (Foster 1968; Kearney and Peebles 1960; Shreve 1942). The shrub is less prevalent and occurs with an understory dominated by grasses in drainage bottoms, where soils are moderately deep to deep with fine sandy loam surface textures and calcareous underlying layers of very gravelly sandy loam or gravelly clay loam (USDA Soil Conservation Service and USDI Bureau of Land Management 1981). Other blackbrush sites with good fertility and soil water also support a herbaceous understory (Bowns 1973). Blackbrush normally occurs on soils low in salt content (McCleary 1968). Seedlings are sensitive to salinity, which may limit its distribution and spread (Wallace and Romney 1972).

Blackbrush is often a component of many transitional shrub communities that provide important forage and habitat for game and livestock. These include spiny hopsage, Nevada ephedra, rabbitbrush, big sagebrush, desert bitterbrush, cliffrose, and pinyon-juniper communities. It is considered a potential candidate for use in revegetation; it occupies or once occupied extensive areas that have suffered severe abuse by destructive grazing practices.

Plant Culture

Blackbrush seed production is highly erratic. Most stands produce a harvestable seed crop in perhaps 1 of every 6 to 10 years. Ripe seed readily detach from the plant and are dispersed by gravity. Seed collection is slow and tedious; consequently, commercial supplies are rarely available. Fruits are cleaned using a fanning mill or gravity separator. Purity of 95 percent and germination of 70 percent are recommended for seed purchases. There are approximately 27,015 seeds per lb (59,557 per kg) at 100 percent purity (see chapter 24).

Seeds require a short wet prechilling period to relieve dormancy. Bowns and West (1976) reported prechilling at 39 °F (4 °C) for 23 days and incubation at 57/40 °F (14/4 °C) provided 80 percent germination in 6 days and 90 percent in 13 days. Natural seedlings are uncommon. Their appearance may be associated with dry autumns and winter or spring precipitation totaling 2 to 5 inches (50 to 130 mm) (Beatley 1974).

Plants can be established by artificial seeding, but sufficient plantings have not been attempted to adequately determine appropriate seeding rates or seedbed requirements. Local seed sources should be used; populations are not adapted to areas other than their sites of origin. Seed can be planted with most conventional seeders. A planting depth of about 0.5 inch (1.3 cm) is recommended. Rodents may aid in natural seed dispersal and planting, but rodent predation of planted seed has been observed (Bowns and West 1976). Fall planting is recommended to provide adequate wet prechilling and reduce rodent problems (Bowns and West 1976). Stark (1966) reported good success from seedings in Nevada, but wildland seedings in Utah have not been as successful. Seedlings developing from plantings in central Utah, north of the species natural range, have failed to persist for more than 2 to 3 years due to cold winter temperatures. Seedlings developed slowly and some were suppressed by herbaceous competition. In general, most attempts to plant blackbrush offsite have not been successful.

Only fair survival has resulted from planting projects using either container or bareroot stock. Container stock grows moderately well in a buffered peat-vermiculite medium, but seedlings are sensitive to overwatering. Four to 6 inch (10 to 15 cm) tall seedlings can be produced in 6 to 10 months under greenhouse conditions. Survival has not exceeded 30 percent from plantings conducted in southeastern Utah. Shading the small transplants improved survival (Kitchell n.d.).

Uses and Management

Dayton (1931) and Allen (1939) reported blackbrush provides fair winter forage for cattle, sheep, goats, deer, desert bighorn, and other game animals. Blackbrush communities are commonly used as winter range for sheep. However, blackbrush is often regarded as a poor forage species with low palatability (Bates 1984; Sampson and Jesperson 1963). Although used by big game and livestock (Gullion 1964), it is usually not a major component of their diet. It may become an important forage during severe winters (Kufeld and others 1973; Sampson and Jesperson 1963). Blackbrush is deficient in phosphorus for sheep and cattle and low in protein during fall and winter (Bowns and West 1976). In addition, the low growing, intricately branching habit of the shrub reduces its

attractiveness to livestock (Provenza and others 1983). Light to moderate grazing may reduce woody materials and spininess and increase production of palatable new growth (Provenza 1977; Provenza and others 1983). Mule deer make moderate use of this shrub in winter and spring (Leach 1956). Its seeds are used by birds and rodents (Mozingo 1987; USDA Forest Service 1937) and it provides cover for many small animals.

Blackbrush is adapted to harsh sites, but its slow growth and limited area of adaptation have restricted its use in revegetation projects on non-native sites. All blackbrush sites do not respond similarly to restoration and management practices. Bates (1984) and West (1969) concluded that blackbrush occupies two different situations, each responding differently to fire and other improvement techniques. In the first situation, blackbrush occurs in monotypic stands as a climax species supporting few native understory species. Shrubs are widely spaced and cover provided by grasses and forbs may be extremely low. Cryptogamic crusts covering interspaces reduce soil erosion; those with a blue-green algae phycobiont provide an important source of soil nitrogen (West and Skujins 1977). These sites are frequently considered for range improvement projects. Burning has not been a successful means of releasing the existing understory due to the unpredictable recovery of native herbs, invasion of annual weeds, and loss of cryptogamic crust that recovers very slowly (Jensen and others 1960). In the absence of annual weeds, these sites often revert back to blackbrush without any intermediate stage (West and Skujins 1977). Attempts to plant substitute shrubby species have not been successful.

Monotypic stands of blackbrush are often associated with shallow soils and soil water conditions that do not favor seeding success. Annual weeds, principally red brome, compete with the shrub seedlings. Attempts to replant blackbrush back onto these sites following wildfires or other disturbances often meet with failure.

The second common revegetation situation occurs on sites where blackbrush invades other plant communities or is naturally present in low density. Invasion normally occurs on sites with deeper soils and better water availability than is found on monotypic blackbrush sites. Blackbrush increases on these sites when heavy grazing suppresses other plants. Under these conditions, burning or chaining can be used to reduce blackbrush density and allow release of existing natives or aid in the establishment of seeded species. Success is dependent on edaphic and climatic conditions. Sites with deeper soils generally respond more favorably (Bates 1984; Halliday 1957).

The successional patterns of recovery following fires are somewhat unpredictable in blackbrush communities. The shrub is reported by some to be a nonsprouter (Bowns 1973; Bowns and West 1976). Most plants are killed if the understory is dense enough to carry a fire. Low intensity burns may not kill mature plants. Bates (1984) reported considerable resprouting following fires in California. Blackbrush seed may remain viable in the soil for several years; new seedlings may emerge from seed banks many years after mature plants are destroyed by fires or other disturbances (Bates 1984). Blackbrush seedlings establish very slowly following fires (Anderson 2001; Wright and Bailey 1982); red brome and other annuals develop quickly and dominate burned sites, often precluding blackbrush recovery (Rickard and Beatley 1965). However, Bates (1984) observed blackbrush reestablishment from seed on sites occupied by annual and perennial grasses following wildfires. Thus, the species may exert some competitiveness with herbaceous species in some locations.

Jensen and others (1960) found burns in Nevada effectively killed blackbrush plants. Unless native perennial grasses and broadleaf herbs recovered rapidly following burns on these sites, annual weeds quickly dominated and prevented blackbrush recovery. Some shrubs, including turpentine bush, desert bitterbrush, and desert peachbrush, are capable of recovering following fires, and if present prior to burning, may soon dominate burns where blackbrush was once common (Bowns 1973).

In California, annuals quickly invaded blackbrush burns, but were replaced by perennial herbs within 10 to 15 years (Bates 1984). A mixed shrub community then appeared in about 30 years, eventually reverting back to solid stands of blackbrush if the stands were poorly managed. Not all sites responded so favorably. Once annual weeds established, the reentry of more desirable herbs and shrubs was often limited. Burning or chaining increased the density of other shrubs present after treatment.

Blackbrush communities provide desirable ground cover and soil protection and should not be removed or converted to other species unless the treatments are assured of some success. Anchor chaining has been effective in reducing blackbrush density where it exists in pure stands or intermixed with pinyon-juniper. Brush beating has also been used to decrease shrub density, remove older wood, and stimulate new growth (Bowns and West 1976). Neither chaining nor brush beating kills all shrubs. Double chaining for example, initially killed about 25 percent of the plants on two large blackbrush chaining projects in southern Utah (Monsen n.d.). Crested, intermediate, and pubescent wheatgrass were seeded at both sites, producing good understory stands. Blackbrush resprouted and regained its earlier productivity in about 10 years. Its productivity was not suppressed by the presence of the seeded grasses. Indian ricegrass has also responded

favorably following chaining of certain blackbrush sites. Blackbrush is particularly compatible with Indian ricegrass, and when protected from livestock grazing these sites often support a mixed grass-shrub community (Jeffries and Klopatek 1987).

Varieties and Ecotypes

Native stands in the Colorado River drainage in southeastern Utah provide the seed for most blackbrush revegetation projects. However, collections acquired from this area have not demonstrated adaptation to other locations. If artificial plantings are contemplated, seed should be acquired from native stands growing near the planting sites. Different ecotypes demonstrate specific attributes that appear to be genetic traits. Certain ecotypes demonstrate adaptability to arid desert conditions; others express compatibility with herbaceous understory plants, and some appear better able to recover from burning.

Cotoneaster acutifolia

Peking Cotoneaster

Peking cotoneaster is an unarmed, low-spreading shrub, often reaching 12 ft (3.7 m) in diameter (fig. 8). Plant height is usually less than 5 ft (1.5 m). The shrub is described as deciduous (Welsh and others 1987), but numerous leaves often remain on the plant until late winter. Branches are numerous, reddish brown, and arcuate to horizontal. Flowers are small, perfect, regular, and solitary or in cymes terminating lateral branches. Flowers are white or pink. The fruit is a black, two-celled pome about 0.4 inch (1 cm) long (Johnson and Anderson 1980; Welsh and others 1987).

Figure 8—Peking cotoneaster, an introduction from China, has received considerable use in midwestern windbreaks and shelterbelts where it provides winter cover and food for birds and big game.

Ecological Relationships and Distribution

Peking cotoneaster was originally introduced from northern China in 1883 as an ornamental shrub (Hoag 1958; Leslie 1954; Slabaugh 1974). It has been planted for conservation and shelterbelt purposes throughout the United States, particularly in the northern Great Plains and upper Midwest. It is also used in the southern Canadian prairie provinces (Johnson and Anderson 1980; Slabaugh 1974). Like other *Cotoneaster* species, Peking cotoneaster is commercially cultured and sold for ornamental plantings. A number of varieties have been developed and are widely used. Plants have demonstrated a wide range of adaptation when planted in shelterbelts and conservation plantings in the West and Midwest.

Plant Culture

Peking cotoneaster normally flowers in early May; fruits ripen in September or October (Slabaugh 1974). Plummer and others (1968) reported that fruits do not ripen until mid November in Utah. Fruits remain on the shrub until mid to late winter. Abundant crops are often produced on cultivated hedges and shelterbelt plantings. Fruits become rather dry as they ripen. Mature fruits are easily dislodged from the shrub and are hand collected in late fall or early winter after some leaves have fallen. Seed are removed by macerating the fruits and flushing the pulp with water. The remaining seeds and pulp are then dried and screened. Empty seeds are removed by flotation (Slabaugh 1974). Conditioned seedlots normally are very pure with little debris. The average number of cleaned seeds per lb varies from 21,984 to 32,310 (48,465 to 71,231 per kg) (Plummer and others 1968; Slabaugh 1974). Purity of 98 percent and germination of 80 percent are recommended for seed purchases.

Germination of Peking cotoneaster is restricted by the presence of a hard, impermeable seedcoat and embryo dormancy (Slabaugh 1974). Scarification with sulfuric acid and wet prechilling pretreatments are recommended to hasten germination (Fordham 1962). However, fall nursery or wildland plantings usually provide sufficient wet prechilling. An alternating temperature regime of 50 °F (10 °C) for 15 hours and 77 °F (25 °C) for 9 hours, with light supplied during the warm cycle, usually provides optimal germination conditions for pretreated seed (Slabaugh 1974).

Peking cotoneaster is commonly grown as nursery stock for outplanting and is usually lifted after the second growing season. Cuttings are easily propagated; the plants layer readily. Wildings or rooted

stem layers can be harvested early in the spring for field plantings. Doran (1957) reported softwood cuttings of cotoneaster taken in early summer root well.

Wildland seedings have been only marginally successful. Seed germination is erratic. Seedlings grow slowly and are easily suppressed by herbs. Planting success is improved if the seedbed is kept weed free. Established plants are more resilient and persist well. This shrub rarely suffers heavy damage from insects, disease, or use by small mammals. Little damage has been noted during heavy grasshopper infestations.

Uses and Management

Peking cotoneaster has been most widely used for windbreaks, shelterbelts, conservation, and ornamental plantings (Hoag 1958; Johnson and Anderson 1980; Leslie 1954; Slabaugh 1974; Wyman 1949). The shrub is used in multi-row windbreaks and cover plantings to protect soils and reduce wind erosion. It furnishes a low, dense groundcover that provides year-long protection. The plants are also commonly used in roadway, recreation, or conservation plantings where ground cover, low maintenance, and aesthetics are important. Plants are attractive and provide glossy green foliage with persistent red or black berry-like pomes. The shrub withstands snow deposition and is used to trap snow and protect roadways and buildings.

Peking cotoneaster is commonly used to control erosion in residential areas, recreation sites, and wildlands. It is particularly useful in these areas as plants establish well from transplanting and quickly improve ground cover. Transplants can be planted at various spacings depending on the availability of seedlings. Planted shrubs will spread to occupy the planting site, but do not seed into adjacent areas.

Peking cotoneaster is adaptable to many ranges where native species have been lost and are difficult to reestablish. It has been used to provide winter food for various birds and big game (Johnson and Anderson 1980; Miller and others 1948). The plant exhibits high palatability to game and livestock and is moderately tolerant of grazing (Plummer and others 1968). It is readily grazed in midsummer by mule deer (Kufeld and others 1973; Leach 1956). Winter browsing has been heavy in Utah. Spring and fall use is light. Game animals are attracted to the shrub and can damage landscape plantings. Peking cotoneaster should not be used in roadway or other plantings where wildlife concentrations create hazards.

Peking cotoneaster may be used to improve areas where game animals concentrate and more productive forage and cover is essential. This shrub can be planted to enhance depleted native communities and attract and reduce animal use of native species. It can also be planted to reduce erosion on disturbed sites and to protect watershed and soil values.

Varieties and Ecotypes

There are no releases.

Cowania stansburiana

Stansbury Cliffrose or Cliffrose

Stansbury cliffrose has often been identified as a variety of *C. mexicana* var. *stansburiana* [Torr.] Jeps. However, we have elected to accept it as a separate species as proposed by McArthur and others (1983b). Plants are long-lived, erect, evergreen, aromatic shrubs or small trees 3 to 18 ft (1 to 5.4 m) tall with stiff, often somewhat brittle stems and gray shreddy bark (Cline 1960; Welsh and others 1987). New growth is flexible with glandular bark. Stansbury cliffrose has an extensive root system with long, spreading, and descending roots (Sutton and Johnson 1974). Roots may form symbiotic nitrogen-fixing associations with *Frankia* (Nelson and Schuttler 1984). Plants are resinous and strong smelling. The light to dark green leaves are clustered along the branches and are 0.5 to 1 inch (1.2 to 2.5 cm) in length with revolute margins and five to seven teeth at the apex. Leaf surfaces are glandular dotted and resinous above with a white tomentum beneath (Blauer and others 1975; Munz and Keck 1959). About 90 percent of the showy, fragrant, cream to yellow flowers appear during the first flush of flowering and are formed on lateral spurs of the previous year's wood. Later flowers appear sporadically throughout the summer near the tip of the current year's leaders (Shaw and Monsen 1983b). Later flowers are particularly abundant following summer rains. Flowers are about 0.8 inches (2 cm) in diameter and are normally perfect with two series of stamens enclosing 5 to 12 hairy pistils. Fruits are plumose achenes (fig. 9) dispersed by gravity and wind (Blauer and others 1975).

Figure 9—Stansbury cliffrose branch with mature achenes, note the plumose styles.

Ecological Relationships and Distribution

Stansbury cliffrose is distributed from southern California east to Colorado and south to Sonora and Chihuahua (USDA Forest Service 1937; Welsh and others 1987). It does not occur north of about the 42 °N parallel (McArthur and others 1983b). It is found primarily on dry, rocky, well-drained silty to gravelly soils of foothills and mesas growing in blackbrush, chaparral, oak, desert shrub, mixed grass-desert shrub, mountain brush, and pinyon-juniper woodlands up to the edge of ponderosa pine forests at elevations from 3,000 to 9,000 ft (900 to 2,700 m) (Blauer and others 1975; McArthur and others 1983b; Welsh and others 1987).

Cowania and *Purshia* are closely related genera but differ in many physical characteristics (table 1) and geographical distribution (McArthur and others 1983b; Stutz and Thomas 1964; Thomas 1957). Because of these differences, we prefer to retain the genus name *Cowania* even though Welsh and others (1987) recently transferred its species to *Purshia*.

Disjunct flowering periods normally prevent hybridization between antelope bitterbrush and Stansbury cliffrose. Antelope bitterbrush usually flowers earlier than Stansbury cliffrose (McArthur and others 1983b; Shaw and Monsen 1983b), but aspect or site conditions may result in overlapping periods of anthesis and pollination. Stutz and Thomas (1964) and Thomas (1957) reported that hybridization is so common that no populations of antelope bitterbrush in Utah have been examined that are free from the influence of Stansbury cliffrose. Introgression of antelope bitterbrush into Stansbury cliffrose is less common, but does occur. McArthur and others (1983b) concluded that two adaptive products have evolved through natural hybridization. Desert bitterbrush, the southern adaptive derivative, is one product. The second is less distinct. It occurs in areas north of Utah on sites not occupied by Stansbury cliffrose and consists of antelope bitterbrush populations that express Stansbury cliffrose characteristics, particularly low palatability. Stutz (1972) suggested selection pressure resulting from heavy browsing has favored the less palatable plants.

Both *Purshia* and *Cowania* were present in the Madro-Tertiary geoflora, which evolved from the Arcto-Tertiary and Neo-Tropical geofloras in response to increasingly drier conditions in the Southwest (Axelrod 1958, McArthur and others 1983b). McArthur and others (1983b) postulated that the weak isolation barriers now existing between the two genera indicate that the present zone of contact of the two species developed after a long separation. Much of the area where they now coexist was occupied by Pleistocene lakes and glaciers as recently as 12,000 years ago.

Table 1—Morphological characteristics separating *Cowania* and *Purshia* (after Stutz and Thomas 1964).

Character	*Purshia*	*Cowania*
Twig pubescence	heavy	glabrous
Dorsal leaf pubescence	heavy	glabrous
Hypanthium glands	none	3+/mm^2
Stalked glands	absent	present
Pistils	1 or 2	4+
Style length	<1.5 cm	1.6 - 3.4 cm
Style pubescence	puberulent	plumose
L/W ratio of achenes	<3.1	>3.3
Stamen insertion	hypanthium margin	hypanthium throat
Leaf margin revolution	slight	pronounced
Hypanthium pubescence	pubescent	glabrous
Stamen series	one	two
Lobes/leaf	three	five+
Leaf glandulosity	none	3+/mm^2
Leaf retention	deciduous	evergreen

Plant Culture

Although Stansbury cliffrose grows in semiarid regions it usually produces at least some seed each year. Abundant or commercially harvestable seed crops develop in about 2 out of every 3 to 4 years. Although flowering usually occurs after the last spring frost, unusually late frosts can diminish seed yields.

The period of floral development, anthesis, and fruit development lasts from 68 to 78 days in southern Idaho (Shaw and Monsen 1983b). Anthesis and pollination occur over a 10-day period. Fruits then mature about 37 days later. The plants are insect-pollinated and self-incompatible, consequently seed production is significantly impacted by high winds, rainy periods, unusually hot temperatures, and other factors that influence insect pollination.

Fruit (achene) ripening is less uniform for Stansbury cliffrose than for antelope bitterbrush, but the bulk of the fruit can generally be harvested on one date. Fruits are hand collected by striking the limbs with a paddle or stick to knock them into collection hoppers or trays. The brittle styles are removed with a Dybvig or barley debearder and separated by fanning. Seeds are not removed from the achene to avoid damaging the embryo (Young and Evans 1983). Generally about one-third of the harvested material by weight consists of viable seed (achenes) (Alexander and others 1974). There are about 64,600 seeds per lb (64,500 per kg) (Alexander and others 1974; Plummer and others 1968). Purity of 95 percent and germination of 85 percent are recommended for seed purchases (see chapter 24).

Seed can reportedly be warehouse stored for 5 to 7 years (Alexander and others 1974; Plummer and

others 1968; Springfield 1973), or even as long as 15 years (Stevens and others 1981a). Germination tests conducted on seed lots harvested from the same area in different years exhibit similar germination patterns. However, some differences do occur. Poorer and slower germination results from unfavorable growing conditions during the year of seed production; more rapid and complete germination characterize seed produced during years of abundant production (Jorgensen n.d.). Shaw and Monsen (1983b) reported the loss of achenes prior to the time of maturation was 13 percent in 1979 and 52 percent in 1980. Although insects were a major factor, losses could not be attributed to insect damage alone.

Stansbury cliffrose seed requires a wet prechilling treatment to release dormancy. The optimal treatment duration varies with population and year of harvest. Consequently, seed should be planted in fall or winter; spring seeding should be avoided. Meyer and Kitchen (n.d.) found that the rate and total germination percentage increased from 30 percent after 2 weeks of wet prechilling at 33 °F (1 °C) to 100 percent in 7 days after 6 weeks of wet prechilling. Seed maintained at 33 °F (1 °C), began germinating during prechilling within 8 weeks and completed germination in 11 weeks. Plummer and others (1970b) reported 89 percent germination after 90 days at alternating temperatures of 32/85 °F (0/31 °C) and 99 percent germination after 90 days of alternating temperatures of 32/38 °F (0/3 °C). Young and Evans (1981b) recommended prechilling at 32, 36, or 39 °F (0, 2, 4 °C) for approximately 6 weeks. Seeds do not require light for germination (Sabo and others 1979).

Stansbury cliffrose is generally fall seeded in a mixture with other shrub seed. Seed can be planted with most conventional drills or seeders. Cleaned seed must be incorporated into the soil to a depth of about 0.25 to 0.50 inch (6 to 12 mm) (Alexander and others 1974; Plummer and others 1968). Surface broadcasting is generally unsuccessful if the seed is not subsequently covered. Seedling emergence is similar to that of antelope bitterbrush, occurring early in spring. Small seedlings are sometimes subjected to late frosts. During the establishment period, seedlings are quite sensitive to competition and water stress. However, once established, Stansbury cliffrose seedlings tolerate drought, heat, and soil salinity better than antelope bitterbrush or Apache plume (Plummer and others 1968). Seedlings are not capable of competing with cheatgrass, red brome, or dense stands of some perennial grasses.

Stansbury cliffrose is easily grown as bareroot (Shaw 1984) or container stock (Landis and Simonich 1984); it develops rapidly if properly cultured. One-year-old bareroot seedlings generally attain satisfactory size for field transplanting. Container plants are usually propagated from seed, but stem cuttings can be rooted (Shaw and Monsen 1983b). Because Stansbury cliffrose is an evergreen shrub, plants are sensitive to lifting and transplanting if not properly hardened or dormant. Survival of actively growing plants is generally low.

Grasshoppers utilize Stansbury cliffrose (Edgerton and others 1983) but have not been observed to seriously damage or eliminate new plantings. Weedy competition on the planting site should be controlled by burning, mechanical, or other means of seedbed preparation prior to transplanting (Giunta and others 1978; Shaw and Monsen 1983b).

Uses and Management

Stansbury cliffrose is regarded as a desirable winter forage for big game as well as cattle and sheep (Blauer and others 1975; Plummer and others 1968; Robertson 1974; Tueller 1979; USDA Forest Service 1937). Kufeld and others (1973) reported that mule deer make heavy use of it in fall, winter, and spring but only moderate use in summer. Some Stansbury cliffrose stands are grazed by big game and livestock during all seasons. However, the species is not as universally palatable as antelope bitterbrush (McArthur and others 1983b; Stutz and Thomas 1964). Plants often receive negligible use in spring and summer in areas where other forage is available (USDA Forest Service 1937). Certain ecotypes, including some southern Arizona populations, evidently have low palatability in all seasons. Two dimensional chromatograms of their phenolic compounds can be distinguished from those of more palatable populations (Blauer and others 1975).

Like other evergreen species, Stansbury cliffrose maintains its protein levels and energy values in winter (Dittberner and Olsen 1983; Smith and Hubbard 1954; Welch and others 1983a). In a common garden study in southern Idaho, Stansbury cliffrose leaders were found to contain a significantly higher percentage of crude protein in winter (8.4 to 8.6 percent, dry weight basis) than those of antelope bitterbrush or Apache plume, but slightly less than those of desert bitterbrush (Welch and others 1983a). The *in vitro* digestible dry matter of Stansbury cliffrose exceeded that of all species tested (37.6 percent).

Stansbury cliffrose can withstand heavy grazing and does occur in areas where winter use is quite intense. Flowering and production of new growth may be stimulated by 65 percent use; browsing in excess of 80 percent of new growth decreases vigor (Wasser 1982). Stands frequently sustain game animals during years of heavy snow accumulation and should be managed to ensure forage availability during the critical midwinter period.

Stansbury cliffrose has been seeded on a variety of sites to improve diversity and winter wildlife habitat value of vegetation (Edgerton and others 1983). Good stands can be established in the mountain brush zone and in most pinyon-juniper communities (Davis 1983; Giunta and others 1978; Monsen and Christensen 1975). Stansbury cliffrose is frequently intermixed with Wyoming big sagebrush, blackbrush, and salt desert shrubs and can be successfully reseeded on such sites. Although Stansbury cliffrose frequently grows on soils derived from limestone, it is not limited to such sites. Establishment and survival are less certain when the species is planted in shrub communities where it does not occur naturally. However, plantings have established and survived successfully for nearly 40 years in antelope bitterbrush communities in south central Idaho and for over 10 years in northeastern Oregon and eastern Washington (Blauer and others 1975; Edgerton and others 1983; Monsen and Shaw 1983c). Stansbury cliffrose is not fire tolerant and should not be planted in areas subject to repeated burning.

On native sites Stansbury cliffrose may function as a pioneer species following disturbances (Wright and others 1979). It has been considered a candidate plant for mined areas, roadways, and other disturbed sites. It provides only moderate erosion control due to its upright habit and low growth rate (Dittberner and Olsen 1983; Smith and others 1978). Its frequency of nodulation by the nitrogen-fixing endophyte is generally low and varies with collection date and location (Nelson 1983). Plants have been successfully established on mine sites near Alton, UT, and on the phosphate mines of southeastern Idaho (Ferguson and Frischknecht 1985; Monsen, data on file, Shrub Science Lab., Provo, UT). Replacement of topsoil is required to attain satisfactory stands. Results of roadway seedings and transplanting trials in Utah and Idaho have been erratic, even when plantings are conducted in areas where Stansbury cliffrose naturally occurs.

Stansbury cliffrose is an attractive, drought-tolerant ornamental. The leaves are evergreen, the flowers and fruits are showy, and flowering occurs over a prolonged period. Mature shrubs can become rather ragged in profile, but respond well to pruning.

Stansbury cliffrose seedlings grow slowly and may require 3 to 4 years to reach a height of 6 to 12 inches (15 to 30 cm) (Monsen and Christiansen 1975). Growth thereafter is much more rapid. In a big game exclosure near Boise, ID, Stansbury cliffrose planting stock grew more slowly than several sources of antelope bitterbrush for the first 4 to 5 years, but exceeded their growth rates thereafter. Both species produced seed 5 to 6 years after planting (Shaw and Monsen 1983b).

Seedlings of Stansbury cliffrose must be protected from excessive competition and heavy grazing until plants are 3 to 5 years of age. In addition, Stansbury cliffrose stands have been and are being lost due to the invasion of weedy annuals that restrict natural or seeded shrub establishment and expansion and ultimately contribute to the loss of the shrub overstory (Cline 1960; Price 1982). Sites should be managed or treated to create a weed-free seedbed and maintain a suitable native understory after planting.

Stansbury cliffrose frequently does not recover from burning, chaining, or other methods of mechanical treatment. Multiple stemmed shrubs are more tolerant than older single-stemmed shrubs (Plummer and others 1968). Extreme variability in response to fire has been reported (Ferguson 1983; Howard 1995; Wright and others 1979), perhaps reflecting differences among ecotypes. Attempts to improve existing stands using these treatments have not been successful unless the sites are also seeded.

Varieties and Ecotypes

The extensive natural hybridization of Stansbury cliffrose with antelope and desert bitterbrush, and to a lesser extent Apache plume, provides an immense array of material for improving palatability; increasing drought, heat, and fire tolerance; broadening areas of adaptation; enhancing evergreen growth characteristics and forage traits; and manipulating growth habits of these taxa (McArthur and others 1983b; Monsen and Davis 1985; Stutz 1972). Improvement of seedling vigor, establishment, and initial growth rates would enhance the use of Stansbury cliffrose and its hybrids.

Stansbury cliffrose selections from central Utah have been among the most successful and productive populations seeded on pinyon-juniper sites in Utah (Monsen and Davis 1985). Hybrids with antelope bitterbrush collected from Utah County, UT, also offer excellent forage traits, including evergreen growth, high productivity, dramatic regrowth, good palatability, and an upright growth form. Davis (1983a) listed five different central Utah accessions of Stansbury cliffrose that have performed best in artificial seedings in Utah nearly 30 years after planting. Studies were based on continuous evaluations from 60 sites and include such factors as growth, persistence, and vigor.

Stansbury cliffrose introgressions with desert bitterbrush acquired from Benton, CA, demonstrate a wide range of adaptation and survival under harsh circumstances. Selections from hybrids with desert bitterbrush show promise for improved fire tolerance and adaptation to arid situations.

Crataegus douglasii

Douglas or River Hawthorn

Douglas or river hawthorn is a compact, deciduous, deep rooted shrub or small tree growing 3.3 to 13 (26) ft (1 to 4 [8] m) tall (fig. 10). The bark is smooth and reddish brown, becoming reddish bronze in winter. Stems are armed with stout, usually straight thorns 0.4 to 0.8 inch (1 to 2 cm) long. The petiolate leaves are 1.2 to 2.4 inches (3 to 6 cm) long, usually less than half as wide, and lanceolate to elliptic ovate. Leaf edges are serrate to doubly serrate. Leaves turn bright red in fall. Flowers are perfect, regular, and epigynous, developing in corymbose cymes that terminate short lateral spurs. The clusters of fragrant white blossoms sometimes appear to cover the crown of the plant. Fruits are lustrous black, glabrous pomes about 0.25 inch (0.6 cm) in diameter that resemble small apples. They are fleshy, dry, and mealy, and contain light yellow pulp with one to five seeds. Flowering occurs in May and June; fruits ripen from July to September (Brinkman 1974e; Hitchcock and others 1961; Welsh and others 1987). Fruits are dispersed by gravity and animals.

Ecological Relationships and Distribution

There are approximately 300 species of *Crataegus* distributed throughout the Northern Hemisphere. In North America the genus is most abundant east of the Rocky Mountains. However, approximately 8 to 10 species occur in the Rocky Mountain area (Preston 1968). Hawthorn taxonomy is extremely complex; the genus consists of numerous species exhibiting great variation. Hybridization is common, particularly in the central and eastern United States. Characteristic of the subfamily Pomoideae, their chromosome number is n = 17 (McArthur and Sanderson 1985).

Douglas hawthorn, the most common species in our area, is distributed from Alaska east to Alberta and the Dakotas and south to California and northern Wyoming. It also occurs in Michigan and Ontario (Hitchcock and others 1961). In sagebrush and ponderosa pine communities it is largely confined to riparian zones where it may form dense thickets. It is well adapted to deep, moist, organic soils, but may be found on soils ranging from silty to rocky clay loams. Although it commonly grows on well-drained sites, Douglas hawthorn is capable of withstanding periods of soil saturation (Stark 1966). The species is an alternate host for cedar apple rust and may be damaged by leaf spot in drier locations (Krebill 1972; Stark 1966).

Figure 10—Douglas hawthorn is an excellent wildlife species that often occurs in or near riparian areas.

Plant Culture

Ripe fruits are hand collected. Freshly collected fruits must be kept cool and not allowed to mold prior to extraction. Seed can be separated from fleshy material with a Dybvig cleaner or blender and water followed by air drying and fanning. A variable percentage of the seed is usually unsound but cannot be removed by flotation. Some of these may be separated on a gravity table. There are about 15,050 seed per lb (33,179 per kg) at 100 percent purity (see chapter 24). Treatment with concentrated sulfuric acid has been used to release dormancy. The appropriate length of acid treatment varies from 0.5 to 3 hours depending on the seedlot (King 1947; McKeever 1938). Effectiveness of acid scarification has not been consistent; acid can penetrate the seed coats and damage the embryos of fresh seed. Embryo dormancy is released by a 3 to 5 month wet prechilling (King 1947; McKeever 1938; SEAM 1976). Because of the variability in dormancy among seedlots, combinations of standard pretreatments may be only partially effective in its release. Tetrazolium or excised embryo tests are often used as indicators of seed quality because current germination tests are time consuming and not highly reliable.

Results of direct seedings have been erratic. Spot plantings in desirable locations conserve seed and provide developing seedlings with the best opportunity for establishment.

Douglas hawthorn is most reliably established from planting stock. Container and bareroot seedlings are easily propagated, handled, and planted with good survival on adapted sites. In the bareroot nursery, seed should be planted to provide a seedling density of 25 per ft^2 (278 per m^2). Untreated seed should be planted in early fall, but wet prechilled seed must be spring planted (Hartmann and others 1990; Van Dersal 1938). Container seedlings of uniform size are most economically produced from germinants (Landis and Simonich 1984). Rooting of hardwood or softwood

cuttings is not recommended (Marchant and Sherlock 1984). Root cuttings have been used to propagate cultivated ornamental *Crataegus* species (Wyman 1971). Seedlings may be planted in mixtures with other shrubs, but should be protected from competition with perennial grasses and weedy species.

Uses and Management

Douglas hawthorn is a valuable shrub deserving more frequent inclusion in revegetation projects. It has been successfully used in conservation and wildlife projects to furnish soil protection and food and cover for wildlife. It is well suited to mixed plantings with other shrub species. The dense thickets provide hiding and thermal cover food for birds, small mammals, bear, big game, and livestock. They add valuable structural diversity on grassland sites. Winter mule deer use was evaluated as moderate to heavy in Washington (Brown and Martinsen 1959). Douglas hawthorn receives moderate summer use by mule deer (Kufeld and others 1973). Use by white-tailed deer and livestock is variable (Van Dersal 1938). Douglas hawthorn is rated as a valuable honey plant and fruits are heavily used by birds.

Fruits of Douglas hawthorn are high in sugar, but low in fats and protein. They were eaten fresh or dried and used in pemmican by Native Americans. They are sometimes used for jams and jellies (Craighead and others 1963). Where adapted, Douglas hawthorn is an excellent candidate for landscape plantings in parks and recreation areas.

Natural reproduction from seed is often prevented by heavy use and trampling in riparian areas where game and livestock tend to congregate. Seedlings develop slowly and should be protected from browsing and competition with weeds and grasses during the first two seasons. Young seedlings may be girdled by rodents. Established plants are not easily damaged by excessive browsing.

Varieties and Ecotypes

Although Douglas hawthorn exhibits many good attributes, selection trials have been limited. Appropriate growth forms of Douglas hawthorn may be selected for shelterbelt and windbreak plantings. The deep rooted, thicket-forming plants are useful for stabilizing mine spoil banks, riparian sites, and other disturbances. They are resistant to beaver damage (Marchant and Sherlock 1984). A number of hawthorn species and varieties are native to riparian zones in the Intermountain region and may be selected for the revegetation of adapted sites (Hitchcock and others 1961). Columbia hawthorn is a small tree or shrub with red fruit and thorns 1.5 to 3 inches (4 to 7 cm) long. It is distributed from British Columbia and Alberta south to Oregon, Idaho, and Montana. It grows well in heavy clay soils over basalt. Yellow hawthorn is found from central Utah east to Pennsylvania and southeastern Canada.

Fallugia paradoxa

Apache Plume

Apache plume, the only species of its genus, is a much-branched shrub 2 to 7 ft (0.6 to 2.2 m) tall (fig. 11). Branches are white to straw colored with flaking or scaly bark (Harrington 1964). Leaves are described as often evergreen in the southern portion of its range (Blauer and others 1975; Deitschman and others 1974b; USDA Forest Service 1937) and persistent or deciduous in cooler areas (Munz and Keck 1959; Welsh and others 1987). Leaves are borne in fascicles along the branches and are 1.2 to 1.8 inches (3 to 5 cm) long. They are cuneate with revolute margins and pinnately divided into three to seven linear lobes (Welsh and others 1987). Leaves are lepidote on both surfaces, light green above and rusty below (Harrington 1964; Munz and Keck 1959; Welsh and others 1987). The large showy, perigynous flowers, 1.2 to 1.8 inches (3 to 4 cm) broad, develop singly or in few-flowered cymes. A typical flower has five broad sepals alternating with five bracts and five large white petals. Numerous stamens are inserted in three series on the margin of the hypanthium. There are 20 to 30 pistils. The hairy achenes are 0.25 inch (6 mm) long with plumose persistent styles that elongate to 1 to 2 inches (2 to 5 cm) at maturity (Deitschman and others 1974b; Young and Young 1986). The distinct plumose styles resemble an Indian war bonnet, hence the name “Apache plume.”

Figure 11—Apache plume is a resprouting relative of bitterbrush that often grows in dry washes.

Flowers are bisexual or rarely staminate (McMinn 1951). Blauer and others (1975) found monoecious as well as dioecious populations. At a study site near Richfield, UT, Blauer and others (1975) encountered shrubs with mostly perfect flowers. However, some plants had well-developed stamens but rudimentary and nonfunctional pistils. Other plants bore flowers with well-developed pistils, but rudimentary and nonfunctional stamens. Plants grown from seed collected at this location exhibited similar differences when grown at a study location near Boise, ID (Shaw and Monsen 1983b). McArthur (n.d.) considers many populations to be functionally dioecious.

Ecological Relationships and Distribution

Apache plume is found on a wide variety of sites from southeastern California to southwestern Colorado and south into Mexico and western Texas, largely outside the Great Basin (Deitschman and others 1974b). It is more abundant in the southern portion of its range. Apache plume grows in a variety of plant communities from the lower desert brush types up through the pinyon-juniper woodlands to open ponderosa pine communities at elevations from 4,000 to 8,500 ft (1,200 to 2,550 m) (Dietschman and others 1974b; Monsen and Davis 1985). It is commonly found in washes and ephemeral waterways, but also occurs on rocky or gravelly slopes and alluvial fans. Plants tend to be widely spaced, even when in pure stands.

Apache plume superficially resembles Stansbury cliffrose; both have lobed leaves and clusters of long plumed fruits. Unlike Stansbury cliffrose, Apache plume produces functionally dioecious plants (Blauer and others 1975; McArthur and others 1983b), and it does not form symbiotic nitrogen fixing root nodules with the actinomycete *Frankia* spp. (Klemmendson 1979; Nelson 1983; Righetti and others 1983). The species occur in broadly overlapping areas (Benson 1957; Blauer and others 1975), and a few suspected natural hybrids have been reported (Blauer and others 1975). Some seeds have been produced by artificial crosses, but no progeny have been produced (Blauer and others 1975). Chromosome number for Apache plume is n = 7 compared to n = 9 for Stansbury cliffrose.

Plant Culture

Flower buds are formed on elongated peduncles produced from vegetative growth of the current season. Buds may appear on terminal or lateral leaders or from new root sprouts (Rehder 1940). Flowering begins as early as April but may extend into August (Rydberg 1954; Van Dersal 1938). Plants flower from April to June in California (McMinn 1951), and as late as October in Arizona (Kearney and Peebles 1960). Plants established in southwestern Idaho flowered erratically from May until early October (Shaw and Monsen 1983b). Time from the appearance of floral buds to fruit ripening was 67 days in 1979 and 86 days in 1980.

Pollination is insect dependent; the flowers attract a variety of colorful bees, ants, hornets, and beetles (Blauer and others 1975). Good seed (achene) crops occur at 1 to 3 year intervals (Deitschman and others 1974b). Because flowers of Apache plume appear in late spring, seed crops are usually not damaged by spring frosts. Determining the appropriate date to harvest seed is difficult; seeds ripen unevenly over a period of several months. Most flowers develop early in the season, producing up to 90 percent of the annual seed crop. As seeds ripen they are detached and dispersed by the wind. Consequently, the period for collecting the maximum amount of seed may be rather short, perhaps only 1 to 2 weeks in duration. Later blooming is associated with summer rains.

Achenes turn from green to reddish as they ripen and plumes sometimes change from reddish to white. They are harvested by dislodging the fruits from the bush. The entire fruit, including the achene and plume is collected. Fruits comprise only 15 to 20 percent of the collected material by weight. Unless the plumes are removed with a barley debearder, the collected material remains in a thick entangled mass that cannot be seeded. There are approximately 546,000 seeds (achenes) per lb (1,203,712 per kg) at 100 percent purity. For seed purchases, acceptable purity is 80 percent and germination is 75 percent (see chapter 24).

Apache plume has been somewhat difficult to establish from direct seeding. A better understanding of the species' seed germination requirements and seedbed ecology would facilitate its use. Seeds are nondormant and germinate quite readily. Plummer and others (1969) reported 60 and 70 percent germination after 60 days at temperatures of 32 and 38 °F (0 to 3 °C). Deitschman and others (1974b) found seeds sown in nursery beds germinated within 4 to 10 days.

Although the plumed seeds are wind dispersed and adapted to shallow or surface seeding, broadcast seeding without seed coverage has not been a satisfactory means of planting. Apache plume is generally included in shrub seed mixtures that are planted separately from grasses. The seeds are easily sown with conventional drills if the styles are removed. Seed should be planted 0.25 to 0.5 inch (6 to 12 mm) deep in a firm seedbed. Fall seeding or seeding prior to the season of most dependable soil water is recommended. Rodents often gather and bury or eat seeds that have fallen from shrubs as well as sown seed. Seeding in late fall or winter when rodents are less active reduces these losses.

Seedlings emerge and grow rapidly under favorable conditions. They are reasonably drought tolerant, especially those that persist through the first summer.

The small plants are not able to persist amid herbaceous competition.

Bareroot and container reared seedlings are easily started and grow rapidly with irrigation, often flowering during the first growing season. When grown under field or nursery conditions in northern climates, the seedlings are mostly deciduous. Once the leaves have fallen, the plants are dormant and can be lifted and transplanted. The brittle stems must be handled carefully to prevent damage. In addition, the root system usually consists of a main root with few side branches. Any damage to the roots can be detrimental to field survival. Greenhouse-maintained plants tend to remain evergreen. These must be adequately hardened or overwintered in a shade house and planted as dormant stock or field survival will be reduced.

Uses and Management

Apache plume occurs throughout the dry, hot portions of the pinyon-juniper, big sagebrush, and southern desert shrublands. It is a useful species for these difficult-to-plant areas and can be planted on southern aspects and shallow soils. To date, Apache plume has most frequently been planted on drier portions of pinyon-juniper communities in central and southern Utah. Seed of the more northerly-occurring ecotypes is harvested for these projects. Once established Apache plume also does well on sites within its range occupied by green ephedra, Stansbury cliffrose, and black sagebrush. It can be planted on benchland sites where spiny hopsage, shadscale, blackbrush, low rabbitbrush, desert bitterbrush, littleleaf mountain mahogany, and singleleaf ash may occur. It is also adapted to fourwing saltbush, winterfat, and roundleaf buffaloberry sites. The species has been established from seed or planting stock on big sagebrush and antelope bitterbrush/bunchgrass ranges in central and northern Utah, southwestern Idaho (Shaw and Monsen 1983b), and northeastern Oregon (Edgerton and others 1983), all outside its native range.

Apache plume does not form thick stands. When seeded with other shrubs it quickly thins out to occupy only specific microsites. This characteristic has also been observed when it is planted on mine wastes and road disturbances. Apache plume has been slow to spread from seed, particularly when planted outside its natural range. Few seedlings are noted, even following years of heavy seed production. On coarse soils, vegetative spread occurs through root proliferation and root sprouting. Sprouts are more numerous during years with good precipitation or following physical damage to the plant. Individual sprouts may attain heights of 1 to 2 ft (30 to 70 cm) in one season (Monsen n.d.).

Although Apache plume's palatability to cattle and sheep is generally considered low, it is rated as good on some ranges. It does not receive heavy summer browsing by livestock on most sites. However, because of its fine twigs and evergreen leaves, it is a fairly valuable winter forage, particularly in the southeastern portion of its range (Ferguson 1983; Monsen and Davis 1985; USDA Forest Service 1937). The bushy habit provides good cover for birds and mammals (Blauer and others 1975).

Ferguson and Frischknecht (1985) considered Apache plume a secondary species for use on mine disturbances in northeastern Utah. It is not nodulated by the nitrogen-fixing endophyte *Frankia* (Nelson 1983; Nelson and Schuttler 1984). Because of its ability to spread vegetatively, Apache plume can be used to provide ground cover and soil protection in dry regions where infrequent storms can cause considerable erosion (Thornburg 1982). It is capable of recovering by vigorous crown sprouting. On native sites it spreads naturally onto disturbed areas.

Apache plume provides diversity for landscape plantings, particularly for dry, low maintenance situations. The white branches and the flowers and plumes are showy and quite unusual. Under cultivation the plant can be over irrigated and will not withstand even partial shade. Increased sprouting and a thicker, bushy habit can be obtained for landscape or erosion control plantings by trimming or grazing the planting. Apache plume has been cultivated as far north as Massachusetts (Deitschman and others 1974b).

The Tewa Indians of New Mexico used bundles of the smaller branches of Apache plume as brooms and the larger straight branches as arrow shafts (USDA Forest Service 1937).

Varieties and Ecotypes

Ecotypic differences have been observed among Apache plume collections currently under test. Shrubs of different populations vary in size and growth habit. Some populations appear better adapted to more northerly climates than others. Breeding system expression, palatability, and rootsprouting following fire also vary. There are at present no released varieties of the species.

Holodiscus discolor

Creambush Oceanspray

Creambush oceanspray, also known as arrowwood, hardhack, rockspirea, and mountain spray, is a highly variable, but usually erect multiple-stemmed, deciduous shrub (fig. 12). Mature plants range from 2.5 to 10 (20) ft (1 to 3 [6] m) in height, with large tree-like forms growing in coastal areas. Young twigs are fine hairy; bark of the older stems is gray to deep grayish red. Leaf buds are covered by two to three purplish-brown bud scales. The alternate leaves are 1 to 4 inches (2.5 to 10 cm) long and ovate to ovate lanceolate with lobed to doubly toothed edges. Upper surfaces are

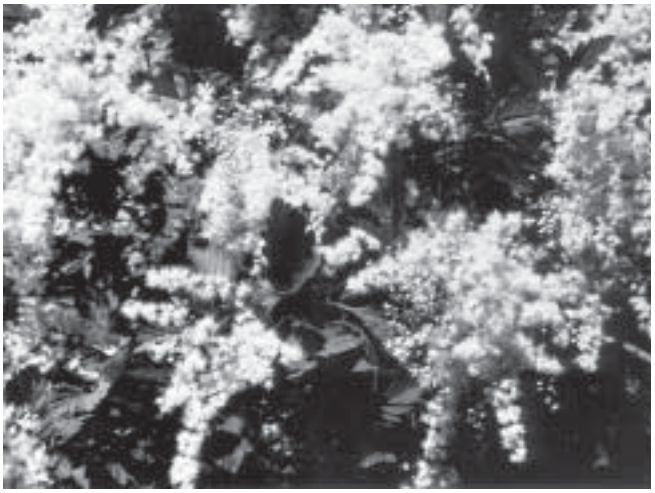


Figure 12—Creambush oceanspray in full bloom.

hirsute, while lower surfaces are pilose lanate to lanate and sometimes glandular. The common name creambush oceanspray is derived from the appearance of the diffuse, showy panicles of tiny, perfect, perigynous, white to pink flowers. Panicles are 4 to 7 (12) inches (10 to 17 [30] cm) long and overtop the shrub. Flowers are about 0.2 inch (5 mm) in diameter, regular, and 5-merous; petals exceed the sepals. Dried flower parts and panicle branches turn brown and persist well into the winter. Fruits are light yellow hirsute achenes approximately 0.1 inch (2 mm) long.

In communities where it exists, creambush oceanspray is one of the first shrub species to leaf out in spring (Orme and Leege 1980). Floral buds develop in late spring and flowering occurs from late June to late August, depending on location. Fruits mature in late summer and may persist into fall. Seeds are wind dispersed (Hitchcock and others 1961; Orme and Leege 1980; Stickney 1974a; USDA Forest Service 1937).

Ecological Relationships and Distribution

The genus *Holodiscus* existed in the Madro-Tertiary geoflora of western North America. It is now disjunct across the tropics, and occurs in western North America and Columbia. Creambush oceanspray is distributed from British Columbia east to western Montana and south along the coast to southern California. It grows in northeastern Oregon, Idaho, and northeastern Nevada (Hitchcock and others 1961; Munz and Keck 1959; Stark 1966; USDA Forest Service 1937). Creambush oceanspray grows on a wide variety of sites at elevations ranging from sea level to 7,000 ft (2,100 m). It is adapted to rich, deep soils of coastal forests, riparian areas, and canyon bottoms. It may also be found growing on dry, shallow soils or rocky talus slopes and along streams in drier areas (Patterson and others 1985). Creambush oceanspray is associated with drier conifer types of the interior and is a climax species in a number of forested communities (Cholewa and Johnson 1983; Cooper and others 1987; Halverson and others 1986; Steele and others 1981). An understory shrub layer of mallowleaf ninebark and creambush oceanspray is common in ponderosa pine and Douglas-fir forests in eastern Washington, northeastern Oregon, northern Idaho, and western Montana (Daubenmire and Daubenmire 1968; Steele and others 1981).

Creambush oceanspray occurs as a climax in open stands of conifers; it survives fires and other disturbances by resprouting from buds on the root crowns to become a member of early seral brushlands (Mueggler 1966; Stickney 1986). Mixed seral brushfields provide valuable forage and cover for deer, elk, and other wildlife. Regeneration from seed following burns is often limited and seedlings develop slowly (Ferguson 1983; Wright and others 1979; Young 1983). However, regeneration from seed may be important following extremely hot fires (Stickney 1974a). Owens (1982) found weight and length of current annual leader growth increased directly with degree of canopy mortality. However, regrowth was slightly lower for complete canopy mortality than for the 51 to 99 percent mortality class. Prescribed burning at 10 to 15 year intervals has been recommended to rejuvenate brush fields that have grown beyond the reach of browsing animals (Orme and Leege 1980).

Plant Culture

Collection of creambush oceanspray achenes is tedious; supplies are rare and costly. Fruits are "combed" from the branches by hand in late fall and conditioned by air drying and screening out larger material with a fanning mill. Achenes of oceanspray are among the smallest of shrub fruits. Only a small percentage of the seeds are normally sound; these are identified by examining wet seed through a dissecting microscope for the presence of an embryo (King 1947). Seeds require wet prechilling at 34 to 36 °F (1 to 2 °C) for about 120 days to break dormancy (Marchant and Sherlock 1984; Young and Young 1986).

Seeding may be accomplished by broadcasting fresh achenes over a rough seedbed in fall and allowing them to be covered by natural soil sloughing. Achenes may be mixed with seeds of other shrub species, but they should not be sown with grasses or forbs. Spots to be planted should be carefully selected to make best use of the seed. Seeding results have been erratic.

Creambush oceanspray is readily propagated from bareroot or container stock. Achenes should be fall sown in the nursery or artificially prechilled and spring sown. Cleaned achenes can be planted at

reasonably uniform spacings. They can be surface sown and covered by dragging a lightweight chain over the seedbed. Seedlings develop rather slowly and may be lifted as 1-0 or 2-0 stock depending on size specifications and growing conditions. Container seedlings are propagated by planting germinants or about 10 wet prechilled seeds in each container. Plants can be grown from cuttings, but techniques have not been refined (Everett and others 1978a). Marchant and Sherlock (1984) achieved 19 percent rooting success with softwood cuttings harvested in late June and propagated under a greenhouse mist system and 12 percent rooting success with hardwood cuttings overwintered in a cold frame.

Uses and Management

Creambush oceanspray is generally not considered a palatable shrub, particularly when alternative browse species are available (Daubenmire and Daubenmire 1968; USDA Forest Service 1937). It is taken by deer and elk; peak use occurs in fall and winter (Stickney 1974a). Use varies geographically depending on ecotype and associated species. Creambush oceanspray receives year round use by elk and deer in eastern Washington, where it forms an important component of the available browse (USDA Forest Service 1937). Garrison (1953) recommended that browsing be limited to 50 to 60 percent of current annual growth on these sites. In the northern Rocky Mountains, use by big game is limited, but the species can be important on some winter ranges (Leege 1969; Stickney 1974a). Use increases tremendously the first winter following fires, but decreases the second winter (Leege 1969). Palatability of creambush oceanspray is rated fair for cattle and poor to fair for sheep (USDA Forest Service 1937). The species tends to increase on heavily grazed sites (Hall 1973; USDA Forest Service 1937). The quantity of the plant consumed in summer and fall in these areas may be considerable due to its abundance and accessibility.

Creambush oceanspray is a useful erosion control plant. The species is adapted to steep, dry, rocky areas with shallow, sandy to clay loam soils (Stark 1966). Seedlings quickly develop a spreading, highly branched fibrous root system. Their low palatability and their ability to resprout following top damage contribute to their value in stabilizing critical sites such as roadcuts and fills (Hungerford 1984; Stark 1966). In some areas, creambush oceanspray is grown as a horticultural species for its dark green foliage, extremely long flowering period, and orange to dull red fall coloration (Sutton and Johnson 1974). It is one of the first shrubs to leaf out in the spring. The small, dry fruits were eaten by Native Americans.

Seedlings establish readily from seed or transplant stock, but grow at only a moderate rate. Consequently, they require protection from grass and forb competition for one or two growing seasons. Excessive browsing is rarely a threat to developing seedlings, but they may be girdled by rodents or trampled by big game or livestock.

Varieties and Ecotypes

To date, selection work with *Holodiscus* species has been limited. The erosion control and ornamental potential of both creambush oceanspray and rockspirea deserve further investigation.

Holodiscus dumosus

Rockspirea

Rockspirea, bush oceanspray, or rock spray spiraea is somewhat similar in appearance to creambush oceanspray, but has a lower and more compact growth habit (fig. 13). The rounded plants branch from the base and range from 3 to 12 ft (1 to 4 m) in height with crown diameters of 5 to 10 ft (1.5 to 3 m) (Hitchcock and others 1961; Sutton and Johnson 1974; Welsh and others 1987). Inflorescences and leaves are smaller. Leaves are decurrent along the petioles; blades are shallowly or coarsely toothed, sometimes with a few secondary mucronulate serrulations. Roots are densely fibrous and spreading. Flowering occurs unevenly all summer (Mozingo 1987). The species has n = 18 chromosomes (McArthur and Sanderson 1985).

Rockspirea is distributed from northeastern California across central and southern Oregon and Idaho to Wyoming and south to Chihuahua, Mexico (Hitchcock and others 1961) at elevations from 2,500 to 12,000 ft (762 to 3,660 m) (Dittberner and Olsen 1983; Harrington 1964; Hopkins and Kovalchek 1983). It occurs in a wide array of plant communities including

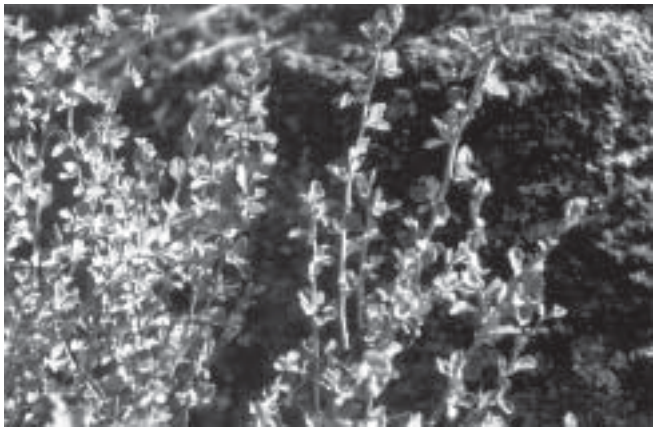


Figure 13—Rockspirea has smaller leaves and a more compact growth habit than creambush oceanspray; it often occurs on cliffs and rock outcrops.

big sagebrush, pinyon, curlleaf mountain mahogany, chaparral, aspen-lodgepole pine, spruce-fir, Douglas-fir, white fir, and ponderosa pine forests (Sutton and Johnson 1974; USDA Forest Service 1937). Within its range it commonly occurs on dry to moderately dry sandy or gravelly soils, rocky ridges, talus slopes, and basalt outcrops (Alexander and others 1974; Hitchcock and others 1961; Welsh and others 1987). It is frequently a codominant in climax communities, but has been reported to occur as a pioneer species following disturbances in a white fir/Rocky Mountain maple/rockspirea habitat type, where it persisted as the site recovered (Alexander 1985).

Cultural and management practices recommended for creambush oceanspray may be generally applied to rockspirea. King (1947) determined that although there are about 5,400,000 achenes per lb (12,000,000 per kg), only about 7 percent were sound. These required wet prechilling at 41 °F (5 °C) for 18 weeks to release dormancy. Heat generated by wildfires may also stimulate germination.

The palatability and forage value of rockspirea generally receive low ratings (USDA Forest Service 1937). Kufeld and others (1973) reported its use by mule deer was moderate in fall and light during the remainder of the year. It is used by birds and rabbits to some extent (Sutton and Johnson 1974; Van Dersal 1938). Based on results of clipping studies in Oregon, Garrison (1953) recommended a maximum of 50 to 60 percent use for sustained production. Present primarily on summer ranges where other species receive preferential use, excessive grazing of rockspirea rarely occurs, and, at least on some western juniper/big sagebrush habitat types of eastern Oregon, the species tends to increase when other species receive excessive use (Ferguson 1983; Hopkins and Kovalchik 1983). Rockspirea thrives on dry slopes and unstable hillsides. It has high potential for use in revegetating disturbed sites (Johnston 1987; Stark 1966).

Seeding practices and propagation of nursery stock are as described for oceanspray. Plants are occasionally planted as ornamentals because of their long flowering period, attractive foliage, and compact growth habit (Stark 1966; Sutton and Johnson 1974). Use of the species to date has been seriously limited by a lack of commercially available seed.

Management of the species is also as described for creambush oceanspray. Little is known of the plant's regenerative ability following use, fire, or other physical damage (McMurray 1987a). Sprouting capabilities have not been well documented. Some regeneration might occur from wind-dispersed seed or from soil seed banks.

Varieties and Ecotypes

There are no releases.

Peraphyllum ramosissimum

Indian apple

Indian apple is a deciduous rounded shrub growing to 6 ft (2 m) in height from numerous, gray-barked basal stems (fig. 14). Fascicles of simple, nearly sessile oblanceolate leaves 0.6 to 0.8 inch (15 to 20 mm) long, and 0.2 to 0.4 inch (5 to 9 mm) wide are produced at the ends of short lateral spurs of the season. Leaves are glabrous above with a minute pubescence below. Perfect, 5-merous, epigynous flowers appear with the leaves, singly or in clusters of two to five. Leaves may be dropped in midsummer, possibly in response to water or temperature stress. Flowers are regular, perfect, and fragrant with spreading pink to rose petals. The style and the 15 or more stamens inserted on the edge of the hypanthium are exserted at anthesis. Fruit is a yellowish, bitter tasting, apple-like pome, 0.5 inch (12 mm) in diameter containing four seeds. In Utah, Indian apple flowers from April to July. Fruits ripen and are gravity or animal dispersed in July or August (Hitchcock and others 1961; Welsh and others 1987).

Ecological Relationships and Distribution

Peraphyllum is a monotypic genus of the subfamily Pomoideae distributed from southern and eastern Oregon along the east side of the Sierra Nevadas through central California and east to western Colorado and northwestern New Mexico at elevations ranging from 3,000 to 9,000 ft (900 to 2,700 m) (Dayton 1931; Ferguson 1983). It grows from the sagebrush/grass, pinyon-juniper, mountain brush, and oak/sagebrush zones to the lower fringes of ponderosa pine forests

Figure 14—Indian apple is an intricately branched shrub with potential for use in low maintenance landscaping.

(Hitchcock and others 1961; Welsh 1982). Chromosome number is n = 17 (McArthur and Sanderson 1985). Historically, Indian apple appeared in the Conifer Woodland Element of central Nevada's Upper Miocene floras in an area where the Arcto-and Madro-Tertiary floras overlapped (Axelrod 1950).

Plant Culture

Seed is harvested by hand picking or beating the fruits into containers. Fresh or dry fruits are macerated in a Dybvig or blender with water. Pulp that cannot be separated by flotation may be removed from the seed by fanning after the pulp is dried. Approximately 6.5 to 10.3 lb (2.9 to 4.6 kg) of cleaned seed may be obtained from 100 lb (45 kg) of fruit (Swingle 1939). There are approximately 23,000 seeds per lb (50,706 per kg) at 100 percent purity. Acceptable purity is 95 percent and germination is 50 percent for seed purchases (see chapter 24).

Seed requires a wet prechilling period of approximately 45 days at 38 °F (3 °C) to relieve dormancy (Belcher 1985; SEAM 1976; Smith 1974b). Germination of seedlots tested by the Coeur d'Alene Forest Service Nursery ranged from 60 to 80 percent (SEAM 1976). Seed testing techniques have been described by Belcher (1985). Seeds remain viable for up to 5 years if stored in a cool, dry, well ventilated container (Smith 1974).

The existence of distinct ecotypes, possibly restricted to specific soil types, makes selection of appropriate seed sources important. Seed should be fall planted on medium textured, well-drained soils in adapted areas (Stark 1966). Seeding may be accomplished by hand planting or drilling with other shrubs, but separately from grass and forb species. Little seed is available commercially; production of bareroot or container planting stock may maximize the number of seedlings obtained (Ferguson 1983).

Uses and Management

The forage value of Indian apple varies with accession and associated plant species. It is grazed by deer, particularly in fall. The fruits are used by birds and rodents. Indian apple can be incorporated into windbreak and conservation plantings on arid lands. The thick branching habit of the shrub offers cover for birds and other small animals in winter, even after the leaves have fallen. It also has potential for landscaping in arid areas, along roadways, and in recreation areas (Monsen and Davis 1985). It increases diversity on adapted sites. Indian apple is highly persistent once established, leading Blauer and others (1975) to suggest that it be used as a rootstock for related, but less tenacious species.

Initial survival of Indian apple plantings is often quite low. Seedlings grow slowly and may require protection for up to 3 years following planting. Indian apple may be entirely defoliated by grasshoppers when their populations are high. However, plants can recover even after successive defoliations.

Varieties and Ecotypes

Indian apple accessions have received little testing. When selecting ecotypes for revegetation, emphasis should be placed on plant size, fruit production, growth rate, and palatability.

Physocarpus malvaceous

Mallowleaf Ninebark

Mallowleaf ninebark is an open, multiple-stemmed shrub 3 to 8 ft (1 to 2.5 m) tall (fig. 15) that spreads vegetatively from long rhizomes (Hitchcock and others 1961; Welsh and other 1987). Roots are shallow and spreading. Bark is gray to red brown, shredding in thin layers. Leaves are alternate and currant- or mallow-like with three to five palmate lobes. Leaves are doubly crenate, nearly glabrous above, stellate pubescent to glabous below, and about 0.75 to 3.2 inches (2.0 to 8.0 cm) long. Clusters of stellate white flowers develop on the terminal corymbs. Flowers are regular and perigynous. Fruits are paired, densely stellate, flattened follicles with ascending beaks that dehisce along two sutures. Each follicle contains 1 to several tiny, hard, shiny, pyramiform seed each about 0.1 inch (2 mm) long (Gill and Pogge 1974a). Mallowleaf ninebark flowers in May or June and sets seed in August or September. Some fruits persist on the plant through the winter.

Figure 15—Mallowleaf ninebark grows rapidly; its dense root systems stabilize soil on unstable disturbances.

Like other shrubby members of the subfamily Spiraeoideae native to western North America, the chromosome number for mallowleaf ninebark is n = 9 (McArthur and Sanderson 1985). Species with n = 7 and n = 9 occur among Asian taxa of the genus (McArthur and others 1983b).

Ecological Relationships and Distribution

Mallowleaf ninebark occurs east of the Cascades from British Columbia and Alberta south through Nevada, Utah, and Wyoming. It grows in association with mountain big sagebrush, aspen, and many conifer communities at elevations from 5,200 to 10,800 ft (1,560 to 3,240 m) (Welsh 1982). It may be found on dry open slopes, talus slopes, northern exposures, in scattered to heavy timber, and on riparian sites (Davis 1952). Mallowleaf ninebark is adapted to deep, well-drained organic soils of medium texture and pH of 7.0 to 7.5 (Marchant and Sherlock 1984), but it will grow on drier, sandy or rocky soils (Daubenmire and Daubenmire 1968; Ferguson 1983). It is often abundant and highly productive.

Mallowleaf ninebark is frequently a member of seral shrub communities that develop following logging or wildfires in conifer forests (Olsen and Nagle 1965; Owens 1982). The species is highly adapted to fire; it resprouts from the root crown or horizontal rhizomes. The more completely buried rhizomes have the greatest resprouting capacity (Bradley 1984). Owens (1982) and Merrill (1982) found that number of plants and twig production increased on burned sites relative to unburned sites. In addition, recovery is enhanced by arrival of seed from undisturbed sites. The light seed is dispersed over long distances by wind and gravity (Young 1983).

Seral shrub communities provide forage and cover for deer, elk, and other wildlife, but rapidly grow out of reach of browsing animals. Overmature brushfields have been rejuvenated by prescribed burning, cutting, or topkilling tall shrubs with herbicides (Merrill 1982; Mueggler 1966; Orme and Leege 1980). Control of brush species to promote conifer regeneration has also been accomplished with herbicides (Miller 1981; Miller and Pope 1982a,b).

In addition to mallowleaf ninebark, several other ninebark species occur within the Intermountain region. Dwarf ninebark occurs in pinyon-juniper and related habitats of Idaho, Nevada, Colorado, and Utah. Mountain ninebark is found on moist soils of aspen and coniferous forests from Nevada east to Wyoming and south to Arizona and New Mexico. Pacific ninebark also grows on moist soils, but is restricted to California and the area west of the Cascades in Oregon and Washington. A disjunct population occurs in northern Idaho (Ferguson 1983; Hitchcock and others 1961).

Plant Culture

Mallowleaf Ninebark seed are hand collected by detaching the dried flower heads (Van Dersal 1938). Seed is separated from debris using a barley debearder and an air screen fanning machine. There are approximately 756,000 seed per lb (1,666,700 per kg). Acceptable purity for seed purchases is 98 percent and germination 40 percent (see chapter 24). Seed is expensive and rarely available. Little is known of the seed biology of this species. A high percentage of the tiny seeds are normally not sound. Sound seeds are dormant and require a 77-day prechilling at 40 to 43 °F (4 to 6 °C) (Gill and Pogge 1974a; Marchant and Sherlock 1984).

Direct seeding is accomplished by broadcasting seed onto a rough seedbed in fall and allowing natural soil sloughing to cover it. Best results are obtained when seed is planted separately from other species in selected spots. Seedlings can establish with some shade and limited herbaceous competition.

For bareroot nursery plantings, mallowleaf ninebark is fall seeded or artificially wet prechilled and spring seeded. Seed should be covered lightly and mulched. Swingle (1939) estimated that a pound of seed would yield about 30,000 usable seedlings. Seedlings are lifted as 1-0 to 2-0 stock depending on purchase specifications and growing conditions. Container stock may be propagated from germinants or cuttings. Hardwood stem cuttings are easily propagated and frequently used. Container and bareroot stock develop slowly, producing densely branched root systems. Both container and bareroot seedlings establish readily (Monsen n.d.).

Uses and Management

The value of mallowleaf ninebark as a forage plant varies with season, location, class of game or livestock being considered, and availability of other vegetation. It is generally considered to be more valuable on ranges where better forage plants are depleted or unavailable, and on drier sites (Noste and Bushey 1987). Stands are rarely lost as a result of browsing. The USDA Forest Service (1937) rated mallowleaf ninebark as fair for sheep, fairly good for goats, and poor for cattle; Van Dersal (1938) rated it as good browse for sheep, goats, and cattle. Kufeld and others (1973) reported it receives light spring use and moderate summer and fall use by mule deer. In cafeteria style feeding trials with tame mule deer, Smith (1953) found mallowleaf ninebark was one of the most highly preferred native forages in the Logan, UT, area from May 1 to June 20. Because of its deciduous habit, it is of little value on winter ranges. New growth is more heavily browsed by deer for up to 3 years following burning (Noste and Bushey 1987).

Mallowleaf ninebark has potential value as an erosion control plant. It grows rapidly, producing a network of rhizomes and a densely branched fibrous root system. It is a useful species for the restoration of high elevation acid minespoils in Nevada (Butterfield and Tueller 1980; Everett and others 1980). In spite of its rapid growth rate, mallowleaf ninebark receives little use in windbreak and farmstead plantings because of its bushy growth habit (Olsen and Nagle 1965). Mallowleaf ninebark has gained acceptance as an ornamental in some areas. It is a hardy, easily grown plant with attractive white flowers and dull to bright reddish brown leaf coloration (Gill and Pogge 1974a; Sutton and Johnson 1974). Plants that become too bushy can be pruned back.

Once established, seedlings of mallowleaf ninebark grow rapidly compared to those of many other members of the Rosaceae. They compete successfully with other shrub species, but require some protection from grass competition for one or two growing seasons. Seedlings are not browsed heavily if alternative forage is available, but they may suffer predation by rodents and trampling by big game and livestock.

Potentilla fruticosa

Shrubby Cinquefoil

Shrubby cinquefoil, also known as bush cinquefoil, buckbrush, hardhack, ninebark, or yellow rose, is a rather short lived, densely branched, round-topped to low spreading shrub with spreading and fibrous roots. It produces white to bright yellow flowers throughout the summer, when adequate soil water is available (fig. 16) (USDA Forest Service 1937). The shreddy brown bark of the main stems peels off in long strips. Leaves are pale to gray-green, leathery, 0.4 to 1.2 inch (1 to 3 cm) long, and pinnately compound with five to seven narrow, often revolute, leaflets. Leaves turn yellow in fall, but may be retained over winter. Flowers are 5-merous, complete, and solitary or in three to seven-flowered cymes. Each flower is 0.75 to 1 inch (2 to 2.5 cm) in diameter with a saucer-shaped hypanthium and five petals. There are 10 to 30 stamens and numerous pistils. Fruits are golden tan, teardrop-shaped achenes crowded on a hairy receptacle. Individual achenes are 0.04 to 0.08 inch (1 to 2 mm) long with very thin seed coats covered with white hairs. Fruits mature and are dispersed continuously by wind and gravity throughout the flowering season (Hitchcock and others 1961). However, in Alberta, Canada, flowering apparently occurs in two flushes, one in May and the other in August (Scotter 1975). Fruits mature in mid to late summer and fall.

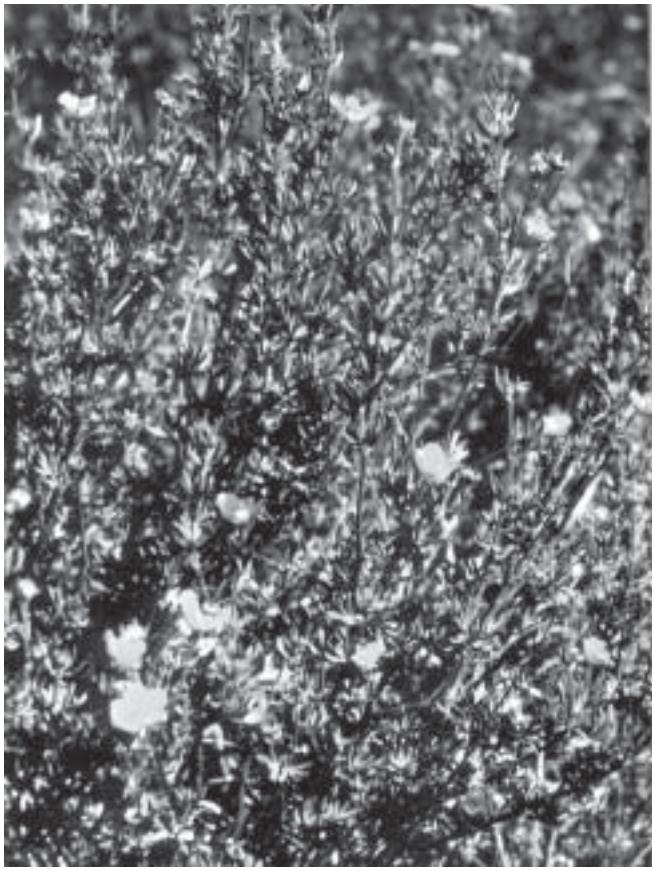


Figure 16—Shrubby cinquefoil is a common riparian species in wet meadows at mid to upper elevations.

Ecological Relationships and Distribution

There are about 250 species of *Potentilla* occurring in temperate to subarctic regions of the Northern Hemisphere (Young and Young 1986). Shrubby cinquefoil is widely distributed in the Northern Hemisphere, ranging east from Alaska's north slope to Greenland and Labrador and south to California, New Mexico, Minnesota, and New Jersey. It also grows in Europe and Asia (Hitchcock and Cronquist 1973; USDA Forest Service 1937). In common with several mesic shrubby North American members of the subfamily Rosoideae, the diploid chromosome number of shrubby cinquefoil is 2n = 14 (McArthur and Sanderson 1985); that of European plants is 2n = 28 (Elkington and Woodell 1963). Hitchcock and others (1961) reported hybridization occurs within this genus, but hybridization of shrubby cinquefoil with other species has not been observed (Elkington and Woodell 1963).

Shrubby cinquefoil is associated with cool climates and wet areas; it grows from plains and lower foothills to above timberline over an elevation range of 6,100 to 12,000 ft (1,850 to 3,600 m) (Belcher 1985). In the western United States shrubby cinquefoil is a common summer range plant in wet subalpine meadows. It also grows near springs and marshes and along streambanks and floodplains in chaparral, sagebrush, aspen/lodgepole pine, ponderosa pine, Douglas-fir/white

fir, and spruce/fir forests (Sutton and Johnson 1974; Welsh 1982; Welsh and others 1987). It is most abundant on areas with deep, wet, medium-textured soils and can withstand some salinity (Davis 1952; Stark 1966).

The response of shrubby cinquefoil to burning depends on the season, site conditions, and fire intensity, and may vary among populations. Plants may be relatively unaffected to heavily impacted by burning (Fischer and Clayton 1983; Mueggler and Stewart 1980). Little damage is incurred by low intensity spring burns that fail to kill the root crown (Wasser 1982), particularly on wet or rocky sites. Plants regenerate rapidly by sprouting from root crowns, rhizomes, and stem layering (Wasser 1982). Severe burns occur when dense mature stands burn in late summer, particularly under droughty conditions. Some soil seed reserves may also be lost under such circumstances with the result that recovery occurs very slowly.

Plant Culture

Seed collection is difficult. Fruits are scattered over the crown of the plant and ripen unevenly during the growing season. Plants are not shade tolerant and produce little seed when shaded (Scotter 1975). Little seed is mature at any given time and hand collection proceeds slowly. Consequently, seed is rarely available commercially (Ferguson 1983). Seed is cleaned with a debearder and fanning mill. It may be stored in a warehouse for 5 years. Seventy percent is considered an acceptable level for both purity and germination for seed purchases (see chapter 24). Seed quality is highly variable, but often rather low (Elkington and Woodell 1963; Wasser 1982).

Little information is available regarding germination requirements of shrubby cinquefoil seed. Vories (1981) reported the species is difficult to grow from seed. Belcher (1985) and SEAM (1976) found no germination pretreatment was required although a water soak at 86 °F (30 °C) for 18 hours did enhance germination. McDonough (1969) applied an 11-minute soak in sulfuric acid and obtained 73 to 87 percent germination at 90/72, 72/63, and 63/53 °F (32/22, 22/17, and 17/12 °C). Light is required during incubation (Young and Young 1986). Tetrazolium and x-ray testing instructions were provided by Belcher (1985).

Direct seeding information is scarce, but seeding can be successful on sites with good soil water. Babb (1959) recommended planting as soon as seed ripens. Planting before mid-July or in late fall was recommended by Wasser (1982). Seeding may be accomplished by drilling, broadcasting, or spot seeding on prepared sites (Wasser 1982). Seeds are small and should be covered lightly, about 0.25 inches (6 mm) deep or less (Wasser 1982).

Bareroot and container stock can be produced from seed. Container stock started from germinants or small transplants requires a 3 to 5 month cropping season (Landis and Simonich 1984). Wildings are an alternative source of planting stock.

Production of shrubby cinquefoil for the commercial ornamental market generally involves vegetative propagation of horticultural varieties. Plants are capable of natural root sprouting following disturbances (Wasser 1982). Stem layering also occurs and may be effective in spread and survival where inundation occurs (Elkington and Woodell 1963). Vegetative propagation is accomplished by rooting softwood or semihardwood stem cuttings in a greenhouse. Root cuttings, layers, and crown divisions are also propagated (Doran 1957; Mahlstede and Haber 1957; Toogood 1980).

Uses and Management

Shrubby cinquefoil is an indicator of heavy grazing; it may become more abundant when other species are depleted. It is outcompeted by grasses and declines if grazing is eliminated. Although its palatability is often low due to its coarse, astringent foliage (Dayton 1931), game and livestock will use shrubby cinquefoil when other species are not available (Wasser 1982). Young plants are generally more palatable than mature shrubs (Wasser 1982). In general, it is more palatable to sheep and goats than to cattle and horses (Sampson and Jesperson 1963). Because of its higher elevational distribution, it normally occurs on summer ranges, but where available in winter, it is sometimes used because of its semi-evergreen habit and dominance in some areas (USDA Forest Service 1937).

Kufeld and others (1973) found mule deer make light use of shrubby cinquefoil in winter and take only trace amounts in spring and summer. Elk and white-tailed deer make some use of the plant during all seasons. Bighorn sheep use it primarily in autumn (Van Dyke and others 1983). Seeds are consumed by birds and small mammals (Wasser 1982). Palatability of shrubby cinquefoil varies geographically and seasonally. It is generally more palatable in spring and summer (Plummer and others 1968). Although it is avoided by big game in Alberta, it is unusually palatable in parts of Montana and Arizona. Livestock also make greater use of it on scattered high altitude summer ranges of the southwestern states, southwestern Montana, southeast Idaho, and Utah (Dayton 1931; Ferguson 1983; USDA Forest Service 1937). Plants are moderately tolerant of browsing, but they can be damaged by repeated grazing, particularly during periods of drought when plants may become hedged and stunted and eventually lost (USDA Forest Service 1937; Wasser 1982).

Whether transplanted or grown from seed, shrubby cinquefoil is a useful soil stabilization species for disturbed sites with fairly wet soils. It is useful for mine reclamation, roadway plantings, and game range rehabilitation (Dittberner and Olsen 1983; Fedkenheuer and others 1980; Ferguson and Frischknecht 1985; Stark 1966; Wasser 1982). It is an excellent species for ornamental plantings because of its rapid growth rate, ease of cultivation, attractive semi-evergreen leaves, colorful flowers, and long flowering period.

Although shrubby cinquefoil seedlings have been described as weak, they begin to grow rapidly once established and are better able to survive herbaceous competition than most other rose species. Plants are cold, but not drought tolerant (Sutton and Johnson 1974). If planted in areas not heavily grazed by game or livestock, they develop to maturity in about 5 years (Wasser 1982).

Varieties and Ecotypes

Considerable natural variability has been observed in this species. Numerous ornamental varieties of shrubby cinquefoil are marketed commercially. However, the species has received little testing for wildland uses. Populations with a rapid growth rate, spreading growth habit, and low palatability should be of greatest value for soil stabilization and streambank erosion control. Numerous showy flowers, a long flowering period, low palatability, and evergreen leaves are desirable characteristics for populations used for landscaping in recreation areas.

Prunus americana

American Plum

American or Pottawatami plum is an erect shrub or rarely a small tree. In the Great Plains it grows from 9 to 26 ft (3 to 8 m) in height (fig. 17) (Harrington 1964; Hitchcock and others 1961). In Utah plants are thicket-forming shrubs up to 16 ft (5 m) tall (Welsh and others 1987). Regeneration by rhizome sprouting is the main method of spread (McMurray 1987b; Welsh and others 1987). Branches are thornlike at the tip. Leaves are 1 to 2.8 inches (2.5 to 7 cm) long, elliptic to ovate or lanceolate and sharply long attenuate. They have pubescent, glandular petioles. Small umbels of white flowers are borne before the leaves on spur branchlets or axillary buds formed the previous season. Fruits are fleshy yellow to red drupes 0.8 inch (2 cm) in diameter, each with a single large stone. Some fruits may be hard and dry (Welsh and others 1987). Seed are dispersed by gravity and frugivorous mammals.

Plant Culture

American plum ranges from Manitoba through northeastern Canada and south to New Mexico and northwestern Florida (Grisez 1974; Hitchcock and Cronquist 1961). It occurs in the Rocky Mountain region and has been introduced into portions of the Intermountain area west of its native range. It will grow on deep soils in mountain brush, pinyon-juniper, and sagebrush grass habitat types receiving at least 16 inches (40 cm) of annual precipitation (Plummer and others 1968; Thornburg 1982). Within its native range it is often a climax dominant or codominant, but it may be an early seral species in some forested habitat types (Elkington and Woodell 1963). It acts as a colonizer on unstable sites along streams or rivers (Elkington and Woodell 1963; Mueggler and Stewart 1980). Where introduced in the Intermountain region, it often grows in sandy to loamy soils along ditch banks, drainage areas, and around home or farm buildings where supplemental water is available. Plants are capable of withstanding some salinity.

American plum does not establish well from direct seeding. However, it can be established from bareroot or container stock transplanted singly or in rows or clusters to meet planting objectives. Rootstocks are utilized for propagation of domestic plum in northern climates (Grisez 1974). American plum grows well in mixtures with other woody species. Herbs with some shade tolerance do well as understory species.

American plum will sprout when burned, trampled, or otherwise damaged. Spread also occurs from seed transported by animals. The species has good drought and excellent cold tolerance.

Figure 17—In the Intermountain area, American plum is a thicket-forming shrub that spreads from rhizomes.

Ecological Relationships and Distribution

American plum flowers in April or May and fruits ripen in September or October (Grisez 1974; Plummer and others 1968). Fruits are harvested, conditioned, and stored as described for common chokecherry. Seed requires a 60 to 150 day wet prechilling to relieve dormancy (Grisez 1974). There are about 810 seed per lb (1,786 per kg) at 100 percent purity. Acceptable purity is 98 percent and germination 70 percent for seed purchases (see chapter 24).

Uses and Management

American plum has been planted for many years in conservation plantings, windbreaks, and shelterbelts in the Midwest and Western States. It provides excellent escape, nesting, thermal, and travel cover for big game, livestock, and small mammals and birds. Leaves, twigs, and fruit are utilized by these animals.

American plum can be an important component of erosion control plantings and low maintenance landscape projects. It has excellent potential for use in recreation areas, roadside rest areas, roadways, and administrative sites. It is also used as an aesthetic screen for wildlife in areas requiring thermal and concealment cover.

Varieties and Ecotypes

A number of American plum cultivars have been selected, primarily for their fruiting characteristics. There are no selections specifically developed for wildland use. Available material varies considerably in its range of adaptability and suckering habit. Stock adapted to the planting site and suitable for the planting goals should be acquired.

Prunus andersonii

Desert Almond or Anderson Peachbrush

Mozingo (1987) described desert almond as "one of the most beautiful and probably the most unappreciated shrubs in the western Great Basin." Also known as desert peach, Anderson almond, or Nevada wild almond; desert almond generally occurs as low growing, densely shrubby, clonal plants. Each clone may cover several acres. Individual stems are evidently short lived, usually producing 6 to 8 annual rings (Kay and others 1977f; Young and Evans 1973, 1974). The plants have an average height of about 3 ft (1 m), but range from 1.5 to 6.5 ft (0.5 to 2 m) in height (fig. 18). They are intricately branched and densely thorny; each branch ends in a sharp spine. Narrow leaves develop in fascicles on short, lateral branches. Small pink to light red flowers appear in April to June and cover the shrub. The flowering period for separate clones within an area may vary by up to a month, ensuring that some flowers and fruits will survive late frosts (Kay and others 1977e). Fruits ripen in June or July. The drupes resemble small, dry, fuzzy greenish-orange peaches and have a thin, rather dry fleshy layer. The thick hard coat of the stone opens easily along one suture (Mozingo 1987). Fruits and seeds are dispersed by gravity and wildlife.

Figure 18—Desert almond is a clonal shrub valuable for soil stabilization, cover, and as a low water-use ornamental.

Ecological Relationships and Distribution

The native range of desert almond extends from northeastern California southward along the eastern slopes of the Sierra Nevada Mountains and eastward across western and southern Nevada at elevations from 3,450 to 7,400 ft (1,050 to 2,250 m) (Ferguson 1983; Munz and Keck 1959; Young and Evans 1973). It is a fairly drought tolerant species, most commonly found scattered through big sagebrush and pinyon-juniper communities on foothills, mesas, alluvial terraces, and in canyons. It is especially common on coarse sandy or gravelly to rocky soil derived from decomposing granite (Dayton 1931; Smith and others 1978).

Plant Culture

Seedling establishment apparently occurs only infrequently. Seedlings have been noted following removal of woody species in sagebrush/grass and pinyon-juniper sites (Young and Evans 1973, 1974); they develop from soil seedbanks or from off-site seed transported by mammals (McMurray 1987c). Plants resprout vigorously following fire (Young and Evans 1978b). Clones may survive into later seral stages of the community; maximum occurrence is on old burns that have reached mid-successional stages (Koniak 1985).

Fruits are hand collected. Conditioning involves macerating the fruits in a Dybvig or blender and floating the pulp. To relieve dormancy, Kay and others (1977f) recommended a 30 day wet prechilling; 60 days were recommended by SEAM (1976). Seed should be fall planted to provide for field prechilling. Container and bareroot seedlings have been used successfully. Planting stock can also be propagated from cuttings, although the success rate may not be high. Everett and others (1978a) recommended use of cuttings collected during the period of seed maturation. Rooting required approximately 6 weeks under a greenhouse mist system.

Uses and Management

Desert almond has good potential for use as a soil stabilization species on disturbed sites due to its low, dense growth form, clonal habit, and good establishment. Everett (1980) obtained second year survival of 77 percent and 25 percent for containerized desert almond seedlings planted on south- and north-facing roadcuts, respectively, near Reno, NV. Seedlings were tenacious, but tended to grow slowly. Smith and others (1978) obtained 3-year survival of 73 percent when desert peachbrush seedlings grown in containers 1.5 ft long (0.5 m) were transplanted in holes drilled into granitic bedrock near Mammoth Lake, California. They recommended the species for granitic sites within its range.

Desert almond foliage is somewhat palatable, accessible, and probably seasonally important. Livestock and wildlife make some use of the species, particularly in spring or when summer storms induce new leaf production (Dayton 1931). The dense patches provide good cover for birds and other small animals. Desert almond has good potential as a low maintenance ornamental for roadsides, parks, and campgrounds because of its colorful flowers and long flowering period.

Varieties and Ecotypes

No improved varieties are available for revegetation projects. Some variability among clones has been noted, but comparative testing of different populations has been limited. Desert almond has been grown as far north as Boise, ID, (Monsen n.d.).

Prunus besseyi

Bessey Cherry

Bessey cherry or western sand cherry is a low-growing shrub with numerous spreading basal stems 1 to 5 ft (0.3 to 1.5 m) tall (fig. 19) (Vories 1981; Welsh 1982). Leaf blades are 0.6 to 2 inches (1.5 to 5.0 cm) long and 0.2 to 0.7 inch (5 to 18 mm) wide, elliptic to oblanceolate, and acute to cuspidate apically. Leaves, sepals, petals, hypanthia, and fruits are glabrous. White flowers appear with the leaves in clusters of two to four. The black fruits are 0.5 to 0.7 inch (12 to 18 mm) in diameter. Flowering occurs in April or May; fruit ripening and dispersal occur from July to September in Nebraska (Grisez 1974), and from August to September in Utah (Plummer and others 1968).

Ecological Relationships and Distribution

Bessey cherry is native to the Great Plains and is distributed from Manitoba south to Wyoming, Colorado, and Kansas (Grisez 1974). The species is commonly used as a dwarfing rootstock for other *Prunus* species. It has been introduced into the Intermountain region in wildlife and conservation plantings and by dispersal from orchards. Bessey cherry has been successfully established on sites ranging from basin big sagebrush communities to openings in ponderosa pine forests. Adkins (1980) reported survival in conservation plantings in eastern Washington was 28 percent in the 9 to 12 inch (23 to 30 cm) precipitation zone; survival ranged from 3 to 61 percent when plants were fully established. He concluded that in low precipitation areas Bessey cherry produced inadequate growth to provide good cover and was unable to compete successfully with cheatgrass and other annual and perennial weeds.

Figure 19—Native to the Great Plains, Bessey cherry has been used in wildlife and conservation plantings in the Intermountain region.

Plant Culture

Seed collection, conditioning, storage, and planting practices are generally as described for common chokecherry. Seed is often collected from stock maintained at a nursery or from conservation plantings. Swingle (1939) found an average of 17 lb (7.6 kg) of seed could be recovered from 100 lb (45 kg) of fruit yielding 1,500 to 2,260 clean seed per lb (3,300 to 4,980 per kg). Babb (1959) obtained greatest germination following a 100 day wet prechilling at 41 °F (5 °C) or 120 days at 33 °F (1 °C); he noted a high degree of variability in requirements among seedlots. A 72 hour gibberellic acid soak (3.46 g Rootone F/1000 g H_2O) followed by wet prechilling for 20 days at 41 °F (5 °C) was recommended by SEAM (1976).

Bessey cherry can be direct seeded. Seed should be fall planted 0.5 to 1.0 inch (1.0 to 2.5 cm) deep on seedbeds cleared of competition. The species can also be established from container or bareroot stock (Monsen 1974). It can be propagated from buds, grafts, suckers, or root cuttings (Babb 1959). For windbreaks or conservation plantings, a 4 ft (1.2 m) spacing is recommended (Cook 1981).

Uses and Management

Monsen (1974) and Monsen and Christensen (1975) recommended use of Bessey cherry to provide good ground cover and soil stabilization on adapted sites in Utah and Idaho. It has been used extensively in the Midwest as a low growing erosion control and wildlife plant; it provides fruits and cover for birds and other small animals. Attractive flowers, fall leaf coloration, and its low, spreading growth habit make Bessey cherry a unique plant for landscaping.

Rodents and birds often collect planted seed and emerging seedlings. Severe damage to planted Bessey cherry seedlings has resulted from rodent girdling (Brown and Martinsen 1959). Plants developing from seed or planting stock should be protected from excessive grazing and competition with grasses and forbs.

Varieties and Ecotypes

Some selections have been developed for horticultural plantings, but no specific material has been developed for wildland uses.

Prunus emarginata _____

Bitter Cherry

Hitchcock and others (1961) recognized two varieties of bitter cherry: *Prunus emarginata* var. *mollis*, an arborescent variety growing to 42 ft (15 m) in height and distributed west of the Cascade Mountains, and var. *emarginata*, a more shrubby form with an open growth habit and several crooked stems commonly 3 to 13 (26) ft (1 to 4 [8] m) tall that grows in and east of the Cascade Mountains (Hitchcock and others 1961). The deep reddish-purple bark on young twigs of both varieties turns gray to dark brown on older branches and stems. The entire, alternate leaves are 1.2 to 2 inches (3 to 5 cm) long, glabrous to pubescent, and oblong to obovate with crenulate to serrate margins. Stipules are caducous and attenuate to linear. Corymbs of 3 to 12 white insect-pollinated flowers (fig. 20) are produced from axillary buds on twigs of the previous season. Flowers are complete, regular, perigynous, and 5-merous. Sepals are produced on a turbinate, deciduous, disk-lined hypanthium that varies from glabrous to hairy. There are 12 to 20 exserted stamens and a single pistil. Only one of the two ovules develops. The fruit is a bitter tasting, red to black, one-seeded drupe from 0.3 to 0.5 inch (8 to 12 mm) in diameter. Bitter cherry flowers from April to June. Fruits ripen from July to September depending on elevation and local weather conditions (Grisez 1974; Plummer and others 1968). Fruits are dispersed in August or September. Seed are often distributed by birds and mammals.

Figure 20—Bitter cherry flowers from April to June, depending on elevation. Fruits are used by many birds and mammals.

Ecological Relationships and Distribution

Bitter cherry occurs from the Pacific Coast of British Columbia east to northern Montana, and south to southern California and southwestern New Mexico (Ferguson 1983; Hitchcock and others 1961). Its elevational range varies with latitude. In the north it grows from sea level to 3,000 ft (915 m); in the southwest it occurs from 5,000 to 9,000 ft (1,525 to 2,745 m) (USDA Forest Service 1937).

Bitter cherry is most frequently found in the upper portion of the ponderosa pine belt. It is frequently found on well drained, moderately fertile, rocky sites such as ridge tops and southwest slopes in mountain brush communities. It is capable of resprouting following burning and often dominates other shrubs in seral brushfields. Bitter cherry grows along watercourses in grasslands and sagebrush communities.

Plant Culture

To maximize the number of viable seed obtained, fruits should not be harvested until they are bright red and fully mature (Grisez 1974). Fruits are collected by hand stripping or by placing tarps under trees to catch them following natural dispersal. They may also be harvested with a mechanical tree shaker. Swingle (1939) reported that about 25 lb (11.4 kg) of seed can be obtained from 100 lb (45.5 kg) of fruit yielding 1,800 to 5,471 seeds per lb (3,965 to 12,050 per kg).

A Dybvig or commercial blender may be used to macerate the fruit. All pulp and juice should be cleaned from the stones. Part of the pulp and some low quality seeds can be removed from the mixture by flotation, the rest by drying and fanning. Dried fruits are cleaned by hammermilling at a low speed, followed by fanning. Specific storage requirements have not been ascertained for bitter cherry (Grisez 1974); seeds are commonly stored as described for common chokecherry.

Bitter cherry seed fill is generally low. Filled seeds are difficult to germinate. Treatments to increase germination give inconsistent and generally poor results. Germination of treated seed is generally less than 20 percent (Monsen and Davis 1985). Poor germination has discouraged use of this species in direct seedings. The species can be intertransplanted using bareroot or container seedlings on favorable sites. Seedlings grow remarkably well on dry and exposed sites with shallow soils where few other shrubs establish. Wildings and root cuttings are alternative methods of propagation.

Uses and Management

Bitter cherry is frequently planted to provide browse for wildlife and livestock. Elk, deer, and moose eat twigs and buds of plants growing on ridges and open slopes of winter ranges. The species is ranked as highly valuable for elk in summer and fall (Kufeld 1973). Mule deer use trace amounts in winter and make moderate use of the plant during other seasons (Kufeld and others 1973). Its palatability has been ranked as poor to fair for cattle and fair to fairly good for sheep. Major livestock use occurs primarily in late summer or fall when other vegetation is no longer available. In many areas dense thickets of bitter cherry grow out of reach of grazing animals, but provide good cover. Lower growing forms may be heavily browsed. Fruits are consumed by birds and mammals; rodents harvest the seed.

Bitter cherry may be planted on shallow soils of disturbed sites within its natural range to control erosion on roadways and other disturbances (Monsen and Davis 1985). Butterfield and Tueller (1980) and Everett and others (1980) concluded bitter cherry held considerable promise on acid mine spoils in Nevada. Establishment from seed or seedlings can be hindered by trampling and grazing; the seedlings develop slowly. Rodents consume seed and damage seedlings. Swihart and Yahner (1983) found rodents preferred *Prunus* species over the remaining 29 common windbreak and conservation species tested. For cottontails, *Prunus* fell into a neutral to preferred category. Seedlings develop slowly and must be protected from competition with more aggressive plants for up to 3 years following establishment.

Bitter cherry spreads by root sprouts; new shoots develop readily following burning. Leege and Hickey (1971), working near the Lochsa River of northern Idaho, found spring and fall burns increased bitter cherry sprouting about equally; mortality was slightly higher in fall than in spring. Spring burning was recommended for decreasing height of shrubs in seral brush fields and improving browse conditions for elk. Adequate regrowth occurred during the summer to provide fall forage.

Varieties and Ecotypes

There are no releases.

Prunus fasciculata

Desert Peachbrush

Desert peachbrush is a low growing, intricately and divaricately branched deciduous shrub with a rounded growth form (fig. 21). Shoots may attain heights of 5 ft (1.5 m) and diameters of 8 ft (2.4 m). Plants have a deep taproot as well as a spreading fibrous root system. They are not rhizomatous (Harrington 1964; Welsh and others 1987).

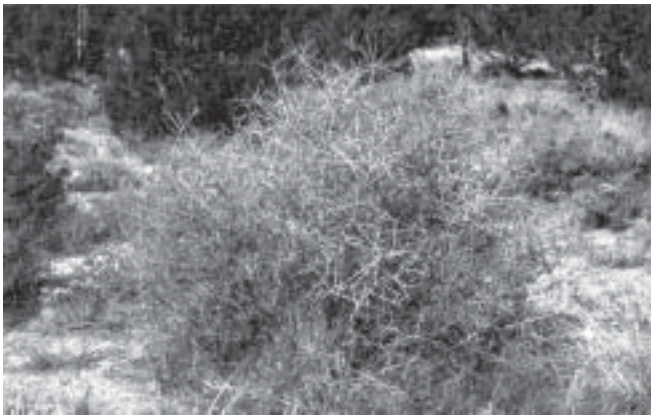


Figure 21—Desert peachbrush provides soil stabilization and cover for wildlife. Because of its unique branching habit, it has potential as a low maintenance ornamental.

Branches are grayish white, ending in pointed spines. The light green leaves are 0.1 to 0.2 inch (2.5 to 5 mm) long and 0.04 to 0.2 inch (1 to 5 mm) wide, cuneate to spatulate, and entire to few toothed at the apex. Flowers are small with five cream colored petals. Fruit is a pubescent greenish-orange drupe with a rather dry fleshy layer.

Ecological Relationships and Distribution

Desert peachbrush occurs in central and southern Nevada, southwestern California, and western Arizona on valley floors and foothills at elevations from 2,050 to 5,800 ft (625 to 1,770 m) (Ferguson 1983; Welsh and others 1987). Desert peachbrush occurs in association with chaparral, basin big sagebrush, Wyoming big sagebrush, sand sage, blackbrush, creosotebush, fourwing saltbush, quailbush, and lower pinyon-juniper communities. It can be found on well drained to heavy soils ranging from basic to neutral. Greatest area of occurrence is on sandy to rocky loam soils in depressions along drainage areas, intermittent streams, and creeks. Within these areas plants occur as individuals or more typically in small groups, usually with a rather sparse understory. Following fire, desert peachbrush sprouts readily and profusely from the root crown. Seed dispersal and seedling establishment may be heavily dependent on rodents that gather and cache seed.

Plant Culture

Harvestable seed crops are produced in about 1 of every 5 years. Fruits are gathered by hand stripping or by beating them into a container. The pulp attached to the stony endocarp is thin and dry and does need not be extracted. Leaves and sticks are separated by screening. Fruits are then dried and stored or seeded. There are about 4,500 seed per lb (9,900 per kg). Viability is generally good and is retained for 5 to 10 years of storage following harvest (Stevens and others 1981a). Seed retained in storage for 20 years exhibited fair viability. Acceptable germination for seed purchases is 90 percent and purity 70 percent (see chapter 24).

Seed can be drilled or broadcast and covered. It must be placed 0.5 to 1 inch (1.25 to 2.5 cm) deep in a firm seedbed. Fall or winter seeding provides the wet prechilling period required to relieve dormancy. A strong, fast growing seedling is produced and good establishment is common if soil water conditions are favorable. This species can also be propagated and outplanted quite easily as bareroot or container nursery stock (Monsen and Davis 1985). Considerable numbers of seedlings sometimes establish naturally from rodent caches.

Uses and Management

Desert peachbrush is generally seeded in a mix with other shrubs to improve diversity. California quail and Gambel quail, chukar, nongame birds, and small mammals use it extensively for cover, nesting, and forage. With the exception of pronghorn (Smith and Beale 1980), livestock and big game make little use of the species. Although the shrubs are sometimes infested with tent caterpillars, they persist in spite of defoliation.

Desert peachbrush establishes and does well when seeded on disturbed sites. Individual plants can cover large areas. Branches contact the soil surface over most of the area and provide considerable ground cover and soil protection. Perennial forbs and grasses emerge and develop beneath and adjacent to the crown. Desert peachbrush can establish on roadcuts and fills, in sand and gravel pits, and on mined areas. It also has ornamental potential, especially for low maintenance landscaping projects. The intricate branching pattern, grayish-white stems, and light green leaves give the plant a unique appearance.

Seeded plants should be given 2 to 3 years to establish and attain reasonable size prior to grazing. Once established, this species is very hardy and can withstand considerable use.

Desert peachbrush has performed well when planted on big sagebrush sites. It can be interseeded or intertransplanted in crested wheatgrass or native perennial herb seedings. Growth of established seedlings is not suppressed by annual grasses. Because of its ability to persist, even with wildfires and invasions of annual weeds, increased study and use of desert peachbrush to improve diversity of plantings on desert shrublands within its range are warranted.

Varieties and Ecotypes

There are no subspecies or released varieties of desert peachbrush. Little selection work has been attempted, but the species is being tested as a drought tolerant rootstock for other *Prunus* species (Welsh and others 1987).

Prunus spinosa and *Prunus tomentosa*

Blackthorn and Nanking Cherry

A number of introduced *Prunus* species from eastern Europe and Asia are adapted to mountain brush, upper pinyon-juniper, and big sagebrush communities of the Intermountain region. Blackthorn and Nanking cherry, both Asian species, have been successfully planted in the Intermountain West. Blackthorn grows to 13 ft (4 m) and Nanking cherry to 10 ft (3 m) in height (Grisez 1974). Flowers of both species are generally numerous and very showy. Blackthorn produces a fleshy, dark purple, glabrous fruit; fruits of Nanking cherry are semifleshy, light purple, and pubescent.

Both species have been used in shelterbelt, windbreak, and conservation plantings. They have high potential for use in and around recreational areas, administration sites, low maintenance landscaping projects, and on disturbed sites such as roadcuts and fills or mine disturbances.

Both species transplant very well. However, they are fairly difficult to establish from direct seeding. Fall planting is required as the seed require wet prechilling. Good diversity can be provided by including these species in mixtures with other shrubs. Grasses and forbs grow well in association with both species, but seedlings should be protected from herbaceous competition. They have excellent resistance to insects and grasshoppers, good cold tolerance, and are fairly drought tolerant. Livestock and big game make some use of twigs and leaves; fruits are taken by birds and rodents. Birds use these species for cover, nesting, and brood rearing.

Seed and bareroot or container stock of both species may be obtained from commercial nurseries in the Midwest and Intermountain regions.

Prunus virginiana

Chokecherry

Chokecherry is a thicket-forming shrub or small tree with several deep roots and a well-developed, fibrous root system (fig. 22). Plants develop rhizomes that are 0.4 to 0.6 inch (1 to 1.5 cm) in diameter and extend laterally about 3 ft (1 m) from the stems. New stems sprout from the rhizomes and the root crown. Leaves are alternate and elliptic, about 0.1 to 4 inches (2.5 to 10 cm) long and finely serrate along the edges (Welsh and others 1987). Purplish-red glands are usually found near the tip of the petiole or along the leaf base. The leaves are bright green above and paler beneath. They turn bright red in early autumn.

Elongate racemes of fragrant white flowers develop from April to June. Racemes are about 3 to 6 inches (8 to 15 cm) long. The insect-pollinated flowers are perfect; five petals spread from a gland-lined hypanthium. Only one of the two ovules normally develops. The fruits are red to purplish-black cherrylike drupes about 0.4 inch (1 cm) in diameter; each contains a single seed with a stony endocarp (Grisez 1974; Welsh and others 1987). Seeds ripen from July to September. Fruit production is greater during years of average or better rainfall and on plants growing in full sunlight.

Hitchcock and others (1961) recognized three varieties of chokecherry. Common chokecherry is a large shrub or small tree growing to 50 ft (15 m) in height with bright to deep red fruits. Black chokecherry is a small to medium sized shrub or small tree 13 (20) ft (4 [6] m) tall with dark, nearly black fruits and thick leaves. Western chokecherry ranges from 7 to 13 (20) ft (2 to 4 [6] m) tall with dark, nearly black fruits and thick leaves.

Ecological Relationships and Distribution

Chokecherry occurs primarily in central and eastern United States. It ranges from Saskatchewan to Newfoundland and south to Kansas and North Carolina (Hitchcock and others 1961; USDA Forest Service 1937). Black chokecherry is distributed from eastern British Columbia to the Dakotas and southward east of the Cascades from northern California to New Mexico. Western chokecherry occurs primarily

Figure 22—Chokecherry provides palatable and nutritious browse that is used by many wildlife species.

along the west coast from British Columbia south to California (Hitchcock and others 1961; Welsh and others 1987).

Chokecherry is distributed from low elevation foothills into mountainous areas at elevations from sea level to 9,000 ft (2,750 m) on sites with annual precipitation of 12 to 30 inches (305 to 760 mm) (Thornburg 1982; USDA Forest Service 1937). It is often associated with sagebrush, mountain brush, pinyon-juniper, and dry conifer types. It grows on moderately acidic to basic or saline soils with silty to sandy textures that are moderately deep, fertile, and usually well drained. Scattered plants or small clumps may be found on talus slopes and other rather dry sites; larger thickets develop along streams and around springs, ditches, or roadsides in semi-arid areas. In higher elevation communities, common chokecherry tends to occur on more open sites and along riparian areas. It is not adapted to high water tables or prolonged flooding (Wasser 1982).

Plant Culture

Chokecherry spreads by seed. It also spreads vegetatively from buds produced on rhizomes and the root crown. However, it is not commonly propagated by vegetative means. Leafy softwood cuttings can be rooted, but hardwood cuttings are not recommended (Hartmann and others 1990; Marchant and Sherlock 1984).

The drupes fall soon after reaching maturity (Grisez 1974). Birds and mammals harvest and spread the seed. Germinability may be increased after seeds have passed through their digestive tracts (Grisez 1974). Fruits are collected either by hand picking or beating them into a canvas or into a container. Seed harvested too early may have low germinability. If harvested too late, many seeds may already have fallen and others will split while being cleaned, leaving the embryo vulnerable to mechanical damage (Grisez 1974; Marchant and Sherlock 1984). Harvested fruits should not be exposed to heat as mold may develop, and viability may be reduced. Fruits are cleaned by macerating the fleshy material with a Dybvig cleaner and flushing with water to remove the flesh from the seed. This is followed by drying and further cleaning with a clipper cleaner. Fermentation may facilitate cleaning, but may adversely affect germination (Grisez 1974). There are about 4,100 cleaned seed per lb (9,020 per kg) (see chapter 24). For seed purchases, acceptable purity is 90 percent and germination 70 percent.

Seed may be sown immediately after cleaning without further drying. Short-term storage for a few months requires only air drying. Optimal long-term storage conditions have not been determined, but warm, humid conditions result in rapid deterioration of seed quality. On the other hand, excessive drying can also be harmful. Belcher (1985) and Marchant and Sherlock (1984) reported that air dried seed stored in sealed containers at 37 to 41 °F (3 to 5 °C) will remain viable for 3 to 5 years.

Chokecherry seeds generally have fairly high viability, but germination of untreated seed is generally quite low. About one-half of the viable seed will germinate in 69 days (Wasser 1982). Western chokecherry generally germinates more readily than black chokecherry (Monsen and Davis 1985). Wet prechilling can increase both the rate and percent of germination. Seed is wet prechilled at 36 to 41 °F (20 to 23 °C) for 120 to 180 days (Wasser 1982). Thoroughly soaking the seed prior to wet prechilling may improve effectiveness of the treatment. Wet prechilling is adequate if the stones have cracked, but the radicles have not yet emerged. The rate of radicle emergence is normally rather low, but can be further reduced, if necessary, by lowering the prechilling temperature once the stones have broken open (Grisez 1974; Wasser 1982). Fracturing the endocarp, boiling, freezing, and various chemical treatments have provided inconsistent results and are sometimes detrimental (Grisez 1974). The Association of Official Seed Analysts recommended a 60 to 90 day wet prechill period at 37 to 41 °F (3 to 5 °C) for testing germination (Belcher 1985). They also provided tetrazolium testing and radiographic procedures.

Nonprechilled seed must be fall seeded, but artificially prechilled seed may be planted in spring. Seed should be planted 0.5 to 1 inch (1.25 to 2.5 cm) deep in a firm seedbed. Seed can be drill seeded or metered through a seed dribbler mounted on a crawler tractor. The former method has provided excellent results (Stevens 1992). This species can be seeded individually or as a component of a mixture of other shrubs and nonaggressive forbs and grasses. Seedlings establish most successfully when planted on sites that receive at least 15 inches (38 cm) of annual precipitation (Monsen and Davis 1985). They have often been planted on drier sites with poor success. Seedlings of black and western chokecherry are not highly competitive, but become more so after 2 to 3 years (Monsen and Davis 1985; Plummer and others 1968; Thornburg 1982). Once the root system becomes well established, plants can exist with other woody species or herbaceous vegetation and can withstand considerable grazing.

Bareroot stock of all chokecherry species may be grown in the nursery. However, seed and new seedlings are often gathered by birds and small rodents. One growing season usually provides stock of adequate size for transplanting (Shaw 1984). Although initial growth of germinants is very rapid, the rate sometimes drops off considerably during the growing season; a 2 year cropping period is often necessary

(Marchant and Sherlock 1984). Bareroot seedlings have a strong taproot system. Rhizome and new shoot development are initiated early in the season, often prior to lifting. New growth can easily be damaged during lifting and planting, thus reducing the success of establishment (Monsen n.d.). Seed, germinants, or small transplants can be used to propagate container stock. Seedling development requires a 3 to 5 month cropping period (Landis and Simonich 1984).

Uses and Management

Chokecherry has been extensively used to improve wildlife habitat. Plants typically form relatively open thickets that allow livestock and big game access to abundant amounts of nutritious and palatable browse. Despite its deciduous nature, chokecherry maintains relatively high nutrient levels in late fall and winter (Dietz 1972). Chokecherry provides fairly palatable browse for big game and is widely utilized by elk, moose, and bighorn sheep (Plummer and others 1968); it is also the preferred deer browse on many winter ranges throughout the Intermountain west (Dietz 1972; Kufeld 1972; Kufeld and others 1973). Chokecherry receives its greatest use in spring and fall, but elk and deer use it to some extent year around. It is moderately palatable to all classes of livestock, although it seems to be more heavily browsed by sheep than cattle (USDA Forest Service 1937; Wasser 1982). Fruits are taken by birds, bear, and many small mammals (Aune and Stivers 1985; Blauer and others 1975; Gullion 1964; Noste and Bushey 1987; Wasser 1982). Plants are productive and withstand moderate use. However, repeated heavy browsing results in highlining, hedging, and lower availability of forage. New sprouts may be killed by trampling or browsing. Grazing does not affect the next year's fruit production; flowers are borne on twigs of the season.

Chokecherry may be toxic if consumed in large amounts; leaves contain the glucoside amygdalin (Noste and Bushey 1987). Young shoots contain the greatest concentrations. Most problems occur in spring and early summer. Following fall frosts, the plants become essentially harmless. Livestock are not likely to consume fatal amounts of chokecherry except in areas of animal concentration.

Chokecherry is extremely valuable for watershed and streambank stabilization, restoration of mine and roadway disturbances, landscape plantings in recreation areas, and increasing diversity in conservation and windbreak plantings (Ferguson 1983; Plummer and others 1968; Shaw and Cooper 1973; Wasser 1982).

All chokecherries are edible, but have an extremely sharp and biting flavor if eaten before fully ripe. The fruits make excellent wine, jellies, syrup, honey, flavorings, and perfume oil. Native Americans used the dried fruits to make pemmican cakes for winter use (Welsh and others 1987). Tea was prepared from the stems and bark (Craighead and others 1963).

All species of chokecherry are well adapted to fire, particularly if burned when dormant or when soil moisture is high (Anderson and Bailey 1980; Tisdale and Hironaka 1981; Young 1983). Although top growth is easily killed, vigorous sprouting from rhizomes or the root crown provides for rapid recovery following the initial decline (Leege and Hickey 1971; Noste and Bushey 1987). After the first postburn season, numbers of stems and coverage by the species can exceed preburn levels for a number of years. Although establishment from seed is quite rare on undisturbed sites, the species may be dependent on seedbanks for postfire regeneration, at least in riparian areas or higher elevation communities (Kramer 1984; Wright and others 1979; Young 1983).

Varieties and Ecotypes

There are no releases.

Purshia glandulosa

Desert Bitterbrush

Desert bitterbrush is an evergreen shrub resembling Stansbury cliffrose and frequently mistaken for it. Welch and others (1987) described desert bitterbrush as ranging from 5 to 9 ft (1.5 to 2.7 m) in height (fig. 23), generally upright, but sometimes low and

Figure 23—Desert bitterbrush is a stable hybrid derivative of Stansbury cliffrose and antelope bitterbrush.

spreading. Branchlets are prominently glandular. The glandular leaves are 0.1 to 0.4 inch (3 to 10 mm) long and up to 0.2 inch (5 mm) wide, cuneate, glabrous above, and slightly tomentose beneath. Petals are 0.2 to 0.3 inch (5 to 8 mm) long and creamy white to yellowish. Achenes are oblique and 0.8 inch (2 cm) long, including the elongate style. Glandular evergreen leaves and smaller, elongate achenes differentiate desert bitterbrush from antelope bitterbrush (fig. 24).

Ecological Relationships and Distribution

Desert bitterbrush is restricted to southern California, southern Nevada, southern Utah, and northern Arizona (Koehler and Smith 1981; McArthur and others 1983b; Nord 1965; Stutz and Thomas 1964). Koehler and Smith (1981) and Stutz and Thomas (1964) considered it to be a hybrid derivative of Stansbury cliffrose and antelope bitterbrush parentage that arose from hybridization and subsequent introgression between these two species (McArthur and others 1983b). This hybridization is a relatively recent development and populations remain genetically distinct. Welch and others (1987) transferred cliffrose, *Cowania*, to the genus *Purshia* because hybrids of cliffrose, antelope bitterbrush, and desert bitterbrush occur where the distribution of these species overlap.

In southern Utah, desert bitterbrush grows principally in the blackbrush type, and in pinyon-juniper extensions into this type, at elevations from 3,460 to 4,470 ft (1,055 to 1,363 m) (Welsh 1987). It is more common in southern Nevada and California than in Utah. It often occupies sites where cool and warm desert species interface and is often the dominant or codominant shrub when present.

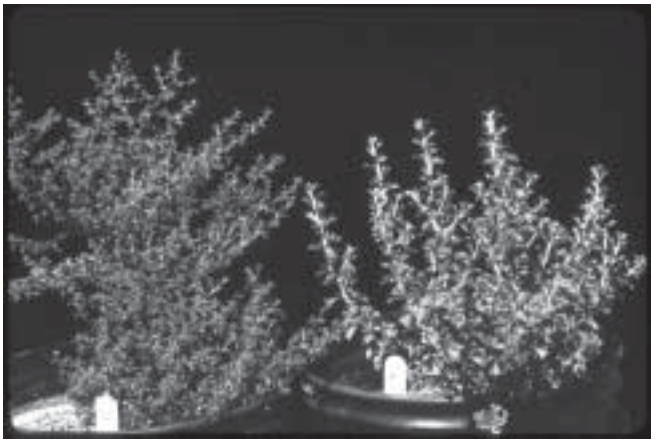


Figure 24—Desert bitterbrush, (left) is distinguished from antelope bitterbrush (right) by its glandular, evergreen leaves.

Plant Culture

Seed production, harvesting, conditioning, and storage are similar for desert and antelope bitterbrush (Deitschman and others 1974c; Giunta and others 1978). When ecotypes of both species are grown at common garden sites in Idaho and Utah, desert bitterbrush is normally smaller in stature than the erect antelope bitterbrush growth form. It produces less seed than antelope bitterbrush and good seed crops occur less frequently. There are approximately 21,000 seed per lb (46,200 per kg). Seed retain viability for up to 25 years when stored under warehouse conditions (Stevens and Jorgensen 1994). For seed purchases recommended purity is 95 percent and germination 90 percent (see chapter 24).

A high percentage of desert bitterbrush achenes fail to mature normally. Commercially harvestable seed crops are produced once in every 2 to 6 years at native collection sites. Consequently, it is necessary to harvest adequate quantities of achenes in good years to fill anticipated needs (Plummer and others 1968). Desert bitterbrush seed orchards have been established at various locations in Utah and Idaho in an attempt to develop more consistent seed production centers.

Germination requirements of desert and antelope bitterbrush are similar. Both require short periods of wet prechilling to release dormancy. Desert bitterbrush seedlings are more difficult to establish than those of antelope bitterbrush. They grow more slowly and attain maturity later when grown together in common gardens. Seedlings also grow more slowly under nursery conditions with regular irrigation. Because of its slow growth, desert bitterbrush is less competitive with annual weeds than antelope bitterbrush.

Direct comparison of establishment attributes between the two species of bitterbrush may create a somewhat distorted picture. It is adapted to more xeric sites and when planted in such areas can perform well. It usually grows in areas receiving less than 14 inches (36 cm) of annual precipitation. Artificial plantings on these sites are often unsuccessful; the precipitation received may be too low or erratic to permit establishment. However, desert bitterbrush seedlings are relatively hardy and can survive adverse weather conditions if they once establish. Rodents quickly gather planted desert bitterbrush seed. Consequently, planting in late fall or winter is advised to reduce seed predation. Seeding directly into a weedy understory should be avoided. Seedlings normally require 1 to 3 years to fully establish. Both bareroot and container grown seedlings establish well and can be used to provide more rapid establishment.

Uses and Management

To date, most plantings of desert bitterbrush have been made on upland pinyon-juniper sites where antelope bitterbrush is native (Davis 1983a). In general, antelope bitterbrush ecotypes respond better than desert bitterbrush at most of these planting sites. However, desert bitterbrush plants have established and persisted on antelope bitterbrush sites in central and northern Utah, southern Idaho, and south-central Idaho. Desert bitterbrush plantings have also been successfully established on pinyon-juniper/blackbrush sites in southern Utah (Davis 1983a). Desert bitterbrush exhibits important vegetative traits such as production of semi-evergreen leaves, ability to resprout following fire, and good drought tolerance.

Desert bitterbrush demonstrates adaptability to disturbances and can be used to seed infertile mine spoils and roadways in adapted areas. Welch and others (1983a) reported that it reduces soil erosion and provides habitat for game and non-game animals. Roots may form symbiotic nitrogen-fixing relationships with the endophyte *Frankia* (Nelson 1983). Once established, desert bitterbrush grows well with herbaceous understory plants and can be managed to provide seasonal herbage, particularly winter forage for big game and livestock. Welch and others (1983a) found desert bitterbrush plants in a southwestern Idaho common garden retained a significantly greater quantity of leaves in winter than collections of antelope bitterbrush and cliffrose. Crude protein content of the desert bitterbrush accessions exceeded that of the other two species. Palatability may be somewhat lower than that of antelope bitterbrush. However, where desert bitterbrush occurs, variety, quality, and quantity of other browse species are often low. As a result, considerable use is made of the species, particularly by deer and cattle. Its growth habit provides much needed shade and cover for small game and birds. Seeds are collected, eaten, and cached by rodents, birds, and reptiles. Insect populations associated with desert bitterbrush are often high, especially during flowering and seed set.

Varieties and Ecotypes

No selections of desert bitterbrush have been developed for release (Davis 1983a). Ecotypes vary in growth form from decumbent to upright. Populations or ecotypes having good drought tolerance (Davis 1983a), fire tolerance, winter leafiness (Welch and others 1983a), and nitrogen-fixation capabilities (Righetti and others 1983) have been identified. Because desert bitterbrush, antelope bitterbrush, and Stansbury cliffrose hybridize freely, it may be possible to combine desired attributes of these three species.

Purshia tridentata

Antelope Bitterbrush

Antelope bitterbrush is an intricately branched, deciduous shrub varying in growth habit from low decumbent spreading forms to upright arborescent plants over 13 ft (4 m) in height (fig. 25) (Blauer and others 1975; Welsh and others 1987). Leaves are alternate, simple, pinnatified or apically three-toothed and usually glandular. Flowers are borne on short spurs of previous year's growth. They are numerous, white to yellow, and about 0.3 inch (8 mm) in diameter (Harrington 1964; Munz and Keck 1959; Welsh and others 1987). The fruit is a cartilaginous achene 0.2 to 0.5 inch (6 to 12 mm) long (Young and Evans 1983) with a persistent tapering style and a black pyriform seed (Blauer and others 1975). Plants are reported to be long lived. Nord (1965) found the average age of decumbent plants growing above 8,000 ft (2,440 m) in northern California was 52 years; at

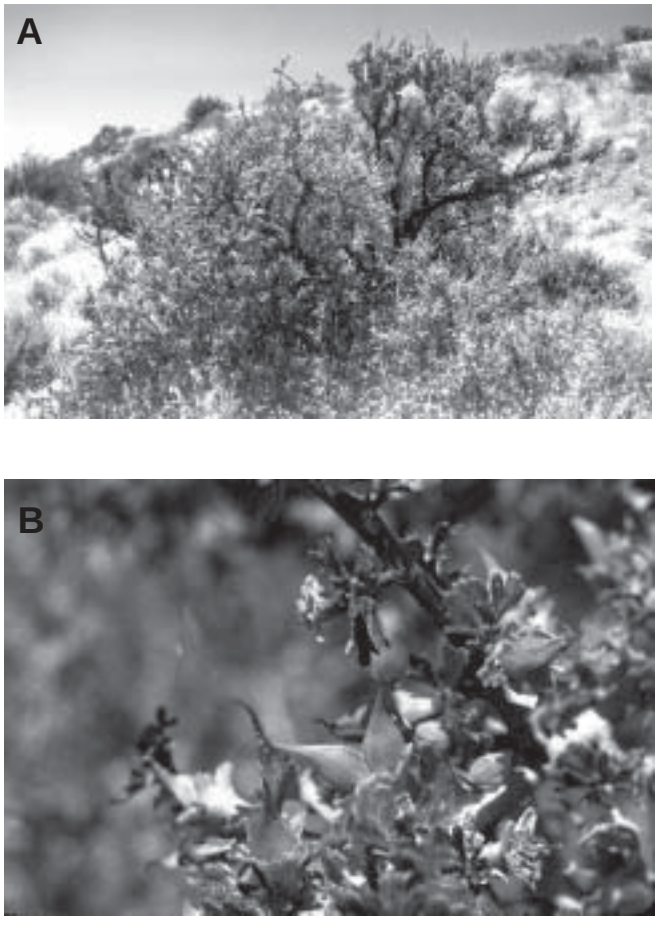


Figure 25—(A) Mature antelope bitterbrush plant and (B) fruit.

other locations the average age exceeded 150 years (Ferguson 1983a; Nord 1959).

Populations of antelope bitterbrush are extremely variable. Giunta and others (1978) described ecotypes with differing growth forms, fire tolerance, rates and periods of growth, seed production, drought resistance, nutritional qualities, heat tolerance, cold hardiness, climatic adaptation, resistance to disease or insect damage, palatability to game or livestock, evergreen habit, vegetative reproduction, and shade tolerance. Winward and Findley (1983) recognized similar variations in Oregon and California populations, but also noted marked differences in leaf size, shape, color, presence or absence of glands, flowering, and seed set. Many differences observed among populations are genetically influenced (Klemmedson and Ferguson 1969; Nord 1959a; Plummer and others 1968; Wagle and Vlamis 1961). Ecotypes maintain their native growth habits and morphological characteristic when planted over a wide range of sites. However, climatic and edaphic conditions alter growth response to some extent (Davis 1983a; Edgerton and others 1983; Nord 1965; Shaw and Monsen 1983a).

Ecological Relationships and Distribution

Cowania is derived from the neotropical Tertiary flora that emerged in the Sierra Madre region of Mexico during the Tertiary epoch (Axelrod 1958). McArthur and others (1983b) postulated that *Purshia* is an early derivative of *Cowania* that evolved in isolation. Chromosome number for both genera is n = 9 (Alderfer 1977; McArthur and others 1983b; Sanderson 1969). Present contacts between *Purshia* and *Cowania* are considered very recent; their partially separated flowering periods form a weak isolation barrier. Natural hybrids are found throughout most of Utah and Nevada where *Cowania* and *Purshia* overlap (Stutz and Thomas 1964). The hybrids backcross with the parental stock, producing genetic introgression in both genera. Introgression is considered to be the major process contributing to genetic differentiation of ecotypes (McArthur and others 1983b; Stebbins 1959; Stutz and Thomas 1964; Thomas 1957). Desert bitterbrush is a southern adaptive derivative resulting from this process. In addition, cliffrose characteristics are present in most populations of antelope bitterbrush that occur beyond the northern margins of cliffrose distribution (Stutz and Thomas 1964).

Antelope bitterbrush occurs from the Cascade Mountains eastward through the Rocky Mountains and from British Columbia south to Arizona and New Mexico (Ferguson 1983; Hitchcock and others 1961; Koehler and Smith 1981; McArthur and others 1983b; Stutz and Thomas 1964). It grows in big sagebrush, pinyon-juniper, and mountain brush communities and ponderosa pine forests. At lower elevations, in the southern portion of its range, it extends into blackbrush communities. It may also be encountered on high mountain exposures intermixed with aspen, limber pine, and Douglas-fir. It usually exists at elevations ranging from 200 ft (60 m) in the Pacific Northwest to 11,500 ft (3,510 m) in the Sierra Nevada Mountains in areas receiving 12 to 25 inches (30 to 64 cm) of annual precipitation (Nord 1965; Stanton 1959; Tew 1983).

Antelope bitterbrush is often a component of mixed shrub communities (Blaisdell 1953; Ferguson and Medin 1983; Holmgren and Basile 1956), and is frequently a dominant in the northwestern part of its range (Franklin and Dyrness 1973; Mueggler and Stewart 1980; Nord 1965). Prostrate and semi-erect growth forms of antelope bitterbrush occur most commonly as understory plants in forested communities or at high elevations (Nord 1965). Some low-growing types are also encountered at low elevations and under dry conditions, but the upright, tree-like forms usually dominate on more xeric sites (Nord 1965).

Some ecotypes are adapted to specific soil conditions. Prostrate growth forms occur on shallow, coarse textured soils in central Idaho, while tall, erect forms grow on deep productive soils where basin big sagebrush may also occur (Tew 1983a). Plummer and others (1968) reported that ecotypes from neutral or slightly acidic soils in Idaho are not adapted to calcareous soils of central Utah. Davis (1983a) found that only 24 of 259 accessions planted on pinyon-juniper sites in Utah scored performance index values that would recommend their use in these areas.

Antelope bitterbrush ecotypes vary in their response to burning. Adams (1980) suggested that antelope bitterbrush evolved as a fire climax. Edgerton (1983) reported rapid establishment of new seedlings following fire in ponderosa pine/antelope bitterbrush communities in the southern Cascade Mountains. Reestablishment from seed occurs erratically in response to climatic conditions and may be limited by grazing, rodent activity, presence of annual weeds, and other factors. Emergence from rodent caches is common in many areas.

Resprouting capabilities vary with ecotype. Some ecotypes in forested communities recover well by resprouting after burning (Martin 1983; Rice 1983; Sherman and Chilcote 1972; Zlatnik 1999). Driver and others (1980) found 100 percent resprouting of plants burned in a ponderosa pine/grass/antelope bitterbrush habitat type. Antelope bitterbrush plants recovered well from spring burning in ponderosa pine-antelope bitterbrush-pinegrass habitats, but little resprouting followed fall burning when soil moisture was low (Driver 1983).

Billings (1952), working in the western Great Basin, and Hormay (1943) in California found that antelope bitterbrush rarely resprouted following fire and suggested burning would permanently eradicate the species. Blaisdell (1953) found that not all plants growing on the Upper Snake River Plain in Idaho resprouted even after a light burn. Murray (1983) reexamined sites studied by Blaisdell and reported no antelope bitterbrush recovery 43 years after burning. Bunting (1985) and Bunting and others (1987) concluded that the columnar ecotypes growing in central Idaho do not recover from burning. At Wallsburg, UT, 80 to 90 percent of the antelope bitterbrush plants burned in a wildfire resprouted the first year following the fire. By the end of the third year mortality exceeded 90 percent. This pattern is commonly observed following wildfires in antelope bitterbrush stands in Idaho and Utah.

Plant Culture

Antelope bitterbrush was perhaps the first native shrub used for wildlife habitat and rangeland restoration in the Intermountain region. Since the early 1940s antelope bitterbrush has been seeded in many areas in the western United States. Holmgren and Basile (1956) reported that of approximately 50 species tested in Idaho, antelope bitterbrush was the easiest to establish from direct seeding.

Nord (1965) reported that young plants growing on native sites usually begin producing seed in about 10 years. By contrast, plants grown in cultivated nurseries, or in native stands managed for seed production, often begin producing seed when 2 to 4 years of age. Latitude, elevation, season, and site conditions influence vegetative phenology and the date of seed maturation (Nord 1965).

Leaf growth of antelope bitterbrush precedes the appearance of floral buds. At a common garden near Boise, ID, leaf growth of ecotypes from a wide geographic range was initiated between March 17 and 23 (Shaw and Monsen 1983b). Leaves reached mature size by about mid April when flower buds were beginning to develop. Leader growth of the different ecotypes was initiated during the first week of May, coinciding with anthesis. Most stem elongation occurred in June and early July. Stem growth rate diminished in July. Little elongation occurred in late summer or fall. All five ecotypes examined responded similarly.

Climatic conditions favorable to good seed production antedate the crop by at least 1 year; flower buds develop primarily on second year wood (Nord 1965). Plants that receive favorable moisture produce good leader growth and increased root reserves that support seed production the following year (McCarty and Price 1942) (fig. 25b).

Shaw and Monsen (1983b) reported that accessions of antelope bitterbrush growing in a common garden in southern Idaho set and matured seed in 42 to 48 days in 1979 and 57 to 60 days in 1980. Blaisdell (1958) found the period of flowering and seed maturation was slightly longer (66 days) at sites near Dubois, ID. Seed maturation dates can be predicted with reasonable accuracy. Nord (1965) developed an equation using elevation and latitude to predict mean dates of seed maturation for stands in California. Actual harvesting dates generally fell within 6 to 10 days of predicted dates.

Accurate determination of seed ripening dates is critical for commercial seed harvesters as seeds shatter quickly when mature. Achene development progresses through a number of recognizable stages. In southern Idaho developing achenes reach nearly mature size by mid June (Shaw and Monsen 1983b). During this period of rapid growth, the endosperm remains milky. About 10 to 16 days prior to maturation, the endosperm changes from white to dark red (blood stage). Achenes dry rapidly during the last 3 to 5 days of this period.

Achenes can wither and abort at any stage of development. Late frosts, poor or inadequate soil water, and insect damage are principal reasons for crop failure. Many failures occur during the "blood stage" just prior to achene maturation. Insects may destroy a large proportion of the seed crop (Basile and Ferguson 1964; Basile and others 1964; Ferguson 1967; Ferguson and others 1963; Furniss 1983; Furniss and Barr 1975). Shaw and Monsen (1983b) reported 50 to 60 percent of all flowers that initially appeared failed to develop a mature fruit in a southern Idaho seed orchard as a result of insect damage.

Prospective seed collection sites must be inspected frequently, particularly when seeds are in the blood stage to determine when and where harvestable crops will be available. Harvesting is accomplished by striking branches with a paddle to dislodge seeds into canvas or metal trays (Giunta and others 1978; Nord 1967). Most native sites produce 150 to 200 lb of seed per acre (168 to 224 kg per ha) although production may approach 500 lb per acre (560 kg per ha) (Nord 1965).

Few seed nurseries have been established on agricultural land. Cultivated plantings should be established on or near native sites. Plantings should be located in areas protected from high wind; flowers are cross pollinated by insects and seed shatter easily (Blauer and others 1975). In southern Idaho 6 to 10 year old plants of an upright ecotype planted at 6 ft (1.8 m) spacings produced more seed per acre than plants planted at 6 by 12 or 12 by 12 ft (1.8 by 3.7 or 3.7 by 3.7 m) spacings. However, as plants attained mature stature, those at 6 ft (1.8 m) spacings became so overgrown that seed harvesting became impractical. Depending on growth habit, shrubs should be

spaced 12 to 15 ft (3.7 to 4.6 m) apart to permit good seed production and facilitate site maintenance and seed harvesting.

Maintaining a stand of native herbs as an understory is a practical approach for controlling weeds and supporting predatory insects. Field cultivated plants appear to benefit from cultural treatments, but response to fertilizer, water, and pesticides is not known. Native stands of antelope bitterbrush can also be managed for seed production. Plants respond favorably to pruning, thinning, weed control, and protection from grazing.

Annual collections of antelope bitterbrush from western rangelands have sometimes exceeded 40,000 lb (18,182 kg). Considerable seed is harvested annually from most Intermountain and Northwestern States. Demand varies considerably from year to year. Areas in south-central Idaho and northern California tend to produce more consistent seed crops than most sites within the Intermountain region. More seed is usually harvested from areas in central Idaho and the Pacific Northwest than is used in those regions. However, seed collected from central Utah and eastern Nevada is generally not sufficient to meet regional demands. Likewise, the quantity of seed harvested from arid regions and decumbent growth forms growing in ponderosa pine and aspen communities is generally inadequate.

Seed are easily hand harvested. Effective mechanical harvesters have not been developed (Nord and others 1967). Air-dried collections are cleaned by first screening to remove sticks and debris. The husks are then detached with a barley debearder, Dybvig, or other scarifier. Remaining material is again screened to separate seed from the detached husks (Giunta and others 1978). At 100 percent purity there are approximately 15,000 seed per lb (33,000 per kg). Seed are reasonably hard and are not easily broken, fractured, or damaged when cleaned or planted. Recommended purity for seed purchases is 95 percent and germination 90 percent (see chapter 24).

Cleaned seed can be stored under warehouse conditions for extended periods without loss of viability. Afterripening improves germination. Stevens and others (1981a) reported a significant increase (79 to 86 percent) in germination between the second and third year of storage. Seed germination remained unchanged after 20 years of warehouse storage, but decreased to 24 percent after 25 years. Antelope bitterbrush seed can usually be stored without suffering extensive insect damage, but storage areas must be kept rodent free.

Antelope bitterbrush seed are large, smooth, and fairly heavy. Consequently, they are easily carried through most seeders. When planted in mixtures, antelope bitterbrush can be used to carry other light-weight seed through seeding mechanisms. Seeds require a 2 week wet prechilling to release dormancy, thus they should be fall or winter seeded.

Recommended seeding rates for antelope bitterbrush vary considerably. The shrub may be drill seeded, interseeded in rows at various interspacings, or hand planted in clearings or selected spots. Hubbard (1964) recommended drilling at a rate of 3 lb per acre (1.4 kg per ha). Extensive pinyon-juniper chainings have been interseeded using a Hansen seed dribbler. Rows are usually spaced 8 to 12 ft (2.4 to 3.7 m) apart when mechanical interseeders are used (Stevens and others 1981b). Between 5 and 20 seeds are usually dispensed per linear ft (16 to 66 per m) in each interseeded row. At a rate of 20 seeds per ft (66 per m), approximately 87,000 seeds are planted per acre (214,974 per ha), if rows are spaced 10 ft (3 m) apart. This equates to 3 to 5 lb per acre (3.4 to 5.6 kg per ha) depending on the seed lot planted.

Hand seeding has been used extensively to plant steep or inaccessible slopes. Herbaceous vegetation must be cleared to enhance shrub seedling survival. Clearings amid annual or perennial vegetation should be between 2.5 to 3.3 ft (0.75 to 1 m) square to effectively reduce competition. Hand seeding antelope bitterbrush and other shrub seed into depressions created by uprooting pinyon-juniper trees following anchor chaining is also a successful planting technique.

Rodents actively gather planted seed (Evans and others 1983; Young and Evans 1978a,b), and forage on small seedlings. Rodent damage can be extremely serious and limit planting success. This problem can be reduced by planting late in fall after rodents hibernate. Coating seeds with a combination of Arasan and Endrin eliminates nearly all rodent predation (Medin and Ferguson 1980), but the toxic effects of Endrin on other animals have eliminated its use. Everett and Stevens (1981) found thiourea treatments reduced deer mouse predation. However, the compound is now classified as a carcinogen. No other chemical has been developed that effectively diminishes rodent predation.

Evans and others (1983) and Reichman and Oberstein (1977) reported that size and depth of seed caches influenced detection by rodents. Rodents locate seed primarily by olfactory cues (Howard and Cole 1967; Johnson and Jorgensen 1981), thus edaphic conditions can affect seed discovery (Johnson and Jorgensen 1981). Rodents were better able to locate antelope bitterbrush seeds when two or more seeds were planted together. Rodents failed to locate individual seeds placed 0.4 inch (1 cm) deep, but removed 75 percent of the seeds if two seeds were placed together at this depth. Predation increased to 98 percent when more than 10 seeds were planted together. Evans and others

(1983) found that planting depth affected seed detection. Rodents consumed all seeds placed on the soil surface or planted at a depth of 0.4 inch (1 cm), but only about 50 percent of seeds planted between 0.8 and 1.6 inch (2 and 4 cm) deep.

Available cover also strongly influences seed predation. Evans and others (1983) reported significantly less rodent predation of seed caches in burned areas lacking plant cover than in unburned sites with considerable vegetative cover. Similar responses have been noted in seedings on mine and roadway disturbances. Rodents apparently cache antelope bitterbrush seeds in small openings, but are not likely to venture onto exposed sites for extended foraging.

Planting success of range and wildlife seedings in different plant communities also indicates considerable differences in rodent foraging habits (Basile and Holmgren 1957; Casebeer 1954; Holmgren and Basile 1959; Nord 1965). Success has generally been better in pinyon-juniper communities cleared of trees by anchor chaining than on burned antelope bitterbrush/bunchgrass ranges infested with cheatgrass.

Booth (1980) and Evans and others (1983) found pretreating antelope bitterbrush seeds with a fungicide reduced damping-off problems and ultimately increased the number of successfully established seedlings. Cutworms and wireworms can also destroy newly developing seedlings of antelope bitterbrush (Hubbard 1956), but outbreaks are usually limited to isolated situations.

Compared to most shrub and many herb species, antelope bitterbrush seedlings establish quite successfully even under harsh circumstances. Consequently, the shrub can be used to revegetate roadways, mine disturbances, and other infertile sites. If protected from browsing, young plants grow rapidly and provide considerable forage and ground cover within 3 to 5 years.

Antelope bitterbrush is often interseeded with a combination of grasses and broadleaf herbs. However, Monsen and Shaw (1983c) reported that intermediate wheatgrass and crested wheatgrass planted as an understory can significantly reduce or minimize natural seedling recruitment of this shrub. It is essential that the shrub be seeded with less competitive herbs. Interseeding antelope bitterbrush onto sites dominated by cheatgrass is not recommended unless remedial treatments are employed to reduce or replace the cheatgrass understory.

Bareroot or container seedlings are frequently used to circumvent seed predation by rodents and speed establishment. Dormant or carefully hardened seedlings should be planted before native antelope bitterbrush shrubs at or near the planting site break dormancy (Carpenter 1983). Establishment success is usually quite high. Antelope bitterbrush seedlings and young plants are often browsed heavily. Project seedings or plantings should be large enough to dissipate animal browsing or establishment may be adversely affected.

Uses and Management

The broad genetic base of antelope bitterbrush and its wide geographical distribution (Stutz and Thomas 1964; Thomas 1957), provide considerable opportunity to promote the use of natural and artificial populations and hybrids with specific traits. Few other shrub species are so diverse.

Antelope bitterbrush is widely regarded as an important browse plant for big game and domestic livestock. It has been planted extensively in big game habitat improvement projects throughout the Intermountain and Pacific Northwest regions to provide a forage base in areas where game and livestock use may be seasonally heavy. Numerous seeding and transplanting projects have been conducted to improve sites where shrub populations have been depleted or eliminated. Antelope bitterbrush grows well with a wide number of native understory species and other shrubs and is often planted in mixtures to reestablish plant diversity. It forms important associations with various conifers, mountain brush species, and bunchgrasses. However, in certain areas this plant exists with few other species and may be the dominant plant encountered. In either situation, reestablishing the shrub improves wildlife habitat, watershed resources, and community and structural diversity.

A wide array of ecotypes exists within the broad geographic range of antelope bitterbrush. Numerous ecotypes have been propagated and planted at various study sites in the western United States. Some collections exhibit adaptation to a rather broad range of site conditions; others require rather specific edaphic and climatic conditions. An upright growth form from Sanpete County, UT, for example, performed much better than any other source when seeded on a broad array of Utah sites (Davis 1983). A natural hybrid of antelope bitterbrush and Stansbury cliffrose displayed better survival, persistence, and herbage yield than most other antelope bitterbrush ecotypes when seeded on a number of Utah sites.

Planting failures sometimes result when antelope bitterbrush ecotypes are planted on similar parent materials but at elevations about 2,000 ft (610 m) higher than the native stands. In addition, ecotypes have failed to persist if sources from strongly basic soils are planted on acidic sites, or vice versa. Selective grazing by livestock, big game, rodents, and insects has also eliminated specific ecotypes when they were planted in small test plots (Edgerton and others 1983; Giunta

and others 1978). If nonfire-tolerant ecotypes are planted on sites subjected to burning, entire stands can be eliminated in a single fire. Land managers should be very selective when considering the use of seed collections obtained from areas differing from the prepared planting site in edaphic or climatic conditions.

Antelope bitterbrush is particularly well adapted to harsh sites and frequently acts as a pioneer species. Consequently, it is frequently seeded on mines, roadways, and similar sites. Decumbent and semi-erect growth forms can be used to control erosion; they provide a dense, spreading ground cover capable of spreading by stem layering.

Plants may form symbiotic nitrogen-fixing relationships with the endophyte *Frankia* (Nelson 1983). Antelope bitterbrush is more frequently nodulated than other rosaceous nitrogen-fixing species, but the degree of nodulation varies considerably among antelope bitterbrush populations. The significance of nitrogen fixation in arid land rosaceous species is poorly understood.

Fire-tolerant ecotypes have been utilized to plant areas subjected to frequent burning. Most ecotypes planted for this purpose retain their resprouting characteristics when planted on adapted sites. Consequently, selection programs have been conducted to identify populations that are capable of resprouting.

Antelope bitterbrush possesses many attributes that contribute to its widespread use. Seed are large, easy to collect, process, store, and plant with conventional equipment. Sufficient seed crops are produced with frequent regularity to provide satisfactory amounts of seed for most project plantings. In addition, nursery and greenhouse-grown transplants are easily produced and establish well when outplanted. Commercial growers produce good quality stock, and with careful planning, land managers can normally contract production of adapted ecotypes.

The broad array of available growth forms provides a useful assemblage of material for planting disturbances. With proper selection, adapted ecotypes can be used to provide windbreaks, serve as conservation and wildlife plantings, or be used for more formal maintenance landscape purposes. Different growth forms can be used to enhance recreational sites, summer homes, and parkways.

Because antelope bitterbrush is a major wildlife species and establishes quite well, some grasslands and shrublands have been converted to antelope bitterbrush by artificial seedings. Some plantings have failed when the shrub was not well suited to the problem area. Attempts to convert wildland sites to antelope bitterbrush stands should be carefully evaluated. Unless adapted ecotypes of antelope bitterbrush exist, more suitable species should be selected for planting.

Varieties and Ecotypes

Numerous populations of antelope bitterbrush with distinctive attributes have been recognized and are commercially harvested and sold (table 2). Ecotypes from central Utah are widely used for big game habitat improvement, but are best adapted to calcareous soils. Decumbent growth forms commonly found as an understory in lodgepole pine or ponderosa pine forests are used in revegetation of forested sites. Upright ecotypes from southern Oregon and central Utah are used to stabilize sandy soils and restrict human activity.

'Lassen' antelope bitterbrush, the only release to date, is a robust, upright ecotype that produces and maintains moderate quantities of overwintering leaves that provide a source of protein for fall and winter grazing (Shaw and Monsen 1986; Welch and others 1983a). This selection is native to Lassen County, CA, where it grows on coarse textured, granitic soils. It has done well throughout the Pacific Northwest and the Intermountain regions when planted on sandy, slightly acidic or neutral soils in areas receiving 14 to 18 inches (36 to 46 cm) of annual rainfall. Seedlings are vigorous and grow rapidly.

Rosa woodsii ultramontana _____

Woods Rose

Hitchcock and others (1961) and Welsh and others (1987) described Woods rose as a deciduous shrub with a growth habit ranging from nearly prostrate to upright and height from 3.3 to 10 ft (1.0 to 3.0 m). Its root system is dense and fibrous. Thick briar patches of arching branches are formed by heavy suckering from spreading rhizome systems. Branches are armed with straight to curved infrastipular spines. They may produce internodal prickles, but are occasionally unarmed. The alternate leaves are odd pinnate with five to nine ovate to obovate or elliptic leaflets. The leaves are 0.6 to 5.1 inches (1.5 to 13 cm) long and 0.2 to 1 inch (0.4 to 2.5 cm) wide, singly to doubly serrate, and pubescent to glandular or rarely stipitate glandular. The fragrant flowers are solitary or in few-flowered corymbs or corymbiform cymes that terminate lateral branches of the season (fig. 26). Each flower has five persistent erect to spreading sepals and five white to deep rose petals. Numerous stamens are inserted on a disk lining the throat of the calyx. Carpels are numerous. The "hips" are globose to ellipsoidal and 0.2 to 0.5 inch (6 to 12 mm) in diameter. They turn a bright orange red at maturity. Each contains 15 to 30 straw colored to white achenes 0.1 to 0.2 inch (3 to 5 mm) long with long stiff hairs along one side.

Woods rose blooms from late spring to summer depending on water availability. Fruits ripen in late fall and remain on the shrub through winter (Blauer and others 1975; Hitchcock and others 1961).

Table 2—Principal ecotypes of antelope bitterbrush used in wildland restoration projects.

Ecotype/origin	Elevation	Mean annual precipitation	Growth form	Attributes	Areas of adaptability	Availability		References[c]
						Seed[a]	Transplants[b]	
	feet	*inches*						
Boise Front Ada Co., ID	2,800	17	Erect	Highly productive, good seedling vigor, excellent cover	Neutral to acidic soils, south-central Idaho	4	3	2,3,4
Bryce Canyon Garfield Co., UT	7,000	16	Spreading to semi-erect	Leafy, highly available forage, resilient to heavy browsing, excellent ground cover	Colorado River drainage, but widely adapted	2	1	3,4
Columbia Basin, eastern Washington		12-16	Spreading	Excellent drought tolerance, highly available forage, good ground cover	Columbia River, western and central Idaho			2,3
Elko Elko Co., NV	5,200	14	Semi-erect	Excellent drought tolerance, persistent responds well following fires, widely adapted	Northern Nevada, western Utah, big sagebrush and pinyon-juniper sites	3	2	3,4
'Lassen' Lassen Co., CA	4,200	14	Erect	Good winter leaf retention, seedling vigor, palatability	Mid-elevations, northern California eastern Oregon, southern Idaho	4	2	5
Maybell Moffat Co., CO	6,000	14	Spreading to semi-erect	Stem layering, adapted to sandy soils, good ground cover	Specifically adapted to sandy soils	3	2	3
Panguitch Lake Garfield Co., UT	8,250	20	Decumbent	Cold tolerant, excellent summer forage, resists browsing, excellent ground cover	Spruce-fir,aspen, and mountain brush types, exposed sites, windblown exposures	2	1	
Pinto Washington Co., UT	6,000	14	Upright	Drought tolerant, productive, good forage, excellent wildlife habitat, consistently good seed crop	Adapted throughout the pinyon-juniper type within the Great Basin	2	1	
Sanpete Sanpete Co., UT	5,000	14	Erect, upright	Excellent seedling vigor, highly productive, good seed producer, persistent	Most widely adapted ecotype tested throughout the pinyon-juniper type within the Intermountain area	4	2	1,3,4
Shoshone Lincoln Co., ID	4,200	10	Decumbent	Drought tolerant, spreader, adapted to rocky lava substrates	Southern Idaho, basalt soils	1	1	
Snowville Box Elder Co., UT	5,100	15	Semi-erect	Cover and forage for big game and upland birds,excellent seed producer	Adapted to big sagebrush and pinyon-juniper communities	3	2	
Starvation Canyon Wasatch Co., UT	8,124	18	Decumbent, spreading	Highly palatable, excellent summer forage, resistant to heavy grazing	Adapted to high elevations, aspen openings	2	2	3,4
Salt Lake Salt Lake Co., UT	5,525	17	Erect, upright	Good seed producer, forage available	Well-drained soils, mountain brush and upper elevations of pinyon-juniper communities	3	2	3,4

[a]Seed availability: (1) Erratic producer - limited amounts available; (2) Fair to good producer - limited amounts collected; (3) Fair to good producer - moderate amounts collected most years; (4) Fair to good producer - large collection sites, seed usually available; (5) Good producer - seed normally available.
[b]Transplant availability: (1) Produced only on request; (2) Produced mainly on request; (3) Produced mainly on request, some speculative rearing; (4) Produced for speculative sales.
[c]References: (1) Davis (1983a); (2) Edgerton and others (1983); (3) McArthur and others (1983b); (4) Plummer and others (1968); (5) Shaw and Monsen (1986).

Figure 26—Woods rose flowers in late spring or early summer. Fruits ripen in fall and contain about 15 to 30 achenes.

Ecological Relationships and Distribution

Rosa is a difficult genus taxonomically. It occurs throughout the Northern Hemisphere, and exhibits a high degree of intraspecific variability. There are approximately 115 species of *Rosa* in temperate North America (Young and Young 1986). About 10 of these occur in the Rocky Mountains and most will hybridize (Hitchcock and others 1961). Chromosome number for this group is n = 7. The genus *Rosa* was represented in the western American element of the Arcto-Tertiary Flora (Axelrod 1950).

The native range of Woods rose extends from British Columbia to southern California and east to Saskatchewan, Minnesota, Missouri, and Texas. There are two varieties. The eastern variety, *Rosa woodsii* var. *woodsii* occurs on plains and prairies as far west as eastern Montana. Plants are about 3.3 ft (1 m) tall with crowded leaves. The leaflets are 0.4 to 0.8 inch (1 to 2 cm) long and gland tipped. The cordilleran variety, *Rosa woodsii* var. *ultramontana*, covers the western portion of the species range. It is taller than var. *woodsii*, often reaching heights of 3.3 to 6.6 (9.9) ft (1 to 2 [3] m). Its leaves are also larger, up to 2 inches (5 cm) long by 1 inch (2.5 cm) wide with coarse teeth that are not gland tipped. It exhibits tremendous variation in height, spininess, vegetative spread, and drought tolerance. This variety occurs from plains to alpine areas along marshes, lake shores, and in other riparian communities of the sagebrush, juniper, mountain brush, aspen, and spruce-fir zones. Plants may be found in well drained, wet to dry, loamy to sandy soils on all aspects, and in moderate shade to full sunlight. Woods rose grows at elevations from 2,800 to 11,000 ft (850 to 3,355 m) (Welsh and others 1987), generally in areas receiving 16 to 20 inches (41 to 51 cm) of annual precipitation (Monsen and Davis 1985; Wasser 1982).

Woods rose invades disturbed areas along roadways, eroded drainages, fence rows, irrigation canals, and abandoned fields. It is intolerant of poor drainage, high water tables, and prolonged flooding (Wasser 1982). Ecotypes vary in drought tolerance; flowering is more adversely affected by drought than is rhizome growth.

Woods rose resprouts following fire. However, intense fires or repeated burns can damage or kill the shallow root crown. Annual growth may increase following light to moderate burns (Wasser 1982).

Plant Culture

Woods rose begins flowering when plants are 2 to 4 years old. Plants growing in full sunlight produce more flowers than those growing in shade. Good seed crops are produced at about 2 year intervals (Gill and Pogge 1974b). The hips of Woods rose are harvested by hand as soon as they ripen and before the flesh begins to soften. Achenes are extracted by macerating the hips in water in a blender or Dybvig and floating off the pulp and empty achenes. Achenes should be dried thoroughly prior to storage. Acceptable viability is retained for 2 to 4 years by sealing the dry achenes in containers at 34 to 38 °F (1 to 3 °C) (Gill and Pogge 1974b). There are about 45,300 seed per lb (99,868 per kg) at 100 percent purity. Acceptable germination for seed purchases is 95 percent and purity 70 percent (see chapter 24).

Dormancy of Woods rose seed is caused by inhibitors in the seed coverings and mechanical restriction of the pericarp wall (Jackson and Blundell 1963). In nature, consumption and digestion of seeds by animals disperse the seed and alleviates dormancy (Morris and others 1962; Shaw 1974). Overall seed viability is decreased by digestion, but dormancy of unharmed seed is reduced. A wet prechilling at 34 to 41 °F (1 to 4 °C) for 30 to 365 days is recommended to relieve dormancy of planted seeds (Gill and Pogge 1974b). Warm pretreatment for 60 days at room temperature preceding the wet prechilling may also be helpful. Hot water and acid treatments have been used prior to wet prechilling with mixed results (Gill and Pogge 1974b).

In the field, seed may be broadcast or drilled at a rate of about 0.5 to 1.0 lb per acre (0.6 to 1.1 kg per ha). It should be covered with 0.25 to 0.75 inch (0.6 to 1.9 cm) of soil. Seed can be mixed with other shrub seed, but it should be seeded separately from grasses; seedlings are only poorly to moderately competitive with herbs. Seed may also be spot planted in areas cleared of competition. Due to variability in seed dormancy among seed collections, and the extremely long wet prechilling requirements, results of seedings have been quite erratic.

Transplanting, although more expensive than direct seeding, is often recommended, at least for small planting sites. Bareroot stock is usually lifted after one growing season. Seedlings produce an extensive root system during the first growing season in the nursery. They may initiate new rhizome growth prior to lifting. Rhizome growth is initiated early in spring. New rhizomes are easily damaged during lifting and outplanting. Large bareroot seedlings with shoots 2 to 3 ft (0.6 to 0.9 m) tall are grown at some nurseries. These are useful on unstable or dry sites; the large root system provides anchoring and a greater water absorption area, and the long shoots are not easily buried by soil sloughing. Augers or other special planting tools may be required to properly plant these seedlings. Wildings may be dug when dormant and kept in cold storage for later transplanting. They should be handled and planted like bare root stock.

Containerized seedlings may be grown as tublings or as larger plants. Seedlings may be started from seed, small transplants, or cuttings (Landis and Simonich 1984). They require at least a 3 to 5 month cropping time.

Hardwood cuttings collected when dormant may be stored at 34 °F (4 °C) and rooted in the nursery in areas with mild climates or under a greenhouse mist system in other areas. Softwood cuttings of partially mature wood root quickly (10 to 14 days) under a mist system. Rooted cuttings may be transplanted in fall, overwintered in a shadehouse or cold frame, or transferred to a nursery bed (Gill and Pogge 1974b). Everett and others (1978a) recommended the use of hardwood rather than softwood cuttings. They used a mist system and 0.8 percent indole-3-butyric acid to induce rooting in a greenhouse. Layers or suckers may also be propagated in the nursery or greenhouse and field planted when adequate root systems have developed (Hartmann and Kester 1990).

Uses and Management

Because of its wide geographic distribution and revegetation values, Woods rose is a candidate for use in a wide variety of planting situations. High survival rates of transplanted seedlings make Woods rose a desirable and reliable addition to many projects. Livestock, game animals, and rodent populations may require control during the period of establishment. Rodents consume planted seed and young seedlings sometimes suffer serious debarking and girdling (Spencer 1958; Wasser 1982). Plants are sometimes attacked by leaf spots, rusts, downy mildews, blights, and cankers. Periodic close use, mowing, or burning under safe conditions may improve the appearance and stimulate production of plants along roadways or in recreation areas.

Woods rose is an extremely useful plant on disturbed sites such as roadcuts and fills, gullies, riparian areas, and mining disturbances where soil stabilization is essential (Monsen 1974, 1975; Plummer and others 1968). At the Leviathan Mine in western Nevada, Woods rose and mountain snowberry provided the highest third year survival and cover of the species tested (Everett and others 1980). Suckers were produced the third year. Plants survived in spite of a low soil pH (4.1) and low nitrogen. Liming and other amendments were recommended. Although natural seedlings may invade disturbances, they are easily buried by soil sloughing. However, seedlings do develop quite rapidly if established from rooted cuttings or nursery stock. The fibrous, rapidly developing root system and rhizomes provide soil stabilization. Rhizomatous spread has been noted by the third year after transplanting, augmenting the stabilization process. In addition, the brushy habit, thorniness, and low palatability of some ecotypes permit development of impenetrable thickets that reduce livestock and wildlife trampling on unstable sites. Many ecotypes, however, are grazed rather heavily. Planting them in a mixture with other shrubs is advised to take advantage of differing growth habits and microsite requirements and maximize the diversity obtained.

Woods rose obtained the highest assessment of suitability of 18 shrubs tested on forest roads in northwestern Montana (Hungerford 1984). The assessment was based on growth, spread, vigor, survival, flowering, and regeneration. Overall survival after 4 years was 62 percent with similar survival on south, west, and east aspects. Plants spread by root sprouting and were indistinguishable after 4 years. The plant was recommended for use in this area to hold soil against wind and water erosion in open to light shade and in dry to moist soil. Everett (1980) found Woods rose and antelope bitterbrush were among the best species tested for revegetating roadcuts in Nevada. After 3 years, Woods rose survival remained high and the species was among the best for both north and south slopes when ranked by the amount of cover produced. The species also exhibited the highest survival of species tested on forest roadcuts at 14 locations on two forests in eastern Washington (Tiedemann and others 1976). Overall survival of Woods rose was 56 percent

on the Colville National Forest and 63 percent on the Okanogan National Forest. Plants were generally of rather low vigor and on these sites may have required fertilization. Successful planting required stems tall enough that they were not buried by raveling.

Woods rose is used by big game during most seasons; it generally receives heaviest use in early spring and fall (Blauer and others 1975; Wasser 1982). Plants are moderately grazing tolerant, particularly on moist soils. Palatability of leaves and stems varies with ecotype, density of prickles, and availability of other forage. Wood rose is rated as valuable in winter and highly valuable in summer and fall for elk (Kufeld 1973). Mule deer make light use of it in winter and fall (Kufeld and others 1973). In a cafeteria style study, Smith (1953) found Woods rose was one of the most preferred shrubs for mule deer throughout the summer (May 1 to September 30) in northern Utah.

Woods rose provides food and excellent nesting, escape, and thermal cover for birds and small mammals during all seasons (Blauer and others 1975; Thornburg 1982; Young and Young 1986). Although not highly preferred, the hips remain on the shrubs well into the winter and provide an excellent energy source for many species when the ground is covered with snow (Mace and Bissell 1986; Monsen and Davis 1985; Plummer and others 1968; Welch and Andrus 1977).

Nutritive value of Woods rose varies considerably by season. In the Black Hills of South Dakota, protein value varied from 4.9 percent in summer to 12.0 percent in spring for stems and from 5.7 percent in fall to 16.4 percent in spring for leaves (Dietz 1972). Rose hips have high digestibility and are moderately high in crude protein in winter; they provide food for many birds and rodents.

Rose hips have been used as preserves and as an ingredient in herbal tea and candy. They are high in vitamin C. American Indians used the bark, roots, and stems to produce a dressing for wounds, sores, and burns. Roots were used for treating diarrhea (Craighead and others 1963). Woods rose has high ornamental value for recreation areas, parks, and campgrounds. The dense growth habit can also be used to direct pedestrian traffic and provide low maintenance shrubbery. The attractive fruits, flowers, and fall coloration also contribute to its landscape value.

Varieties and Ecotypes

No populations of Woods rose have been released for commercial production. Tremendous variability occurs in growth habit and many other characteristics. Some accessions have a wide range of adaptability.

Several additional *Rosa* species are used in wildlife plantings. *Rosa nutkana* is distributed from Alaska south to northern California and the Blue Mountain region of Oregon. It also extends south into Colorado and Utah at moderate elevations. *Rosa acicularis*, a circumpolar species, extends south from Idaho and Montana to northern New Mexico. *Rosa gymnocarpa* occurs from sea level to 6,000 ft (1,830 m) from British Columbia to northwestern Montana, south to the Sierra Nevada Mountains of California and the Blue and Ochoco Mountains of eastern Oregon (Hitchcock and others 1961). It is a larger shrub with a more erect and less thicket-like growth habit than Woods rose. Uses and culture of these species are generally as described for Woods rose.

Rubus leucodermis

Black Raspberry, Blackcap

Black raspberry or blackcap is a sprawling, deciduous shrub with arching biennial canes ranging from 3 to 10 ft (1 to 3 m) in length (Hitchcock and others 1961). Prickles of the leaves, petioles, and stems are retrorsely curved. The pinnate leaves are petiolate with linear, caducous stipules, and three to five doubly serrate leaflets. Leaflets are green and nearly glabrous above and white tomentose beneath. They are about 2.4 to 5.6 inches (6 to 14 cm) long; the terminal leaflet is 1 to 3 inches (3 to 7.5 cm) long. Perfect, 5-merous white flowers are produced in racemes in groups of two to seven. Stamens and pistils are numerous. Fruits consist of aggregates of black drupelets on a convex receptacle. Each drupelet contains a hard seed. Flower and fruit development occur unevenly through the summer. Seed is dispersed by birds and mammals.

Ecological Relationships and Distribution

Rubus is distributed worldwide, but is most common in temperate regions of the Northern Hemisphere. There are several hundred species. Many taxa are interfertile; most are polymorphic, and a few are apomictic. *Rubus* belongs to the subfamily Rosoideae and has chromosome number n = 7 (McArthur and Sanderson 1985).

Black raspberry is distributed from British Columbia east to Montana and south to California and New Mexico (Davis 1952). Although commonly a plant of moist environments such as riparian zones and forest openings, black raspberry also exists on dry, open slopes of mountain brush communities and on talus slopes or roadbanks. It spreads by layering and rhizome sprouting as well as from seed and may be one of only a few species growing on some rocky sites.

Uses and Management

Ferguson (1983) considered black raspberry the most likely of the *Rubus* species to be used for revegetation

purposes. It is easily propagated vegetatively and transplants readily. On roadcuts, drainageways, or other disturbed sites it grows rapidly, spreads vegetatively, and provides soil stabilization as well as dense cover and food for birds and other small animals. Black raspberry grows rapidly and is used only lightly as a summer forage by big game and livestock, thus its establishment is normally not hindered by excessive use.

Plant Culture

Seed dormancy and cultural practices for black raspberry are similar to those described for thimbleberry. Time requirements for wet prechilling and scarification have not been determined. Fruits are collected when they are black and detach easily from the receptacle. Use of planting stock rather than seed on disturbed sites may provide better and more rapid success; these sites offer poor conditions for seed germination and early seedling establishment. Planting stock may be grown from seed. Root cuttings, suckers, layers, stem cuttings, and leaf-bud cuttings are easily started (Hartmann and Kester 1990). Root cuttings may be treated as wildings, particularly on moist sites. Seedlings grow fairly rapidly, but are sensitive to dense competition and shading.

Varieties and Ecotypes

There are no releases.

Rubus parviflorus _____

Thimbleberry

Thimbleberry is a low growing, rhizomatous, thicket-forming shrub. It is unarmed, deciduous, and 2 to 7 ft (0.5 to 2.0 m) tall (Hitchcock and others 1961). Bark of the main stems is gray to brown and shreddy. Stems, petioles, and leaves are unarmed and stipitate glandular. The large leaves are long petioled with membranous lanceolate stipules. They are alternate, simple, palmately lobed, and veined from a cordate base. Leaves are 2 to 6 inches (5 to 15 cm) long and 0.6 to 2 inches (1.5 to 5 cm) wide. The showy, white flowers are perfect and 5-merous, in groups of two to seven in flat-topped cymes or terminal corymbs (fig. 27). Stamens and pistils are numerous. Fruits are approximately 0.5 to 1 inch (1.2 to 2.5 cm) wide aggregates of coherent red drupelets that are thinly fleshy and almost dry at maturity. Fruit aggregates form over a conical receptacle, thus the common name “thimbleberry.” Each drupelet contains a single hard beige to pink seed about 0.1 inch (2 mm) long. Flowering and fruit ripening continue through the summer. Seeds are dispersed by birds and mammals.

Figure 27—Thimbleberry spreads by seed or resprouting in natural forest openings and disturbed areas.

Ecological Relationships and Distribution

Thimbleberry is distributed from Alaska east to Ontario and south to Chihuahua, Mexico. It grows in all western States from elevations near sea level on the Pacific Coast to near 10,000 ft (3,050 m) in Colorado (Harrington 1964; Sutton and Johnson 1974; USDA Forest Service 1937). Thimbleberry forms dense patches in natural forest openings or disturbed areas, but it is also fairly common in areas shaded by forest canopies, brushfields, or woody riparian plants, particularly in the southern portion of its range. It is a particularly common understory species in the humid forests of the Pacific Northwest.

Thimbleberry grows on moist, sandy loam soils rich in organic matter, but may also be found on rocky talus slopes, road banks, and creek bottoms. It regenerates rapidly from rhizome and root crown sprouting following burning or logging (Cholewa and Johnson 1983; Leege and Hickey 1971; Mueggler 1966; Noste and Bushey 1987). Buried thimbleberry seeds have been reported in a number of forest seed bank studies

(Kramer 1984). Although Kramer (1984) found low densities and low viability of thimbleberry seeds in soil banks for three forest habitat types in central Idaho, he concluded that the rhizomatous nature of the species would allow even isolated seedlings to spread over significant areas.

Plant Culture

Good seed crops are produced almost every year but fruits are difficult to collect in large quantities as they are scattered over the crown of the plant and ripen unevenly. Ripe fruits are bright red and detach easily from the receptacle. They are dispersed by gravity and by animals that consume them.

Fruits are hand collected. Seeds are extracted by macerating the fruits in water in a Dybvig or blender and floating off the pulp. Remaining debris and light seed are removed by drying and fanning. Dried seeds may be stored at 41 °F (5 °C) for several years (Brinkman 1974h).

Dormant embryos and an impermeable endocarp prevent rapid seed germination. In nature, dormancy is overcome by warm pretreatments and wet prechilling occurring between early summer seed fall and spring germination, although seeds are capable of remaining viable in the soil for more than 1 year if germination conditions are not met (Brinkman 1974h). A 2-hour soak in sulphuric acid or a 7-day soak in 1 percent sodium hypochlorite are commonly used germination pretreatments. However, results of acid scarification have been erratic (Marchant and Sherlock 1984).

Swingle (1939) and Babb (1959) recommended planting the seed immediately after it is harvested. Summer seeding in the nursery provides warm pretreatments and wet prechilling that relieve both blocks to germination for many *Rubus* species (Babb 1959; Brinkman 1974h). A 90-day warm pretreatment at 68 to 86 °F (20 to 30 °C), followed by a 90 day wet prechilling at 41 °F (5 °C) in the laboratory, prepares seed for spring sowing.

Thimbleberry is easily established from seed-grown bareroot or container stock. Plants are also easily propagated from layers or suckers. Sprigging, the collection and planting of dormant rhizomes, provides a means of quickly obtaining large quantities of plants.

Uses and Management

Rubus was ranked first among 18 genera of shrubs in terms of the number of wildlife species using them (Martin and others 1951; Robinette 1972). The drupelets are sought by birds and many other animals; leaves are used to varying degrees in summer. The dense sprawling plants provide cover for small animals during all seasons. Kufeld and others (1973) reported that mule deer take trace amounts of thimbleberry in fall and moderate amounts in summer. Thimbleberry is ranked as highly valuable and valuable for elk in summer and fall, respectively (Kufeld 1973). Palatability for livestock varies with geographic location and plant association. In general, it is considered worthless to poor for cattle and fair for sheep, although it may be heavily used if other vegetation is scarce or unpalatable (USDA Forest Service 1937).

Primary values of thimbleberrry in revegetation plantings are to provide soil stabilization and thickets for wildlife food and cover on disturbed forest sites, sand dune areas, and streambanks. Seedlings are not likely to be browsed heavily unless other more palatable vegetation is unavailable. They are susceptible to white fly and spider mite infestations (Marchant and Sherlock 1984).

Thimbleberry is a common plant of seral shrub communities; it resprouts following logging or burning, and establishes in natural forest gaps. Burned plants resprout from root crowns and rhizomes. Intense fires might destroy these structures, but permit germination of seed banked in the soil (Noste and Bushey 1987). Gratkowski (1978), Leege and Hickey (1971), and Miller and Kidd (1983), discussed the response of thimbleberry to burning and herbicide treatments, practices used to kill shrubs and permit conifer regeneration or rejuvenate overgrown shrub fields to improve browse availability for wildlife.

Varieties and Ecotypes

None.

Sorbus scopulina

Greene's Mountain Ash

Greene's mountain ash is an attractive semi-erect shrub, branching from the base and forming thickets by suckering or layering (fig. 28). Bark of younger stems is smooth and yellowish gray becoming grayish red on older stems. Young growth is sparingly to densely grayish strigillose pilose. Winter buds are glutinous and white hairy to glabrous. The alternate deciduous leaves are glossy dark green above and pale and glabrous beneath, turning a showy red orange in autumn. They are pinnately compound with 7 to 13 serrate leaflets each, short cuneate to acute at the base, and acuminate at the tip. Stipules are green, membranous, and caducous to persistent. The inflorescence is a 70 to 200 flowered flat-topped corymb. The creamy-white flowers are perfect, 5-merous, and regular (Preston 1968). Hypanthium lobes are triangular, persistent, and white hairy externally. There are 15 to 20 stamens and two to five carpels and styles. Fruits are fleshy scarlet to orange pomes that dry to a purplish color. Each contains four seeds

Figure 28—Greene's mountain ash fruits persist into winter and are consumed by birds and other wildlife species.

(Harris and Stein 1974; Hitchcock and others 1961; Welsh and others 1987). The shrubs flower from May to July and fruits mature from August through October. Many fruits remain on the plant through winter. Seeds are spread primarily by birds.

Ecological Relationships and Distribution

Approximately 50 species of *Sorbus* are distributed through temperate and subarctic areas of the Northern Hemisphere (Hitchcock and others 1961). The chromosome number n = 17 is typical of woody Pomoideae genera in the western United States (McArthur and Sanderson 1985). Greene's mountain ash is distributed from Alaska east to Alberta and south to California, New Mexico, and the Dakotas (Welsh 1982). It grows in openings in conifer forests from foothills to subalpine or alpine sites at 4,000 to 9,000 ft (1,200 to 2,700 m) (Davis 1952; Stark 1966; Welsh 1982). Greene's mountain ash grows in sun or partial shade on well-drained, neutral to acidic soils forming dense patches or intermixed with other shrub species (Van Dersal 1938). It is common in mountain brush communities of forest openings, riparian areas, and on disturbed sites.

Plant Culture

Fruit should be gathered immediately when ripe to prevent losses to birds. Seeds are collected by hand or shaken onto a canvas. Maceration of fruits in water in a Dybvig or commercial blender separates seeds from the remainder of the fruit. The pulp contains germination inhibitors and is removed by flotation and by fanning and screening the dried seed and trash (Hartmann and Kester 1990; Heit 1968). Seed quality is often low. Seed should be dried to a 6 to 8 percent water content and stored dry in sealed containers at 34 to 38 °F (1 to 3 °C) (Harris and Stein 1974). Properly stored seeds remain viable for 2 to 8 years.

Seed requires wet prechilling for germination. A 72-hour soak in gibberellic acid (3.46 g Rootone-F/1000cc/distilled H_2O) followed by a 90-day wet prechilling at 41 °F (51 °C) was recommended by SEAM (1976) and Belcher (1985). Seed can also be given a 115-day warm pretreatment at 77 °F (25 °C) followed by a 75-day wet prechilling at 41 °F (5 °C), although exact requirements vary widely between and within seedlots. Laboratory germination tests require extended incubation periods. Excised embryo tests and tetrazolium chloride tests are frequently used alternatives; both can be completed rapidly (see Belcher 1985). Results of both tests are generally higher than laboratory germination test results (Harris and Stein 1974).

Greene's mountain ash may be established by sowing untreated seed in late summer to provide warm and cold wet pretreatment periods. Laboratory prechilled seed may be spring planted. Seed should be covered lightly. Even when wet prechilled, seed lots often germinate in the field over a 2 to 3 year period. Seed should be planted in areas where it will be protected from competing vegetation.

Production of planting stock may be necessary if seed supplies are limited or more rapid establishment is desired. Container and bareroot stock are usually grown from seed. Bareroot stock develops slowly and may require two growing seasons before lifting. Propagation by cuttings and layering is difficult. Wildings may be used as alternative sources of planting material if only small quantities of plants are needed.

Cook (1981) recommended use of Greene's mountain ash on adapted sites below 6,500 ft (2,000 m) in Wyoming, and suggested that it be planted at 4 ft (1.2 m) spacings. Young plants develop rather slowly and require protection from competition with grasses and forbs. Seedlings are tenacious and evidently not very vulnerable to insect and disease problems. They are taken by deer (USDA Forest Service 1948).

Uses and Management

The persistent fruits of Greene's mountain ash are taken by bears and birds in the fall and into the winter. Moose often browse the shrubs heavily in winter. Twigs are eaten by game and livestock. Dayton (1931) reported that Greene's mountain ash produces good sheep feed. It provides good cover and soil stabilization on steep sites within its range as it spreads to form dense thickets. As an ornamental, it offers attractive foliage, flowers, and fruits for mass plantings in full sunlight or partial shade. The foliage and berries are brightly colored in fall, and clusters of berries remain on the plant through the winter (Sutton and Johnson 1974).

Miller (1981) and Miller and Kidd (1983) examined the response of Greene's mountain ash on seral shrub fields in northern Idaho to various herbicide treatments. Lyon (1966) found that plants were eliminated by burning.

Varieties and Ecotypes

Various selections are used for horticultural plantings, but none have been developed for wildlife or wildland uses.

Sorbus sitchensis

Sitka Mountain Ash

Sitka mountain ash grows from 3 to 13 ft (1 to 4 m) tall with a rounded crown. It may be distinguished readily from Greene's mountain ash; leaves consist of 7 to 11 leaflets, each semitruncate to rounded at the tip and usually at least one-third as broad as long. The winter buds, young growth and inflorescences are rufous hairy; the calyx is glabrous externally. Stipules are persistent and the fruits are red with a slight bluish cast (Hitchcock and others 1961; Preston 1968). They are dispersed by birds, but some persist on the tree through winter.

Sitka mountain ash is distributed from Alaska and the Yukon south to the Cascades in northern California and east to British Columbia and northwestern Montana at elevations from 2,000 to 10,000 ft (610 to 3,050 m) (Hitchcock and other 1961). Although it frequently grows in wet soils along streams, it may also be found in forest openings created by natural forest gaps, logging, burning, or other disturbances.

Sitka mountain ash produces abundant seed crops. Harvesting, cleaning, storage, germination, and planting requirements are similar to those described for Greene's mountain ash. Seeds sown late or without adequate wet prechilling do not germinate. Approximately 1 to 5 lb (0.45 to 2.25 kg) of seed may be extracted from 100 lb (45 kg) of fruits (Harris and Stein 1974).

Marchant and Sherlock (1984) considered the species a useful high altitude shrub for rocky sites. Management and use of the species are as described for Greene's mountain ash. It is frequently cultivated as an ornamental.

Spiraea betulifolia

Bridal Wreath

Bridal wreath spiraea, birchleaf spirea, or white spiraea is a low, glabrous, deciduous shrub or subshrub ranging from 0.5 to 2 ft (0.2 to 0.6 m) in height (Hitchcock and others 1961). Plants occur singly or in dense patches interconnected by rhizomes. Stems are slender and yellowish brown to brownish with few branches. The simple, alternate, oval to obovate leaves range from 1 to 2.8 inches (2 to 7 cm) in length; the largest leaves occur near the tips of vegetative and flowering branches. The leaves immediately subtending the inflorescence tend to be slightly smaller. Leaves are short petiolate, exstipulate, strongly veined, and coarsely or doubly serrate to shallowly lobulate along the upper one-half to two-thirds of the leaf. Upper leaf surfaces are smooth and shiny; lower surfaces are pale.

Inflorescenses are dense, flat-topped terminal corymbs 1 to 3.2 inches (3 to 8 cm) in diameter (fig. 29). The tiny, white to pinkish 5-merous flowers are perfect, perigynous, and regular. Stamens are numerous and exceed the petals. Fruits consist of five light brown, dehiscent, several-seeded follicles. Flowering occurs from June to early August; fruits ripen from mid July to early September. Fruits normally dehisce in October and seeds are shed over time as winter

Figure 29—Bridal wreath spiraea produces flat corymbs of white flowers.

storms dislodge them from the follicles (Hitchcock and others 1961; Stickney 1974c; USDA Forest Service 1937).

Ecological Relationships and Distribution

The genus *Spiraea* includes about 70 species distributed through temperate and cooler areas of the Northern Hemisphere. About 10 species are found in the western United States, concentrated in mid-elevations of mountainous areas. They are particularly abundant in the Douglas-fir region of the western United States. The genus is a member of the subfamily Spiraeoideae. Chromosome number of the North American species is n = 9. Asian species commonly have chromosome numbers of n = 9 or n = 7 (McArthur and Sanderson 1985).

Bridal wreath spiraea occurs from sea level to 11,000 ft (3,300 m) and is distributed from British Columbia to north-central Oregon and east to Saskatchewan and South Dakota. It grows on a wide range of sites from riparian areas to open or wooded valleys, hills, and rocky slopes. It is particularly abundant on logged, burned, or otherwise disturbed mesic forest sites at intermediate elevations. It is the dominant understory for a number of forest habitat types and community types in the Rocky Mountains where ponderosa pine, lodgepole pine, grand fir, subalpine fir, and aspen are the dominant overstory species. Common shrub associates include roses, huckleberries, willows, and snowberries.

Plant Culture

Bridal wreath spiraea grows in full sun or shaded areas, although most seed is produced on shrubs growing in full sunlight. Cleaning involves rubbing the follicles to release the seeds and sieving to separate the seeds from the trash. The tiny seeds are nondormant. Germination reportedly occurs following 120 days of wet prechilling at 32 to 34 °F (0 to 1 °C) (Stickney 1974b); this mechanism permits emergence shortly after snowmelt. Bridal wreath spiraea may be planted by spot seeding disturbed sites in fall or spring. Seed may be mixed with other shrub seeds, but should be planted separately from grasses and forbs.

Propagating and planting bareroot or container stock provides for better utilization of the normally limited seed supplies and more rapid development of cover on disturbed sites than does direct seeding. Bareroot stock may be propagated from seed. Hand seeding may be required in the nursery; it is difficult to clean the seed to a high level of purity and the light seed does not flow well through a drill. Seed should be covered very lightly and mulched. Bareroot stock may also be obtained by lining out hardwood cuttings in the spring. Container stock is grown from germinants or from hardwood or softwood cuttings (Babb 1959). Hartmann and Kester (1990) recommended the use of leafy softwood cuttings taken in summer. Cuttings are treated with a root-promoting substance and rooted under high humidity. Container and 1-0 or 2-0 bareroot seedlings develop rapidly and are easily handled and transplanted.

Uses and Management

Although it produces abundant available forage, bridal wreath spiraea has been rated as worthless for cattle and poor to fair for sheep (USDA 1937). The dried leaves persist on the plant in fall and may receive moderate use after leaves have fallen from other species. Kufeld and others (1973) reported bridal wreath spiraea receives light winter use and heavy summer and fall use by mule deer. Because of its low palatability, livestock and wildlife rarely damage established stands of bridal wreath spiraea. Consequently, it may become abundant in heavily grazed sites (USDA Forest Service 1937), spreading vegetatively and from seed.

Spiraeas, particularly those species that spread rhizomatously, are valuable plants for soil stabilization along waterways. Adapted species or varieties may be selected for specific areas and conditions. Bridal wreath spiraea has also been used to stabilize roadways, burns, and logged areas. It develops rapidly, producing a spreading root system and rhizomes. The value of this and other spiraea species for site stabilization is increased by its typically low palatability to game and livestock.

A largely unexploited potential of native spiraea is their use as landscape plants. They are easily established and maintained and produce attractive foliage and showy flowers, although flowering is normally restricted to a short period.

Plants developing from seed or transplants mature rapidly. Those growing in full sunlight may flower and produce seed during the first or usually the second growing season. Although seedlings are reasonably vigorous, their growth may be restricted by competition with weeds or seeded grasses. Young seedlings may be trampled by game or girdled by rodents.

Most horizontal rhizomes and fibrous roots are located beneath the mineral soil surface. After fires or other injury, rhizomes sprout vigorously just behind the damaged tissue. Roots beneath the surface of mineral soil also resprout (Bradley 1984; McLean 1967; Fischer and Clayton 1983). Merrill (1982) reported white spiraea achieved a greater volume and biomass on burned sites relative to unburned sites 1 year after burning. This difference was maintained over a 4 year study. Rate of recovery was related to moisture conditions.

Varieties and Ecotypes

None.

Spiraea densiflora

Subalpine Spiraea

Subalpine spiraea occurs from British Columbia south to northern California, Idaho, and Wyoming at elevations ranging from 2,000 to 11,000 ft (600 to 3,300 m) (Hitchcock and others 1961). It grows along lakes and waterways and on wooded to open rocky slopes, frequently in association with lodgepole pine and western white pine. It is a low, highly branched shrub 1.6 to 3.3 ft (0.5 to 1 m) tall with strong root stocks (fig. 30). Flowers develop in small flat topped to rounded pink to rose corymbs 0.8 to 1.6 inches (2 to 4 cm) wide. Young stems, inflorescences, and lower surfaces of leaves are thickly puberulent. Most material in the Intermountain region belongs to var. *splendens*.

Figure 30—Subalpine spiraea inflorescences are thickly puberulent, flat to rounded corymbs of pink to rose flowers.

Spiraea douglasii

Douglas Spiraea

A relatively tall species, Douglas spiraea grows from 3 to 8 ft (1 to 2.4 m) in height with erect stems branching primarily below the center. The species spreads by rhizomes, often forming thickets in openings along lake and stream margins, bogs, and swamps. It grows on boggy or peaty ground and wet heavy soils subject to annual flooding (Marchant and Sherlock 1984). Stems are pubescent to glabrous. The oblong-elliptic leaves are serrate above the center. They are 1.6 to 4 inches (4 to 10 cm) in length, dark green above, and woody beneath. The inflorescence is a pyramidal rose to pink panicle 1.6 to 11.8 inches (4 to 30 cm) long with numerous tiny flowers (fig. 31). Dry flower parts are retained as brown tufts overtopping the shrub in winter. Fruits are dry, glabrous, beaked follicles. Seeds are green to brown and less than 0.1 inch (2 mm) long.

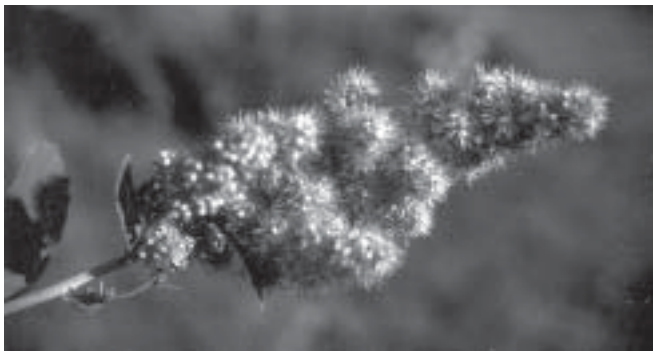


Figure 31—Elongate panicles of pink to rose flowers characterize Douglas spiraea.

Ecological Relationships and Distribution

Douglas spiraea is distributed from Alaska south to northern California and Montana, occurring primarily in coastal areas (Davis 1952; USDA Forest Service 1937).

Plant Culture

Douglas spiraea is easily propagated from cuttings. Marchant and Sherlock (1984) obtained 98 percent rooting of softwood cuttings under mist in June and 98 percent rooting of hardwood cuttings in fall. They recommended lining out hardwood cuttings in spring and lifting them the same fall for outplanting. Stock could also be spring lifted and outplanted. Sprigs or chunks of rhizomes can be dug when dormant and spring planted in areas with moist soils.

Uses and Management

Because of their large size, rhizomatous habit, and ease of propagation, both varieties of Douglas spiraea are prime candidates for revegetation of riparian areas, where adapted. They also have potential for use as ornamentals.

Varieties and Ecotypes

Spiraea douglasii var. *menziesii* is separated from var. *roseata* by its tomentulose inflorescence. It occurs from southern Alaska to northwestern Oregon and northern Idaho. It is one of the most palatable spiraeas and is rated as fair to good fall forage for cattle and sheep (USDA Forest Service 1937). The variety *roseata* occurs primarily in central Idaho (Hitchcock and others 1961). It is a smaller and less palatable shrub.