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Chapter 23

Shrubs of Other Families

Introduction

Numerous genera and species of shrubs occur throughout the Intermountain region in addition to those included in the Asteraceae, Chenopodiaceae, and Rosaceae families. Although shrubs are widespread throughout this region and dominate many areas, species richness is low compared to the shrub flora of the Pacific United States, Chile, western Australia, and South Africa (Stebbins 1975). Generally, evolution proceeds most rapidly when populations are isolated from one another and exposed to different environmental conditions (Dobzhansky 1970; Stebbins 1950); this is the case in the Intermountain region. However, fewer numbers of species within this region are, in part, due to the relatively recent advance and retreat of continental seas, drastic environmental changes, and instability that result in a high rate of extinction (Stebbins 1975).

Most species included in this chapter have been used in revegetation programs. Many other shrubs are recognized as important, but information related to their propagation, seed production, germination, or establishment by direct seeding is not available.

Chapter Contents by Species

Consequently, they are not widely used in large-scale seedings where uniform stands are expected. A number of important species could be more widely utilized in artificial revegetation and increased through management if more information related to their culture was available.

Sixty-seven species representing 20 families are discussed in this chapter. These species occur over a wide range of conditions and habitats. Certain species are common and widespread; others are less abundant and often restricted to localized conditions. However, all are important. In combination, these shrubs offer a diverse range of material for planting and management. *Eriogonum* and *Ceanothus* are examples of two widespread genera discussed in this chapter. Approximately 130 species of *Eriogonum*, including shrubs and broadleaf herbs, occur within the Intermountain region (Welsh and others 1987). Of these, fewer than 10 have been evaluated or used for range or wildland plantings (Miles and Meikle 1984; Plummer and others 1968; Sampson and Jespersen 1963). By contrast, about two dozen species of *Ceanothus* are reported in this same region and slightly more than half have been studied for wildlife, watershed, or horticultural uses. In most instances only one or two species of any genus discussed in this chapter have been studied as potential revegetation species. Seed or planting stock of most species is often relatively scarce.

Shrubs discussed in this chapter occupy rather specific sites. Mountain snowberry, Rocky Mountain maple, and Gambel oak are confined to specific elevations and climatic conditions, yet occupy rather large acreages, often as the dominant species. Other shrubs, including green ephedra and singleleaf ash, are common throughout the southern portion of the Intermountain area but do not extend into the colder northern section. By contrast, red elderberry and dwarf snowberry occupy only mountainous situations.

A characteristic of many shrubs discussed in this chapter is their close association or relationship to soil or site conditions. Rather extensive areas of willow occur through many vegetative communities but are most often confined to moist soils. The relationship of blue elderberry, bush penstemon, and other shrubs that are also adapted to specific soil conditions is less well understood.

Introduced grasses have not been found to be as specifically adapted as many of these shrubs. This is an important consideration; some shrub-dominated associations have been planted to introduced species, mostly grasses. Attempts have been made to substitute other species for native shrubs. Many substitute plants do not provide the forage or cover values expected or simply are not adapted for long-term persistence on some sites. Thus, it is important to learn restoration and management practices required to perpetuate endemic shrub associations.

Some shrubs are particularly important during various stages of succession. Species of redstem ceanothus, snowbrush ceanothus, and red elderberry recover well following fires and assume dominance after coniferous forests have burned. These shrubs provide important habitat, but unless they are able to perpetuate during cyclic fire events, game and livestock habitat may eventually diminish as conifers gain dominance.

Many shrubs occur as components of associated forest and herbaceous communities. Considerable fluctuation in species composition often occurs as a result of fires, and from extremes in climatic events, grazing, and disease. The opportunity to reestablish plants on these disturbances is, in part, dependent upon use of ecotypes with appropriate adaptive features. In an attempt to enhance the shrub component where desirable species have been lost, planting in some situations, has been very successful. Characteristics that ensure the survival of shrubs under adverse conditions are important in selecting plants to rehabilitate mine disturbances and other harsh sites.

Some shrubs are often the only or dominant species to occur on harsh and disturbed sites. Soils throughout many areas of the Intermountain region are infertile and do not support large numbers of species. It is unlikely that successional changes will result in the replacement of many shrubs with other, equally adapted species in such areas. Certain species of buckwheat and penstemon are able to populate harsh, exposed sites. Many of these sites are important midwintering areas where high quality forage is essential for big game animals. In addition, these exposed sites are often invaded by weeds that may enter and, subsequently, spread to adjoining locations. Without the presence of adapted species, weedy plants can invade open and seemingly harsh situations.

Many shrubs are important forage plants. Some are browsed readily throughout the year; others are selectively grazed during certain seasons. For example, Gambel oak, Rocky Mountain maple, redstem ceanothus, and Martin ceanothus are often heavily browsed and can contribute a considerable amount of forage throughout the entire year. Green ephedra, Utah juniper, and Oregon grape usually are grazed during specific seasons.

Woody plants provide not only forage, but are equally important as cover and concealment for wildlife. Utah juniper, Gambel oak, skunkbush sumac, Rocky Mountain maple, and willows are very important for this purpose. Many shrubs discussed in this chapter are also useful for soil stabilization, watershed protection, and ground cover. Deerbrush ceanothus, Scouler willow, mountain snowberry, thinleaf alder, and golden currant are examples of species useful for conservation plantings. The native shrub communities provide aesthetic and cultural resources that are unique to the Western United States.

Important characteristics of a number of shrubs are listed in table 1. Seeding recommendations for major vegetative types and conditions are discussed in chapter 17. Shrubs adapted to these situations are included in the seeding recommendations. Seed characteristics are found in chapters 24 through 27.

Family Aceraceae

Acer glabrum
Rocky Mountain maple

Description—Rocky Mountain maple is a long-lived, shade-tolerant, deciduous shrub or small tree native to North America (Van Dersal 1938). Plants vary in height from 6 to 20 ft (1.8 to 6.1 m) (Harrington 1964), and also demonstrate considerable variation in stature, leaf form, and fruit shape (Kartesz and Kartesz 1980). Some plants reach 20 to 30 ft (6.1 to 9.1 m) in height with multiple trunks up to 1 ft (0.3 m) in diameter, but they occur most often as shrubby plants with multiple stems less than 15 ft (4.6 m) tall (Haeussler and Coates 1986; Hitchcock and Cronquist 1973). Leaves are simple, opposite (Alexander and others 1987), palmately three- to five-lobed or three foliate, and mainly 0.8 to 3.2 inches (2 to 8 cm) wide (Welsh and others 1987) (fig. 1). The herbage is glabrous.

Figure 1—Leaves of Rocky Mountain maple are opposite and palmately five-lobed.

Table 1—Species characteristics of selected Intermountain shrubs.

Vegetative types[a] to which the species is adapted	Ease of cleaning seed	Ease of seeding	Ease of transplanting	Germination	Initial establishment	Final establishment	Persistence	Natural spread	Growth rate	Herbage yield	Availability of current growth	Palatability, early spring growth	Palatability, summer growth	Edible foliage retained fall and winter	Grazing tolerance	Seed production	Soil stability	Compatibility with other species	Shade tolerance	Flooding tolerance	Disease and insect resistance	
Alder, thinleaf	3[b]	2	5	4	4	5	4	4	4	5	4	3	4	2	4	3	5	5	5	4	5	A,WM,PP,MB,R
Apache plume	1	3	3	4	2	3	4	3	2	3	4	3	4	4	5	2	4	4	2	3	4	MB,JP,BS,WS,BB
Ash, singleleaf	4	3	2	2	2	3	5	2	2	3	4	2	4	4	5	2	4	4	1	2	4	MB,JP,BS,WS
Barberry, creeping	3	4	4	2	2	3	4	4	2	2	2	3	3	5	4	2	3	4	4	3	4	A,PP,MB,JP,MS,BS
Bearberry	3	4	4	2	1	3	4	3	2	2	4	2	2	4	4	2	5	4	4	2	4	A,PP
Birch, bog	3	2	3	3	3	4	4	4	4	4	3	3	4	3	4	2	4	4	4	4	3	SA,A,PP,WM,R
Birch, paper	3	2	5	4	4	4	4	4	5	4	3	2	4	2	4	3	4	4	4	4	3	A,PP,WM,MB,R
Birch, water	3	2	5	4	4	4	4	4	5	4	2	2	4	2	4	3	4	4	4	4	3	A,PP,WM,MB,R
Bitterbrush, antelope	4	5	5	5	4	5	4	4	4	4	4	3	4	4	5	5	4	5	4	2	4	PP,MB,JP,MS,BS,BB
Bitterbrush, desert	4	5	3	5	4	3	3	3	3	4	4	3	3	4	5	4	3	4	2	2	4	MB,JP,BS,BB
Blackcap	3	2	5	2	2	4	5	5	4	4	4	2	3	2	4	1	5	4	5	4	3	A,WM,PP,MB
Blackbrush	3	5	2	4	1	1	4	3	1	3	3	3	4	3	5	1	3	3	1	2	5	BS,WS,BB
Buckthorn, cascara	3	5	4	3	3	3	4	3	4	4	4	3	4	3	4	3	4	4	4	4	4	A,PP,MB,MS
Buffaloberry, roundleaf	3	4	2	2	2	3	3	2	2	3	3	3	3	4	4	1	4	3	1	2	4	MB,JP,BS,WS,BB
Buffaloberry, russet	3	4	4	2	2	4	4	3	3	3	4	3	4	4	4	2	4	3	5	3	4	SA,A,PP
Buffaloberry, silver	3	4	4	3	3	4	5	4	4	4	4	3	4	3	4	3	4	4	4	3	4	WM,MB,JP,BS,WS,BS,IS,R
Ceanothus, deerbrush	5	5	5	4	4	4	4	4	5	5	5	3	4	3	5	3	5	4	3	3	4	A,PP,MB
Ceanothus, Fendler	5	5	3	3	2	3	3	3	3	4	3	3	4	4	5	2	4	3	2	1	4	A,PP,MB,PJ,MS
Ceanothus, Martin	2	4	4	3	3	5	5	4	3	4	3	3	4	3	5	2	5	4	4	2	4	A,MB,PJ,MS,BS
Ceanothus, prostrate	3	5	4	4	3	3	5	4	2	2	2	3	4	4	5	2	5	3	4	2	4	A,PP,MB,MS
Ceanothus, redstem	3	5	5	4	4	5	5	5	5	5	5	3	4	3	5	3	4	4	4	3	4	A,PP,MB,R
Ceanothus, snowbrush	3	5	5	4	4	5	5	5	5	5	5	3	4	4	5	3	5	4	4	3	4	A,PP,MB,MS
Ceanothus, wedgeleaf	3	5	5	4	3	4	4	4	4	5	5	3	4	4	5	3	5	4	3	2	4	A,PP,MB,MS
Cherry, Bessey	3	4	5	4	4	4	4	1	4	3	4	4	4	2	4	4	4	4	4	3	3	A,WM,PP,MB,JP, MS,BS
Cherry, bitter	3	5	4	2	2	4	5	3	3	4	4	5	4	3	5	3	5	4	3	2	4	A,PP,MB,JP,MS
Chokecherry, black	3	3	4	3	2	4	5	4	4	5	4	5	4	3	5	4	5	4	4	3	3	SA,A,PP,MB,JP,R,MS
Cinquefoil, bush	4	3	4	2	2	4	5	3	3	3	4	4	4	3	4	2	4	4	4	4	4	SA,A,WM,R
Cliffrose, Stansbury	2	4	3	4	3	3	4	4	3	4	4	3	4	5	5	4	3	5	1	2	4	PP,MB,JP,MS,BB
Currant, golden	3	5	5	4	4	4	5	4	4	4	5	5	5	2	4	3	4	4	4	4	3	WM,PP,MB,JP,MS,R,BS,R
Currant, sticky	3	3	4	3	2	3	3	2	3	4	4	4	4	3	4	3	3	4	4	3	4	SA,A,PP,MB

(con.)

Table 1 (Con.)

Vegetative types[a] to which the species is adapted	Ease of cleaning seed	Ease of seeding	Ease of transplanting	Germination	Initial establishment	Final establishment	Persistence	Natural spread	Growth rate	Herbage yield	Availability of current growth	Palatability, early spring growth	Palatability, summer growth	Edible foliage retained fall and winter	Grazing tolerance	Seed production	Soil stability	Compatibility with other species	Shade tolerance	Flooding tolerance	Disease and insect resistance	
Currant, wax	3	4	4	2	2	4	4	3	3	3	4	4	4	3	4	2	3	4	3	3	4	A,PP,MB,JP,BS
Cypress, Arizona	2	4	3	3	3	4	4	1	3	3	3	3	5	4	4	3	3	3	2	3	4	MB,JP,MS,BS
Dogwood, redosier	3	4	5	3	3	4	4	4	5	4	4	4	4	3	4	3	4	5	4	4	4	A,PP,WM,MB,JP,R
Elaeagnus, autumn	3	5	5	3	3	4	5	3	4	4	4	4	4	3	4	3	4	4	4	3	4	PP,MB,MS,WM
Elderberry, blue	3	4	4	1	2	5	5	3	5	5	4	5	5	2	5	3	4	5	3	3	5	A,PP,MB,JP,MS,BS,R
Elder, box	3	2	5	5	4	2	2	3	4	2	2	4	4	1	4	4	3	3	2	4	4	A,MB,JP,MS
Elderberry, red	3	4	4	1	2	5	5	3	5	5	4	5	5	2	5	3	4	4	4	4	5	SA,A,PP,MB
Ephedra, green	5	5	2	5	4	3	4	2	2	3	4	4	5	5	5	3	3	4	1	1	5	MB,JP,MS,BS,WS,SS,BB
Ephedra, Nevada	5	5	2	5	4	3	4	2	2	3	4	4	4	5	5	2	3	4	1	1	5	MB,JP,BS,WS,SS,BB
Eriogonum, sulfur	3	5	3	4	4	5	3	5	4	3	3	4	4	4	4	3	3	3	3	2	3	PP,MB,JP,MS,BS,WS
Eriogonum, Wyeth	3	5	3	4	4	5	4	4	4	3	4	4	4	4	4	3	3	4	4	2	4	SA,A,PP,MB,JP,MS,BS,WS
Forestiera, New Mexico	2	4	4	3	2	4	5	2	4	2	3	2	5	3	4	4	3	4	2	2	4	MB,JP,BS,WS
Greasewood, black	3	4	3	4	1	4	5	2	3	3	3	3	5	2	5	3	3	4	1	5	5	BS,WS,SS,BG,IS
Hackberry, netleaf	3	4	4	2	2	4	5	3	2	4	3	3	4	3	4	2	4	4	3	3	4	WM,PP,MB,MS,R
Hawthorn, Douglas	3	3	4	1	2	4	5	5	2	3	4	2	3	3	4	2	3	4	3	4	3	WM,PP,MB,MS,R
Honeylocust	3	4	5	3	3	4	5	4	4	3	3	2	4	2	2	3	3	3	3	2	2	PP,MB,JP,MS
Honeysuckle, bearberry	3	3	5	2	1	4	5	3	3	4	4	5	5	4	4	2	4	4	4	3	4	SA,A,WM,MB
Honeysuckle, Utah	3	4	5	4	2	4	5	3	4	4	4	4	4	2	4	2	4	4	4	3	5	A,PP
Honeysuckle, orange	3	4	5	3	2	4	5	4	4	4	4	3	3	4	4	2	5	3	3	2	4	A,PP,MB
Hopsage, spineless	3	4	4	4	4	2	4	3	3	3	3	4	5	3	5	3	4	3	1	3	5	JP,BS,WS,SS,BB
Hopsage, spiny	3	4	2	4	1	2	5	1	2	2	2	5	1	1	5	2	3	3	1	3	5	JP,BS,WS,SS,BB
Indian apple	3	5	3	3	3	3	5	3	3	4	4	5	4	2	5	3	4	3	3	2	3	PP,MB,JP,MS,WS
Juniper, creeping	5[c]	5	3	1	1	4	5	2	2	2	4	2	2	5	5	2	4	2	3	2	4	A,PP
Juniper, Rocky Mountain	5[c]	5	3	2	1	4	4	5	2	3	4	3	2	5	5	3	3	2	3	3	4	A,MB,JP,MS,BS
Juniper, Utah	5[c]	5	1	1	1	5	5	5	2	2	3	2	3	5	5	2	1	4	2	2	4	MB,JP,MS,BS,WS,SS,BB

(con.)

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Kochia, gray-molly	3	4	3	3	2	4	5	3	2	2	2	4	5	4	5	2	4	4	1	3	4	WS,SS,BG
Kochia, forage	3	4	4	4	2	4	5	4	3	4	4	4	5	4	5	4	4	4	2	2	4	MB,PJ,MS,BS,WS, SS,BB, C,AW
Locust, black	3	3	4	3	4	4	5	4	4	3	3	2	4	3	3	3	3	3	3	2	3	PP,MB,JP,MS
Maple, bigtooth	3	3	3	4	2	2	3	3	3	4	4	5	4	2	3	4	4	4	4	3	4	A,MB,JP
Maple, Rocky Mountain	3	2	2	2	1	2	3	3	3	2	3	4	4	2	3	3	3	5	5	3	3	A,PP,MB
Mockorange, Lewis	1	2	3	4	3	3	4	4	4	4	4	3	2	4	4	3	3	2	2	3	2	A,PP,WM,MB,MS
mountain ash, Greene's	3	4	3	3	2	3	4	4	2	3	3	3	2	3	4	3	2	2	2	3	3	A,WM,PP,MB
Mountain lover	2	3	2	2	2	2	4	3	3	4	3	4	2	3	4	2	2	4	2	4	4	SA,A,PP,WM,MB
Mountain mahogany, curlleaf	2	4	3	4	3	3	4	3	3	3	3	3	5	5	4	3	3	3	3	1	3	PP,MB,JP
Mountain mahogany, littleleaf	2	4	3	4	3	2	4	3	3	3	4	3	4	4	4	3	4	2	2	1	3	PP,MB,JP
Mountain mahogany, true	2	4	3	4	4	3	4	4	4	3	4	4	4	2	4	3	4	3	3	2	3	A,PP,MB,JP,MS
Ninebark, mallowleaf	3	4	4	4	3	3	4	4	3	4	4	4	2	4	4	2	3	4	3	3	4	A,WM,PP,MB,MS
Oak, Gambel	5	2	1	4	3	2	4	2	3	4	4	1	5	2	5	3	5	3	4	3	4	A,MB,JP
Oceanspray, creambush	4	4	4	3	3	4	4	3	3	3	4	2	2	5	5	2	3	3	3	4	3	A,WM,PP,MB,MS,R
Peachbrush, desert	5	4	4	5	4	4	4	4	3	3	3	5	4	1	4	3	3	3	1	3	3	MB,JP,BS,WS,SS,BB
Penstemon, bush	4	5	5	4	4	4	4	3	3	5	4	4	4	3	3	3	2	3	4	3	1	A,PP,MB,MS
Plum, American	3	2	3	3	2	4	4	4	3	3	3	4	4	1	4	3	4	3	3	4	4	WM,MB,R
Rabbitbrush, Douglas	4[d]	2	4	3	3	4	4	5	3	3	3	3	4	3	4	3	3	4	2	2	4	A,PP,MB,JP,MS, BS,WS,SS
Rabbitbrush, dwarf	4[d]	2	5	4	4	4	5	5	3	2	3	4	4	4	5	3	5	4	1	1	4	MB,JP,MS,BS,WS,BB
Rabbitbrush, low	4[d]	2	4	3	3	4	5	4	4	3	4	4	4	5	3	4	4	2	3	4	4	A,MB,JP,MS,BS,WS, SS,BG,BB,IS
Rabbitbrush, Parry	4[d]	2	5	4	3	4	4	4	3	5	3	4	4	4	5	3	4	4	2	2	4	SA,A,MB,SS
Rabbitbrush, rubber	4[d]	2	4	4	4	4	4	5	5	5	5	3	3	5	5	4	5	4	2	2	3	SA,A,PP,MB,JP, MS,BS,WS,SS, BG,IS
Rabbitbrush, small	4[d]	2	5	4	4	4	5	5	4	3	3	3	4	4	5	3	4	3	1	1	5	JP,MS,BS,WS,SS
Rabbitbrush, spreading	4[d]	2	5	4	4	5	4	4	4	4	4	5	3	4	4	3	5	3	2	3	4	BS,WS,SS,BG,BB
Rockspirea	4	4	3	2	3	4	4	2	3	4	4	2	3	5	4	2	4	3	2	4	3	SA,A,WM,PP,MS
Rose, Woods	3	4	5	2	3	4	5	3	4	4	3	4	4	2	5	2	4	4	4	4	4	SA,A,PP,MB,JP,MS

(con.)

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Vegetative types[a] to which the species is adapted	Ease of cleaning seed	Ease of seeding	Ease of transplanting	Germination	Initial establishment	Final establishment	Persistence	Natural spread	Growth rate	Herbage yield	Availability of current growth	Palatability, early spring growth	Palatability, summer growth	Edible foliage retained fall and winter	Grazing tolerance	Seed production	Soil stability	Compatibility with other species	Shade tolerance	Flooding tolerance	Disease and insect resistance	
Sagebrush, basin big	4[d]	3	5	5	4	5	5	5	5	5	5	3	3	5	4	4	4	3	2	3	3	JP,BS,SS,BG,BB,C,AW
Sagebrush, Bigelow	4[d]	3	5	5	4	4	4	5	4	3	4	3	3	4	4	3	3	3	2	3	3	JP,BS,WS,SS,BG,BB
Sagebrush, black	4[d]	4	5	5	4	5	5	5	4	3	3	3	5	5	4	4	4	3	1	1	4	MB,JP,MS,BS,SS
Sagebrush, bud	4[d]	2	2	2	1	3	3	2	2	2	2	5	1	2	5	2	2	4	1	2	4	BB,WS,SS
Sagebrush, early	4[d]	3	3	4	4	4	4	4	3	3	3	3	3	4	5	2	3	2	1	4	4	MB,MS
Sagebrush, fringed	4[d]	3	4	3	4	4	4	4	3	3	3	2	5	4	4	3	3	4	4	4	4	MB,JP,MS,BS,SS
Sagebrush, low	4[d]	3	4	5	4	5	5	5	4	3	3	2	2	3	5	2	3	2	2	4	4	JP,BS,WS,SS,BG
Sagebrush, mountain big	4[d]	3	5	4	4	5	5	5	5	5	5	3	4	5	5	3	4	4	3	3	3	SA,A,WM,PP,MB
Sagebrush, pygmy	4[d]	2	2	3	2	2	2	2	2	2	2	3	3	3	4	2	3	4	2	3	4	WS,SS,BB
Sagebrush, silver	4[d]	4	5	5	4	5	5	5	4	5	5	3	4	5	5	4	4	3	3	4	4	SA,A,MB,MS,WS
Sagebrush, stiff	4[d]	2	3	3	2	3	3	3	2	2	3	3	4	3	5	2	3	3	2	2	4	MS,BS,WS
Sagebrush, threetip	4[d]	3	5	5	4	5	5	5	5	5	5	3	3	5	4	4	4	4	3	3	4	MB,MS,BS,WS,JP,MS
Sagebrush, Wyoming big	4[d]	3	5	5	4	5	4	4	4	4	4	3	3	5	4	3	4	3	2	2	3	JP,BS,WS,SS,BG,BB,C,AW
Saltbush, Castle Valley clover	4	4	3	4	3	3	4	3	4	4	4	5	5	4	3	3	2	1	3	4	3	WS,SS,BG
Saltbush, fourwing	4	5	4	4	4	3	4	3	5	5	4	3	5	5	5	5	4	5	1	2	2	MB,JP,MS,BS,WS,SS, BG,BB,IS
Saltbush, Gardner	5	4	4	3	3	3	3	4	3	3	4	4	5	4	5	3	4	3	1	3	3	MB,JP,BS,WS,SS,BG,IS
Saltbush, mat	5	4	4	3	2	3	4	3	2	4	4	5	5	5	3	2	1	1	3	4	3	WS,SS,BG,BB
Saltbush, quailbush	4	4	3	2	2	3	4	5	4	4	4	5	4	2	3	4	3	1	3	4	3	WS,SS,BG,BB
Saltbush, shadscale	4	4	2	2	1	2	3	3	2	3	3	3	5	3	5	2	4	4	1	2	3	JP,BS,WS,SS,BG,BB
Sandsage	4[d]	3	5	4	4	5	4	4	4	3	3	3	3	4	4	3	4	4	2	2	4	JP,BS,WA,BB
Serviceberry, Saskatoon	3	5	3	3	3	3	4	3	3	3	4	4	4	3	4	3	4	4	4	2	3	SA,A,PP,MB,JP,MS
Serviceberry, Utah	3	5	3	3	3	4	4	3	3	3	4	4	4	3	4	3	4	4	3	2	4	PP,MB,JP,MS,BS,BB
Silverberry	3	4	5	3	3	4	4	2	3	3	4	2	3	3	4	4	3	4	3	4	4	WM,PP,MB
Snowberry, common	3	5	5	3	3	4	3	3	4	4	4	4	4	2	4	2	4	3	4	4	4	MB
Snowberry, longflower	3	5	5	2	3	3	4	3	4	4	4	5	3	2	4	1	4	4	2	2	4	A,JP,BS,WS,BB
Snowberry, mountain	3	5	5	3	3	4	5	4	4	4	4	5	4	2	5	2	5	5	4	4	4	SA,A,PP,MB,JP,MS
Snowberry, western	3	5	5	3	3	4	4	3	4	3	4	4	4	2	4	2	4	4	4	3	4	WM,MB,BS
Spiraea, birchleaf	3	3	4	4	3	5	5	3	4	4	5	2	2	5	4	2	4	4	3	4	3	A,WM,PP,MB,MS
Sumac, Rocky Mountain smooth	2	5	5	2	2	4	4	3	4	4	4	3	4	3	4	4	4	4	2	2	4	PP,MB,JP,MS
Sumac, skunkbush	2	5	5	2	2	4	5	3	3	4	4	3	4	3	5	3	4	3	2	3	4	PP,MB,JP,MS,BS,BB

(con.)

Table 1 (Con.)

Vegetative types[a] to which the species is adapted	Ease of cleaning seed	Ease of seeding	Ease of transplanting	Germination	Initial establishment	Final establishment	Persistence	Natural spread	Growth rate	Herbage yield	Availability of current growth	Palatability, early spring growth	Palatability, summer growth	Edible foliage retained fall and winter	Grazing tolerance	Seed production	Soil stability	Compatibility with other species	Shade tolerance	Flooding tolerance	Disease and insect resistance	
Thimbleberry	3	2	5	2	2	4	5	5	3	3	4	2	3	2	4	1	5	4	5	4	3	A,WM,PP,MB
Virginsbower, western	1	2	4	3	2	3	4	4	3	3	3	4	4	1	4	2	4	4	3	2	4	A,PP,MB,JP,MS,BS,BB
Willow, Booth	2	2	4	4	2	4	4	5	5	4	5	5	3	5	4	3	4	4	4	4	5	A,WM,PP,R
Willow, coyote	2	2	4	4	2	4	4	4	5	5	5	3	3	4	4	5	3	4	3	3	4	WM,A,PP,IS,R
Willow, Drummond	2	2	4	4	2	4	4	5	5	4	5	5	3	5	4	3	2	4	4	4	5	SA,A,PP,WM,R
Willow, purpleosier	2	2	5	4	2	4	4	2	5	4	5	4	4	4	4	4	5	4	4	4	4	A,WM,PP,MB,R
Willow, Scouler	2	2	5	4	2	4	4	4	5	5	5	4	4	4	4	4	5	4	4	3	4	A, WM,PP,R
Willow, whiplash	2	2	5	4	2	4	4	4	5	4	5	4	4	4	4	3	4	4	4	4	4	A,PP,P-J,WM,R
Winterfat, common	3	2	5	5	4	4	4	4	5	3	3	4	4	4	5	3	3	5	1	2	4	MB,JP,BS,WS,SS,BG,BB,IS
Wormwood, oldman	4[d]	3	5	1	1	4	2	3	5	3	3	3	5	3	4	1	5	4	2	1	5	SA,A,PP,MB,MS

[a]Vegetative type or community to which the species is adapted: SA = Subalpine; WS = Wyoming big sagebrush; A = Aspen-conifer; SS = Shadscale saltbush; WM = Wet and semiwet meadows; BG = Black greasewood; PP = Ponderosa pine; BB = Blackbrush; MB = Mountain brush; IS = Inland saltgrass; JP = Juniper-pinyon; R = Riparian; MS = Mountain big sagebrush; C = Cheatgrass; BS = Basin big sagebrush; AW = Annual weeds.

[b]Key to ratings: l = Poor–difficult; 2 = Fair; 3 = Medium; 4 = Good; 5 = Excellent–easy.

[c]In the flesh.

[d]Less than 15 percent purity.

Twigs are usually gray with smooth, reddish-brown bark. Flowers are monoecious or dioecious, appearing in loose, racemose corymbs (Harrington 1964). Fruits consist of two fused samaras about 1 to 1.5 inches (2.5 to 3.8 cm) long, with widely divergent wings, each containing a single seed (Harrington 1964; Hitchcock and Cronquist 1973; Olson and Gabriel 1974).

Ecological Relationships and Distribution—Rocky Mountain maple occurs from Alaska south to California, Arizona, New Mexico, and Nebraska (Little 1979; Welsh and others 1987). In the Pacific Northwest, Rocky Mountain maple is primarily a coastal species, but it is distributed eastward into Idaho, Montana, and western Colorado at elevations between 5,000 and 10,500 ft (1,500 and 3,200 m) (Hitchcock and Cronquist 1973; Harrington 1964). It occurs at elevations of 5,000 to 9,000 ft (1,500 to 2,700 m) in conifer forests of the Sierra Nevada Mountains, northern Coast Ranges, and into western Nevada (Munz and Keck 1959). Welsh and others (1987) reported the plant occurs in all Utah counties at elevations between 5,440 and 10,300 ft (1,700 and 3,100 m).

Rocky Mountain maple is frequently a seral species, but it is able to persist as an understory in climax conifer stands due to its shade tolerance (Mueggler 1965; Ryan and Noste 1985). It occurs intermixed with Douglas-fir, lodgepole pine, ponderosa pine, spruce-fir, and quaking aspen. However, it does not occur as a common understory species with aspen in Utah (Mueggler 1988). It occurs along streambanks in mountainous areas, in moist canyon bottoms, and on slopes (Mozingo 1987; Wasser 1982), primarily in moist habitats (Lotan 1986). This species is frequently associated with mallowleaf ninebark, Saskatoon serviceberry, Scouler willow, Greene's mountain ash, chokecherry, mountain lover, and Utah honeysuckle (Atzet 1979; Johnson and Simon 1987; Mauk and Henderson 1984; Steele and others 1981; USDA Forest Service 1973; Wasser 1982).

Within the Intermountain region, Rocky Mountain maple occurs primarily in mountain brush communities. The species exists over a wide range of sites from well-drained to moist situations. Plants grow intermixed with Gambel oak, chokecherry, and Woods rose in mesic, brushland sites. At lower elevations, its range overlaps with pinyon and juniper, although it usually does not grow in mixtures with these conifers. Where pinyon or juniper occur with maple, the conifers are usually restricted to the more arid sites. In arid regions it is restricted to streams and moist canyons (Mozingo 1987; Wasser 1982), existing as an important species in riparian communities (Brown and others 1977; Mozingo 1987; Myers 1987). It occupies both warm and cool wet areas.

In some situations, Rocky Mountain maple appears to be dependent on the presence of a well-developed soil, with high concentrations of organic matter in the upper portions of the soil profile (Krajina and others 1982; Mueggler 1965). Plants also occur on rocky and gravelly soils and on steep slopes with shallow soils, where a considerable amount of litter has accumulated. At both upper and lower elevation limits, the distribution of Rocky Mountain maple is influenced by topographic features and aspects.

Rocky Mountain maple usually grows on sites that receive between 16 and 30 inches (400 and 760 mm) of annual precipitation. Mature stands will usually persist with limited dieoff during periods of extended drought. A decrease in herbage production may occur if the precipitation level falls below normal, but stand density usually remains unchanged.

Rocky Mountain maple may occur in dense, restricted patches or clumps; yet, open diverse stands often occupy an entire slope or small drainage (fig. 2). When found on south or west aspects, it may be confined to small patches surrounded by bunchgrasses or more xeric species. Mountain brome and slender wheatgrass frequently occur as an understory with this species. These two grasses may increase or decline dramatically from year to year, but the density of overstory maple remains quite consistent.

Grazing, wildfires, and other impacts have not seriously reduced the distribution or density of Rocky Mountain maple. Cutting and burning temporarily reduce some stands, but natural recovery is quite rapid. Weedy species have not seriously affected the presence or vigor of Rocky Mountain maple even though heavy grazing has removed the native understory in some areas.

Figure 2—Rocky Mountain maple may occur as individual shrubs, or more often in small thickets in mountain brush communities.

Rocky Mountain maple is particularly important in many of the conifer forest communities. It is not seriously diminished by a closing canopy (Antos 1977; Habeck 1970; Stickney 1985). It can recover immediately following fire (Cholewa and Johnson 1983; Mueggler 1965) or logging due to its resprouting capabilities. Recovery is from stem resprouting, not by root suckering or rhizome formation (Haeussler and Coates 1986).

Plant Culture—Seeds usually mature in August or September (Olson and Gabriel 1974). Some stands produce seeds once every 2 to 3 years (Olson and Gabriel 1974). However, individual plants scattered throughout a stand usually produce some seeds each year. In addition, certain plants have been observed to produce a viable crop of seeds every year for 3- to 5-year periods. Individual plants often produce an extraordinary amount of seeds. Seeds also tend to ripen more uniformly on certain plants; consequently, seed collection is usually confined to a few plants. Seeds often ripen over a period of 1 month.

Seeds usually remain on the plants for 2 to 4 weeks before being dislodged by wind. When mature, the fruits turn from green to yellow or reddish brown. Seeds can be collected by hand stripping or flailing the bush. Green or immature seed should not be collected. Seeds should be inspected for insect damage and immature embryos before collection. Some collections exhibit about 50 percent germination (Swingle 1939). This percentage can be improved, however, if care is taken to collect mature, well-developed seeds. There are about 13,430 seeds per lb (29,600 per kg) (Olson and Gabriel 1974).

The wings are usually detached from the fruits to aid in handling and planting. Once the wings are removed, empty seeds can be removed by flotation. This is advisable to permit regulation of seeding rates. Seeds should be dried to a water content of 10 to 15 percent before storage (Olson and Gabriel 1974). Seeds can be stored for 1 to 2 years in sealed containers at 35 to 41 °F (1.7 to 5 °C) without serious loss of viability (MacArthur and Fraser 1963). Seeds have dormant embryos that require 6 months of wet prechilling to release dormancy (Shaw 1984). Consequently, fall seeding is advised. However, wet prechilled seeds can be spring planted, particularly under nursery conditions. Seeds dispersed on the soil surface do not maintain viability (Kramer 1984).

Cleaned seeds can be planted with most conventional seeders, but most plantings have been restricted to small, carefully prepared areas where hand seeding has been employed. Seeds should be planted at a depth of 0.5 to 1.5 inches (1.3 to 3.8 cm). Broadcast planting without any followup methods for covering the seeds is not advised. Planting weedy sites should be avoided. Seedlings have grown well and attained considerable size in 1 to 2 years.

To date, most seedings have been confined to sites where the species previously existed. When seeded "offsite," weak and erratic stands have developed. Plants appear to be quite dependent on soil conditions to survive and flourish. When seeded or transplanted on mine wastes, plants have done poorly. However, if sites are top soiled, better stands have established and persisted.

Natural seedlings are usually not abundant. When found, they are encountered in shady areas with little competition (Steele and Geier-Hayes 1992). Under these conditions seedlings have been reported to grow slowly.

Rocky Mountain maple is easily cultured and has been planted in commercial landscape programs. Transplants or wildlings are used in conjunction with other species in formal plantings.

Transplanting 1- to 3-year-old nursery stock has improved stand establishment in areas with poor soils or where some understory competition exists. Older transplants are able to establish and begin growth quite rapidly without a prolonged period of adjustment.

Uses and Management—Rocky Mountain maple has been planted to provide diversity and enhance wildlife habitat. Though it is often confined to small areas, it provides valuable thickets for protection and concealment. It is a useful forage species and occurs in important winter habitats for big game animals (Arno and Hammerly 1977; Beetle 1962; Gaffney 1941; Keay 1977; Martinka 1976; Young and Robinette 1939). Rocky Mountain maple normally supports a productive complex of understory herbs. These sites are important areas for summer grazing by big game and livestock. Stands of Rocky Mountain maple that recover following burning provide considerable forage for big game, livestock, and nongame animals. In most situations plants may grow too tall to be reached by animals, yet they provide excellent cover (Johnson and Simon 1987; Larson and Moir 1987). In more arid situations, the shorter growing forms remain available to browsing animals. Rocky Mountain maple is a palatable species, particularly to big game (Beetle 1962; Keay 1977; Martinka 1976; Mitchell 1950; Smith 1953), but is also used by other animals, including ruffed and blue grouse (Steele and others 1981) and small mammals (Martin and others 1951).

Rocky Mountain maple grows in moist areas. When disturbed, these sites can produce sediment and increase runoff. These sites are important for watershed stability and may require immediate attention if disturbed. Rocky Mountain maple is able to recover following disturbances and can provide soil and streambank protection.

Both Rocky Mountain maple and bigtooth maple are attractive plants, particularly during the fall when

leaves turn red and yellow. Certain plants and clumps exhibit early fall coloration, others are particularly brilliant in color, and some may retain their leaves for extended periods. Also, considerable differences in growth habit and mature size occur among ecotypes. Many native stands have high aesthetic appeal and are important viewing areas and recreational sites. These areas are frequently managed for scenic use. Rocky Mountain maple has not been used as extensively in windbreaks and conservation plantings as other maples.

Varieties and Ecotypes—None.

Family Anacardiaceae

Rhus aromatica
Skunkbush sumac

Description—Skunkbush sumac is an unusually persistent and highly variable species (fig. 3). Welsh and others (1987) described two varieties of this species complex that occur in Utah. *Rhus aromatica* var. *simplicifolia* has simple leaves and occupies xeric sites in southeastern and southwestern Utah. *Rhus aromatica* var. *trilobata* leaves are trifoliolate, and plants grow on mesic sites including streambanks, seeps, and riparian communities. Shrubs occur singly or in dense patches and may be connected by woody rhizomes, which often exceed 20 ft (6.1 m) in length (Sanford 1970). Root systems are deep and extensively branched. Plants are deciduous, woody, spreading, and moundlike to erect, often forming clumps or thickets. They normally range from 2 to 7 ft (0.6 to 2.1 m) in height (Hitchcock and others 1961; Welsh and others 1987); some may reach heights of 15 ft (4.6 m) (Thornburg 1982). Crown diameter often exceeds the height and may be more than 30 ft (9.1 m) (Plummer and others 1968; USDA Forest Service 1976c). Stems are numerous, woody, spreading, highly branched, and brown hairy when young; they develop a gray bloom with age (Barkley 1937; Wasser 1982). Leaves are 1 to 3 inches (3 to 7 cm) long, trifoliate, petiolate, and puberulent beneath. The terminal leaflet is fan shaped, shallowly to deeply incised or lobed, and coarsely crenate. Lower leaflets are half as large and shallowly crenate. The resinous, acrid sap of the twigs and leaves is nonpoisonous, but produces a disagreeable odor, hence the common name, skunkbush sumac (Stubbendieck and others 1986). Plants are polygamo-dioecious. The inflorescence consists of a cluster of spikes located near the branch apex (Goodrich and Neese 1986). Buds and flowers are inconspicuous, pale yellow, and mostly imperfect. Fruits are orange red, sticky, berrylike drupes, each containing a single bony seed (Brinkman 1974g; Stubbendieck and others 1986; Welsh and others 1987).

Figure 3—Skunkbush sumac established from a direct seeding provides important wildlife habitat.

Ecological Relationships and Distribution—Skunkbush sumac is widespread and highly variable; it ranges from Alberta south to Iowa and Mexico, and west to southeastern Oregon and California (Harrington 1964). It is found at elevations from 3,500 to 8,000 ft (1,100 to 2,400 m) (Hitchcock and others 1961; USDA Forest Service 1937) on sites with annual precipitation between 10 and 20 inches (250 and 510 mm) (Wasser 1982). It grows in the mountain brush and pinyon-juniper types of the Intermountain region and the plains and foothills of eastern Wyoming and Montana (Welsh and others 1987). It is a primary or secondary species growing in sand hills of the plains and Southwest (Wasser 1982). At lower elevations it may be found with blackbrush, basin big sagebrush, or Wyoming big sagebrush. It also occurs in openings in oakbrush and ponderosa pine forests (Vories 1981). Plants growing in rocky foothills are usually smaller in stature and less productive than the more typical upright forms of the mountain brush communities (Welsh and others 1987). Skunkbush sumac is generally drought and cold tolerant, but these characteristics vary among ecotypes.

Skunkbush sumac is commonly found along stream courses where it occurs intermixed with other shrubs or as an understory with cottonwoods. Although dense stands are usually not encountered, scattered plants or thickets may be widely distributed in openings along riparian areas; plants require full sunlight to partial shade. On dry sites it occurs in swales and drainageways where it may receive extra moisture. It requires well-drained soils with deep water tables (Wasser 1982), and although it tolerates short-term

flooding where it occurs along streams, it is not capable of surviving long-term flooding.

Skunkbush sumac occurs on a wide range of soils ranging from sandy textured soils to heavy clay-textured materials (Johnson and others 1966). In Utah, it is particularly well adapted to heavy shale outcrops, and sometimes salty outcrops, where few other shrubs are adapted (Plummer 1977). It grows on both acidic and basic soils including slightly alkaline soils (Johnson and others 1966; Vories 1981). It occurs on deep fertile soils and also on shallow, rocky, less-developed soils.

Plant Culture—Fruits of skunkbush sumac form dense clusters near the ends of small branches. The clusters are scattered over the surface of the entire bush. Flowers appear from March to April (Brinkman 1974g). Fruits ripen from June to September (Plummer and others 1968; Van Dersal 1938), and many remain on the shrub until midwinter. Most seeds are removed by birds or other animals (Brinkman 1974g).

Fruits may be harvested over a period of 2 to 3 months during early fall and winter, but they are more difficult to clean if they have been allowed to dry on the shrub. Fruits are collected by hand picking or flailing the stems after leaves have fallen in early winter. Fruits adhere to the plant and are not easily dislodged. This characteristic interferes with seed collection and results in high seed costs. Harvested fruits are macerated using a Dybvig cleaner and flushed with water to remove the pulp. The remaining material, including the seeds, is then dried and fanned to remove small debris. Seeds can be cleaned to purities exceeding 90 percent. There are approximately 20,000 cleaned seeds per lb (44,100 per kg) (Brinkman 1974g; Plummer and others 1968; USDA Forest Service 1948). Recommended laboratory standards for seed purchases are 40 percent germination and 95 percent purity. Cleaned seeds remain viable for up to 5 years under open, dry storage.

Seed production varies among sites and ecotypes. Most upland populations produce some seeds each year, but abundant crops must be produced to justify commercial harvesting. Seeds from many useful ecotypes or collection sites normally are not harvested or sold because production is quite low. Consequently, poor seed-producing ecotypes are not collected and used in restoration programs. Seeds from more limited, but productive, stands are normally harvested and sold for extensive plantings. Thus, the most adapted ecotypes are not always used.

Seed germination may be restricted by the presence of a hard, impervious seedcoat and embryo dormancy. Both forms of dormancy vary widely among seedlots. Seedcoat permeability may be increased by a 20-minute to 2-hour sulphuric acid scarification (Babb 1959; Brinkman 1974g; Glazebrook 1941; Heit 1968a). A wet prechilling for 30 to 120 days is required to release embryo dormancy (Babb 1959; Heit 1970; Swingle 1939). Duration of acid treatment and wet prechilling periods required vary among seedlots. Physical rupturing of the seedcoat using mechanical methods also increases germination (McKeever 1938), but procedures have not been developed to treat large seedlots. Fall seeding often provides the necessary cold treatment to release embryo dormancy (Brinkman 1974g), but very erratic results have occurred, possibly due to differences in seedcoat imposed dormancy (Boyd 1943; Monsen 1987; Monsen and McArthur 1985).

Erratic seed germination is the principal factor preventing extensive seeding of this shrub. Differences in germinability are not entirely related to ecotypes or site of collection. Plants from sites in north-central Wyoming and south-central Montana are in considerable demand for mine restoration, but these ecotypes are difficult to germinate. Means to stimulate or assure field germination are not well understood, and until these problems are corrected, use of skunkbush sumac will be adversely affected.

Seeds that have been properly pretreated will normally germinate in 30 to 45 days, once germination begins (Monsen and Christensen 1975). Germination is usually completed in 30 days under nursery conditions (Brinkman 1974g). This long germination period can adversely affect survival of wildland plantings. Soil at many sites does not remain moist long enough to ensure germination and seedling establishment.

Different ecotypes of skunkbush sumac occur throughout its range. Adapted seed sources must be selected for range seedings or transplanting projects. Scarified seed should be fall planted to provide overwinter wet prechilling; scarified seeds sown in the spring must first be wet prechilled. Seed should be planted approximately 0.5 inch (1.3 cm) deep or slightly deeper in dry, coarse-textured soils. Skunkbush sumac may be seeded at the rate of 2 to 4 lb per acre (2.2 to 4.5 kg per ha), depending on row spacings. It may be broadcast on rough surfaces or in pits. If drill seeded, it should be planted with other slow-growing shrub species in rows separate from faster growing species.

Seedlings grow moderately well, but young plants are not highly competitive with herbs (Monsen 1987). Consequently, this species should not be seeded together with grasses. Young plants can be stunted by herbaceous competition and may not recover (Monsen 1987). Established seedlings are quite hardy and resilient. Range or wildland seedings normally require 2 to 5 years to fully establish.

In the bareroot nursery seed should be planted about 0.5 inch (1.3 cm) deep. A seeding density of 25 viable seeds per linear ft (82 viable seeds per linear m) was recommended by Brinkman (1974g). At the Los

Lunas Plant Material Center seeds are planted at a density of 182 per linear ft (600 per linear m) of row to yield 23 usable plants per linear ft (75 per linear m) (Frazier 1979). Beds should be mulched to prevent excessive drying. Plants may be lifted as 1-0 or 2-0 stock, depending on their growth rate. Field transplanted seedlings should be at least 8 to 11 inches (20.3 to 28 cm) tall. Container stock is most easily established from germinants and requires a 4- to 6-month cropping time (Landis and Simonich 1984). Ferguson and Frischknecht (1981) and Stevens (1981) reported that large, well-rooted stock is easily transplanted. Skunkbush sumac is grown by many commercial nurseries, and wildland plantings of bareroot stock have been highly successful.

Doran (1957) reported that cuttings of *Rhus* root well when taken in July and potted in a sand-peat media. This provides a means of propagating collections from specific locations that are difficult to rear from seed.

Field cultivation of skunkbush sumac has been successful in improving seed production. Producing seed from agricultural fields or nursery sites could undoubtedly provide a means of marketing desired ecotypes and providing a more stable market.

Uses and Management—Skunkbush sumac has been extensively used in windbreaks, shelterbelts, and conservation plantings (Brinkman 1974g; Hassell 1982; Swenson 1957). As an ornamental, it grows rapidly and develops dense foliage (Johnson 1963; Olson and Nagle 1965; Steger and Beck 1973). The leaves and berries turn brilliant shades of red and orange in the autumn. Mature plants withstand burial by drifting sand and sprouting from the crown. Plants are also able to survive when soil is eroded from the upper portions of the root system. These characteristics, along with its cover value, low palatability, ability to resprout after fire, longevity, and ability to withstand climatic extremes, qualify sumac as a valuable species for revegetation (Johnson 1963; Olson and Nagle 1965; Swenson 1957).

Skunkbush sumac requires little maintenance in conservation plantings. Plants do not become decadent with age, but remain healthy and robust. Many other shelterbelt species often decline in vigor or are subject to crown damage from wind, insect attack, or snowfall. Skunkbush sumac is generally not adversely affected by these agents, but persists and becomes a major species in older plantings.

Skunkbush sumac has been widely used in recreation sites, parkways, campgrounds, and roadway rest areas. It frequently recovers by sprouting following disturbances, and can be managed to assure the presence of native species in recreational sites. It withstands traffic and campground activity; consequently, it is used to screen landscape trails, roadways, and structures. The plant is particularly important for recreational sites in semiarid areas in the Intermountain region and the Southwest.

Selected ecotypes of skunkbush sumac have proven well adapted to unstable disturbances. It has been used to stabilize sand dunes (Kozlowski 1972), roadways, and mine sites (Hassell 1982; Monsen and Christensen 1975). However, direct seedings and transplants establish and grow at only moderate rates for the first few years. Although survival is often high, plants do not provide extensive ground cover during the establishment period. Once well established, annual growth increases, and the plants begin to provide considerable ground cover and soil protection.

Skunkbush sumac can be used to stabilize disturbed watersheds, including riparian sites. Its growth habit provides excellent ground cover, and plants are able to resist soil deposition. It is particularly useful for restoration of meadows and other riparian sites where erosion and gully cutting have drained wetlands and lowered water tables.

The spreading moundlike growth form of some ecotypes and the ability of the shrub to form dense thickets by root sprouting cause skunkbush sumac to be a valuable cover plant for birds (Adkins 1980). In addition, the fruits of skunkbush sumac are consumed by many bird species (Brinkman 1974g), particularly during winter months, as berries remain on the bush (Swenson 1957). Consequently, the shrub has been selectively planted in windbreaks and associated conservation plantings to provide forage and cover for birds.

Skunkbush sumac has been most widely planted in the Intermountain area for big game habitat. It is often planted in mixtures with other more preferred forage plants. The shrub is selectively planted on less fertile sites in big sagebrush, pinyon-juniper, and mountain brush communities where ground cover and big game habitat are required (Plummer and others 1968). It grows slowly, normally requiring 10 to 20 years to attain mature stature (Monsen 1987), but it is one of the most successful shrubs established from rehabilitation plantings. Initial establishment and ratings of young plantings are regarded as only fair, but long-term performance ratings are good to excellent. Swenson (1957) and Adkins (1980) also reported good to excellent survival for 20-year-old cover and windbreak plantings of skunkbush sumac in eastern Colorado and eastern Washington.

Palatability of skunkbush sumac is rated low for livestock and fair to good for big game, depending on the ecotype and other browse species available (Dayton 1931; Stanton 1974). It has been planted in mixtures for range and wildlife habitat to provide forage and cover. In Montana and Wyoming it is considered a preferred browse species and receives heavy winter

use (Mueggler and Stewart 1980; Tweit and Houston 1980) and moderate use in the summer (Sanford 1970). Throughout other portions of its range, the plant is only lightly grazed (Sanford 1970). Sheep often browse the shrub at all seasons. Skunkbush sumac is a particularly important forage plant in midwinter during periods of deep snow cover. It occupies windblown slopes that often remain open and available for browsing. Skunkbush sumac recovers well from wildfires, sprouting vigorously from underground rhizomes (Dwyer and Pieper 1967; Wright and others 1979). It is an important shrub in areas where fires can be used to enhance vegetative conditions.

Varieties and Ecotypes—"Bighorn" skunkbush sumac, developed by the Los Lunas Plant Materials Center, is a tall, upright variety selected from trials conducted at locations from New Mexico to Montana and North Dakota (Thornburg 1982). Seed of this variety does not exhibit embryo dormancy and requires only a 10 to 25 minute acid scarification (Frazier 1979). Populations of skunkbush sumac vary widely in size, growth habit, leaf characteristics, and range of adaptation; they provide many opportunities for future selection work.

Family Anacardiaceae

Rhus glabra
Rocky Mountain smooth sumac

Description—Rocky Mountain smooth sumac is a small, little-branched, thicket-forming shrub (Van Dersal 1938). Mature plants usually do not exceed 3 to 6 ft (0.9 to 1.8 m) in height. Root suckers develop from the parental plant, and new shoots may appear 10 to 13 ft (3.0 to 4.0 m) from the base of the shrub (fig. 4). Branchlets are glabrous and glaucous. The leaves are mostly 4 to 12 inches (10 to 30 cm) long with 7 to 21 leaflets. Leaves are lanceolate, mainly 0.6 to 3 inches (1.5 to 8 cm) long, acuminate, serrate, and range in color from dark green to light green. The inflorescence consists of a panicle about 4 to 8 inches (10 to 20 cm) long, containing many white flowers. The fruit is a globular, red, thinly fleshy drupe. It is about 0.2 inch (4 mm) long and covered with a dense layer of short red hairs (Harrington 1964; Welsh and others 1987).

Ecological Relationships and Distribution—Rocky Mountain smooth sumac is widespread in North America (Welsh and others 1987). It occurs from British Columbia to California, Oregon, and Arizona, and eastward to the Atlantic Coast (Munz and Keck 1959). It is common from Nevada and Mexico to New Hampshire and Georgia (Davis 1952; Hitchcock and Cronquist 1973). In Utah it occurs on a variety of sites including desert shrub, riparian, pinyon-juniper, and mountain brush communities at altitudes between 3,590 and 7,710 ft (1,100 and 2,350 m) (Welsh and others 1987). Harrington (1964) reported that the shrub occupies valleys and slopes throughout the western portion of Colorado at elevations between 5,500 and 7,500 ft (1,700 and 2,300 m).

Rocky Mountain smooth sumac often exists in disjunct stands in dry places, usually in open areas without overstory shade. Large patches or clumps often occur alone without other shrubs, but intermingled in groupings with other plants. It grows on a variety of soils including sandy as well as heavy-textured materials. It is a climax species with various bunchgrasses in the Northwest, although the native grasses have often been replaced by annual cheatgrass (Daubenmire 1970; Franklin and Dyrness 1973). This species grows along streams and canyon bottoms aligning riparian communities, but does not occur in wet areas. It occupies steep slopes and streambanks intermixed with numerous upright trees and shrubs, but not as an understory in dense patches of vegetation. It is extremely drought tolerant, and is encountered on open south- and west-facing slopes with big sagebrush, antelope bitterbrush, and mountain brush species. Rocky Mountain smooth sumac also forms thickets in the prairie grasslands (Weaver and Fitzpatrick 1934).

Plant Culture—Rocky Mountain smooth sumac normally produces an abundant seed crop. If grown on favorable sites, plants usually produce heavy seed crops each year. Even under arid situations, plants produce some viable seeds. Plants flower from June to August, and are not subjected to late spring frosts that

Figure 4—Rocky Mountain smooth sumac produces distinctive clusters of red drupes.

damage seed crops of many shrubs. The flowers are small and borne in terminal or axillary clusters (Brinkman 1974g). Initially, the developing fruits do not appear to be very abundant, but as fruits ripen in fall or early winter, large, dense clusters of red fruits develop (Lovell 1964; Plummer and others 1968; Radford and others 1964; Van Dersal 1938). The fruits are easily collected by handpicking or beating the shrub to dislodge them. Fruits are usually collected in fall after the leaves have dropped and the fruits are more visible. Fruits can persist on the bush until late winter without loss of seed viability. Consequently, seed collection may be delayed until late winter.

Once the fruits are harvested they should be cleaned to remove the fruit coat and dry pulp. The fruit is a small drupe having a single bony nutlet (Brinkman 1974g). The fruit is normally dry at the time of harvest, and the flesh is often left on the seed; however, the dry fruit makes planting more difficult, particularly when mixed with other seeds. When cleaned, the seeds are more easily stored or seeded.

Seeds are cleaned using a macerator to grind away the pulp. Water is used to float and separate the pulp from the seeds (Brinkman 1974g; Swingle 1939). If the fruits are dry, soaking with water is often required before maceration. High yields of good seed are normally obtained from most seed collections. Cleaned seeds consist of from 45 to 75 percent of the fruit or material initially collected (Brinkman 1974g). Seed numbers range between 23,000 and 48,000 per lb (50,700 and 105,800 per kg) (Johnson and others 1966; Lovell 1964; McKeever 1938; Plummer and others 1968; Swingle 1939).

Seed germination may be erratic (Monsen and Christensen 1975), and inhibited by a hard impervious seedcoat (Heit 1967a; Johnson and others 1966) and a dormant embryo. Pretreatment using sulfuric acid or hot water to increase seedcoat permeability has been employed (Johnson and others 1966), but mixed results have occurred due to differences in structure of the seedcoat (Brinkman 1974g; Heit 1967a; Lovell 1964). Seeds can be wet prechilled at 40 °F (4.4 °C) for 2 months (Brinkman 1974g) to relieve embryo dormancy.

Seeds should be planted in late fall or early winter at a depth of 0.75 to 1.5 inches (2 to 4 cm). Some seedlots germinate much better than others, particularly if pretreated. Attempting to predetermine planting success from new seedlots is difficult. Nursery seedings are often heavily sown to assure establishment of satisfactory stands.

Success from seeding wildland sites has been extremely erratic due to poor or very erratic germination. Excellent quality transplant stock can be grown as bareroot or container stock. One-year-old bareroot stock is easily cultured and field planted with good success. Consequently, harsh sites can be successfully planted with transplant materials. Rooted suckers can be field dug and transplanted with good results if lifted when dormant. Doran (1957) recommended root cuttings be taken in December.

Uses and Management—Rocky Mountain smooth sumac is a highly useful shrub. It is important for wildlife habitat, ground cover, and conservation plantings. However, its usefulness in large-scale restoration plantings has been limited by low or erratic seed germination.

Plantings of Rocky Mountain smooth sumac on wildland sites have been enhanced by seeding the shrub alone or with a few other species in well-prepared seedbeds. Planting in late fall in areas free of competitive herbs has improved stand establishment. Once established, small seedlings and young plants are very hardy and survive periods of drought. New plantings are not damaged by moderate grazing, insects, or disease, and are able to develop normally under most circumstances.

Seedling survival can be quite erratic. Some small seedlings are quite vigorous and grow at moderate rates, but natural thinning usually results in the loss of a number of young plants. Plummer and others (1968) ranked this shrub as low to fair for the development of mature stands from direct seedings. Seedling losses usually result from erratic seed germination; many seedlings emerge in late spring when soil water is rapidly being depleted. Such seedlings usually do not survive.

Plants form a single main stem during the first and second growing seasons. During this time an extensive root system is developed. Plants that survive the first growing season are quite persistent, and few plants succumb after that date. Plants reach maturity quickly; within 6 years the shrub is sufficiently developed to produce flowers and seed. Spread by underground rooting usually begins within 10 years after planting. Thereafter, root suckering may occur each year, but the pattern is somewhat erratic. Numerous suckers may appear in some years, but not in others. The size and area occupied by a clump of plants tend to stabilize within 20 to 30 years. Natural spread may continue after this time, but maximum spread is usually attained within this time span. Natural spread is not always restricted by the presence of other species. New shoots often emerge in areas occupied by closed stands of native bunchgrasses, big sagebrush, and antelope bitterbrush.

Rocky Mountain smooth sumac is an important forage plant for wildlife. The fruits are eaten by a large number of birds (Miller and others 1948; Stanton 1974). It is moderately browsed by big game in the spring, fall, and winter months, but is more heavily grazed in the summer (Hill and Harris 1943; Kufeld and others 1973; Nemanic 1942; Plummer and others

1968; Smith 1953; Snyder 1937). When this shrub occurs on big game wintering ranges and is available, it is heavily browsed when access to other species is restricted by deep snow. Some populations are more heavily grazed each year than others.

Rocky Mountain smooth sumac is relatively easy to establish by transplanting on harsh, unstable sites (Plummer and others 1968). Consequently, it has been successfully used to plant mine disturbances, roadways, and unstable watersheds. Although it establishes well and spreads to provide soil stability, erect open stands usually develop on semiarid sites. Plants growing on more mesic sites develop dense protective ground cover. Under most conditions, this species can be used to provide soil protection, particularly if understory herbs are also planted.

Rocky Mountain smooth sumac is a useful shrub to plant on unstable slopes, streambanks, and roadfills where mass movement may occur. Plants naturally spread by roots to furnish excellent site stability. Unstable soils can be quickly stabilized by transplanting large stock (2-year-old plants) 2 to 3 ft (0.6 to 0.9 m) apart. The plants spread rapidly and fully occupy the area in 1 to 3 years.

Rocky Mountain smooth sumac has been used to revegetate mine disturbances, as it will grow in soils with low fertility. It does not establish or compete very well if sites are heavily seeded to herbs and fertilized at high rates.

This shrub is widely used as an ornamental because of its low growth form, attractive fruits, and fall coloration. It is used to stabilize and beautify steep banks, roadways, parks, and recreation sites. It has been cultivated since 1620 (Brinkman 1974g). Rocky Mountain smooth sumac is also useful in windbreak and conservation plantings. It withstands extreme cold temperatures, and can be used on exposed, windblown sites to protect soils and entrap snow.

Rocky Mountain smooth sumac survives wildfires, and is an important plant where burning may create erosion and watershed problems. This species can recover quickly from fire, and provides needed cover the first year after burning. Along with Gambel oak, maples, Saskatoon serviceberry, and chokecherry, the species readily resprouts and protects steep watersheds.

Varieties and Ecotypes—None.

Family Berberidaceae

Mahonia aquifolium
Shining barberry

Description—Mature plants are 0.3 to 6.6 ft (0.1 to 2.0 m) or more tall. Leaflets are more than twice as long as broad, glossy on the upper surface and dull beneath (fig. 5), with more pronounced spiny tips than Oregon grape. The species frequents moist, rich humus soils on the floor of conifer forests, but sometimes grows on exposed rocky slopes, brushy hillsides, and in aspen or alder stands. Marchant and Sherlock (1984) report that it is rather slow growing during the first season and slow to establish on wildland sites. The species integrates with Oregon grape in northeast and north-central Washington, thus the two taxa may be varieties of a single species.

Distribution—Shining barberry is distributed from British Columbia and northern Washington to northeastern Idaho, and south from the eastern edge of the Cascade Mountains to the coast, as far as the southern Willamette Valley.

Plant Culture—Shining barberry has not been extensively used in wildland plantings. Transplants have been grown for small plantings, but direct seedings are rare. Plants normally produce some fruits or berries each year, and seeds can be collected and processed as described for Oregon grape. Seeds are difficult to germinate uniformly, and information is needed to properly culture this species.

Uses and Management—Shining barberry is infrequently used for low-maintenance landscaping, erosion control, and conservation plantings. It is grown by some commercial nurseries, but is not commonly used in most wildland restoration projects.

Varieties and Ecotypes—None.

Figure 5—Glossy, elongate, spine-tipped leaves characterize shining barberry.

Family Berberidaceae

Mahonia fremontii
Fremont barberry

Description—Fremont barberry is a large shrub of dry slopes and ridges in pinyon-juniper types of the Southwest. It grows 3 to 12 ft (0.9 to 4 m) tall and produces small, compound, spiny leaves and dark blue or red berries. This shrub has yellow wood (fig. 6).

Ecological Relationships and Distribution—Fremont barberry is distributed across the Southwest from western Texas through Sonora to Baja California and north, and from California through southern Utah and Colorado. It grows on deep sandy soils in valley bottoms and draws. It is also encountered amid rocky outcrops and steep canyon slopes. A number of individual bushes often grow together in small patches, although this shrub does exist interspaced with other woody species. It is found in the warmer drier regions of southern Utah and northern Arizona. It grows intermixed with Utah juniper, Stansbury cliffrose, blackbrush, and Nevada ephedra. It is common in draws and washes that may receive infrequent runoff.

Plant Culture—Berries are generally not produced each year. Special climatic conditions must occur to promote flowering and seed production. However, bushes planted in more mesic situations in central Utah have consistently produced abundant crops most years.

Seeds are formed in a berry that dries at the time of maturation. Seeds are large and easily extracted and separated from the dry fruit. A hard seed coat restricts exchange of water and air. In addition, most seeds require some wet prechilling to germinate.

Both container and bareroot nursery stock have been grown for restoration plantings. Plants have been reared and used in cultivated gardens and nursery sites. With some irrigation and culture, plants attain large stature, provide distinct gray-green foliage, and form an attractive display of red fruits.

Uses and Management—This shrub has been used in some recreation plantings, but has potential to restore disturbances in the southwest shrub complex.

Varieties and Ecotypes—None.

Family Berberidaceae

Mahonia repens
Oregon grape, creeping barberry, mountain holly, creeping mahonia

Description—Oregon grape is a perennial creeping shrub with evergreen hollylike leaves (fig. 7). It seldom grows taller than 1 ft (30 cm). The shrub spreads by stolons, rhizomes, and stem layering; individual plants sometimes attain a diameter of 4 to 6 ft (1.8 to 3.3 m). Leaves are evergreen, leathery, and pinnately compound with five to seven (rarely three or nine) leaflets that are less than twice as long as broad. Leaflets are spinulose, glossy to dull on the upper surface, and dull to glaucous on the lower surface. Perfect, regular flowers develop in fascicled bracteate racemes in the leaf axils. The perianth consists of five alternate whorls of three members each; all are yellow. Those in the outer whorl are tiny bracts; the next two whorls are the sepals, and the

Figure 6—Fremont barberry produces attractive red fruit and small, leathery evergreen leaves. It grows in a variety of southwestern shrub communities.

Figure 7—Oregon grape, a perennial creeping shrub, occurs on well-developed soils as an understory in conifer forests.

inner whorls are the petals. Petals are bilobed with two glands at the base. There are six stamens and a one-celled ovary. Fruit is a one- to several-seeded, deep blue, glaucous berry about 0.3 inch (8 mm) in diameter (Harrington 1964; Welsh and others 1987).

Oregon grape growth is intermittent in winter and more active in spring (Wasser 1982). Flowering occurs from March to July. Fruits ripen from September to October and may remain on the plant into winter. Seeds are dispersed by birds and mammals (Rudolf 1974).

Ecological Relationships and Distribution—Oregon grape ranges from British Columbia to Alberta and North Dakota and southward on the east side of the Cascade and Sierra Mountains through the Great Basin, Arizona, and New Mexico. It grows with junipers, pinyon, aspen, mountain brush, lodgepole pine, spruce-fir, and ponderosa pine at elevations ranging from near sea level to 10,000 ft (3,000 m) (Harrington 1964; Hitchcock and others 1964; Wasser 1982; Welsh and others 1987). It is abundant in coniferous forests receiving more than 15 inches (38 cm) of annual precipitation, and is fairly common on north-facing slopes and other moist sites in plains, foothill shrublands, and low-elevation woodlands. Oregon grape tolerates full sun and partial to deep shade of shrubland and coniferous forests. It requires well-drained, more-or-less neutral (pH 5.5 to 7.0) soils, and is only weakly tolerant of salinity (Stark 1966). Oregon grape is intolerant of poor drainage and high water tables. Although it grows in deep, medium-textured soils, it is also common on shallow, rocky sites (Bailey 1949; Harrington 1964; Plummer and others 1968; Wasser 1982).

Plant Culture—Good fruit crops occur erratically. Fruits are most often collected by hand. Berries of more upright populations can be beaten into containers (Rudolf 1974). Pulp is removed by macerating the fruit in a Dybvig cleaner. The seeds and pulp are dried, lightly chopped, and separated by screening. Seed may be stored dry in air-sealed containers at 34 to 37 °F (1 to 3 °C) for 4 to 8 years without significant loss of viability (Heit 1967c). Seeds kept under uncontrolled warehouse conditions have remained viable for 13 years (Stevens and Jorgensen 1994). There are 71,000 seeds per lb (156,600 per kg) at 100 percent purity. Minimum purchasing standards are 95 percent purity and 85 percent germination.

Seed dormancy is complex and variable. A wet prechilling period of 1 month at 34 °F (1 °C), followed by 2 months at 70 °F (21 °C), and 6.5 months at 34 °F (1 °C) relieves dormancy of some seedlots (Rudolph 1974; Wasser 1982). In some cases a 5-day water soak may successfully substitute for wet prechilling (USDA Forest Service 1972). Incubation of excised embryos at 68 °F (20 °C) for 10 to 14 days is recommended as a relatively rapid means of testing germination.

Seed and dried berries may be fall sown in the field or nursery, or wet prechilled seed may be planted in spring. Fall seeding is preferred. Seedlings are vigorous. Bareroot seedlings may be transplanted after one or two seasons of growth in nursery beds. Container plants can also be established from seed (Landis and Simonich 1984).

Seed germination is erratic and may lead to unpredictable stands, although establishment from planting stock is usually quite good. Creating depressions for water catchments around planted seedlings, and watering immediately following planting may be helpful, particularly on rocky sites.

Plants may be propagated vegetatively from cuttings taken from spring through fall and rooted on mist benches (Hartmann and others 1990). Best results are obtained if basal cuts are made between the nodes about 1.2 inches (3 cm) above the base of the current year's growth (Doran 1957). Rooting may be hastened by treatment with 5,000 ppm IBA. Layers are occasionally used for vegetative propagation.

Transplants are generally used instead of direct seeding for landscape and erosion control purposes to reduce the time until plants reach mature size. Nursery-grown stock and wildings are easily transplanted. Large stock is more difficult to transplant due to the development of thick stolons. Commercial planting stock is widely available, but the seed or transplants should originate from an area with characteristics compatible with those of the planting site.

Uses and Management—Oregon grape has been used in landscape planting as an evergreen ground cover. It is quite useful because of its colorful flowers, berries, and leaves. Under cultivation Oregon grape will grow 2 ft (61 cm) tall. The prickly, hollylike leaves are brilliantly red to bronze colored in winter and are used in Christmas decorations. Its spreading habit and ability to grow on fairly dry, exposed, rocky slopes, make it a good candidate for mined lands, game ranges, highways, and recreation areas. Ecotypes growing as an understory with ponderosa pine and other conifers are, however, not well suited to dry, exposed sites.

The forage value of Oregon grape has been rated as nearly worthless for livestock and wildlife in summer (USDA Forest Service 1937). Smith (1953) ranked it last of 33 shrubs tested as summer forage for mule deer in northern Utah. However, both livestock and wildlife use the plants when other vegetation is scarce, particularly during winter (Monsen and Christensen 1975). Kufeld (1973) found Oregon grape valuable for Rocky Mountain elk in fall and winter but of low value in spring and summer when other vegetation was available. Mule deer use it to a moderate extent in winter, spring, and fall (Kufeld and others 1973). Patton and Ertle (1982) reported that in the Southwest it

receives greatest use by elk in winter; mule deer use it in the spring and fall. Plants are quite tolerant of browsing. Once frosted in fall, Oregon grape berries become more palatable and are used by birds and small mammals (Thornburg 1982). The species is also considered desirable for honey production. Plants contain several alkaloids, including berberine, which has medicinal uses (Suess and Stermitz 1981). The inner bark and wood of barberris species are yellow and were used by Native Americans to prepare a yellow dye.

Seedlings grown on adapted sites may be vigorous, but require several years to reach mature size. Control of rodents and rabbit populations has been necessary to establish young plants in shelterbelts in the Midwest, as Oregon grape is preferred by cottontail rabbits (Swihart and Yahner 1983). Mature plants resprout following burning, and are resistant to browsing.

Improved Varieties—None. A number of released varieties have been developed for the ornamental trade.

Family Betulaceae

Alnus incana
Thinleaf alder

Description—Thinleaf alder is a deciduous, multistemmed shrub or small tree (fig. 8). Plants are usually 3 to 13 ft (0.9 to 4 m) tall (Welsh and others 1987), but may attain heights of 40 ft (12.2 m) (Arno and Hammerly 1977; Patterson and others 1985). The bark is gray to brownish (Patterson and others 1985; Preston 1948); twigs are puberulent and commonly glandular (Welsh and others 1987). Leaves are broadly elliptic or ovate-oblong, 0.4 to 1.2 inches (1 to 3 cm) long with a dull green color and doubly dentate margins (Hitchcock and Cronquist 1973; Patterson and others 1985). Male and female flowers are borne in separate catkins on the same plant. The staminate catkins are clustered at the ends of twigs, each 1 to 4 inches (2.5 to 10 cm) in length (Hitchcock and Cronquist 1973). The pistillate catkins arise from branches of the previous season (Welsh and others 1987) and occur in groups of three to nine on the ends of branches. These eventually develop into small cones that are 3.6 to 5.2 inches (9 to 13 cm) in length (Hitchcock and Cronquist 1973; Patterson and others 1985). The fruit is a small single-seeded nutlet with narrow wings (Haeussler and Coates 1986; Mozingo 1987; Schopmeyer 1974a).

Ecological Relationships and Distribution—Welsh and others (1987) recognized thinleaf alder as a portion of a huge circumboreal complex, with *Alnus incana* spp. *rugosa* var. *occidentalis* being the Old World portion and *Alnus incana* spp. *rugosa* var. *rugosa* representing the American plants. Thinleaf alder, also referred to as mountain or river alder, is one of approximately 30 species of this genus that occurs in North America, Europe, and Asia (Schopmeyer 1974a). It is widespread from Alaska and the Yukon south to New Mexico and California, usually growing at elevations between 5,000 and 10,000 ft (1,500 and 3,000 m) in the southern portions of its range (Harrington 1964).

Like most other alders, thinleaf alder occurs in mountainous regions, often growing along streams and in wetlands. It is adapted to drier sites and grows as an understory with various conifers. It spreads naturally onto disturbances and clearings caused by wildfires, road construction, and related activities. At lower elevations and on drier sites, thinleaf alder is more restricted to wet areas along streams, seeps, and moist mountain slopes (Arno and Hammerly 1977; Hansen and others 1988a; Komarkova 1986). It does

Figure 8—Small multistemmed trees of thinleaf alder border a small stream in eastern Idaho.

extend into big sagebrush communities at lower elevations growing along streams, seeps, and springs. It is most prevalent in the Douglas-fir, ponderosa pine, spruce-fir, and lodgepole pine communities within the Intermountain region. It occupies sites that may be seasonally flooded or where water tables remain near the soil surface. Although often restricted to areas with high water tables, it is also found on well-drained sites. It is often abundant as an understory with conifers, as it is shade tolerant (Haeussler and Coates 1986; Hansen and others 1988b; Kauffman and others 1985; Kovalchik 1987; Padgett and Youngblood 1986; Youngblood and others 1985).

Thinleaf alder grows on well-developed, highly organic soils (Kovalchik 1987), but occurs on well-drained, poorly developed, cobbly gravels and sandy textured soils (Hansen and others 1988a; Kovalchik 1987). This shrub is able to invade flooded or burned sites (Crane 1982; Zasada 1986). It responds as an early seral species (Kauffman and others 1985; Zasada 1986), and is very often abundant following disturbances. It is commonly encountered dominating disturbed sites including roadways and riparian habitats.

Plant Culture—Both staminate and pistillate catkins develop during the growing season and persist through most winter months. The catkins begin growth early in spring before leaves develop. Flowering occurs in early March and April, depending on elevation and site location. Fruits ripen in early fall (Schmidt and Lotan 1980). Fruits are small winged nutlets borne in pairs on bracts of small cones or strobiles—when dispersed they are spread by wind or water (Haeussler and Coates 1986; Mozingo 1987; Schopmeyer 1974a). Thinleaf alder normally produces abundant seed crops most years. Some individual plants bear heavy crops every year. There are about 675,000 cleaned seeds per lb (1,488,000 per kg) (Schopmeyer 1974a). Seed viability is quite variable. Schopmeyer (1974a) reported some collections contain less than 5 percent viable seed. However, good quality seed can be obtained by collecting from healthy bushes early in the season before seeds shatter. Bushes with disfigured cones or infested with disease should be avoided. Also, seeds from plants that are weakened by climatic stress should not be harvested. Seed samples should be cleaned and tested for germination before seeding rates are determined. Seeds should not be stored in open warehouses for more than 2 years because viability decreases rapidly after this time. If possible, air-dried seeds should be stored in sealed containers at 34 to 38 °F (1 to 3 °C) (Schopmeyer 1974a). Seeds are nondormant when collected and do not require wet prechilling to germinate (Haeussler and Coates 1986).

Thinleaf alder seeds are small, lightweight, and easily dispersed. Broadcast seeding, particularly using aircraft, may create irregular stands, as seeds can be carried considerable distances with strong winds. Seedlings developing from seeds broadcast on rough seedbeds establish well if the surface does not dry rapidly. Seedlings do not establish well on compacted surfaces and impervious soils. Thinleaf alder has been broadcast seeded in a slurry using a hydromulch, but with limited success. Better stands have been achieved by dry seeding.

Thinleaf alder seeds can be planted with most drill seeders. If seeded alone in nursery beds, the seedlot may require dilution with inert material to aid in regulating the seeding rate. However, many precision nursery seeders can plant pure alder seeds. Seeds should be placed about 0.25 inch (0.6 cm) deep on firm, but noncompacted, seedbeds. Planting on seedbeds having considerable surface litter has been quite successful.

Within its range of climatic adaptation, thinleaf alder will invade fresh disturbances. It responds as a pioneer plant capable of establishing in open areas (Zasada 1986). It is able to compete well with herbaceous species when seeded on both disturbed and undisturbed sites. Seedlings develop quickly and can establish amid considerable herbaceous competition. New shrub seedlings often invade roadway and mine disturbances where seeded herbs have previously established. On infertile soils, thinleaf alder may grow more vigorously than the herbs.

Thinleaf alder is not universally adapted to all soil disturbances and it is particularly sensitive to competition from some species. Although the shrub invades areas seeded to grasses, its growth can be suppressed by some herbaceous species, particularly smooth brome. Planted seedlings that do not become inoculated with soil organisms remain small and can be suppressed. Although these factors are not well understood, irregularities in plant performance on disturbed sites can be expected.

Thinleaf alder can be easily propagated and planted as bareroot nursery stock or container material (Platts and others 1987). Transplants usually establish quickly and grow considerably during the year of planting. One-year-old transplants develop fibrous root systems that greatly enhance survival. Thinleaf alder is reported to fix nitrogen (Haeussler and Coates 1986). Plants inoculated with nitrogen-fixing organisms begin growth soon after planting. Other plants that apparently lack these organisms grow slowly, but respond dramatically if inoculated. Adding soil containing natural microflora to containerized stock appears beneficial. When plants are established on harsh sites, fertilizer applications have benefitted initial growth.

Seedings of thinleaf alder on sites supporting a herbaceous cover are often successful in conifer forest communities. This shrub has frequently invaded roadways, logging disturbances, and mine sites that were first seeded to introduced and native herbs (Plummer 1977).

The shrub invades seeded areas where established herbs are weakened due to decreases in soil fertility. Its seedlings apparently are very competitive and vigorous. Once established, few other plants grow as rapidly.

Uses and Management—Thinleaf alder is particularly useful in providing cover and forage for wildlife. Abandoned logging roads and other disturbances that are seeded to grasses often are invaded by thinleaf alder, snowbrush ceanothus, chokecherry, and other important browse plants. Game animals seek these areas to graze the variety of plants. Animals also utilize thinleaf alder in burned and cutover lands; plants quickly recover and produce an abundance of herbage. Use by big game animals varies among sites. Light to moderate use has been reported by deer, elk, and moose (Heale and Ormrod 1982; Kauffman and others 1985; Knowlton 1960, Kufeld 1973). However, Kufeld and others (1973) reported that alder is an important browse for mule deer. Beaver and other small animals and birds also utilize this species (Arno and Hammerly 1977; Rue 1964). Thinleaf alder provides excellent cover for wildlife. It occupies riparian zones, wetlands, and brush fields where animals concentrate. The establishment and growth traits of this species cause it to be one of the most useful shrubs for revegetation of riparian sites in the Intermountain region.

Varying degrees of use by cattle and sheep are reported for thinleaf alder (Dittberner and Olsen 1983; Roath and Krueger 1982). Animals selectively graze certain stands more heavily than others. Use is somewhat regulated by access, acceptance of associated plants, and season of grazing. Livestock graze thinleaf alder very heavily in many riparian areas. The plant is frequently maintained in a stunted condition, but is able to recover when grazing is well managed. New plantings can be destroyed by heavy grazing.

Thinleaf alder is particularly useful as a ground cover and erosion control plant. It is one of a few shrubs that, as a seedling, is able to compete with seeded herbs, and can be seeded in mixtures. It grows rapidly and provides cover and herbage within a few years. It is well adapted to a wide array of soil conditions, particularly infertile sites. Its ability to fix nitrogen apparently contributes to its adaptability to harsh situations. The presence of thinleaf alder benefits the growth of understory herbs, and thus improves ground cover and stability on erodible sites. When transplanted onto open disturbances it grows rapidly and is able to stabilize sites where seeding is difficult.

Thinleaf alder has been used successfully to revegetate road and logging disturbances in the Idaho Batholith and on a number of mine sites. It has spread onto abandoned mine disturbances, including rocky dredge piles and exposed substrata.

Collections of thinleaf alder do not appear to be as site specific as many other shrubs. Plantings have been successful over a range of elevations and site conditions. The species should not be planted on sites where it does not normally occur, but it can be used on mine or road disturbances within its natural range of occurrence.

Thinleaf alder plants are not usually lost to insect damage, climatic stress, or herbivore grazing. The species is long lived and compatible with overstory trees. It is able to exist in open or shaded areas and can be used as a low maintenance species in recreational plantings. Thinleaf alder is an attractive shrub and can be used as a screen or specimen plant for horticulture plantings. It remains vigorous and green the entire summer and may be used to reduce fire spread around recreational sites.

This species has been overlooked in many wildland restoration programs. Although recognized as a rapid-developing species capable of producing considerable biomass, it has not been emphasized for watershed or wildlife plantings.

Varieties and Ecotypes—None.

Family Betulaceae

Betula glandulosa
Bog birch

Description—Bog birch is a deciduous, highly variable, spreading to erect monoecious shrub ranging from 0.3 to 19.7 ft (0.1 to 6 m) tall. Plants have one to many main stems and deep, spreading root systems. Alternative common names are glandular, resin, swamp, marsh, and dwarf birch. Young branches are densely puberulent and resinous with yellowish wartlike, crystalline glands. Bark is reddish-brown to gray or purplish and does not readily peel. Lenticels are rarely conspicuous. Leaves are alternate, oval to orbicular, elliptic, or sometimes obovate or ovate. They are 0.4 to 0.8 inch (1 to 2 cm) in length, but range from 0.2 to 1.6 inches (0.5 to 4 cm) long, with finely serrate or crenate-serrate edges (fig. 9). Blades are bright green, thick and leathery, glandular on both surfaces, glabrous above, and paler and puberulent beneath. Staminate catkins are elongate and pendulous in clusters of one to four. They develop in summer and flower with or before leaf development the following spring. Staminate flowers are three per cluster, each with three perianth segments and two stamens subtended by three bracts. Pistillate catkins appear with the leaves. They are conelike, erect, and solitary with two or three flowers per bract. Fruits are narrow-winged, single-seeded samaras. Flowering occurs from April to September. Samaras ripen from July to October (Brinkman 1974c; Hitchcock and others 1964;

Figure 9—Stems of bog birch have reddish to purplish bark and thick, serrate leaves.

Viereck and Little 1972; Welsh and others 1987); they are dispersed by wind, gravity, and sometimes water. They may also be blown for some distance across crusted snow. Throughout much of the species range, reproduction is primarily by seed. In the northernmost limits of its range, seedlings are rare and plants spread primarily by layering (Hermanutz and others 1989; Weis and Hermanutz 1988).

Ecological Relationships and Distribution—Bog birch is widely distributed from the interior of Alaska across northern Canada to Labrador and Greenland. In the West, it is found in mountainous areas from coastal British Columbia to California and Colorado at elevations from 4,000 to 11,000 ft (1,200 to 3,400 m) (Dittberner and Olsen 1983; Harrington 1964; Welsh and others 1987). Bog birch occurs in wet meadows, fens, swamps, bogs (sphagnum and nonsphagnum), muskegs, moist-to-wet tundra, wet meadows, and along low gradient streams and lakes. It is also found on sites where the water table remains high from runoff in nearby uplands. Bog birch maintains itself in these moist habitats and appears to be a climax species under such conditions (Marr 1961; Pojar and others 1984). In alpine areas it may also be found in dry rocky habitats (Brayshaw 1976; Komarkova 1986). Bog birch is highly frost tolerant and is widely distributed in permafrost areas (Krajina and others 1982). Its shade tolerance is moderate to high.

Bog birch most often occurs on wetland sites in lodgepole pine, Engelmann spruce, or subalpine fir forest types (Hansen and others 1988b; Kovalchik 1987; Olson and Gerhart 1982; Pierce and Johnson 1986). It is frequently associated with alder, willows, Woods rose, Douglas spiraea, blueberry, mountain huckleberry, and redosier dogwood. Herbaceous species associated with bog birch include rushes, horsetails, soft-leaved sedge, beaked sedge, bluejoint reedgrass, and tufted hairgrass (Hitchcock and others 1964; Kovalchik 1987; Patterson and others 1985; Welsh and others 1987; Youngblood and others 1985).

Bog birch commonly grows in fens, swamps, or bogs having large accumulations of organic matter derived from sphagnum or nonsphagnum plant materials. On flood plains it often grows in soils with textures ranging from silty to fine sandy loams to organic loam textures (Kovalchik 1987). Mineral requirements of bog birch may vary with population. Krajina and others (1982) and Moss and Wellner (1953) reported the species occurs in acidic or humic soils that are low in nutrients, particularly calcium and magnesium. They noted the absence of bog birch from swamps and fens with high nutrient contents derived from adjacent uplands. However, Pojar and others (1984) noted the reverse to be true.

Plant Culture—Most samaras are wind dispersed in fall. Smaller quantities are released through the winter and early spring as the catkins disintegrate on the shrub. Many of these may be consumed by birds. Samaras are sometimes collected from the surface of crusted snow. Fruits are harvested, processed, and stored as described for water birch. There are between 3 and 5 million cleaned seeds per lb (6,600,000 and 11,000,000 per kg) (Brinkman 1974c). Culture is as described for water birch (Brinkman 1974c; Lotan 1981). Kelly (1970) reported that bog birch's value in rehabilitation is limited; it does not transplant easily. In the northern portion of the species range, few viable seeds are produced, and bog birch spreads primarily by stem layering (Hermanutz and others 1989; Weis and Hermanutz 1988).

Uses and Management—Bog birch is consumed by many wildlife species. Moose, elk, and mule deer make moderate to heavy use of the shrub in summer and winter (Dorn 1970; Kufeld 1973; Kufeld and others 1973; Zach and others 1982). Pine siskin, chickadees, kinglets, and many other birds use the catkins, buds, and seeds (Brayshaw 1976; Komarkova 1986; Pojar and others 1984; Stephens 1973). Livestock make only light to moderate use of bog birch except in late summer when the boggy soils dry out (Dayton 1931; Hansen and others 1988b; Kovalchik 1987). Energy and protein value of the species are low.

Wetland areas supporting bog birch burn only infrequently due to the normally high water content of the vegetation and soil (Crane 1982; Kovalchik 1987). Such sites frequently act as firebreaks, but sometimes burn during dry summers or in late fall. Shoot systems may be destroyed but the plants resprout rapidly, particularly if the organic layer of soil around the base is not removed. Germination of wind-dispersed seeds from surviving plants, or seeds arriving from offsite,

might be facilitated or enhanced by the presence of exposed mineral soils.

Varieties and Ecotypes—None.

Family Betulaceae

Betula occidentalis
Water birch

Description—Water birch, also known as spring or red birch, ranges from shrublike to treelike in growth habit (fig. 10). Plants grow rapidly and are short lived. They may attain heights of 36 ft (11 m), with clump diameters of up to 20 ft (6 m), and major trunk diameters of 1 ft (0.3 m). New stems develop from the root crown, eventually forming dense, multistemmed clumps with ascending branches and open crowns (Hansen and others 1988a; Youngblood and others 1985). The thin, smooth bark is dark brown to black on young trunks; it becomes lustrous coppery to brownish red on older trunks. Lenticels are light colored and vertical. The alternate, deciduous leaves are petiolate with bright green stipules. They are glabrous to pubescent, glandular, ovate to suborbicular or slightly obovate, and 1 to 2 inches (2.5 to 5 cm) long. The blade apex is rounded to acute, the base usually rounded, veins prominent, and the margins sharply once or twice serrate.

Male and female flowers develop in separate inflorescences on a single plant. Staminate catkins are formed during the summer or fall and rapidly elongate into tassel-like catkins 1 to 4 inches (2.5 to 10 cm) long the next spring. Staminate flowers grow in clusters of three; each consists of three perianth segments and two stamens, all subtended by three bracts. Blooming occurs as the leaves expand. Female flowers develop in conelike catkins 1 to 1.5 inches (2.5 to 4 cm) long. Water birch flowers in April and May. Fruits turn brownish tan as they ripen in fall. Samaras are shed from the catkins in fall and winter and are dispersed by wind, gravity, and sometimes water. They may be blown for considerable distances across crusted snow. Weather conditions and foraging by seed-eating birds contribute to overwinter disintegration of the catkins (Brinkman 1974c; Lanner 1983).

Figure 10—Water birch forms attractive foliage and flowers as it grows along valley bottoms and riparian sites.

Ecological Relationships and Distribution—There are more than 40 species of *Betula* in the North Temperate and Arctic Zones. Some taxa hybridize, producing intermediate populations in zones of distribution overlap (Dugle 1966; Hitchcock and Cronquist 1973). Water birch is distributed from Alaska to California and east to Saskatchewan and New Mexico. It forms dense thickets in riparian woodland communities and in moist areas of drier habitats (Arno and Hammerly 1977; Hansen and others 1988a; Padgett and Youngblood 1986; Welsh 1974). It is common along streams, on steep slopes, or on alluvial terraces from Engelmann spruce, ponderosa pine, and Douglas-fir zones to sagebrush communities (Hansen and others 1988a,b; Padgett and Youngblood 1986; Youngblood and others 1985). Communities tend to remain rather stable in spite of annual flooding (Padgett and others 1989; Youngblood and others 1985). However, the plants are susceptible to windthrow because they grow on sites with high water tables and are usually shallow rooted (Lanner 1983). In eastern Washington, Oregon, western Idaho, and southern British Columbia, water birch hybridizes with paper birch, producing many localized intermediate forms (Dugle 1966; Hitchcock and others 1973). It is closely related to bog birch (*Betula glandulosa*), and in western Canada hybridizes with this species (Dugle 1966).

Water birch is listed as a dominant species in a number of communities or habitat types of the Intermountain region (Hansen and others 1988a,b; Olson and Gerhart 1982; Padgett and others 1989; Youngblood and others 1985). It occurs with many woody riparian tree and shrub species including cottonwoods, maples, aspen, thinleaf alder, willows, alder, and redosier dogwood (Lanner 1983; Olson and Gerhart 1982; Padgett and others 1989). It is also associated with many shrubs that are facultative riparian species such as Woods rose, Nutka rose, chokecherry, Saskatoon serviceberry, currant, and skunkbush sumac (Hansen and others 1988a,b; Kelly 1970; Olson and Gerhart 1982; Padgett and others 1989; Youngblood and others 1985).

Water birch is adapted to soils ranging in texture from silty to sandy to coarse-textured types that contain at least 35 percent rock fragments. These often have

thin profiles and overlie river cobbles or other rocky substrates (Hansen and others 1988b; Padgett and others 1989). Nutritional requirements for magnesium and calcium are relatively high (Krajina and others 1982).

Plant Culture—Seeds should be collected from selected young, accessible, highly productive trees by hand stripping the catkins into bags before they begin to disintegrate. Fruits are sometimes shed on snow and may be hand collected.

Catkins should be thoroughly dried prior to extraction. The tiny samaras are separated from the catkins by screening them through a round-holed screen and fanning to remove the remaining bracts (Brinkman 1974c). Samaras should be dried prior to storage at 36 to 38 °F (2.2 to 3.3 °C).

Seed fill and quality vary greatly among years. Fill should be estimated prior to harvest by observing seeds under transmitted light (Patterson and Bruce 1931). Wet prechilling for 4 to 8 weeks releases embryo dormancy. Dormancy may also be overcome by germinating seeds in light (Brinkman 1974c; Yelenosky 1961).

Plantings are generally established from bareroot or container stock rather than from seed. Emergence of seedlings from direct seedings on wildlands is erratic. Only 15 to 20 percent of the planted seeds of these species usually produce usable seedlings. Seeds planted in nursery beds or containers must be covered as lightly as possible (Hartmann and others 1990). Covering may not be necessary if the soil surface is kept moist. Newly emerged seedlings are susceptible to damping off at low temperatures (Marchant and Sherlock 1984). They benefit from shade for the first 2 or 3 months (Brinkman 1974c). Seedlings develop rapidly, producing dense root systems, and may be transplanted after one or two growing seasons (Brinkman 1974c). Cuttings are difficult to root, but leafy cuttings will root in summer if planted under glass and treated with IBA (Doran 1957; Hartmann and others 1990). Low-growing forms are easily propagated by layering.

Seed or cuttings used to produce planting stock should be harvested from areas near the planting site. Seedlings should be planted early in spring while native birch near the planting site is still dormant. Seedlings planted on adapted sites with good soil water establish well and grow rapidly if protected from browsing and competition.

Uses and Management—Water birch provides food and cover for many wildlife species (Kufeld 1973; Gullion 1964; Rue 1964; Stark 1966). It is useful for streambank stabilization in adapted areas. It grows rapidly, producing a dense, fibrous, but shallow root system. It is useful in shelterbelts if adequate water is available (Cook 1981), and has some potential as an ornamental. The hard wood is used locally for firewood and fenceposts (Lanner 1983).

Dense thickets or corridors of water birch provide thermal, hiding, and travel cover for a wide array of wildlife species (Hansen and others 1988a). Palatability of water birch to big game is usually low. It may be used when other browse is limited (Hansen and others 1988b; Kufeld 1973; Kufeld and others 1973). Its presence in many riparian woodland communities contributes to their structural diversity and provides habitats for many bird species (Lanner 1983; Youngblood and others 1985). Seeds, catkins, buds, and sap of water birch are used by many birds including grouse, redpolls, pine siskin, chickadees, kinglets, rednapped sapsucker, and broad tailed hummingbirds (Brinkman 1974c; Gullion 1964; Platts and others 1987).

Water birch is not highly palatable to livestock, although it is used to some extent by sheep and goats (Youngblood and others 1985). Dittberner and Olsen (1983) rated energy and protein values as fair. Productivity is often reduced by flooding and sedimentation, and the nearly impenetrable monotypic stands reduce livestock access (Hansen and others 1988a).

Water birch is usually associated with riparian communities that act as firebreaks and burn only during late summers or dry years. Shoots will burn in intense fires. Burned plants generally resprout from the root crown, which is often protected to some extent if the soil is wet. New plants may also develop from seed delivered by wind or water from areas outside the burn. Germination is favored by exposure of mineral soils and reduced competition following fires (Crane 1982; Hansen and others 1988a,b).

In Utah, water birch is recommended for landscape plantings in residential areas developed on historic mule deer winter range. Many traditionally used landscape plants in these areas have been heavily browsed and damaged by mule deer. Water birch is normally browsed only moderately by mule deer and recovers quickly (Austin and Hash 1988).

The root systems of water birch stabilize banks; overhanging branches shade the water and supply organic matter, which improve fish habitat (Youngblood and others 1985). Soils on steep streambanks may be susceptible to erosion, especially along trails used by livestock and wildlife. Heavy recreational use associated with fishing may also increase sloughing rates (Hansen and others 1988a). Stands should, therefore, be maintained for their streambank stabilization value (Hansen and others 1989; Youngblood and others 1985).

Varieties and Ecotypes—None.

Family Betulaceae

Betula papyrifera
Paper birch

Description—Paper birch is a treelike species growing from 60 to 130 ft (18.3 to 39.6 m) tall and 2 to 3 ft (60 to 90 cm) in diameter from a deep root system (fig. 11). Alternative names are canoe, white, and silvery birch. Trees are distinguished by their grayish white to coppery bark with long brown horizontal lines. The outer bark often peels in long strips; the inner bark is orange. The leaves are ovate to acuminate and doubly serrate, usually with tufts of hairs in the vein axils on the lower surface. Leaves are 2 to 5 inches (5 to 13 cm) long and 1 to 2 inches (2.5 to 6 cm) wide. Male flowers develop in early spring on long, yellowish, pendulous catkins. Female cones are 1 to 2 inches (2.5 to 6 cm) long, hanging from slender stalks. Fruits are translucent samaras with the wings slightly broader than the nutlet. Paper birch and water birch hybridize widely in areas where their ranges overlap (Hitchcock and others 1961; Marchant and Sherlock 1984; Welsh and others 1987).

Figure 11—White-barked, multiple-stemmed paper birch is often found growing in a forest openings.

Ecological Relationships and Distribution—Paper birch is distributed from Alaska east to Newfoundland and south across the northern tier of States including Washington, northern Idaho, and Montana. It occurs in riparian habitats, dry bogs, swamps, and poorly drained acidic soils with pH as low as four (Marchant and Sherlock 1984). It also grows on open slopes, rock slides, forest openings, and disturbances. It occupies soils with silty loam, sandy, and gravely textures. It is an aggressive pioneer species on logged or otherwise disturbed areas, and rapidly invades areas where mineral soils are exposed.

Plant Culture—Culture and management are largely as described for water birch (Brinkman 1974c). Cones are more accessible, abundant, and easily harvested from young trees. Minimum seed-bearing age is about 15 years (Brinkman 1974c). Catkins may open during dry, cold periods from late fall well into winter; when large numbers of samaras are deposited on the surface of crusted snow.

Seeds are cleaned using, a number seven sieve to separate fruits from chaff (Marchant and Sherlock 1984). There are 610,000 to 4,120,000 cleaned seeds per lb (1,344,800 to 9,083,000 per kg); the average is 1,380,000 seeds per lb (3,042,000 per kg). Longevity of seeds dried to a water content of 1 to 5 percent and stored at room temperature is about 1.5 to 2 years. Viability tends to decrease rapidly at greater water contents, even if seeds are kept in cold storage (Brinkman 1974c).

Seeds require a wet prechilling treatment of at least 30 days or fall sowing to produce nursery stock. Surface-sown seeds exposed to light will germinate without cold wet prechilling. Seedlings are subject to damping off if crowded or if temperatures are cool. They are resistant to frost but not shading (Krajina and others 1982). Propagation from cuttings is not recommended (Marchant and Sherlock 1984).

Uses and Management—Seedlings have been used for revegetating riparian sites and forest disturbances, improving wildlife cover, landscaping recreational sites, and in ornamental plantings. Plants have established and survived well, but have not been extensively used in wildland plantings. Young plants grow quite rapidly and compete well with understory competition. Paper birch resprouts following fire and is capable of withstanding both periodic flooding and drought (Marchant and Sherlock 1984). It is browsed to some extent by wildlife, horses, and cattle. Fruits are eaten by many birds.

Varieties and Ecotypes—None.

Family Caprifoliaceae

Lonicera ciliosa, Orange honeysuckle
Lonicera involucrata, Bearberry honeysuckle
Lonicera utahensis, Utah honeysuckle

Introduction—There are about 180 honeysuckle species distributed across the Northern Hemisphere, Africa, Java, and the Philippines (Brinkman 1974f), although only about 20 species occur in North America (Hitchcock and others 1959). All are widely planted for their fragrant flowers and ornamental fruits. Some species provide food and cover for wildlife and are valuable for erosion control and shelterbelt plantings (Adkins 1980; Brinkman 1974f; Plummer 1977; Plummer and others 1968; USDA Forest Service 1985a).

Different species of honeysuckle possess important traits that are useful for range and wildland enhancement. Some of the more important characteristics include consistent and abundant fruit production, low stature, cover for birds and small mammals, excellent establishment traits from direct seeding and transplanting, rapid growth, and excellent windbreak attributes and conservation features.

Plant Culture—All three species described in this chapter produce small berries and seeds. Berries are usually dislodged by stripping or beating the stems when fruits are mature. Seeds are extracted from the berries by macerating the pulp and flushing with water. Once seeds are cleaned, they are easily seeded with conventional seeders. Seedlings develop quite successfully, but most plantings have been completed using bareroot or container transplants.

Family Caprifoliaceae

Lonicera ciliosa
Orange honeysuckle

Description—Orange honeysuckle is a native trailing or twining vine. Stems are branched and may become 20 ft (6.1 m) long (Hitchcock and others 1959). Although plants normally grow in wet sites in aspen and conifer forests, they are also encountered in open areas on rocky and shallow soils. This vine naturally occurs in southwestern Canada, from Oregon to California, and east to Idaho and Montana (Hitchcock and others 1959). Individual plants can spread over large areas on fertile or disturbed soils. They root at the junction of each node if the stem remains in contact with a wet soil surface (Monsen 1975). This species is easily transplanted from stem cuttings.

Uses and Management—The orange yellow to orange red flowers and foliage are very attractive and could be used in roadside, summer home, and recreational landscaping. In northern Idaho this species has survived serious air pollution created by smeltering operations, while a number of other native shrubs have succumbed (Monsen 1975).

Varieties and Ecotypes—None.

Family Caprifoliaceae

Lonicera involucrata
Bearberry honeysuckle

Description—Bearberry honeysuckle is a native shrub that is found throughout the Intermountain West from Alaska to Quebec and south to California, New Mexico, and Mexico (Viereck and Little 1972; Welsh and others 1987). It has yellow to purplish tinged flowers (fig. 12) and black fruit. There are about 326,000 seeds per lb (718,700 per kg) at 100 percent purity. This shrub grows to 2 to 6 ft (0.6 to 1.8 m) tall. It occurs on fertile soils along streambanks and in riparian sites in the aspen, Douglas-fir, and spruce-fir communities.

Uses and Management—Bearberry honeysuckle has been planted with some success in conservation and wildlife projects. It has not done well when planted on disturbed sites. This species is used by large and small game and livestock during spring and summer

Figure 12—Bearberry honeysuckle, widespread in Western North America, is used in conservation plantings because of its attractive flowers.

months. It has potential for restoring disturbances within its natural range, but its seeds are not easily harvested, thus seed availability is limited.

Varieties and Ecotypes—None.

Family Caprifoliaceae

Lonicera utahensis
Utah honeysuckle

Description and Distribution—Utah honeysuckle is a native shrub that grows 3 to 6 ft (0.9 to 1.8 m) tall (Welsh and others 1987) (fig. 13). It has pale yellow to yellowish-white flowers and red fruit. It occurs from British Columbia and Alberta, south to California and Wyoming. It is fairly common in the Intermountain West within mountain brush, ponderosa pine, aspen, and spruce-fir communities.

Uses and Management—This shrub has good fire tolerance, and is used extensively by livestock and game during the summer and fall seasons. Utah honeysuckle does well under heavy grazing and survives heavy trampling. It has excellent ornamental characteristics including showy flowers and fruit. The plant establishes well from transplanting and can withstand considerable traffic and other abuses. It should be considered for use in restoration projects, recreational areas, summer homes, and administrative sites.

Varieties and Ecotypes—None.

Figure 13—Distinctive flowers and leaves of Utah honeysuckle, an understory shrub that grows with mountain brush, ponderosa pine, aspen, and conifer forests.

Family Caprifoliaceae

Sambucus cerulea
Blue elderberry

Description—Blue elderberry (fig. 14) is a large spreading shrub or small tree growing to 10 ft (3.0 m) tall. It has distinctive opposite branches and leaves, pithy young stems, and older grayish stems with irregularly furrowed and ridged bark. Flowers are white and borne in large flat-topped clusters (compound cymes). Fruits are black to blue (Hitchcock and others 1959; Welsh and others 1987). The root system is generally fibrous and spreading, but a thick taproot may be present (Haeussler and Coates 1986; Welsh and others 1987).

Ecological Relationships and Distribution—Blue elderberry is most common on moist, well-drained sunny sites, but it is also somewhat shade tolerant (Dayton 1931; Plummer and others 1968; Van Dersal 1938) and occurs at elevations between 4,250 and 8,200 ft (1,300 and 2,500 m) (USDA Forest Service 1937). It ranges from British Columbia and western Alaska south to California, Arizona, New Mexico, Texas, and northern Mexico (Dayton 1931; Harrington 1964; Hitchcock and others 1959; Little 1979; Powell 1988). It may be found on a wide range of soil types, growing from the sagebrush grass zone to well above the mountain brush and ponderosa pine communities. It also grows in openings in aspen and spruce-fir communities (Welsh and others 1987). Blue elderberry is found in canyon bottoms, along streams, and on sites that are wet during the spring. In riparian areas, blue elderberry can occur in dense stands; in other areas individual plants are generally widely spaced. Plants are often abundant in burned areas.

Figure 14—Blue elderberry growing at the base of a rocky slope in eastern Idaho.

Plant Culture—Blue elderberry generally produces a good seed crop every year. Berrylike fruits are produced in large clusters. Each fruit contains three to five seeds (Hitchcock and others 1959). Fruit clusters are easily collected by cutting them from the stem. Seeds are extracted from the fruit by using a Dybvig macerator. The resulting pulp and seeds are dried, then lightly chopped and separated using an air screen fanning machine. Unfilled seeds can be removed by flotation. At 100 percent purity there are about 217,000 seeds per lb (478,500 per kg). Acceptable purity is 95 percent and germination 50 percent. Good viability is retained for up to 16 years (Haeussler and Coats 1986).

Germination of blue elderberry is inhibited by a hard seedcoat and embryo dormancy (Plummer and others 1968). Without artificial treatment, germination of planted seeds may occur sporadically over one to three growing seasons. Scarification in acid or a 2-month warm pretreatment followed by a wet prechilling of up to 5 months improve germination (Brinkman 1974j). Fall seeding is recommended to permit overwinter wet prechilling (Plummer and others 1968). Seeds in the soil seedbank often germinate readily following fire (Heit 1967a).

Elderberries can be established by direct seeding in favorable spots (Plummer and others 1968). Seed may be hand planted in pits on burns, chained areas, or disturbed riparian sites. Elderberry seed may also be planted alone or with other shrubs using Hanson or thimble seeders. Elderberries should be planted separately from grasses to protect the shrub seedlings from competition. Seeds should be covered 0.25 inch (6 mm) deep on a firm seedbed.

Blue elderberry is easily propagated, planted, and established using container or bareroot stock (Plummer and others 1968). Plants grow quickly in nursery beds, and often develop a thick taproot and spreading root system. Root pruning can eliminate or reduce this problem. Blue elderberry can also be established from cuttings (Plummer and others 1968).

Blue elderberry shrubs begin growth slowly in early spring, although rapid vegetative development occurs in June or July. The number of stems and buds, as well as total productivity, fluctuate greatly from year to year. Older branches die back during the winter. New growth develops from large vegetative buds on the rhizomes.

Uses and Management—Blue elderberry has been used successfully in soil stabilization (Plummer and others 1968), riparian plantings (Carson and Edgerton 1989; Goldner 1984), streambank stabilization planting (Lines and others 1979), and for revegetation of mined areas (Ferguson and Frischknecht 1985; Hungerford 1984; Monsen 1984). Fruits of blue elderberry are gathered and used for making wine, jellies, candy, pies, and sauces (Mozingo 1987; Powell 1988).

Blue elderberry is grazed by livestock and wildlife species throughout the year (Dittberner and Olsen 1983; Kufeld 1973; Kufeld and others 1973; Martin and others 1951; Robinette 1972). However, use varies by season (Kufeld 1973; Sampson and Jesperson 1963; Smith and Hubbard 1954; Steele and Geier-Hayes 1987). Spring and summer use are light. Many mature plants grow so tall that by late summer much of the foliage is out of reach of grazing animals. Palatability and use increase dramatically after the fruit ripens and the foliage is frosted (Dayton 1931). Plants are heavily used by cattle, deer, and elk in fall; they are especially palatable to sheep. Use decreases in the winter after leaf fall, but plants provide important herbage. The berries and dried fruit, which often remain on the shrubs through the winter, are consumed and dispersed by birds and many other animals. Buds are used by grouse, rodents, and big game animals in winter. The shrub provides cover for big game and nongame species, and perching and nesting sites for birds (Brown and others 1977; Dittberner and Olsen 1983; Gray and Greaves 1984). Blue elderberry is persistent and recovers well from moderate grazing and trampling (Monsen 1984; Plummer and others 1968; Van Dyne and Payne 1964). Continual, heavy grazing can be detrimental. Seeded areas should not be grazed for two or three growing seasons following seeding. Buds and branches may be defoliated by grasshoppers during mid or late summer during years when population densities are high. Plants generally recover the following year.

Blue elderberry exhibits good fire tolerance (Aro 1971) and is able to resprout from the root following fire (Little 1979; Preston 1948; Steen 1965; Van Dersal 1938). Germination of seed buried in the soil is enhanced by fire (Heit 1967a; Morgan and Neuenschwander 1988).

Varieties and Ecotypes—None. There are many ecotypes within the species. Drought-tolerant, shrubby populations associated with sagebrush types do well with only 12 inches (30 cm) of annual precipitation. Tall, almost treelike populations also occur. Some populations are consistently good seed producers, while others produce erratic seed crops.

Family Caprifoliaceae

Sambucus racemosa
Red elderberry

Description—Red elderberry is a native circumboreal shrub (Hitchcock and others 1959). Two natural varieties occur in the Western United States: *S. r.* var. *microbotrys* has red fruits and is widely distributed,

ranging from Wyoming and northern California south to Mexico. *S. r.* var. *melanocarpa* produces black fruits, and occurs primarily in the Rocky Mountains from Canada south to the Pacific Northwest and Wyoming (Welch and others 1987).

Red elderberry has distinctive opposite branches and leaves. Leaves are pinnately compound, leaflets are five to seven serrate, pointed, 1.2 to 5.9 inches (3 to 15 cm) long, and 0.4 to 2.4 inches (1 to 6 cm) broad. Plants are fairly short, usually about 3 to 6 ft (0.9 to 1.8 m) in height. Stems have warty bark with brown pith; they have a rank odor if bruised and crushed (Kelly 1970; Viereck and Little 1972). The numerous white to cream-colored flowers are borne in terminal pyramidal clusters (cymes) less than 3 inches (8 cm) wide. The fruit is a red drupe that ripens in September. Each drupe contains two to four seeds (Hitchcock and others 1959; USDA Forest Servcie 1985; Welsh and others 1987).

Ecological Relationships and Distributions—Red elderberry occurs in subalpine, spruce-fir, lodgepole pine, and aspen communities (fig. 15). It is distributed across North America from Alaska to Newfoundland and south to New Mexico and Georgia (Great Basin Flora Association 1986; Viereck and Little 1972; Worley and Nixon 1974). It prefers full to intermediate sunlight, and is not found in full shade (Haeussler and Coats 1986). Greatest areas of abundance are in openings where winter snow accumulates and remains late in the spring, riparian areas, meadows, parks, and other wet areas. Red elderberry grows in association with tall and intermediate forbs and grass communities. It occurs singly and in patches of various sizes.

Figure 15—Red elderberry frequently occurs in forested openings and subalpine communities.

Plant Culture—Red elderberry flowers in midsummer. Fruits ripen in mid to late September. Good seed crops are produced most years. Fruit clusters are harvested by cutting them from the stems. Seeds are extracted with a Dybvig macerator. Seeds and pulp are dried, lightly chopped, and processed through an air screen fanning machine to separate seeds and debris. At 100 percent purity there are about 286,000 seeds per lb (630,500 per kg). Acceptable seed purity is 95 percent and germination is 50 percent. Success from direct seeding can be erratic (Plummer and others 1968). Germination requires wet prechilling; therefore, fall seeding is recommended. Seed should be covered lightly and planted in areas where competition will be light for a few years. Red elderberry can be propagated by cuttings, either hardwood cuttings started in winter or softwood cuttings taken during spring and summer (Doran 1957; Ritter and McKee 1964).

Most natural reproduction occurs vegetatively from buds on stems, rhizomes, and root crowns following fire or mechanical damage (Conrad and McDonough 1972; Van Dersal 1938). Some reproduction also occurs from seed. Seeds are dispersed by birds and rodents and can remain dormant in the soil for long periods. Seeds scarified by fire often germinate in large numbers during the first season following burning (Heit 1967a; Hungerford 1984; Kramer 1984).

Uses and Management—Red elderberry is used seasonally by sheep, cattle, deer, bear, porcupine, and elk (Conrad and McDonough 1972; Dayton 1931; Kufeld 1973; Kufeld and others 1973; Martin and others 1951; Ritter and McKee 1964; Smith 1953; Steele and Geier-Hayes 1987; Zager 1980). It is one of the most palatable browse species for elk in Idaho and Montana (Gaffney 1941; Young and Robinette 1939; Zager 1980). Palatability is excellent for sheep following frost.

All top growth is consumed or dies to ground level each fall. Fruits mature in late August and September. They are consumed by birds, rodents, livestock, and big game. Seed is cached and used by rodents. During winter porcupines and mice feed on the buds and bark (Conrad and McDonough 1972). Red elderberry provides valuable nesting and perching habitat and food in the form of berries and buds for a large number of birds (Denslow 1987; Gullion 1964; Martin and others 1951; Van Dersal 1938).

Red elderberry is used to stabilize disturbed and erosion-prone areas, especially on aspen and upper spruce-fir sites, riparian areas, seeps, and other moist sites (Platts and others 1987; Worley and Nixon 1974). Bareroot stock and container-grown stock have been used successfully for planting disturbed riparian areas in aspen and ponderosa pine forests (Platt and others 1987). Red elderberry is used as a colorful

ornamental (Kelly 1970; Ritter and McKee 1964), and should be considered when planting recreational sites, summer homes, and ski areas.

Varieties and Ecotypes—None. There is, however, considerable variation within the species.

Family Caprifoliaceae

Symphoricarpos albus
Common or white snowberry

Description—Common snowberry is an erect, multibranched shrub usually 3.3 to 6.6 ft (1 to 2 m) tall, but ranging from 1.6 to 9.8 ft (0.5 to 3 m) in height (fig. 16). Plants are fibrous rooted with the densely branched root system concentrated near the soil surface. The species is slightly rhizomatous with sprouts from the thick, spreading rhizomes forming dense thickets. The slender upright stems are hollow, smooth, and brownish. Twigs are glabrous and obscurely puberulent. Leaves are opposite, thin, pale green, elliptic to elliptic ovate, and entire or with a few coarse, irregular teeth. They are 0.6 to 2 inches (1.5 to 5 cm) long and 0.4 to 1.4 inches (1 to 3.5 cm) wide with petioles 0.1 to 0.2 inch (2 to 4 mm) long. Leaves on sterile shoots may be somewhat larger. Racemes are terminal or sometimes in the upper leaf axils. They are dense, subsessile and few flowered. The perfect flowers are small, pinkish, and bell shaped. The five-parted corolla is 0.2 to 0.3 inch (5 to 7 mm) long and nearly as wide. The interior is densely hairy. Corolla lobes range in length from one-half to nearly equaling the tube length. Anthers alternate with the petals and nearly equal the filaments in length. There is a single style. The ovary is four locular. Generally two locules produce a single mature seed each. The white pulpy fruits are subglobose or ellipsoid and 0.3 and 0.6 inch (8 to 15 mm) in diameter. Seeds are elliptical, flattened, creamy white, smooth, and 0.16 to 0.2 inch (4 to 5 mm) in length with fleshy endosperm and a tiny, poorly developed embryo (Evans 1974; Hitchcock and others 1959; Hopkins and Rawlings 1985; Kovalchik and others 1988; Marchant and Sherlock 1984; Viereck and Little 1972; Welsh and others 1987).

Figure 16—Open, branching, scattered, pale-green leaves, and shedding bark are distinctive characteristics of common snowberry.

Ecological Relationships and Distribution—Common snowberry occur across the United States and Canada except in the far north of Alaska and Canada and the Southern States. It naturally occurs associated with conifer species, in shade and in openings with full sunlight.

Plant Culture—Common snowberry seeds are white and average 76,000 per lb (167,500/kg). One hundred lb (45 kg) of fresh fruit will yield 3 to 5 lb (1.4 to 2.3 kg) of cleaned seed. Good seed crops are produced in 4 out of 5 years. Flowering occurs from June through July. Fruits remain on the plant into winter or until eaten. Fruits are processed through a Dybvig macerator, dried, and run across an air screen separator. Unfilled seeds are removed by flotation. Germination is delayed by dormancy, which can be overcome with wet prechilling or scarification with sulfuric acid. Germination will occur over a number of years. Young plants grow slowly; however, they can mature and flower in 3 or 4 years.

Uses and Management—Common snowberry is an important forage plant in the West, especially for sheep and deer, which make considerable use of it year around. Elk strip the leaves in the fall. Plants can be lost as a result of excessive use.

This species has been used extensively as an ornamental. It can be directly seeded or transplanted in restoration projects. It does not do well on disturbed sites such as mines and road fills and cuts.

Varieties and Ecotypes—There are a number of ornamental varieties and selections, but none are available for use on rangelands and disturbed sites.

Family Caprifoliaceae

Symphoricarpos longiflorus
Desert snowberry

Description—Desert snowberry is a native, long-lived, deciduous shrub. Plants are low growing, erect to arching, and range in height from 1.6 to 5 ft (0.5 to 1.5 m). The ability of the species to spread by rhizomes is poorly known. Plants exhibit wide variation in leaf and twig pubescence. Young stems are persistent, glabrous to pubescent, and tend to spread at right

angles, giving the plant a thorny appearance. The firm leaves are simple and opposite, 0.2 to 0.6 inch (6 to 15 mm) long and 0.1 to 0.3 inch (2 to 7 mm) wide, oval to lanceolate or oblanceolate, and entire or with one or two teeth. The fragrant flowers are solitary, paired in the leaf axils, or in small, few-flowered, terminal racemes. The calyx and corolla are five lobed and regular. The slender corolla tubes are 0.4 to 0.7 inch (1.0 to 1.8 cm) long, salverform, glabrous, and pale to deep pink. Lobes are much shorter than the tube and rather abruptly spreading. Anthers are sessile, alternating with the corolla lobes. The single style is stiff and hairy above the center. The ovary is four loculed; the two functional locules each contain a single seed. The fruit is a white, waxy, two-seeded berry about 0.3 to 0.4 inch (8 to 10 mm) in diameter. Seeds are 0.2 inch (5 mm) long and acute at the base (Cronquist and others 1984; Davis 1952; Evans 1974; Welsh and others 1987).

Ecological Relationships and Distribution—Desert snowberry occurs on deep, well-drained soils in desert-shrub, pinyon-juniper, sagebrush, mountain bush and ponderosa pine communities from Oregon to Colorado, and south from southern California to Texas. It is the most drought tolerant of the snowberries. It grows intermixed with other species, but not in closed stands.

Plant Culture—Desert snowberry produces white, two-seeded berries. There are an average of 70,000 seeds per lb (154,000/kg). One hundred lb (45 kg) of fresh fruit will yield 5 to 7 lb (2.3 to 3.2 kg) of cleaned seed. Good seed crops are produced in about 2 out of 5 years, depending on spring and summer storms. Flowering occurs in June to mid July. Berries are harvested by hand stripping or beating. Fruits are extracted by maceration through a Dybvig cleaner. Unfilled seeds are removed by flotation. Germination can be erratic. Dormancy can be overcome with wet prechilling and scarification with sulfuric acid. Fall seeding will permit prechilling to occur. Young plants can mature and produce seed in 3 to 4 years and reach full stature in 5 to 6 years.

Uses and Management—Desert snowberry can be an important browse plant for sheep and deer, and to a lesser extent for cattle. It is fairly resistant to grazing. On many overgrazed sagebrush ranges in which the understory species have been eliminated, desert snowberry and sagebrush will remain. Excessive use will result in death of plants.

This species can be seeded or transplanted. It does not do well on severely disturbed sites. It does best on soils with well-developed, undisturbed horizons.

Varieties and Ecotypes—None.

Family Caprifoliaceae

Symphoricarpos occidentalis Western snowberry, wolfberry

Description—Western snowberry is an erect shrub, branching weakly from a woody base and short main branches. Plants are 1 to 3.3 ft (0.3 to 1 m) tall, spreading freely from rhizomes, and often forming dense thickets that exclude other vegetation. Roots are densely branched, shallow, and intermixed with stout creeping rhizomes. Young twigs are puberulent to glabrous. Petioles are 0.1 to 0.4 inch (3 to 10 mm) long. The opposite leaves (fig. 17) are thick, elliptic to ovate, entire or with a few, coarse, blunt, irregular teeth. Most are 0.8 to 3.1 inches (2 to 8 cm) long and 0.4 to 2 inches (1 to 5 cm) wide with somewhat revolute margins. Leaves on sterile shoots are often larger, frequently more lobed, glabrous above, and usually hirsute puberulent beneath, at least along the main veins. Few to many-flowered spikelike racemes are produced at the ends of the twigs and in the upper leaf axils. The five-merous corollas are often wider than long, pink to rose colored, and densely hairy within. Lobes are arcuate spreading. Anthers alternate with the petals and are shorter than the filaments. The style may be hairy near the middle, but is occasionally glabrous. The ovary is four loculed; two locules usually produce one mature seed each. Fruits are subglobose and greenish white, turning black after frost. The two seeds are white, somewhat ellipsoid, and flat on one side with a poorly developed embryo (Cronquist and others 1984; Davis 1952; Hansen and others 1988b; Hitchcock and others 1959; Wasser 1982; Welsh and others 1987).

Figure 17—Western snowberry with ovate leaves and small white flowers is widespread in aspen and conifer forests where it often occurs in dense thickets.

Ecological Relationships and Distribution—Western snowberry is widespread from British Columbia to Manitoba, south to Washington, Idaho, and Colorado. In Utah it is most often associated with riparian communities, mainly with cottonwood and willow species (Welsh and others 1987). It does especially well on sites with high water tables. It is also found in the mountain brush, open conifer sites, and upper pinyon-Rocky Mountain juniper communities, especially on east- and north-facing slopes. It competes well with understory herbivore species.

Plant Culture—Fruits of western snowberry are collected by hand stripping. Seeds are extracted by maceration through a Dybvig cleaner. There are about 74,000 seeds per lb (163,000 seed/kg). One hundred lb (45 kg) of fresh fruits will normally yield 8 to 10 lb (3.6 to 4.5 kg) of seed. Good seed crops can be expected 3 out of 5 years. Flowering occurs from the first of June through late July. Fruits ripen from mid-September to mid-October. Considerable seed dormancy can exist. This can be overcome with moist prechilling and scarification with sulfuric acid. Fall seeding will help to overcome dormancy. Seedling emergence, however, can be erratic over a few years. Plants can be established from nursery-grown container and bareroot stock. Wilding stock can be obtained early in spring while the ground is still moist and before plants break dormancy.

Uses and Management—Western snowberry can be used extensively by sheep and deer, and a little less by cattle. Elk prefer it in the fall after it has been frozen. It can receive heavy browsing and trampling in riparian areas. Excessive use can result in plant death. This species has been used fairly extensively in restoration projects, especially as transplants.

Varieties and Ecotypes—None.

Family Caprifoliaceae

Symphoricarpos oreophilus Mountain snowberry

Description—Mountain snowberry is a spreading to erect branching shrub 4.9 to 6.6 ft (1.5 to 2 m) tall (fig. 18). Leaves and twigs are densely puberulent to glabrous and sometimes glaucous. The thin opposite leaves are elliptic to ovate, entire, or with a few teeth or lobes. They range from 0.4 to 2 inches (1 to 5 cm) in length and 0.1 to 1 inch (0.3 to 2.5 cm) in width. Leaves on sterile shoots may be larger (Mozingo 1987). The cream-colored to pinkish flowers have an unpleasant odor. They are solitary or paired on short, drooping pedicels in the upper leaf axils, or borne on short, few-flowered terminal racemes. The corolla and calyx are five- or occasionally four-lobed. The corolla is longer than wide, elongate campanulate to tubular funnelform. The corolla lobes are one-fourth to one-half as long as the tubular portion of the corolla. The interior of the tube is sometimes hairy below the level of filament insertion, but may be glabrous. The filaments are equal to or shorter than the anthers. The ovary is four-locular. Two locules normally contain several abortive ovules each; the remaining two locules each contain one normal pendulous ovule. Fruits are waxy, white ellipsoid, and about 0.3 to 0.4 inch (7 to 10 mm) long. The hard nutlets or seeds are 0.2 to 0.3 inch (4 to 6.5 mm) long (Cronquist and others 1984; Hitchcock and others 1959; Welsh and others 1987).

Ecological Relationships and Distribution—Mountain snowberry is common in midelevation sagebrush, ponderosa pine, Gambel oak, aspen, Douglas-fir, lodgepole pine, and spruce fir communities in the Intermountain region. It can be found growing from British Columbia to Montana, and south to California, Arizona, and New Mexico (Welsh and others 1987). Plants may be locally abundant, and in some cases form nearly pure stands. Mountain snowberry will dominate aspen stands. This shrub does well in full sunlight and shade.

Plant Culture—Mountain snowberry seeds are collected by hand stripping the two-seeded fruits from the stems. Good seed crops are produced 3 out of 5 years. Seeds are cleaned in a Dybvig macerator. Unfilled seeds are removed by floatation. Germination is delayed by the impermeable endocarp and an immature embryo. Pretreatments include a 3- to 4-month wet prechilling retreatment. Scarification with sulfuric acid is also used to break the dormancy imposed by the endocarp (Evans 1974). The embryo develops to

Figure 18—Mountain snowberry is commonly encountered in open parks and conifer forests.

maturity during an extended period of wet prechilling. There are about 75,000 seeds per lb (165,000/kg). One hundred lb (45 kg) of fresh fruits will yield 6 to 10 lb (2.7 to 4.5 kg) of seed. Flowering occurs through June and July. Fruits mature from mid-September through October.

Successful establishment may be achieved by fall planting. Seeds may be hand planted or drilled. Seeds should not be directly planted with grasses because snowberry seedlings develop very slowly. Mature plants will, however, develop in 3 to 4 years. Mountain snowberry is easily established using nursery-grown bareroot or container stock. Seedlings propagated in the nursery or greenhouse grow relatively rapidly, producing extensively branched root systems. Softwood cuttings taken during the period of flowering or vegetative growth are easily rooted and transplanted (Everett and others 1978a; Mirov and Kraebel 1939).

Uses and Management—This species does not grow well on disturbed roadways, mine sites, or similar disturbances unless areas are top soiled. It has been seeded and transplanted fairly extensively on such sites with good success.

Mountain snowberry is low growing, and is accessible to all classes of livestock and wildlife. This shrub is an important source of forage in the early spring, as it is one of the first shrub species to leaf out. In areas where snowberry is a dominant species, it often provides important forage throughout the spring and fall. The persistent, fleshy fruits of all snowberry species are taken by a variety of birds. Field mice scatter the seeds, and plants are widely established from mice caches.

Varieties and Ecotypes—None.

Family Cornaceae

Cornus stolonifera
Redosier dogwood

Description—There are about 30 species of dogwood; most occur in the Temperate Zone of the Northern Hemisphere. Three species occur in the Rocky Mountain region. Redosier dogwood, named for its red to purplish bark is also known as creek dogwood. It is a deciduous, short-lived, rapidly growing, thicket-forming shrub common to moist places (fig. 19). Its spreading clumps of slender stems rise to 15 ft (4.6 m) in height and 20 ft (6 m) in width from a central crown and spreading root system. Stem layers form on decumbent to prostrate stems that simulate stolons. The degree of vegetative spread varies widely. Bark of young branches is bright red to purplish, later turning gray green. Lenticels are diamond shaped. Leaves are petiolate, opposite, entire, elliptic-ovate to obovate and usually acuminate, 1 to 4 inches (2.5 to 10 cm) long and about two-thirds as wide. They are distinctively pinnately veined and sometimes wrinkled, sparsely strigillose and greenish on the upper surface, and paler with pubescence along the veins and sometimes covering the lower surface. Flowers are clustered in flat-topped, ebracteate cymes. Penduncles and branches are strigose to conspicuously spreading pubescent. Flowers consist of four very small sepals, four white petals, 0.1 to 0.2 inches (2 to 4 mm) in length, four stamens, and a two-carpellate pistil. The white to bluish drupes are berrylike, glabrous to pubescent, and 0.28 to 0.35 inches (7 to 9 mm) in diameter. Flesh is thin and succulent or mealy. There are usually one or sometimes two bony stones. A smooth rather than grooved stone is a major feature separating *C. s.* var. *stolonifera* from *C. s.* var. *occidentalis*, although they are widely hybridized (Hitchcock and others 1961). Redosier dogwood flowers from May to July, depending on location. There may be a second period of flowering later in the summer. Fruits ripen from July to September and remain on the plant for 8 or 10 weeks (Olsen and Nagle 1965; Orme and Leege 1980; Stark 1966).

Ecological Relationships and Distribution—Redosier dogwood is widely distributed across North America, occurring from Alaska to Newfoundland and south from California to the Northeastern States. The species also occurs in central Mexico. It grows at elevations from 1,500 to 10,000 ft (460 to 3,030 m) (Harrington 1964; Thornburg 1982) on moist sites, usually along streams, swamps, low meadows, river and creek banks, fields, and woods in areas receiving more than 19 inches (48 cm) of annual precipitation.

Figure 19—Redosier dogwood with its distinctive red bark, opposite leaves, and stoloniferous habit grows in riparian areas and on other moist sites.

It is one of the earliest shrubby plants to invade bogs and swamps due to the ability of its roots to live immersed in water (Conway 1949). It is frequently associated with stands of alder, birch, and willow, and in moderately moist areas, with mountain maple, blackberries, or wild roses. Large plants grow singly in grasslands, incapable of spreading by layering due to the dense ground cover. Redosier dogwood, highly adaptable to a range of soil types, is found on sphagnum mats with a pH of 3.2 (Jewel and Brown 1929) and alkaline soils of pH 8 (Van Dersal 1938). It grows on soils with textures ranging from silty to clayey. In Wisconsin it is recommended for planting on soils with a pH of 5.0 to 6.0, base exchange capacity of 6.0 me per 100 g, and total nitrogen of at least 0.7 percent (Wilde 1946). Roots of redosier dogwood may be associated with vesicular arbuscular mycorrhiza (Barnhill 1981).

Redosier dogwood will grow in full sun or in shaded areas. In full sun, the plants are dense and compact with many lateral branches. In shade, the growth habit is more open and sprawling with few axillary branches, larger leaves, thinner and less curled blades, and lower leaf/total weight ratios. Shrubs growing in full sun tend to develop richer purple coloring in the fall (Sheppard and Pellitt 1976).

Use of redosier dogwood in landscaping, along highways, and on mine spoils has led to a number of physiological studies to determine the effects of short days, water stress, defoliation, and low temperature in initiating and maintaining various degrees of frost hardiness (Chen and Li 1978).

Lumis and others (1973) found that of 20 deciduous shrubs selected from those growing along highways in Ontario, redosier dogwood exhibited the greatest sensitivity to aerial drift of deicing salt because its buds are exposed in winter. Affected trees exhibited twig dieback, a tufted growth pattern, and a greater susceptibility of flowering buds than vegetative buds.

Heale and Ormrod (1982) evaluated plants used for revegetation of toxic wastes high in nickel and copper at primary base metal smelters and found redosier dogwood exhibited typical symptoms. It was sensitive to both levels of nickel tested (2 and 10 mg per 1), but was sensitive only to the highest copper level tested (20 mg per 1, but not 4 mg per 1).

Uses and Management—Redosier dogwood seedlings establish and grow rapidly on wet sites, making it a useful species for streambank, erosion control, and windbreak plantings. It can withstand moderate browsing, but repeated heavy browsing leads to plant loss (Swihart and Yahner 1983). New plantings begin producing fruit in 3 to 5 years.

Berries of redosier dogwood provide nutrients for pheasants, grouse, and many other birds in early winter (Stokes 1977). In New England redosier dogwood seeds were found in the diets of 95 bird species (McKenny 1939). Beaver, bears, and mountain goats use the fruit, wood, and foliage (Murie 1951; Rue 1964). Rabbits, moose, deer, and elk take twigs and exposed winter buds. Plants on winter ranges sometimes suffer from excessive browsing. Kufeld (1973) rated the forage value of redosier dogwood as valuable in winter and fall and highly valuable in summer. It receives moderate fall and winter use and heavy summer use from mule deer (Kufeld and others 1973). The species provides dense summer cover and partial winter cover for birds and other small animals.

Redosier dogwood is recommended for streambank plantings to stabilize eroding banks and provide shade. It may be used to provide an attractive row in windbreak and conservation plantings in areas with adequate water availability (Cook 1981; Olson and Nagle 1965; Stokes 1977). Varieties selected for ornamental use generally have a more compact growth form. In landscapes it provides obvious color and a graceful growth form during all seasons (Stokes 1977; Sutton and Johnson 1974).

Plant Culture—Fruits are collected as soon as they are ripe to reduce losses to birds. Seeds should be fully mature when harvested; some planting failures have been attributed to use of immature seeds (Smithberg 1974). Embryo dormancy is overcome by a 60- to 90-day wet prechilling at 35 to 41 °F (2 to 5 °C). A tetrazolium chloride or embryo excision test is normally used to indicate seed quality and preclude the lengthy wet prechilling requirement (Heit 1955; Brinkmann 1974d). The double-celled fruits sometimes contain two viable embryos, which may contribute to high germination percentages.

Field seeding is best accomplished by spot seeding untreated seed in fall or wet prechilled seed in spring on favorable microsites. Seedlings must be protected from competition and browsing. Peterson (1953) found that laboratory wet prechilling produced better greenhouse germination than wet prechilling through exposure to winter conditions, or combinations of each type of wet prechilling with scarification. Laboratory wet prechilling also provided the greatest resistance to damping off.

Nursery seeding is accomplished by seeding freshly collected fruits. Dry stored fruits should be soaked in water prior to planting (Heit 1968a). Seeds may also be wet prechilled in the laboratory for spring planting. Seed should be drilled at a density of 40 viable seeds per ft^2 (430 per m^2). Seedlings grow rapidly under favorable conditions. One- or two-year-old bareroot stock may be used for outplantings (Shaw 1984). Plants may also be grown as containerized seedlings (Landis and Simonich 1984).

Redosier dogwood reproduces vegetatively from stolons or layering (Peterson 1953; Smithberg 1974). Layering may be induced by pressing branches to the

ground with hooks and covering them with loose soil. Rooted shoots are later severed, dug, and transplanted. Layers, as well as hardwood or softwood cuttings, may be used for vegetative propagation. Dormant cuttings may be rooted immediately in the field in moist areas, or rooted in a nursery or greenhouse prior to field planting (Doran 1957). Planting stock is generally available commercially, but origin should be matched as closely as possible to the planting site.

Varieties and Ecotypes—None.

Family Cupressaceae

Cupressus arizonica Arizona cypress

Description—Arizona cypress is an erect, somewhat pyramidal, evergreen tree with fragrant, resinous foliage (Johnson 1974c; Welsh and others 1987). Five different varieties were described by Johnson (1974c); these differ somewhat in erectness and crown spread (Sudworth 1915; Wolf and Wagener 1948). Trees are mainly 15 to 70 ft (5 to 21 m) in height (Johnson 1974c; Welsh and others 1987). Trunks are 5 to 20 inches (13 to 51 cm) thick; twigs are stout, branching at nearly right angles; the bark is scaly or furrowed and usually grayish. Leaves are scalelike, sharply pointed, blue green, and 0.1 inch (2 mm) long. Cones are globose, 0.6 to 1 inch (1.5 to 2.5 cm) thick, short-stalked, hard and woody, with six to eight flattened scales bearing a hard point in the center. Seeds are 0.1 inch (2 mm) long and purplish brown (Welsh and others 1987). Plants are monecious. Staminate and ovulate strobili are produced on the ends of the branches. Staminate strobili are long and cylindrical, turning yellow as pollen ripens (Johnson 1974c). Ovulate strobili are small, usually less than 0.3 inch (6 mm) long, and green, with six to 12 distinctly arranged scales (Johnson 1974c).

Ecological Relationships and Distribution—Arizona cypress is distributed from Texas to Arizona and Mexico (Welsh and others 1987). The varieties described by Johnson (1974c) occur in somewhat different locations, mostly in north-central Arizona, southern California, and Mexico. This plant has commonly been grown as an ornamental and Christmas tree throughout much of the West. It has proven adaptable to areas outside its native range, and has been planted on numerous sites including many range and wildland communities (fig. 20). It is best adapted to sites receiving at least 14 to 16 inches (36 to 41 cm) of annual precipitation. Normal occurrence is on north slopes, coves, benches, and canyon bottoms (Sudworth 1915), particularly moist, sheltered canyon bottoms.

Plant Culture—Throughout its natural range, cones develop in late fall and pollen is shed in October and November (Johnson 1974c); seeds mature 15 to 18 months later. At the time of maturity cones are about 1.2 inches (3 cm) diameter. Because cones require approximately 2 years to mature, numerous cones of different ages are borne on a single tree. Some trees produce abundant female cones; other trees are much less productive. Trees less than 10 years of age normally do not produce many cones. Insects often damage the cones; consequently, seeds should be carefully inspected to assure healthy cones and viable seeds are collected. Ripe cones are dark brown or deep purplish brown (Sudworth 1915; Wolf and Wagener 1948).

Seeds are harvested by handpicking or beating the tree to dislodge the hard woody cones onto canvas tarps. Trees can be damaged from excessive flailing. Cones are normally harvested in early to late fall. The cones are serotinous; they open when mature to shed the seeds. The scales surrounding the cones form a tight cluster that can be difficult to open unless quite dry. Drying the seeds normally causes natural shattering in 1 to 2 months. Johnson (1974c) suggested storing the cones for several days in a refrigerator to aid in drying and to prevent cone hardening. Seeds normally separate freely from the cones. Approximately 55,050 cleaned seeds per lb (121,400 per kg) were reported by Johnson (1974c) for collections of *C. a.* variety *glabra*. Between 90 and 100 seeds are produced per cone. Considerably larger numbers are reported for other varieties (Goggans and Posey 1968; Johnson 1974c; Wolf and Wagener 1948). Seeds are flattened or lens shaped with short wings (Johnson 1974c).

Seeds wet prechilled for 30 days at 34 °F (1.1 °C) will germinate readily at incubation temperatures near

Figure 20—A 10-year-old planting of Arizona cypress provides wildlife cover in south-central Idaho.

70 °F (21.1 °C) (Johnson 1974c), but most authors recommend incubation at alternating temperatures of 86 °F (30.0 °C) day, and 68 °F (20.0 °C) night (International Seed Testing Association 1966; Stein 1966; USDA Forest Service 1948). Seeds may be infested with mold or bacteria that reduce germination. Treatment with Captan (N-[(trichloromethyl) thio]-4-cyclohexene-1,2-dicarborimide) or other fungicides will retard fungal development (Johnson 1974c). Because young seedlings are also susceptible to damping off fungi, seedbeds or nursery-grown containers can also be pretreated with a fungicide.

Arizona cypress has been established by fall seeding in a well-prepared seedbed. Seedlings are sensitive to herbaceous competition, and require a weed-free seedbed for 1 to 2 years. Established seedlings are vigorous and grow rapidly when well protected. Plants may attain heights of 2.5 to 4 ft (0.8 to 1.2 m) in 2 to 3 years. They continue to grow rapidly, but may not reach mature stature for 40 years.

Seedlings and transplant stock are easily grown, and the plant is sold by many commercial nurseries. Small stock 6 to 10 inches (15 to 25 cm) high and large ball and burlap trees are usually available.

Uses and Management—Arizona cypress is an important resource in its native range. It provides lumber, wildlife habitat, and watershed protection (Johnson 1974c). This tree has been particularly useful for landscape and erosion control plantings in southern California on a range of soil types at elevations below 6,000 ft (1,800 m) (Horton 1949). It is well suited as a ground cover or landscape plant because it grows rapidly, is long-lived, and has an attractive pyramidal growth form (Horton 1949).

Within the Intermountain States, this tree has been used for conservation and wildlife habitat improvement projects. It has been successfully used as a windbreak or cover plant to protect structures and shelter range and farmlands. It has been used to provide cover in mixed plantings with other trees and shrubs. Being evergreen, it is particularly important as winter cover. It provides a dense amount of foliage from the base to the top of the plant. It has survived wind and heavy snowstorms, but some individuals and populations lack cold tolerance to harsh conditions in mountainous regions in the West.

This tree species has been useful for wildlife habitat improvement in Utah (Plummer and others 1968). It establishes and grows well, particularly from transplanting in mountain brush, pinyon-juniper, and big sagebrush communities. Seed germination is somewhat erratic, and irregular stands have established from direct seedings. Natural spread by seedling recruitment is poor from all plantings within the Intermountain area.

This species has received considerable browsing by big game at all planting sites in the Intermountain area. Game animals use the plant heavily in summer, and in lesser amounts in the spring, fall, and winter. The foliage is quite palatable, and heavy browsing and highlining of the trees normally occurs. Heavy browsing can prune or eliminate leaf and small stem growth from the lower portion of the plant.

Arizona cypress has demonstrated mixed success on mine sites and other disturbances. It is not adapted to infertile mine wastes unless top soiled. It does not serve well as a pioneer species on barren disturbances. Young plants succumb quickly if planted on marginally adapted sites.

Varieties and Ecotypes—None.

Family Cupressaceae

Juniperus horizontalis Creeping juniper

Description—Creeping juniper is a native, decumbent to procumbent or prostrate shrub that normally attains heights of 8 to 12 inches (20 to 31 cm) (Bifoss 1947; Great Plains Flora Association 1986; Welsh and others 1987) (fig. 21). Plants develop in clumps or mats that may exceed 23 ft (7.0 m) in diameter (Hitchcock and others 1969; Stephens 1973). The decumbent or prostrate stems root at the nodes forming well-rooted clumps. Leaves are mostly 0.04 to 0.16 inch (1 to 4 mm) long, decurrent, opposite, scalelike or awl shaped, and acute to spinulose tipped. Cones mature the first season; they are green when immature and ripen to blue purple or blue black. They are glaucous, 0.2 to

Figure 21—Creeping juniper growing as an understory with aspen.

0.4 inch (5 to 10 mm) thick, and mostly three- to five-seeded (Welsh and others 1987). Seeds are reddish brown and ovoid to spherical (Hitchcock and others 1969). Plants are dioecious, and although mature cones may be produced in one season (Welsh and others 1987), 2 years are normally required (Great Plains Flora Association 1986; Miller 1978).

Ecological Relationships and Distribution—Creeping juniper is widely distributed in North America (Little 1979). It occurs from Montana to northern Colorado and Utah, and east to northeastern Iowa, Nebraska, Illinois, and New York (Little 1979). It is abundant throughout Canada (Couchman and Von Rudloff 1965), and occurs from Alaska and the Yukon, east to the Atlantic, and south to British Columbia (Welsh and others 1987). The shrub is widely distributed over a number of different plant communities. It grows in association with grass and broadleaf forbs at low elevations in the northern Great Plains (Girard 1985; Hansen and others 1984; Johnston 1987). It is also associated with conifer forests, aspen, and limber pine (Girard 1985) at high elevations and on more moist sites (fig. 21).

Plant Culture—Staminate cones are produced at the tips of the branches in early spring. Pollination of pistillate cones normally occurs in April and May (Miller 1978). Pistillate cones form globose, berrylike fruits (Great Plains Flora Association 1986; Hitchcock and others 1969; Miller 1978). As they ripen they change in color from green to blue black or bluish purple (Stephens 1973). Cones normally remain on the plant until the late fall or early winter of the second year. When fully mature they drop from the plant.

Seeds are harvested by stripping or picking the ripened cones. Cones can also be dislodged by flailing the branches and dislodging them onto canvases spread on the ground. It is advisable to collect the cones as soon as they ripen. Collecting green cones or immature seeds is not advised, as they are difficult to separate from fully ripened seeds during cleaning. Freshly collected cones should be spread to dry, but can be stored and seeded as dry cones or as cleaned seeds (Johnsen and Alexander 1974). Seeds are normally extracted from the cones by maceration using a Dybvig seed cleaner. The debris is floated away in water (Johnsen 1959; Johnsen and Alexander 1974). If cones are completely dry before cleaning, they may require soaking for a few days to aid in separation. The macerated material is dried and then fanned to separate seeds from the trash. Seeds should be stored in sealed containers at 20 to 40 °F (–6.7 to 4.4 °C) with relative humidity at about 10 percent (Johnsen and Alexander 1974; Jones 1962).

Germination of creeping juniper seed is delayed by embryo dormancy and an impermeable seedcoat. Seeds also require a period of dry afterripening (Pack 1921). To enhance germination, seeds of most junipers are subjected to various pretreatments including wet prechilling at 40 °F (4.4 °C) for 30 to 120 days (Barton 1951; Johnsen and Alexander 1974).

When planted in the fall, seed dormancy can usually be broken by overwinter wet prechilling. Seedbeds should be covered with mulch to ensure the soil remains moist during the time of germination (Johnsen and Alexander 1974). Seeds are normally covered to a depth of at least 0.25 inch (6.4 mm) in a firm seedbed (Stoeckeler and Slabaugh 1965). Seedbeds are frequently shaded during the first growing season to protect the soil surface from rapid drying and reduce the chance of damage from early spring frosts (USDA Forest Service 1948).

Creeping juniper can be propagated from stem cuttings. Portions of the stem that contact the soil and form roots can be cut and separated into individual plants. The stem cutting and excised root system can be planted in containers, grown to a suitable size, and field planted. Stem cuttings can also be rooted easily under greenhouse conditions (Zorg 1954). Stem cuttings taken in early winter (November and December) root readily without the use of rooting compounds (Doran 1957; Kiplinger 1938).

Plantings of 2-year-old bareroot stock have established and survived better than younger, smaller stock. Field lifting and transplanting must be completed in early spring when plants are dormant. Although transplanting may be done later in the season, supplemental irrigation is usually required to assure survival.

Uses and Management—Creeping juniper has not been used extensively in large revegetation projects. Although recognized as an important ground cover and a locally useful forage plant for wildlife, it has been difficult to establish on wildland sites. This species has been able to persist following heavy grazing when more palatable shrubs and herbs have been eliminated. Consequently, rehabilitation programs often do not include this shrub. Creeping juniper normally occurs as scattered plants, occupying ridge crests, rocky slopes, ledges, washes, or areas that are difficult to plant with conventional equipment. Although site accessibility limits planting in some areas, this plant is important for ground cover and wildlife habitat and should not be overlooked.

Creeping juniper provides dense cover on harsh sites. Its low evergreen growth habit provides diversity and cover throughout the entire year. Ecotypes that are semierect or upright furnish better habitat for wildlife. This shrub grows on sites where few other plants are adapted. Because creeping juniper grows on isolated wildlife ranges, it is important to maintain its presence. It occurs in most plant communities and big game winter ranges on sites where soil protection and

forage diversity are critical for protecting watershed and wildlife values. Consequently, it is important that techniques are developed to better accommodate its propagation and field planting.

Creeping juniper normally receives only limited use by big game, but locally heavy winter browsing has been reported (Frischknecht 1975; Miller 1978). Dusek (1975) found that creeping juniper provided a major portion of mule deer diets during March and April in north-central Montana. This plant provides important fall, winter, and spring forage for big game (Dusek 1971; Kufeld and others 1973; Lovaas 1958; Martinka 1968; McKean 1954; Schallenberger 1966). It is more commonly used by deer, but Dirschl (1963) found that creeping juniper provides about 10 percent of the winter diet of pronghorns, and was the dominant forage from December to March in some parts of Saskatchewan. Some ecotypes in the Intermountain States exhibit considerable differences in use by game animals. Selections that receive moderate or heavy use are consistently browsed at these levels, although climatic, edaphic, or other factors may contribute to selective use by game.

Birds and other wildlife seek sites occupied by this shrub. The cones provide food for many game birds and mammals. They remain on the shrub for 1 or 2 years and provide 20 to 40 percent of the total food consumed by sharptail grouse (Miller 1978). Not all plants produce heavy seed crops. Annual production is often quite low, but fruits that do develop are used during winter and early spring periods when other foods are less available.

Creeping juniper begins growth very early in spring. Game animals are attracted to the shrub in late winter and early spring when other forages are less palatable. The plant grows in areas where game may be forced to concentrate during periods of deep snow and adverse weather conditions. At these critical periods, it provides protection, cover, and forage that are crucial for the survival of game animals.

Creeping juniper has been used to restore disturbed watersheds and mine sites. It is extremely difficult to establish by direct seeding because of germination problems. Transplanting has been the most successful means of establishment; however, costs associated with transplanting limit its usefulness. Transplants are difficult to establish on semiarid sites. Small transplants root slowly and require frequent irrigation to fully establish. Thus, it has been difficult to plant sites that do not remain moist through the year of planting. Once established and well rooted, this species survives very well. New plantings are not able to compete well with broadleaf herbs and grasses, and the shrub should be planted alone.

This shrub occupies areas in Wyoming, Montana, and Colorado where considerable surface mining occurs. Use of this shrub has been encouraged where efforts are made to restore native communities. Creeping juniper has established slowly on mine spoils, and appears sensitive to soil conditions. Although it naturally occurs on infertile sites, it is not well suited to all mine wastes and spoil materials. It does best on sites that have been top soiled or contain soil fines capable of holding soil moisture. It has been less successful on rocky, coarse mine wastes and exposed substrata. To be successful on mine disturbances, a balanced amount of soil nutrients must be provided.

This shrub can be used to restore mine spoils where irregular topography is created. If topsoil or surface soil material is reapplied, the plant can be successfully planted to re-create natural communities and landscapes-disturbed areas to match adjacent native plant associations.

Creeping juniper can also be used to stabilize watersheds and erodible sites. It establishes and grows slowly, a major disadvantage in stabilizing erosive soils and steep slopes. However, once established, it is able to withstand windy conditions, and provides excellent ground cover under very exposed and harsh situations. This shrub is also very useful as a landscape species. It is widely used in horticultural plantings in areas including recreational sites, campgrounds, parks, and associated sites where little maintenance is provided. It is particularly useful in planting parks and recreational sites where use of native species is emphasized. It can withstand heavy traffic, and is used to align walkways, roadways, and trails.

Varieties and Ecotypes—Various selections have been developed for horticultural uses that exhibit different colors, or vary in growth habit, leaf texture, rooting habits, and growth rates. However, none have been released for wildland situations.

Family Cupressaceae

Juniperus osteosperma Utah juniper

Description—Utah juniper is a small tree normally with a single stem and several short branches that originate near the ground (fig. 22). Individual trees may exceed 21 ft (6.4 m) in height (Goodrich and Neese 1986). They have thin, fibrous bark that shreds from the trunk and branches (Welsh and others 1987). Welsh and others (1987) described the mature leaves as typically opposite, scalelike, 0.04 to 0.12 inch (1 to 3 mm) long, and yellowish green. Juvenile leaves are decurrent, awl-shaped, sharp, and 0.1 to 0.3 inch (2 to 8 mm) long. Plants are monoecious; staminate cones are yellowish brown and 0.1 to 0.2 inch (3 to 4 mm) long; ovulate cones are subglobose, 0.2 to 0.5 inch (6 to

Figure 22—Stands of Utah juniper furnish considerable cover for a variety of wildlife following chaining and seeding with grasses and forbs.

12 mm) thick and brownish or blue to blue purple at maturity. There are one to two seeds per cone (Arnold and others 1964; Johnsen and Alexander 1974; Tueller and Clark 1975; Welsh and others 1987).

Ecological Relationships and Distribution—Utah juniper occurs from Montana and Wyoming, south to California, Arizona, and New Mexico (Griffin and Critchfield 1972; Hitchcock and Cronquist 1973; Welsh and others 1987; Zarn 1977). It grows with singleleaf pinyon to form vast woodlands, typically existing between more xeric cold desert shrub communities at lower elevations and mountain brush or ponderosa pine at higher elevations. It normally occurs between elevations of 6,000 to 7,500 ft (1,800 to 2,300 m) (Goodrich and Neese 1986), although it is not uncommon between elevations of 2,790 to 8,000 ft (850 to 2,400 m) (Welsh and others 1987).

Utah juniper is the dominant species, along with a number of shrubs and grasses, on many sites that have been subjected to heavy domestic grazing (Clary 1975a) and reduction of wildfires. These management practices have resulted in an increase of trees, coupled with a decrease of understory plants. Pinyon-juniper stands have not only increased in density, but have spread to occupy adjacent shrub and grass communities (West and others 1979). The spread of Utah juniper may be regulated by periods of drought and the occurrence of years of favorable precipitation (Blackburn and Tueller 1970).

Utah juniper is more tolerant of arid regions in the Great Basin (Tausch and others 1981) than singleleaf pinyon; it is the only tree species present in many areas. It forms dominant stands throughout much of southern Utah and Nevada. Treshow and Allan (1979) concluded that the distribution of Utah juniper is primarily regulated by precipitation. Tree stands normally occupy sites that receive from 10 to 25 inches (254 to 635 cm) of annual rainfall (Blackburn and Tueller 1970). Utah juniper is more tolerant of fire and spring frost, and performs better with low summer precipitation than singleleaf pinyon pine (Tueller and others 1979; West and others 1979), yet these factors do not fully explain the distribution and composition of the tree species and communities. At higher elevations, singleleaf pinyon may dominate and is generally more abundant.

Utah juniper is widely adapted to a variety of soil types and parent materials. It grows on limestone, sandstone, granite, and mixed materials (Clary and Jameson 1981). Utah juniper is particularly well adapted to rocky, well-drained, coarse-textured soils (Eckert 1957).

Plant Culture—Good seed crops are normally produced annually by most wildland stands, although abundant seed crops may only occur every 2 to 6 years. Seeds require about 2 years to mature. Cones appear from mid-April to mid-May, and normally mature in late fall or early winter the second year after flowering (Johnsen and Alexander 1974). Cones of different ages are normally found on the same plant. Mature cones are darker in color and are obviously drier than immature cones (Zarn 1977).

Most wildland stands produce commercially harvestable crops, although selected individuals or small groups of trees may be the primary producers. Seed collection, cleaning, and storage practices are similar to those described for creeping juniper and discussed by Johnsen and Alexander (1974).

As with other junipers, the seed coats are impermeable and embryos are dormant (Johnsen 1959; Johnsen and Alexander 1974). Seeds are difficult to germinate without pretreatment. Johnsen and Alexander (1974) recommended a 120-day warm pretreatment at 68 to 86 °F (20 to 30 °C) alternating diurnal temperatures followed by wet prechilling for 120 days at 41 °F (5.0 °C). Incubation at alternating day and night temperatures of 68 to 86 °F (20.0 to 30.0 °C) for 70 days resulted in less than 50 percent germination.

Although Utah juniper spreads well by natural seeding, it is a difficult plant to propagate and it establishes poorly by artificial seeding. Field plantings establish erratically and unpredictably. Erratic seed germination is the primary factor affecting poor seeding establishment. Pretreatments to stimulate and regulate seed germination have been somewhat helpful when seeds are germinated under controlled laboratory conditions. However, pretreatment practices have not significantly improved seedling emergence from wildland plantings. Seedling establishment in nurseries has been enhanced by prechilling seeds or by

mulching and irrigating the seedbeds, but erratic stands still result (Johnsen and Alexander 1974).

Seedlings of Utah juniper that emerge in early spring and survive spring frosts are most likely to survive their first season. Seedlings that germinate late in spring, as soil moisture is depleted, are less likely to survive. New seedlings grow slowly and normally require 2 to 4 years to attain large stature. During this period of establishment, mortality is very high. Young plants that do survive for 1 to 4 years become hardy, and can persist with considerable herbaceous competition and adverse climatic conditions. Blackburn and Tueller (1970) concluded that spread of juniper is favored by years of good seed production followed by 6 years of average or above-average precipitation. Seedling establishment is difficult to predict. Numerous chaining and burning projects have cleared areas and created openings where new seedlings may establish. Chaining and other activities bury surface-deposited seeds, but new tree seedlings do not always invade the treated sites. New tree seedlings may not appear for many years after treatment, and increases may occur after understory species have established a dense cover.

Tree seedling survival is affected by the presence and density of understory herbs. Monsen and others (1987) found that native understory species, including shrubs, have prevented tree seedling encroachment in central Utah. Seeding introduced grasses and broadleaf herbs on pinyon-juniper sites reduces the establishment of tree seedlings, but the influence of individual herbaceous species is not fully understood. The presence of native herbs also limits tree seedling survival.

Tree recruitment is undoubtedly site influenced. Natural recruitment frequently occurs very rapidly on both treated and untreated sites where mature trees have been removed by burning or chaining. On adjacent treated areas, tree recovery has been delayed for extended periods even though all sites receive similar amounts of precipitation. In addition, at some Utah locations, Utah juniper stands cleared of mature trees at different times, have little tree recruitment, but other sites have experienced considerable tree recovery each year after treatment.

When direct seeded, Utah juniper should be planted at a depth of 0.5 to 1.0 inch (1.3 to 2.5 cm) and sown in late summer or fall (Heit 1967b; Johnsen and Alexander 1974; Stoecker and Slabaugh 1965). Hand seeding in small openings where the soil surface is protected by litter, rock, or other debris tends to improve survival.

Utah juniper is widely used in landscape plantings as 2- to 5-year-old container transplants (Johnsen and Alexander 1974). Bareroot transplants have also been cultivated for field plantings. Survival of larger 2- to 3-year-old stock has exceeded that of smaller transplants. Small transplants grow slowly and do not compete as well as larger stock. Utah juniper transplants do not survive well if the primary root of young plants is damaged. This impact is less evident for larger stock.

Utah juniper can be propagated from stem cuttings taken from November through February, but it is difficult to root (Doran 1957; Snyder 1954). Treatment with root-inducing substances may or may not be beneficial (Doran 1957; Zorg 1954).

Uses and Management—Utah juniper is widely regarded as an important plant for big game winter ranges. The plant provides important cover and forage for wildlife (Frischknecht 1975). Nearly all big game animals utilize pinyon-juniper woodlands. This species is not regarded as highly palatable to big game by most authors (Brotherson and Osayande 1980). Rosenstock and others (1989) found that mule deer depended heavily on juniper during winter months, and it is a principal part of their diet during the midwinter period. The species may be regarded as an emergency winter forage plant (Gullion 1964), with only fair energy and protein values (Dittberner and Olsen 1983), but Kufeld and others (1973) concluded that juniper is moderately to heavily grazed by big game during most seasons. The fruits are widely used by numerous birds (Turkowski and Watkins 1976). Big game and livestock graze the understory of pinyon-juniper sites heavily in spring, fall, and winter.

Utah juniper provides essential cover for big game, particularly during the winter months. Animals seek cover and protection, and current chaining practices are now being carefully evaluated to assure that adequate sized openings, escapeways, and concealment cover are retained.

Game animals, livestock grazing, and recreational uses of pinyon-juniper sites have increased dramatically in many locations. Game animals have been forced to use pinyon-juniper areas in the spring, fall, and winter, as access to and use of natural ranges have been diminished by the construction of homes, roads, farms, ranches, and commercial developments. Many pinyon-juniper sites have been converted to shrub/grass communities and managed to prevent tree recruitment. Pinyon and juniper have also spread to occupy sites that are void of competitive understory species. The encroachment has been facilitated by the reduction or control of wildfires. Consequently, pinyon-juniper sites have become increasingly important to the management of wildlife populations. Chaining, burning, and seeding of pinyon-juniper areas for livestock grazing may not be economically practical in all situations, but restoration and improvement for wildlife habitat improvement is beneficial.

Pinyon and juniper communities are an important component of many watersheds. These sites may not receive great amounts of precipitation each year, but plants grow on steep slopes that are subjected to runoff and erosion from high-intensity storms. Closed stands of pinyon-juniper and communities that lack suitable understory provide poor ground cover and are high sediment producers. These sites should be managed to prevent infrequent, but damaging erosion and runoff from unpredictable storm events. Pinyon-juniper woodlands are also subjected to wildfires and other impacts that can diminish tree cover. If the tree communities lack a suitable understory, the burned or disturbed sites become vulnerable to erosion; this significantly impacts downstream resources. Consequently, it is important to maintain a diverse understory of shrubs and herbs that are capable of recovering following these natural disturbances.

Pinyon and juniper communities have been invaded by cheatgrass, even where closed tree stands exist. As mature trees die from fires, insects, or disease, the annual grass spreads quickly, and once in place prevents the recovery of nearly all native species. Extensive areas of pinyon-juniper woodlands throughout the Intermountain region occur with only remnant amounts of native shrubs and herbs, but with scattered and suppressed amount of cheatgrass. As these sites eventually burn, the sites are converted to annual grass communities. The annual grass ranges burn frequently, resulting in a loss of wildlife habitat. To prevent the conversion of pinyon-juniper sites to annual grass, sites can be artificially seeded with desirable understory natives following burning or other disturbances. In addition, potential problem areas can be treated by controlled burns or chaining followed by seeding. This practice has been extensively employed in Utah and other Intermountain States. This problem has not been fully understood and addressed in land management programs.

Deterioration of pinyon-juniper communities within the Intermountain area has had a significant impact on big game populations. Most pinyon-juniper sites have been heavily impacted by previous grazing by livestock and wildlife. This has resulted in a loss of shrub and herb understory. Trees have increased and once in place prevent the return of the desired understory. Consequently, extensive chaining, clearing, and seeding projects have been employed to reduce tree density and allow seeded species to establish. Numerous native shrubs, broadleaf herbs, and grasses have been developed to convert tree-dominated sites into sites dominated by a more diverse array of species.

Varieties and Ecotypes—None.

Family Cupressaceae

Juniperus scopulorum
Rocky Mountain juniper

Description—Rocky Mountain juniper is typically taller than Utah juniper, normally reaching 10 to 20 ft (3.0 to 6.1 m) in height (Welsh and others 1987), but heights of 20 to 50 ft (6.1 to 15.2 m) are not uncommon (Johnsen and Alexander 1974). Crowns are conical to pyramidal or, less commonly, rounded. The bark is thin, fibrous, and shredded. Leaves are opposite, but sometimes in threes, scalelike, 0.02 to 1.2 inches (0.5 to 30 mm) long, green or blue green, sometimes with dorsal resin glands. Juvenile leaves are needlelike and 0.1 to 0.3 inch (3 to 8 mm) long (Welsh and others 1987). Plants are generally monoecious with staminate cones 0.08 to 0.12 inch (2 to 3 mm) long; female cones develop strobili or berrylike structures that are 0.2 to 0.3 inch (4 to 8 mm) thick at maturity (Johnsen and Alexander 1974; Zarn 1977). Arnow and others (1980) distinguished Rocky Mountain juniper from Utah juniper by leaf shape; Rocky Mountain juniper has entire and opposite leaves rather than minutely toothed and somewhat whorled leaves.

Ecological Relationships and Distribution—Rocky Mountain juniper occurs throughout central British Columbia and Alberta, and much of the Pacific Northwest, Rocky Mountains, and Great Basin. It is found from the northern Great Plains, south to Nevada, Arizona, New Mexico, and Texas (Fowells 1965; Hitchcock and Cronquist 1973; Pieper 1983; Welsh and others 1987; Zarn 1977). It is commonly encountered in canyons and cool exposures at higher elevations than Utah juniper, normally occurring as scattered plants rather than extensive stands (Goodrich and Neese 1986). It usually grows with mountain big sagebrush, mountain brush, ponderosa pine, aspen, and Douglas-fir at elevations between 7,000 and 9,000 ft (2,100 and 2,700 m) (Fowells 1965; Goodrich and Neese 1986). At higher elevations it grows with Engelmann spruce and subalpine fir. Although a typical mountain species, it often occurs at low elevations in valley bottoms with cold air drainage (Welsh and others 1987). It is most common in open woodlands or with big sagebrush-grass communities. Throughout central Utah it is particularly abundant with Gambel oak. The erect columnar variety is more common in Utah on open aspects with mountain big sagebrush. It is also common in northern Wyoming and southern Montana.

Plant Culture—Cones appear from mid-April to mid-June, mature from mid-September to mid-December

the second year after pollination, and persist on the plant for 2 to 3 years (Fowells 1965; Johnsen and Alexander 1974). Seeds are harvested, cleaned, and stored as described for other junipers (Johnsen and Alexander 1974). Seed production is erratic, but some seeds are produced every year; abundant crops are produced about every 2 to 5 years. Seeds are collected by hand stripping or beating the limbs to dislodge the cones onto canvas spread on the ground. Seeds are relatively small compared with those of other junipers; the count ranges between 17,850 and 42,100 seeds per lb (39,350 and 92,800/kg) (Johnsen and Alexander 1974).

Germination is delayed because of embryo dormancy and hard impermeable seedcoats; seed pretreatments are recommended to hasten germination. Untreated seeds may require 14 to 16 months to germinate (Afanasiev and Cress 1942). Johnsen and Alexander (1974) reported that Rocky Mountain juniper seeds require a warm pretreatment at 68 °F (20 °C) for 45 to 90 days followed by wet prechilling to initiate germination.

Johnsen and Alexander (1987) suggested different methods of pretreatment and seeding. These include: (1) cleaning the seed followed by warm/cold wet pretreatment and fall seeding; (2) storage of the cones (berries) for 1 year before cleaning, wet prechilling, and fall or spring seeding; and (3) a warm pretreament outdoors from spring to the time of fall sowing.

Seeds should be planted in a firm seedbed at a depth of 0.25 to 0.5 inch (6 to 13 mm). Addition of a surface mulch is helpful. When planting wildland sites, spots should be selected that are somewhat protected and have variable soil conditions. Seedlings do not emerge from bare, open, compacted, or crusted surfaces.

Young Rocky Mountain juniper plants normally grow faster than Utah juniper until they reach mature stature. Fowells (1965) reported fairly uniform growth to an age of 40 years, at which time the growth rate declines. Plants live 250 to 300 years (Tueller and Clark 1975).

This species is easier to rear as bareroot or container stock than Utah juniper. Seeds are somewhat less dormant, and plants usually grow faster when irrigated and fertilized. Commercial growers often produce this species and are able to rear the plant with good success. Transplant stock of various ages is produced and sold as potted container stock or ball-and-burlap plants. Plants are usually 3 to 4 years of age before they are of sufficient size for commercial sales.

Uses and Management—Rocky Mountain juniper (fig. 23) is commonly used for conservation, windbreak, and horticultural purposes. This species has been useful for improving upland game bird habitat on farmlands (Miller and others 1948). Its pyramidal evergreen growth habit provides attractive yearlong protection. The plant is sufficiently drought tolerant to persist on sites receiving 12 to 14 inches (30.5 to 35.6 cm) of precipitation. It is better adapted to alkaline soil conditions than most other junipers (Miller and others 1948). Rocky Mountain juniper is particularly useful when planted in combination with other trees and shrubs as a windbreak or screen. It withstands harsh, cold temperatures, and can be used to protect roadways, buildings, and other facilities.

This species is also of importance as a cover and forage plant for big game. It receives moderate use in winter, spring, and fall (Kufeld and others 1973). However, considerable differences are noted among sites and game animals. Some plants are grazed heavily, but most trees are not grazed extensively. Livestock generally make little use of this plant.

Rocky Mountain juniper furnishes excellent cover for a variety of wildlife. It frequently grows in association with various shrubs that provide winter cover. Big game animals often use stands of Rocky Mountain juniper for cover and protection. Sites that are used for this purpose should be managed to maintain appropriate cover and habitat.

Rocky Mountain juniper frequently grows in canyon bottoms, streams, seeps, and other riparian areas. It provides excellent cover and structural diversity. Plants also normally support a herbaceous understory if sites are properly managed. Small pockets of Rocky Mountain juniper, intermixed with mountain big sagebrush, are important areas for wildlife. The diversity provided by this plant is important for many upland sites where lower growing shrubs occur.

Few other tree species are able to grow where this native normally exists. Because it is relatively slow to establish and mature, removal of this species should be avoided. Restoration projects should be designed to

Figure 23—Young Rocky Mountain juniper trees grow in association with mountain big sagebrush.

leave this species in areas of high importance. Rocky Mountain juniper normally grows on sites that are moist enough to support understory herbs. Herb and shrub seedlings are better able to establish with this overstory tree than with Utah juniper. Direct seeding of herbs can be recommended on areas where scattered plants exist. Complete removal of the trees is not required to accomplish seedling establishment of desired native understory species.

Rocky Mountain juniper has been planted on mine disturbances with mixed success. Small 1- to 2-year-old container stock has not established or persisted well on mine wastes in southeastern Idaho and southern Montana. Larger stock, 2- to 6-year-old potted plants, survive better than smaller stock. Supplemental irrigation for 2 to 3 years significantly improves establishment on harsh sites. Once plants are well rooted, they persist well.

Varieties and Ecotypes—None.

Family Elaeagnaceae

Elaeagnus commutata Silverberry

Description—Silverberry is a native, deciduous shrub, mostly 3 to 6.5 ft (0.9 to 2.0 m) tall, with peltate scales. Plants vary in growth habit, often occurring as thicket-forming shrubs up to 12 ft (3.7 m) tall or frequently as small trees (Johnson and Anderson 1980). Stems are stoloniferous and unarmed. Leaves are 0.5 to 2.8 inches (1.3 to 7.1 cm long), 0.2 to 1.2 inches (6 to 31 mm) wide, elliptic to oblanceolate, acute to obtuse or rounded and silvery on both sides with brown scales. Flowers are one to four per axil, 0.4 to 0.6 inch (1.0 to 1.5 cm) long, and yellowish. The fruit is drupelike, consisting of a dry indehiscent achene enveloped by a fleshy persistent hypanthium. Fruits are 0.2 to 0.4 inch (6 to 10 mm) long, mealy, and silvery (Welsh and others 1987).

Ecological Relationships and Distribution—Silverberry occurs from Quebec to the Yukon, and south to Minnesota, Wyoming, Utah, and northern Colorado (Harrington 1964). In Utah, it is usually restricted to riparian zones at elevations between 6,000 and 8,000 ft (1,800 and 2,400 m) (Welsh and others 1987). Plants occur in areas receiving 18 to 20 inches (45.7 to 50.8 cm) of annual precipitation, but usually require supplemental water even on moist sites (fig. 24). Silverberry is very winter hardy and drought tolerant. In eastern Utah, silverberry grows along streams and dry hillsides (Goodrich and Neese 1986). In the interior of Alaska it grows on rocky, south-facing slopes and sandbars (Viereck and Little 1972), often forming thickets along major streams.

Figure 24—Silverberry grows along stream bottoms with willows and other riparian species in eastern Utah.

Plant Culture—Silverberry plants flower in early summer. The large, silver-green drupelike fruits ripen in late fall and early winter. This shrub produces abundant seed crops at intervals of 1 to 2 years. Ripe fruits can be picked by hand, or the bushes can be beaten to dislodge the fruits onto canvas spread on the ground (Olson 1974). The fruits are easier to clean before they dry. Seeds are extracted from the fruit by maceration in a Dybvig separator, and water is used to grind and float the pulp away (Heit 1968a; Olson 1974). Between 2,700 and 4,600 cleaned seeds are reported per lb (5,950 to 10,140 per kg) of pure seed (Olson 1974).

Silverberry has not been widely used in range and wildlife projects. Seeds should be planted 0.5 to 1 inch (1.3 to 2.5 cm) deep in a firm seedbed. Seedling growth rate is fairly rapid, and young plants persist quite well if planted in adapted areas. Plants also establish well from bareroot or container-grown stock. Silverberry is reported to have stoloniferous stems (Johnson and Anderson 1980), and can spread from underground rootstocks (Viereck and Little 1972). Vegetative spread has not occurred in wildlife plantings in Utah.

Uses and Management—Silverberry has been selectively used throughout the Western United States. It was propagated as early as 1813 (Olson 1974) for windbreaks and shrub row plantings, but has not been used extensively in recent programs. The species has been recommended for windbreak and wildlife plantings in Wyoming (Johnson and Anderson 1980). Plants are grown as ornamentals and windbreaks in the interior of Alaska (Viereck and Little 1972). Plants produce leaves having an unusual silver-green cast. Leaves persist on the shrub until early winter, thus furnishing an attractive background screen.

In Utah, big game have made moderate use of the shrub during the spring and fall months, but they seem to prefer the plant much more as summer browse. Reports by Kufeld and others (1973) and Dusek (1971) described limited fall grazing but increased summer browsing by big game. The shrub has been transplanted with good success on mine disturbances in southeastern Idaho, and has received only limited use by mule deer.

Silverberry appears to have particular value for riparian habitat improvement within its native range. It transplants very well and grows rapidly even with some understory competition. It is able to establish and grow on moist and well-drained soils, typical of disturbed riparian sites. It provides considerable cover for animals and soil protection. It is a well-rooted plant that can provide excellent soil stability, but it does not spread as does Russian-olive to become a serious weed.

Silverberry has considerable value as an ornamental plant for residential and recreational sites. It can be used to enhance parkways, campgrounds, and recreational sites, particularly near streams and semiwet areas. It can be used to screen and protect structures, roadways, trails, and campgrounds. It does not attract heavy use by wildlife and can be used where animal concentration is to be avoided.

Varieties and Ecotypes—None.

Family Elaeagnaceae

Shepherdia argenta
Silver buffaloberry

Description—Silver buffaloberry is a deciduous, thorny shrub with a spreading to ascending growth habitat that attains heights of 6 to 10 ft (1.8 to 3.0 m) (Thilenius and others 1974a; Welsh and others 1987). Goodrich and Neese (1986) reported that plants may reach heights exceeding 22 ft (6.7 m). Branchlets are covered with silvery peltate scales and terminate in sharp thorns. Leaves are opposite, petiolate, 0.2 to 2.4 inches (0.5 to 6 cm) long, and 0.12 to 0.55 inch (3 to 14 mm) wide. They are oblong, elliptic or lanceolate, and silver gray on both sides. Plants are dioecious, with axillary flowers that can be perfect or imperfect. Flowers are 0.1 to 0.16 inch (2.5 to 4 mm) long with yellowish perianths. The red fruit is drupelike, 0.16 to 0.28 inch (4 to 7 mm) long, and edible, though tart (Goodrich and Neese 1986; Sampson and Jespersen 1963; Welsh and others 1987). Staminate flowers have eight stamens alternating with glandular thickenings at the base of the perianth lobes (Welsh and others 1987). The perianth of pistillate flowers is short and tubular, investing the ovary.

Ecological Relationships and Distribution—Silver buffaloberry is distributed from British Columbia to Saskatchewan, and south to California, Nevada, New Mexico, and North Dakota. It occurs along streams in sagebrush and pinyon-juniper woodlands (Sampson and Jesperson 1963). It is widely scattered throughout Utah at elevations between 4,590 and 7,510 ft (1,400 and 2,290 m) along streambanks, terraces, and on moist or wet sites (Welsh and others 1987). It occupies ditch banks, abandoned fields, disturbed fence lines and powerlines (Goodrich and Neese 1986). In Wyoming it grows in bottomlands, on moist hillsides, and on streambanks at elevations up to 7,000 ft (2,100 m) (Johnson and Anderson 1980).

Plant Culture—Plants flower in spring, beginning in early April and continuing into June. Fruits ripen from June to August, and they remain on the bush until December (Plummer and others 1968; Thilenius and others 1974a; Van Dersal 1938). Ripe fruits are most easily collected by flailing the plant, causing the fruits to drop onto canvas spread on the ground. Fruits may be handpicked, but the thorny branches hinder this approach.

Stems, twigs, and leaves must be separated from the fruits before they are macerated and the pulp floated away with water. The seeds (cleaned achenes) are processed with a fanning mill to separate them from small debris. Seedlots can be cleaned to a high purity. There are between 18,000 and 67,000 seeds per lb (39,700 and 147,700 per kg); the average is 41,000 seeds per lb (90,390 per kg) (Thilenius and others 1974a). Mirov and Kraebel 1939 and Plummer and others (1968) reported the average number of cleaned seeds per lb is between 10,800 and 18,000 (23,810 and 39,680 per kg). Cleaned seeds can be stored in open warehouses for at least 5 years without appreciable loss of viability (Plummer and others 1968).

Both embryo dormancy and hard seedcoats restrict or delay germination. Thilenius and others (1974a) found that wet prechilling for 60 to 90 days, followed by exposure to alternating day and night temperatures from 86 to 69 °F (30.0 to 20.0 °C) for 30 to 60 days, resulted in 26 to 93 percent germination.

Seeds sown in fall will germinate in spring. Seeds should be planted at a depth of 0.5 to 1 inch (1.3 to 2.5 cm). Seedlings and young plants have established moderately well on range or conservation plantings. Seedling growth is only fair, but as plants reach 1 or 2 years of age, they become well established and are very persistent. Seeds are easily handled and planted with most conventional planters. Bareroot or container-grown transplants establish better than direct seedings. The shrub is not browsed very heavily, nor adversely affected by insects, consequently it is able to establish without serious delays (Plummer and others

1968). Silver buffaloberry grows moderately well with herbaceous understory species. If 1-year-old transplant stock is planted, very good survival and excellent growth can be attained. The shrub is produced by many commercial nurseries. Root sprouts can be propagated with good success.

Uses and Management—Silver buffaloberry has been widely planted for shelterbelts, game habitat, cover, and watershed protection (Thilenius and others 1974a). It has been used in ornamental plantings because of its gray, willowlike foliage (Sampson and Jespersen 1963). The thorny nature of this plant limits its use in heavily populated areas. However, it can be planted in recreation sites to screen areas, direct foot traffic, and control or restrict use of campgrounds and parks. It is used as the outer row in multirow shelterbelt plantings, but it is often planted alone where a low, dense cover is required (Johnson and Anderson 1980). The shrub is highly susceptible to heart rot, and breakage by wind and snow results as the wood becomes brittle (George 1953). In the Midwest, high winds have uprooted cultivated trees; consequently, this species is not recommended for windbreak plantings, particularly near buildings and walkways. (George 1953).

Silver buffaloberry is recommended for use in pinyon-juniper, big sagebrush, inland saltgrass, and wet meadow communities of Utah for wildlife habitat improvement (Plummer and others 1968). It is especially useful on sandy soils and in moist sites (Thornburg 1982). The thorny thickets created by this shrub provide cover and nesting sites for birds and other animals; quail (Martin and others 1951) and some small mammals take the drupelike berries (Hall 1946). Big game animals make considerable use of the shrub during the summer but only moderate use in the winter (Compton 1966; Dusek 1971; Kufeld and others 1973; Lamb 1968; McKean 1954; Plummer and others 1968).

Although silver buffaloberry is normally recommended for moist site plantings, it has performed well on mine disturbances in southeastern Idaho, Montana, and Wyoming (fig. 25). It has established and grown well on sites receiving 16 to 24 inches (40.6 to 61.0 cm) of annual precipitation. The species has established from transplant stock on mixed, infertile mine wastes and exposed substrata. It has exhibited adaptability to coarse-textured spoils, rocky substrata, and mixed heavy-textured soils. It fixes nitrogen (USDA Forest Service 1948), which explains its excellent vigor and growth on infertile mine spoils. Thornburg (1982) reported that a number of collections are being evaluated for use on mined lands in the northern Great Plains.

This species is used to restore riparian disturbances; it is well suited to both mesic and dry sites. It provides overstory cover, thickets, and low ground cover. It is adapted to streambanks, sandbars, unstable soils, and moist sites in pinyon-juniper and sagebrush communities where few upright species grow. It transplants very well and can be used to populate open, exposed sites.

Figure 25—Silver buffaloberry has been successfully established on mine disturbances in southeastern Idaho.

Varieties and Ecotypes—None.

Family Elaeagnaceae

Shepherdia canadensis
Russet buffaloberry, soapberry

Description—Russet buffaloberry is a native, thornless, small to medium, spreading shrub 3 to 9 ft (0.9 to 2.7 m) tall (Thilenius and others 1974a). Branches are covered with brown peltate scales. Leaves vary in length from slightly less than 0.25 to 3 inches (0.5 to 8 cm). They are ovate to lanceolate, rounded apically and basally, green above and slightly pale beneath. Flowers vary from 1 to several per axil, and 0.08 to 0.12 inch (2 to 3 mm) long. Fruits are 0.16 to 0.28 inch (4 to 7 mm) long, red, and quite succulent (fig. 26). When mixed with water the fruits produce a soapy solution (Welsh and others 1987).

Ecological Relationships and Distribution—Russet buffaloberry occurs as an understory in aspen, fir, lodgepole pine, spruce, open woodlands, and old burns (Goodrich and Neese 1982; Viereck and Little 1972). It often forms dense thickets on gravel bars bordering streams. It is distributed from east-central Alaska to Newfoundland, and south to Maine, New York, Michigan, New Mexico, and Oregon (Viereck and Little 1972). It is widespread throughout Utah at elevations between 6,690 and 10,500 ft (2,000 and

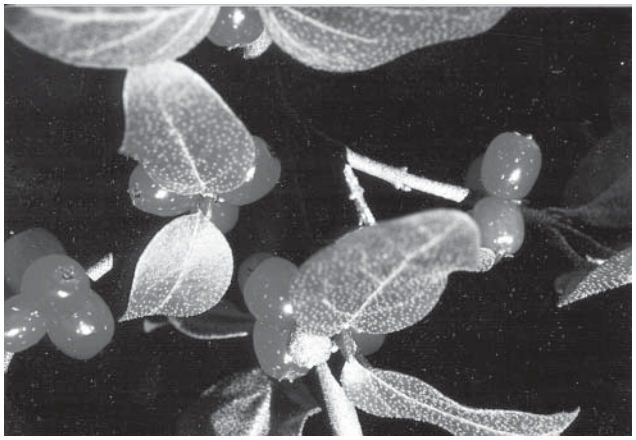

Figure 26—Fruits of russet buffaloberry are brilliant red and highly attractive. Seedlings establish well on mine sites and other disturbances.

3,200 m) (Welsh and others 1987), and it occupies similar elevations in Colorado (Harrington 1964).

Plant Culture—Thilenius and others (1974a) reported that this shrub is well suited for dry, rocky banks, but experimental plantings in central Idaho on mine and roadway disturbances have not been successful. Transplant stock propagated from native stands has not established well when planted on adjacent disturbances. The species appears sensitive to shade, soil disturbances, and competition from understory herbs. It has not established well on mine spoils or on streambanks that have been subjected to soil loss from flooding. Planting success may be significantly improved with the use of better quality stock, but this species has been less widely used and has not been as successful in revegetation plantings as silver buffaloberry.

Uses and Management—Russet buffaloberry occurs at rather high elevations and on sites where logging, road construction, and mining have created considerable disturbances; consequently, it has been used for revegetation of these sites. It provides useful ground cover and improves diversity in lodgepole pine forests where other understory and shrubs are lacking.

Varieties and Ecotypes—None.

Family Elaeagnaceae

Shepherdia rotundifolia Roundleaf buffaloberry

Description—Roundleaf buffaloberry is a short statured plant growing 3 to 6.5 ft (0.9 to 2.0 m) in height. The twigs are stellate hairy with white or yellowish trichomes. Leaves are ovate to oval, rounded apically, silvery green above, pale beneath, and clothed with trichomes that provide a silvery appearance. Flowers are yellowish and very attractive. Fruits are 0.2 to 0.31 inch (5 to 8 mm) long, drupelike, and orange to red (Welsh and others 1987). This is an attractive shrub with distinct silver-green foliage, thick leaves, and colorful fruits and flowers.

Ecological Relationships and Distribution—Roundleaf buffaloberry is native to the blackbrush, ephedra, shadscale, pinyon-juniper, and ponderosa pine communities of southeastern Utah and Arizona (Welsh and others 1987). It is not reported from Colorado. This shrub is endemic to the Colorado Plateau (Welsh and others 1987), and occupies important areas where restoration of native shrubs is desirable (fig. 27). Investigative studies have been conducted to develop methods to culture and establish this species by artificial plantings.

Plant Culture—Seeds of roundleaf buffaloberry are relatively large compared to those of other buffaloberry species. There are about 6,855 cleaned seeds per lb (15,110 per kg) (Plummer and others 1968). Abundant seedcrops are produced infrequently, usually once every 3 to 10 years, although some fruits may be produced on individual plants more often. Plants flower early in spring, and fruits usually ripen in early to late July (Plummer and others 1968). The plants are very attractive because of the color contrast between the fruit and leaves. Berries are processed by maceration to release and separate the seeds. Seeds germinate erratically following extended periods of wet prechilling. Young plants grow slowly, even if protected from competition. Nursery and greenhouse-grown stock also grow slowly, although older plants grow somewhat faster.

Figure 27—Roundleaf buffaloberry is a unique, attractive shrub common to arid regions of the Colorado River drainage.

Uses and Management—This species is most important in the unique desert shrublands of southern Utah and Arizona. It provides useful ground cover, aesthetics, and limited, but seasonal forage for big game (Plummer and others 1968). Attempts to culture this species have only resulted in fair success; but with further research, this species may be of more use for restoration of recreational sites and native shrub communities. It has been successfully used in landscape plantings. It grows well with limited irrigation, and once established produces considerable foliage. It demonstrates utility in recreation plantings for screening campgrounds and related sites. It also provides a useful and attractive native shrub that can be used to restore native communities in highly used recreation sites.

Some collections of roundleaf buffaloberry have not survived when transferred to more northern climates in central Utah. This species normally grows with a limited understory and cannot compete well if planted with a dense cover of herbs. Plants are difficult to establish from transplanting or direct seeding.

Varieties and Ecotypes—None.

Family Ephedraceae

Ephedra nevadensis
Nevada ephedra

Description—Nevada ephedra or jointfir is a member of the gymnosperm family Ephedraceae. This dioecious shrub grows to 5 ft (1.5 m) tall and has evergreen stems with paired scalelike leaves 0.08 to 0.2 inch (2 to 5 mm) long (Welsh and others 1987). One to several male cones are borne at the nodes. Female cones are borne solitary at nodes and produce a pair of pale-brown to yellowish-green seeds (Welsh and others 1987). The stems of Nevada ephedra are divergent, coarse, bluish-green to gray, and produced on older wood. In contrast, green ephedra produces erect, parallel, broomlike stems that are green to yellow green in color (Cronquist and others 1972; Dayton 1931).

Ecological Relationships and Distribution—Nevada ephedra is a native perennial shrub that occurs throughout the Intermountain West in juniper-pinyon, big sagebrush, Indian ricegrass, rabbitbrush, black sagebrush, blackbrush, salt desert, and creosotebush types in central and southern Utah, Nevada, Arizona, California, and Mexico (Cronquist and others 1972). It frequently grows with green ephedra; however, it is usually more abundant on drier sites and in salt desert, black sagebrush, and blackbrush types. This species is generally found growing in areas with 7 to 14 inches (18 to 36 cm) of annual precipitation. Nevada ephedra has good tolerance to soil salinity and can be found growing in well-drained to fairly poorly drained soils ranging from rocky, sandy loams to fairly heavy clays (Dayton 1931; Plummer 1977). Nevada ephedra occurs in open stands of scattered plants, but commonly forms dense, slowly spreading colonies. Individual plants may be connected by underground stolons that develop when branches are covered with windblown sand or silt (Wallace and Romney 1972).

Plant Culture—Seed crops are produced erratically (Cronquist and others 1972; Wallace and Romney 1972). Generally, one good seed crop is produced every 5 to 6 years (fig. 28). Consequently, seed must be harvested and stored for anticipated planting needs. Within the Great Basin, cones appear in April to early May, and seeds ripen in July (Dayton 1931; Turner and Randall 1987). Farther south, cones appear in March and seed matures in June. Seeds are easily collected, cleaned, and seeded. Mature seeds must be collected quickly before they drop from the shrub or are gathered by rodents. They are collected by beating the cones into a container. Establishment and maintenance of seed orchards on adapted sites might alleviate seed supply problems. Four to 6 years should be allowed for stand establishment before significant seed crops are produced. Seeds can be easily separated from debris with an air screen cleaner, providing seeds with better than 99 percent purity. There are about 20,000 Nevada ephedra seeds per lb (44,100 per kg) at 100 percent purity.

Seed remains viable for long periods when stored air dry at room temperature. Seedlots of Nevada ephedra

Figure 28—Nevada ephedra generally grows on dry sites in pinyon juniper, big sagebrush, Indian ricegrass, rabbitbrush, black sagebrush, blackbrush, salt desert, and creosote communities.

exhibited 89 percent germination following 15 years of storage (Stevens and others 1981a). With 25 years of storage, germination was 77 percent (Stevens and Jorgensen 1994). Seeds germinate under a wide range of temperatures without wet prechilling or other pretreatments (Young and others 1977). Seeds of Nevada ephedra will germinate somewhat faster than seeds of green ephedra. Nevada ephedra can be seeded separately or in conjunction with other shrubs, grasses, and forbs within its native range. When drill seeded, Nevada ephedra and most other shrubs do best if planted in separate rows from competitive perennial grasses. Seeding Nevada ephedra through a seed dribbler or thimble seeder provides good results. Nevada ephedra does best when seeded on a firm seedbed and covered to 0.5 inch (1.3 cm) depth.

In most of the Intermountain West, Nevada ephedra should be seeded in fall to allow for effective use of spring soil moisture and precipitation (Plummer and others 1968). In the more southerly regions, good results have been obtained with midsummer seeding, just prior to the summer storm period. Plants often require 5 to 10 years to attain a height of more than 2 ft (61 cm) (Plummer and others 1968), yet seedlings emerge and establish quickly. Seedlings withstand extreme drought once established.

Nevada ephedra can be transplanted with moderate success (Plummer and others 1977). Roots of bareroot stock are generally weakly developed and are very fragile and easily damaged. The root systems of containerized stock are sometimes too small to bind the root plug together. The plug must be carefully removed from the container to avoid breaking the roots. Low root-to-shoot ratios are common for both types of stock, and survival rates are frequently less than 40 percent. Wieland and others (1971) found that *Ephedra* species could be propagated from rooted cuttings. Everett and others (1978a), however, reported little success in rooting cuttings of either Nevada ephedra or green ephedra.

Uses and Management—Nevada ephedra provides forage and cover for cattle, sheep, deer, and antelope (Dayton 1931; Dittberner and Olsen 1983; Kufeld and others 1973; Smith and Beale 1980; Stevens 1983b; Welsh and others 1987). It is reported to be the most important forage plant of the ephedra species (USDA Forest Service 1937). Use is often difficult to detect or measure because browsing causes the young stems to break off at the joints. Nevada ephedra can be an important source of browse during drought and winter periods. Quail and cottontail rabbits use the species for food and cover (Stanton 1974). Seeds are readily gathered and eaten by rodents and birds. Rodents cache seeds, which can then emerge in clusters of new seedlings.

Nevada ephedra has been used to stabilize rocky and sandy areas (Plummer 1977). It is well adapted for use as a low-maintenance, low-water-requiring ornamental for home sites, parks, recreational areas, and administrative areas. It establishes slowly and has not done well on exposed substrata at mine sites or on road disturbances. Plants should not be grazed for two to three growing seasons following seeding. Grazing and trampling should be avoided until shrubs become firmly established and are 5 to 8 inches (13 to 20 cm) tall.

Varieties and Ecotypes—None.

Family Ephedraceae

Ephedra viridis Green ephedra

Description—Green ephedra is also called Brigham tea, Mormon tea, or jointfir. This dioecious shrub has evergreen stems, can grow to 4 ft (1.2 m) tall, and produces a deep fibrous root system (Cronquist and others 1972; Wasser 1982). Green ephedra produces erect, parallel, jointed, broomlike stems that are green to yellow green (Cronquist and others 1972). Leaves are small ligulelike scales, and are opposite at stem nodes. Plants are dioecous; male cones are compound, borne at the nodes or terminal points on the stems. Female cones are solitary or whorled, and sessile or peduncled (Wasser 1932; Welsh and others 1987). Cones are formed in pairs and are slightly boat shaped.

There are two varieties of green ephedra. *E. v.* var. *viridis* has sessile female cones, nonviscid stems, and grows to 6 ft (1.8 m) tall. *E. v.* var. *viscida* has pedunculate female cones and viscid stems. It occurs on sandy soils where it may be grasslike in appearance; it is often covered with sand with only small stems protruding (Kartesz and Kartesz 1980; Welsh and others 1987).

Ecological Relationships and Distribution—Green ephedra is a native, perennial shrub that occurs on shallow to medium depth soils, on sandy or rocky slopes and in valleys (Plummer and others 1968; Wasser 1982) throughout the Intermountain West (Cronquist and others 1972). It occurs in juniper-pinyon-sagebrush, rabbitbrush, black sagebrush, blackbrush, salt desert shrub, ponderosa pine, and mountain brush types (Plummer and others 1968; Stevens 1983b) (fig. 29). Green ephedra frequently grows with Nevada ephedra; however, it is usually more abundant on mesic sites with 9 to 14 inches (23 to 36 cm) of annual precipitation. Green ephedra occurs as dense, individual bushes and in large stands.

Figure 29—Green ephedra exists as an important component of many shrub communities in the foothill regions of central Utah.

It sprouts readily from the root or crown following fire (Young and Evans 1974, 1978b).

Plant Culture—Cones develop in April and May; seeds ripen in July and early August. The large seeds are easily collected, cleaned, and planted. Mature seeds must be collected quickly because they are dislodged from the plant by wind. Seeds are also quickly gathered by rodents and birds. Heavy seed crops are produced erratically (Plummer and others 1968). Generally, one good seed crop is produced every 5 years. Consequently, seed must be harvested and stored for later use. Seeds are harvested by dislodging them into a container. They can be easily separated from debris with an air screen cleaner. Seed lots usually are 99 percent pure. There are about 25,000 green ephedra seeds per lb (55,100 per kg) at l00 percent purity.

Seed remains viable for long periods when stored air dry at room temperatures. Stevens and others (1981a) found that seedlots of green ephedra exhibited 87 percent germination following 15 years of storage. With 25 years of storage, germination declined to 2 percent (Stevens and Jorgensen 1994). Seeds will germinate under a wide temperature range without wet prechilling or other pretreatments (Young and others 1977).

Green ephedra can be successfully seeded with other shrubs, grasses, and forbs within its native range. If drill seeded, it should be planted in separate rows to reduce competition with perennial grasses. Seeding green ephedra with a seed dribbler or thimble seeder has resulted in good success. Seeds establish best when planted at a depth of 0.5 inch (1.3 cm) on a firm seedbed. Rodents often gather planted seeds, and can limit the success of direct seedings.

In the Intermountain region, green ephedra should be seeded in the fall. (Plummer and others 1968; Vories 1981). Seedlings that emerge early and quickly can best withstand extreme drought. Both green ephedra and Nevada ephedra can be transplanted with only moderate success (Luke and Monsen 1984). The roots of bareroot stock and container stock develop slowly and are easily damaged. Survival rates are frequently less than 40 percent.

Uses and Management—Green ephedra provides forage and cover for cattle, sheep, deer, and antelope (Dayton 1931; Dittberner and Olsen 1983; Kufeld and others 1973; Smith and Beale 1980; Stevens 1983a; Welsh and others 1987). It is also grazed by bighorn sheep, rabbits, and quail (Stanton 1974). Green ephedra is heavily hedged by sheep, particularly during winter periods. Because of its evergreen growth habit and abundant herbage that protrudes above the snow, green ephedra is an important species on winter game and livestock ranges. Seeds are gathered and eaten by rodents and birds, which tend to spread the species.

Both green ephedra and Nevada ephedra can be used to stabilize rocky, sandy, and disturbed areas (Plummer 1977; USDA Forest Service 1976; Wasser 1982; Young and others 1979a). However, green ephedra persists much better on disturbances and exhibits adaptation to a wider range of soil conditions.

Although both green ephedra and Nevada ephedra have been used in ornamental and landscape plantings (USDA Forest Service 1976; Wasser 1982), green ephedra has survived much better, and is less sensitive to supplemental irrigation and cultivation.

Varieties and Ecotypes—None.

Family Ericaceae

Arctostaphylos uva-ursi
Bearberry manzanita

Description—Bearberry manzanita is a prostrate, mat-forming, evergreen shrub with stoloniferous stems (Hitchcock and Cronquist 1973; Morris and others 1962; Noste and Bushey 1987; Welsh and others 1987). The branches are ascending; the internodes are usually apparent, puberulent, and sometimes glandular. The exfoliating bark has a dull brown to red color. (fig. 30). Leaves are 0.2 to 1.1 inches (0.6 to 2.7 cm) long, 0.1 to 0.5 inch (3 to 12 mm) wide, oblanceolate to spatulate, and glabrous or puberulent, especially on the margins. The inflorescence is racemose. The axis and bracts are glandular. Flowers are pink to white, and 0.16 to 0.2 inch (4 to 5.2 mm) long. Fruits are 0.2 to 0.4 inch (6 to 11 mm) thick, globose, bright red, and

Figure 30—Bearberry manzanita is a mat-forming, evergreen shrub that provides excellent ground cover.

berrylike with separable nutlets. The four to 10 nutlets are fused or partially fused, 0.12 inch (3 mm) long, 0.08 inch (2 mm) wide, and light brown with a very thick seedcoat (Belcher 1985; Welsh and others 1987).

Many roots appear near the soil surface to form a dense, fibrous system (Berndt and Gibbons 1958). Numerous runners extend laterally from the crown to a distance in excess of 3 ft (0.9 m) (McLean 1967). Bearberry manzanita is able to regenerate by resprouting from stolons (Berndt and Gibbons 1958). Rowe (1983) reported that sprouting also occurs from large lignotubers.

Ecological Relationships and Distribution—Bearberry manzanita is circumpolar in distribution, occurring in North America from Labrador to Alaska, and south to northern California, and the mountains of New Mexico, Virginia, Illinois, and Nebraska (Berg 1974; Sampson and Jespersen 1963). It is common in ponderosa pine and Douglas-fir forests in mountainous regions, and it also occurs in oak woodlands and chaparral types in Arizona and California. Cooper and others (1987), Mueggler and Campbell (1986), and Youngblood and Mauk (1985) reported bearberry manzanita was present in many of the conifer forest and aspen types in Utah and northern Idaho. In Utah it is encountered in conifer forests at 7,000 to 11,500 ft (2,140 to 3,510 m) in the north and north-central portions of the State (Welsh and others 1987).

Bearberry manzanita exists on a variety of soil types including weakly developed soils and coarse-textured materials (Carmichael and others 1978). It is usually regarded as a late seral species. However, it does not form an abundant understory in forest communities in Utah and northern Idaho (Cooper and others 1987; Mueggler and Campbell 1986; Youngblood and Mauk 1985). It persists in open and shaded areas for extended periods, and thus remains as a component of various successional stages of community development.

Bearberry manzanita is generally not considered fire tolerant (McKell and others 1972), but some plants are able to survive burning. Following fire, new shoots develop from portions of the plant that did not burn. Seeds stored in the soil are stimulated to germinate by the heat treatment provided from burning (Carmichael and others 1978), and numerous seedlings may appear 1 to 5 years after a burn (Pase and Pond 1964).

Plant Culture—Flowers appear from March to May; fruits ripen from June to August and are dispersed from August to March (Berg 1974; Everett 1957; McMinn 1951; Munz and Keck 1959).

Fruits are collected by hand stripping, but some can be dislodged by beating the bush with a paddle. Seeds are easier to clean when the fruit is still green. If the fruit is allowed to dry, the fruit coat and fleshy material are difficult to remove. Cleaning is accomplished using a macerater to grind and remove the fleshy material from the seeds. Grinding is frequently conducted using water to flush away the fleshy material. After grinding, the material is dried and screened with a fanning mill to separate the seeds from other materials. Certain seedlots have a large number of empty seeds; these can be removed by flotation or use of a gravity table separator. Seeds can be stored for long periods at room or warehouse temperatures (Glazebrook 1941). Bearberry manzanita produces between 26,800 to 58,000 clean seeds per lb (59,080 to 127,870 per kg) (Berg 1974; Glazebrook 1941; McKeever 1938; Plummer and others 1968).

Seedcoats are thick, hard, and impermeable to water; however, a small opening extends from the surface of the seedcoat to the embryo. This is plugged with a waxlike substance that may be removed by soaking the seeds in sulfuric acid. Wet prechilling treatments are required to overcome the embryo dormancy. In addition, the embryo requires afterrippening (Glazebrook 1941). Most authors recommend various periods of acid scarification, followed by a warm pretreatment and a period of wet prechilling. Berg (1974) and Milstein and Milstein (1976) recommended 2 to 5 hours of acid scarification and planting in summer, or a warm pretreatment at 25 °C (77.0 °F) for 60 to 120 days, then a wet prechill for 60 to 90 days. McLean (1967) suggested an acid soak for 7 hours, followed by a warm, wet pretreatment at 68 °F (20.0 °C) for 90 days, and a wet prechill at 34 °F (1.1 °C) for 90 days. Giersbach (1937) recommended an acid soak for 3 to 5 hours, then overwinter storage outdoors in mulch flats.

Following treatment, seeds are usually incubated at high temperatures. Milstein and Milstein (1976) recommended incubating pretreated seeds at a constant temperature of 78 to 80 °F (25.6 to 26.7 °C). Berg (1974)

suggested either constant temperature incubation at 77 °F (25.0 °C), or alternating 86 °F (30.0 °C) day, and 68 °F (20.0 °C) night. These treatments produced 30 to 61 percent germination in 15 to 30 days. Germination exceeding 90 percent has been reported by Glazebrook (1941).

Early summer planting, following acid soaking, is recommended by Berg (1974), Milstein and Milstein (1976), and Swingle (1939), but early fall seeding of treated seeds is also employed. Seeds are small and should be planted approximately 0.5 inch (1.3 cm) deep. Seed germination will normally occur in 20 to 40 days (Milstein and Milstein 1976). On wildland sites, seedling emergence has been observed to occur in 5 to 10 days. Seedlings are slow developing and can be suppressed by competitive vegetation. Also, seedbeds often dry rapidly and some seedlings fail to survive.

Plants can be easily propagated by stem tip cuttings (Berg 1974). Doran (1957) reported that cuttings taken in late fall or winter (October to February) root well. Eighty-eight percent of cuttings taken in October rooted in 22 weeks, but if treated with IBA, 3 mg per g of talc, 96 percent rooting occurred in 15 weeks. Stem cuttings taken in February rooted best, 90 percent in 11 weeks. Cuttings are rooted under greenhouse conditions using bottom heat at 76 °F (24.4 °C). Once stem cuttings are rooted, they survive field planting very well.

Bearberry manzanita is widely used for horticultural plantings. Considerable information is available related to vegetative propagation and culture (Darbyshire 1971; Dehgan 1972; Dehgan and others 1975; Hildreth 1969; Leopold and Kriedeman 1975). Dehgan and others (1977) recommended stem cuttings be taken in winter or early spring and treated with low IBA concentrations. Rooted cuttings survive better if hardened off gradually, starting with complete shade and progressing to an open situation. Potting material and pots should be well drained to avoid overwatering.

Uses and Management—Various authors consider the genus, *Arctostaphylos*, to provide quality browse (Conrad 1987), but reports by Cada (1971), Cooperrider (1969), Cowan (1947), Gullion (1964), Hill and Harris (1943), Kamps (1969), Kufeld and others (1973), and Lovaas (1958) indicated that the plant receives moderate use by wildlife. In general, it is one of the earliest shrubs to initiate growth in spring. Leaves are also maintained on the shrub during winter, and game animals are attracted to the plant during the winter and spring periods. It often grows on open sites, not heavily covered by snow, that are important winter grazing locations. Game animals frequently utilize the shrub, although it may not be a major portion of their diet.

Bearberry manzanita is widely used for landscape plantings, and numerous selections are available. Because it grows as a low-spreading plant, it has been used in erosion control and watershed plantings. It requires special care to assure establishment by transplanting as container or bareroot stock. Transplants must be dormant when field planted or they are susceptible to damage by frost or drought. Dormant stock that is field planted early in the spring survives well.

Small rooted transplants usually grow slowly, and often fail to survive if planted on unstable slopes or surfaces. Larger transplants (2-year-old stock) survive harsh conditions much better and grow faster. However, growth is usually slow and plants fail to provide immediate ground cover. Normally 3 to 5 years are required before plants spread and occupy a large area. If this species is used to control erosion, transplants should be spaced 1.5 to 2.5 ft (46 to 76 cm) apart, depending on surface conditions.

Collections acquired from wildland sites can be propagated for field plantings, but have demonstrated adaptability to specific site conditions. Materials growing in shaded areas beneath ponderosa pine perform erratically when transplanted in open areas at similar elevations. Transplants also grow poorly on road and mine disturbances, although poor performance may be due to poor planting stock. However, this species appears to be sensitive to soil conditions and has not survived on mine disturbances.

Bearberry manzanita slowly invades road and logging disturbances, but only in areas where some topsoil has accumulated. Although use is questionable on harsh disturbances, its growth habit is an important feature. Topsoiling and use of soil amendments significantly enhance survival and growth rates.

This plant has adapted well when used for recreational sites, landscaping summer homes, and other low-maintenance landscape areas. Considerable differences in ecotypes and growth forms are available to provide diversity in landscape plantings. It could be more widely used within the Intermountain area for this purpose.

Varieties and Ecotypes—Various horticultural selections are available, but materials have not been selected for wildland uses.

Family Fagacae

Quercus gambelii
Gambel oak

Description—Gambel oak (fig. 31) is a member of the white oak subgenus *Lepidobalanus*. Most taxonomists consider Gambel oak part of the *Quercus undulata* complex, which hybridize readily (Welsh

1986). Gambel oak is a native, broadleaf, deciduous shrub that typically forms dense stands (Neilson and Wullstein 1983). It generally grows from 3 to 20 ft (0.9 to 6 m) in height, forming spreading thickets connected by underground rhizomes (Christensen 1949). In the southern end of its range it can be treelike and as much as 20 to 25 ft (6 to 7.6 m) tall (Wagstaff 1985). Leaves are alternate and broadly obovate to oblong lanceolate, with considerable variation among clones. Leaves are somewhat leathery, yellow green to dark green above and pale yellowish and densely hairy below. They turn a deep-reddish color in fall.

This monoecious, wind-pollinated shrub bears red pistillate flowers in the upper leaf axils. Male flowers grow in pendent catkins that are borne singly or in groups at the base of new shoots (Harper and others 1985). Fruits are brown acorns enclosed in a cap. Acorns form and mature in 1 year (Harper and others 1985). Reproduction is primarily vegetative from an extensive, freely branching, underground network of lignotubers (enlarged, stemlike structures covered by numerous adventitious buds), roots, and rhizomes (Tiedemann and others 1987). Lignotubers account for up to 72 percent of the total belowground biomass (Tiedemann and others 1987).

Ecological Relationships and Distribution—Gambel oak is widely distributed throughout the Southern and Central Rockies. In the Intermountain West, Gambel oak occurs in valleys, foothills, on alluvial fans, and on lower mountain slopes between sagebrush, pinyon-juniper, aspen, and spruce-fir types. When it is not the dominant species, it can be found growing as a codominant with big sagebrush, pinyon, juniper, ponderosa pine, mountain mahogany, bitterbrush, cliffrose, aspen, snowberry, spruce, and fir.

Gambel oak occurs between 4,000 and 9,000 ft (1,200 and 2,700 m). Pure stands occur along the Wasatch Mountains, Wasatch Plateau, and west slope of the Rocky Mountains in western Colorado in nearly continuous belts (oakbelt) between 5,500 and 7,000 ft (1,700 and 2,100 m) (Cottam and others 1959). Gambel oak generally requires annual precipitation between 15 and 22 inches (38.1 and 55.9 cm) (Harper and others 1985). However, it does occur in some areas where annual precipitation is as low as 12 inches (30.5 cm). The most common soils in which Gambel oak occurs are calcarcous, heavy, and fine-grained loams. It can also be found on sandy, gravelly, and clay loams, and alluvial sands (Christensen 1955; Tucker and Muller 1958).

Figure 31—Clumps of Gambel oak provide soil protection and habitat for wildlife and livestock.

Gambel oak occurs as a climax species on many sites, and as a mid or early seral species on others (Harper and others 1985). In some areas Gambel oak is considered the ecological equivalent of ponderosa pine (Harper and others 1985).

Plant Culture—Gambel oak reproduces both vegetatively and sexually. Clones expand through both radial and lateral growth (Christensen 1955). Rate of vegetative spread ranges from 1.5 to 12 inches (381 to 360 mm) annually; the average is 4 inches (10 cm) per year (Christensen 1955). Gambel oak sprouts quickly after burning, wood harvesting, chaining, cabling, or other disturbances. Sprouts may appear 10 days after removal of top growth (Harrington 1985). Rate and degree of sprouting are greatest from clones with smaller stems. Clones with stems greater than 12 inches (31 cm) in diameter are poor sprouters (Reynolds and others 1970).

Sexual reproduction is by acorns. Acorns develop and mature in 1 year (Harper and others 1985). They usually ripen in late September and October, and can be collected by beating them into a container. Acorns must be stored in a cool, moist environment or they will dry and die. Storage should not extend beyond the first winter following collection because of rapid loss of viability. Seeding should occur in late fall or early spring. High pregermination mortality can result from predation by birds, mammals, insects, and parasitism. Acorns can germinate in fall after dispersal; they may be killed by frost if not covered by litter and snow (Christensen 1949). Seedlings are susceptible to damage by early fall or late spring frosts, grazing, and summer drought (Neilson and Wullstein 1983). Gambel oak seedlings are rare in many areas, particularly in the northern part of its range (Christensen 1955; Reynolds and others 1970).

Plants can be established from properly planted container stock. Establishment success has also resulted from moving partial clones with front-end loaders. This involves moving and placing 2 to 3 ft (61 to 90 cm) of soil, roots, rhizomes, and lignotubers. Gambel oak wildings do not transplant well.

Uses and Management—Gambel oak and associated species provide valuable food and cover for livestock and many wildlife species. This species is generally not highly palatable, but its abundance and availability, particularly on fall, winter, and spring ranges, make it an important browse species. Gambel oak is regarded as fair forage for all classes of livestock (Harrington 1985). Summer cattle use has been identified in northern Utah (Julander and Robinette 1950). Sheep use can be light (Dayton 1931). Gambel oak is used extensively by mule deer throughout the year (Bowns 1985; Harper and others 1985; Kufeld and others 1973). Elk browse oak during winter and spring (Kufeld 1973; Reynolds and others 1970). Bighorn sheep make use of the plant during summer months (Rominger and others 1988).

Young shoots and new growth are the most preferred portions of this shrub. Preference of most browsing animals for Gambel oak varies with availability of other species. Use increases as other species become less available. Gambel oak can be poisonous to livestock when used exclusively, but when consumed in combinations with other species, it is generally harmless (James and others 1980).

Quantity and quality of associated forage production can be very high in Gambel oak communities. Understory production may reach 3,000 lb per acre (3,360 kg per ha). Understory production within oak clones can be twice as high as between clones. Understory species within clones also green up 2 to 3 weeks earlier in the spring and stay green later in the season than do the same species between clones (Bowns 1985; Stevens and Davis 1985).

In most areas the Gambel oak type has the highest forage productivity potential of any vegetative type in the Intermountain West. It has been severely abused by livestock at many locations. Productive understory species have been grazed out and replaced by less productive plants. In most areas the understory is almost nonexistent. As a result oak density and clone size have increased substantially.

The Gambel oak type is important for livestock, wildlife, and watershed protection. These areas can be critical spring and fall ranges for cattle, sheep, deer, and elk, and winter range for elk. Floods produced by high-intensity July and August rainstorms are common on depleted Gambel oak stands. Heavy snow pack and spring snowmelt have the potential for producing destructive spring runoff from these depleated communities. It is important that the Gambel oak type be well managed and restored to its productive potential.

Gambel oak also provides valuable escape, thermal, and travel cover for deer, elk, livestock, and small mammals. A large number of birds use Gambel oak for nesting, hiding, and resting (Marti 1977). Acorns are highly preferred by deer, elk, hogs, javelina, turkey, band tailed pigeons, squirrels, and numerous small mammals and birds (Christensen 1949; Harper and others 1985; Reynolds and others 1970; Steinhoff 1980). Many small birds and mammals cache acorns for later use.

Gambel oak is a valuable browse and cover plant in many areas, but it can grow too dense and exclude understory vegetation, big game, and livestock. A mosaic of clones or stands interspersed with open areas provides the best habitat for big game and livestock (Stevens and Davis 1985). Management objectives should be directed toward maintaining a mosaic of clones and interspaces. Fire, herbicides, and mechanical treatment can be used successfully to open stands and increase accessibility to clones (Bowns 1985; Stevens and Davis 1985). When Gambel oak is disturbed, understory species should be seeded to improve composition and production and to retard oak suckering and regrowth (Stevens and Davis 1985).

Wood value of Gambel oak can be high (Clary and Tiedemann 1986). Average energy content is estimated at 340,000 Btu per ft^2 (4.77 kcal per g) (Harper and others 1985); it can be an economically important fuel wood with high heat-yielding qualities. Gambel oak has been used successfully for long-term rehabilitation of disturbed sites (Dittberner and Olsen 1983).

Gambel oak resprouts rapidly following fire. Rate of recovery varies with fire severity, climatic factors, and site characteristics (Harper and others 1985). Fire generally does not harm or kill Gambel oak. Spring and fall burns have little detrimental effect. However, summer burns can inhibit regrowth and may even kill Gambel oak (Harrington 1985). Following fire, the rate and amount of resprouting can be reduced by seeding competitive herbs (Stevens and Davis 1985). Gambel oak generally sprouts as early as 10 days after being burned (Harrington 1987). When Gambel oak is burned, chained, cabled, or otherwise disturbed, deer and elk browsing increase (Stevens and Davis 1985). Deer, elk, and livestock seem to prefer burned over oak communities (Harper and others 1983).

Improved Varieties—None. Considerable variation exists with this species throughout its geographical range.

Family Oleaceae

Fraxinus anomala
Singleleaf ash

Description—Singleleaf ash is one of only a few native ashes to occur in the Intermountain region. It is a small, deciduous shrub or tree, commonly 8 to 13 ft (2.4 to 4 m) tall (Welsh and others 1987), but sometimes attaining heights of 26 ft (8 m) (Goodrich and Neese 1986; Harrington 1964). It usually develops

multiple stems, and branchlets that are characteristically four angled. Leaves are simple to two or three foliate, ovate, crenate-serrate to subentire, glabrous, 0.6 to 2.6 inches (1.5 to 6.5 cm) long, and 0.4 to 2.4 inches (1 to 6 cm) wide. Flowers are polygamous and occur in panicles with a minute calyx and no corolla. Fruit is a one-seeded samara, 0.5 to 1 inch (12 to 25 mm) long, 0.31 to 0.4 inch (8 to 10 mm) wide, and winged almost to the base (Goodrich and Neese 1986; Harrington 1964; Kearney and Peebles 1942; Munz and Keck 1959; Welsh and others 1987).

Ecological Relationships and Distribution—Singleleaf ash occurs from Colorado west to California and south to New Mexico and Arizona (Harrington 1964). It is common in west-central and southwestern Colorado at 4,500 to 6,000 ft (1,400 to 1,800 m) (Harrington 1964). It occurs on rocky, sandy canyons along the Green River in Utah (Goodrich and Neese 1986), but is more widespread throughout eastern and southern Utah. It exists in pinyon-juniper woodlands and mixed desert shrub communities mainly on rimrock or along drainages at elevations between 2,900 and 8,500 ft (890 and 2,600 m) (Welsh and others 1987). It occupies dry canyons and gulches between 3,000 and 11,000 ft (910 and 3,400 m) in California (Munz and Keck 1959).

The plant is important on upland sites where it grows intermixed with salt desert shrubs, pinyon-juniper, and basin big sagebrush. It is particularly abundant in the Four Corners region and throughout much of the Colorado River drainage where it occurs on sandstone outcrops and shallow soils (fig. 32). It does not form dense stands, but is normally found scattered among rocky bluffs and ledges. It also occurs on limestone soils, but usually on well-drained sites (Stark 1966).

Figure 32—Singleleaf ash occurs on shallow soils and sandstone outcrops in the Four Corners area.

Plant Culture—Small, rather inconspicuous flowers appear from April to May at about the same time the leaves develop. Flowers are grouped in terminal or axillary clusters. Fruits are long, single-seeded samaras with distinct wings that are borne in clusters. They ripen from mid-July to mid-August (Plummer and others 1968). As fruits mature they change from green to yellow or light brown. Fruits often remain on the bush for a number of weeks before dispersing. Ripened fruits can easily be collected by hand picking or dislodging them onto canvas spread on the ground.

Fruits are dried before cleaning. They are separated from stems and leaves by fanning or with air screen cleaners. The wings can be removed from the fruit by grinding or maceration. Removing the wings aids in planting, but does not affect germination. Seeds of most ash species must be stored in sealed containers at 4l °F (5.0 °C) and 7 to 10 percent moisture content.

Singleleaf ash produces good seed crops infrequently. Abundant crops may be produced once every 3 to 5 years. Insects damage a number of seeds as they ripen. Usually, less than 50 percent of the seeds from wildland collections are viable. A number of freshly collected seeds will germinate, but most are dormant and require wet prechilling. Seeds sown in fall usually receive an adequate wet prechilling treatment and germinate uniformly in spring. Artificial wet prechilling of ash seeds is accomplished by diurnal alternating temperatures of 86 and 68 °F (30 and 20 °C) (Bonner 1974b).

Uncleaned or dewinged fruits are difficult to seed with conventional drills. The fruits are large and irregular in shape and do not flow through seedboxes and seeding equipment. Fruits should be planted in the soil at a depth of about 0.5 inch (1.3 cm).

Trial seedings, primarily in central Utah, have produced irregular stands. This has been attributed to seeding poor quality seed. Seedlings and young plants grow quite slowly. Even under irrigation, nursery-grown plants develop slowly. Wildland planted seedlings often increase only 6 inches (15.2 cm) in height during a single season. As plants reach 3 to 5 years of age, the growth rate increases. A dense, well-branched root system is formed the first year; once established the plants are very persistent.

Singleleaf ash can be grown as transplant stock for field plantings, although transplanting success has been quite erratic. One-year-old transplants are not very large, usually less than 5 to 6 inches (12.7 to 15.2 cm) tall, but with healthy root systems. Survival of transplanted stock has often been 25 to 40 percent, but losses are often attributed to extreme conditions of the planting sites. Growth response of singleleaf ash has varied among collections. Plant materials obtained from eastern Utah have grown quite slowly, but plants establish and persist very well.

Uses and Management—Singleleaf ash is one of only a few shrubs or trees adapted to rocky and arid sites in the sagebrush, salt desert shrub, and pinyon-juniper communities. It develops an upright growth form that provides food and cover for wild animals and domestic stock. The plants are very persistent, and are not eliminated by extended periods of drought or heavy browsing. Singleleaf ash is also well adapted to infertile soils, and performs well in such situations. The plant serves as an overstory species with sagebrush and fourwing saltbush, providing cover and protection for wildlife in barren areas. When intermixed with pinyon and juniper, it provides forage diversity for game and livestock.

Singleleaf ash competes well with pinyon and juniper, and if not heavily grazed, it is able to remain vigorous and healthy amid dense stands of these trees. The species is an important plant for watershed protection; it grows in areas where high-intensity rains occur infrequently, but can cause considerable erosion. This species is also able to persist and provide cover on sites where few other species may occur.

Singleleaf ash has been used to a limited extent on mine sites, roadways, and recreational disturbances. A slow growth rate, however, limits its value in areas where rapid development of cover is desired. It is suited to rocky soils, but is not well adapted to mine disturbances if planted on mine wastes or substrates. It has considerable potential for landscape plantings, particularly in highly scenic areas of eastern and southern Utah. It can be used to restore disturbances near recreational areas, parks, and roadways. Additional information is needed to improve the culture of this important species.

Varieties and Ecotypes—None.

Family Polygconaceae

Eriogonum heracleoides, Wyeth or whorled eriogonum, buckwheat
Eriogonum umbellatum, Sulfur eriogonum, buckwheat
Eriogonum wrightii, Wright eriogonum, buckwheat

Introduction—Eriogonum or buckwheat, as most species are commonly called, occurs only in North America. There are a considerable number of *Eriogonum* species in the Western United States (Dayton 1931, 1960; Harrington 1964; Hitchcock and others 1964; Judd 1962; Welsh and others 1987). The genus includes annual and perennial herbs, subshrubs, and woody shrubs. Most species have taproots; some of the subshrubs have spreading or prostrate stems that root at the joints (Dayton 1960). The shrubby species generally produce semierect stems. Flowering stocks are herbaceous, erect, and leafless. Flowers are small and arranged in umbels, cymes, or racemes. The fruit is a three-angled or three-winged achene (Dayton 1931, 1960; Hitchcock and others 1964; Welsh and others 1987). Sulfur eriogonum, Wyeth eriogonum, and Wright erigonum have been the most successful species used in restoration projects. They are easily cultured and establish well without extensive seedbed preparation or protection of young seedlings. They exist on dry situations, and prefer rocky, sandy, well-drained soils in areas of moderate to low rainfall. Consequently, they are useful shrubs in restoration of harsh sites.

Varieties and Ecotypes—None.

Family Polygconaceae

Eriogonum heracleoides
Wyeth or whorled eriogonum, buckwheat

Description—Wyeth eriogonum is a native perennial, mat-forming subshrub with woody branches and persistent vegetative stems. Stems arise from rosettelike bases and produce distinctive whorled leaves. Flowering stems are densely branched and grow to 2.5 ft (76 cm) in height. Cream-colored to yellow flowers develop on umbellate inflorescences (fig. 33) (Hitchcock and others 1964; Welsh and others 1987). Abundant seeds are generally produced each year. There are about 141,000 seeds per lb (310,800 per kg) at 100 percent purity.

Ecological Relationships and Distribution—Wyeth eriogonum is widely distributed in British Columbia, Montana, Utah, Wyoming, Nevada, and California (Dayton 1960). It is most prevalent in mountain brush and pinyon-juniper communities, but it also occurs in sagebrush-grass, aspen, and spruce-fir types. It invades disturbed sites but is less competitive with annual weeds, particularly cheatgrass, than sulfur buckwheat. This species does well on disturbed sites and openings in various communities and will spread naturally if not heavily used (Plummer 1970). It does increase following burns.

Plant Culture—Wyeth eriogonum, sulfur erigonum, and Wright eriogonum produce good seed crops most years. Even during dry years, some seeds develop. Seeds are quite easily collected by beating them into a container. Seeds are not difficult to clean; they are simply separated from the debris with a fan and screen separator.

Seeds of all three species can be drilled or broadcast seeded, but they should not be planted more than 0.1 inch (3 mm) deep. Fall and winter seeding are preferred. Seeds of all three species germinate readily,

Figure 33—Wyeth eriogonum flowers in early summer and generally produces a reliable seed crop.

resulting in fairly uniform emergence over a 2-week period in early spring. Seedlings are fairly frost and drought tolerant. All three species establish fairly well when planted in combination with grasses, shrubs, and forbs. Aggressive perennial grasses can, however, become dominant.

Sulfur, Wyeth, and Wright eriogonum establish well from direct seeding and spread naturally on severely disturbed sites such as mines, road cuts and fills, construction sites, and gravel and sand pits. These species are generally able to persist and increase in density following wildfires. Buckwheats most often increase in importance.

Uses and Management—Livestock and big game graze Wyeth eriogonum (Dayton 1960). Most use occurs in late fall and winter when other species are dormant, but some use occurs during summer. This species recovers well from heavy use and will increase in density and productivity when grazing pressure is reduced. Birds and small mammals seek out and consume the seeds. This species has considerable ornamental potential, especially on low-maintenance areas.

Improved Varieties—None.

Family Polygonaceae

Eriogonum umbellatum
Sulfur eriogonum

Description—Sulfur eriogonum or buckwheat is a perennial subshrub with a strong taproot and freely branching crown. The branches can be prostrate and mat forming, but are usually upright, growing to a height of 1 ft (30.5 cm). Leaves are oval to oblanceolate, green above and grayish beneath, arising from rosettelike stem tips. The inflorescence is a freely branching umbel on a stem about 1 ft (30.5 cm) long. Leaflike bracts develop near the middle of the flowering stem. Flowers are cream colored to deep yellow or greenish yellow. Flowering stems and floral tissue often persist throughout the winter (Dayton 1931, 1960; Hitchcock and others 1964; Welsh and others 1987).

Ecological Relationships and Distribution—Sulfur eriogonum occurs widely throughout Western North America in big sagebrush, pinyon-juniper, mountain brush, ponderosa pine, spruce-fir, aspen, and subalpine communities (Dayton 1960). It is especially well adapted to rocky and exposed sites, and quickly invades and occupies disturbed areas (fig. 34). Seedlings are persistent and competitive. They grow rapidly and

Figure 34—Sulfur eriogonum directly seeded on shallow soils persists with competitive annual grasses.

will spread into cheatgrass and perennial bunchgrass communities.

Plant Culture—Seeds of sulfur eriogonum can be harvested, processed, and seeded as described for Wyeth eriogonum.

Uses and Management—Sulfur buckwheat can be an important browse species for sheep, goats, cattle, mule deer, elk, and antelope (Dayton 1931, 1960; Kufeld 1973; Kufeld and others 1973; Monsen 1975; Smith and Beale 1980). This shrub is semievergreen and produces useful forage. Plants receive some summer use, but most use occurs in late fall and winter. Even when heavily grazed, sulfur eriogonum survives and spreads on sites where other important forage plants have succumbed (Monson 1975). Birds and small mammals consume the seeds.

The species has been seeded successfully on severely disturbed sites. It provides rapid soil stabilization and will spread fairly aggressively from seeds to fill openings in the community. It is able to survive on unstable soils, but is not able to persist if buried by soil sloughing. Like other species of eriogonum, sulfur eriogonum has considerable ornamental value, especially in low-maintenance, low-precipitation situations.

Varieties and Ecotypes—"Sierra" sulfur flower buckwheat (*E. umbellatum* var. *polyanthum*) was released for use in California.

Family Polygconaceae

Eriogonum wrightii
Wright eriogonum

Description—Wright eriogonum is a low, white, woolly, perennial shrub usually less than 2 ft (61.0 cm) tall. It commonly forms a basal crown from which many branched stems emerge. The leaves are oblanceolate, sharp pointed at the tips, and covered with fine, white, woolly hairs. The white or pinkish flowers are borne in umbels at the apex of rather short leafless flower stalks (Judd 1962; Welsh and others 1987).

Ecological Relationships and Distribution—Wright eriogonum is found primarily in pinyon-juniper, oak woodlands, and chaparral types in southern Utah, California, Arizona, New Mexico, and Texas (Welsh and others 1987).

Plant Culture—This species is easily established by direct seeding. Seedlings are vigorous, drought tolerant, and persistent. Seeds are usually hand harvested and processed with an air separator.

Uses and Management—Wright eriogonum is considered fairly good forage for sheep and goats and fair for cattle (Judd 1962; USDA Forest Service 1937). Under heavy grazing, this species can be replaced by burroweed and snakeweed (Judd 1962). Birds and small mammals seek out and consume the seeds. Wright eriogonum persists well during drought periods and will increase following burns. This species has been seeded successfully on disturbed sites. It can provide rapid soil stabilization and will spread fairly aggressively from seed.

Varieties and Ecotypes—None.

Family Ranunculaceae

Clematis ligusticifolia
Western virginsbower

Description—Western virginsbower is a woody, climbing vine. The vigorous, glabrous to densely strigose, or villous stems grow to 33 ft (10 m) in length, forming masses of vegetative growth that clamber over neighboring trees and shrubs. Root systems are shallow and fibrous. The opposite deciduous leaves are pinnately compound with 3, 5, or 7 lanceolate to broadly ovate to chordate leaflets. Each leaflet is 0.8 to 3.0 inches (2 to 7.6 cm) long and coarsely few toothed, or sometimes lobed or nearly entire. The twisting petioles develop from enlarged stem nodes and curl around supporting vegetation (USDA Forest Service 1937). The sweet-smelling dioecious flowers are clustered in few-to-many-flowered bracteate cymes. The four oblong-lanceolate sepals are white to cream colored, 0.2 to 0.6 inch (5 to 15 mm) long. There are no petals. Male flowers have numerous stamens and no pistils. Stamens of the female flowers are numerous, but sterile. Pistils are numerous in a capitate cluster. The plumose styles of the villous achenes elongate to 1.0 to 2 inches (2.5 to 5.1 cm) at maturity (Clebsch 1979; Harrington 1964; Hitchcock and others 1961; Welsh and others 1987). Chromosome number is 2n = 16. Geographic races are sometimes recognized (Vines 1960).

Ecological Relationships and Distribution—There are more than 200 species of *Clematis*, occurring primarily in the Temperate Zone of the Northern Hemisphere (Hitchcock and others 1964; Rudolf 1974). Western virginsbower is distributed from British Columbia west of the Cascades to the Columbia River, south on both sides of the Cascades to southern California, and east from Saskatchewan to New Mexico (Hitchcock and others 1961; Rudolf 1974; Welsh and others 1987). It commonly occurs along drainages, in riparian communities, and on steep talus slopes and canyon walls where it trails over boulders, banks, and vegetation.

Western virginsbower is common on roadsides and other disturbed sites. It frequently occurs with other woody species such as cottonwood, willow, common

chokecherry, Rocky Mountain maple, bigtooth maple, rubber rabbitbrush, ponderosa pine, and Douglas-fir. It grows on well-drained sandy to rocky soils, ranging from weakly acidic to moderately basic, and may occur on somewhat saline soils (Wasser 1982). It usually grows in areas receiving 12 to 20 inches (30.5 to 50.8 cm) of annual precipitation, but it is most abundant in areas receiving supplementary water. Drought tolerance of established plants varies among populations. Most are weakly to moderately drought tolerant (Wasser 1982). Seeds and vegetative production are markedly reduced in dry years.

Plant Culture—Flowering occurs from March to August and achenes ripen from May to December, depending on geographic location (Mirov and Kraebel 1939; Plummer and others 1968; Swingle 1939). Moderate to heavy seed crops are produced almost every year. Mature fruits are dry and brown with feathery white styles. They are dispersed by wind and gravity; rate of dispersal depends on weather conditions. Fruits are gathered by hand or with a vacuum seed harvester (Plummer and others 1968). Dried fruits are hammermilled with a $^{3}/_{16}$-inch (0.5-cm) screen operated at 1,120 rpm to detach the styles from the achenes (Wasser 1982). Debris is removed by fanning. Seeds are not removed from the achenes.

Estimates of the number of seeds per lb range from 93,000 to 328,000 (205,000 to 723,000 per kg) (Mirov and Kraebel 1939; Rudolf 1974; Swingle 1939). A purity of 20 to 50 percent and germination of 70 percent are recommended for seed purchases. Greater purities are difficult and expensive to achieve. Viability has been maintained for 2 years in dry storage (Plummer and others 1968).

Wet prechilling at 33 to 40 °F (0.6 to 4.4 °C) for 2 to 180 days is required to release embryo dormancy (Heit 1968a; Rudolf 1974; Young and Young 1986). Germination of wet prechilled seeds after 40 to 60 days at 68 to 86 °F (20 to 30 °C) ranged from 11 to 84 percent (Mirov and Kraebel 1939; Plummer and others 1968; Swingle 1939).

Western virginsbower may be direct seeded in mixtures with other shrubs by drilling or broadcasting. Untreated seeds may be fall planted (Rudolf 1974). Seed should be wet prechilled prior to spring planting (Swingle 1939). Seeds should be covered with about 0.3 to 0.5 inch (7 to 13 mm) of soil. Seedlings are vigorous, but growth is reduced by herbaceous competition. Consequently, no more than 50 percent of the mixture should consist of grass seeds. Western virginsbower normally should be seeded in mixtures at a rate of 1 lb per acre (1.1 kg per ha) or less (Wasser 1982). Holmgren (1954) reported good growth rates, but low survival of seedlings emerging from seedings on southern Idaho big game winter range. Seedlings were quite sensitive to competition from cheatgrass and broadleaf herbs.

Bareroot and container stock establish readily and grow rapidly. Seeds should be cleaned carefully to improve stand uniformity in nursery plantings. Container seedlings may be established from seeds or from cuttings of partially matured wood harvested from late spring to late summer. Young wood with short internodes gives less satisfactory results. Leaf bud cuttings taken in summer may be rooted under mist (Hartmann and others 1990). Layering is useful if only a few plants are needed.

Uses and Management—Western virginsbower is used in seeding or transplanting projects to improve cover and forage for many birds and small mammals. Smith (1953) found that captive mule deer preference for western virginsbower was greatest in early summer and decreased considerably by late summer relative to other native shrub forages provided. The plant receives little use by big game on mule deer winter ranges in southern Idaho (Holmgren 1954). Dixon (1934) reported that its palatability to mule deer in California was low. It receives little use by livestock.

Because of its rapid growth rate, generally low palatability, and ability to naturally invade disturbed sites, western virginsbower is a potentially valuable species for restoring disturbed sites with native vegetation (Bailey 1947; Plummer and others 1968; Rehder 1940; Van Dersal 1938). It has been used for soil stabilization on riparian areas and mined lands (Thornburg 1982), and is particularly useful on steep slopes that would otherwise be revegetated only slowly by herbaceous species (fig. 35). Wider use of the species

Figure 35—Western virginsbower growing on a road fill provides excellent soil stabilization.

is precluded by the difficulty of harvesting and processing large quantities of seed. Seedlings established from seeds or transplant stock develop rapidly, often flowering the first year, and provide cover while other planted species develop more slowly. Seeds and seedlings are sometimes consumed or damaged by small mammals. Leaf spots and rusts are often noted on the foliage, and downy mildew is occasionally a problem (Holmgren 1954).

Plants are moderately shade and frost tolerant, but thermal tolerance varies among ecotypes (Wasser 1982). Shoots may be destroyed by wildfires. Some plants survive by resprouting from rootstocks. The species also reestablishes burned areas by wind dispersal of seeds produced offsite (Plummer and others 1968; Thornburg 1982).

Western virginsbowers' cascade of yellowish foliage and clusters of feathery styles make it a unique and attractive ornamental for use in dry areas (Plummer and others 1968). The plant requires a large shrub or small tree for support. It may be trained to grow over a fence or trellis. Late winter pruning confines the plant to smaller areas (Clebsch 1979). Plants are most productive if planted well away from the supporting plant in slightly acid to moderately alkaline soil. Rich, moist soil and mulching provide needed thermal protection for the root system.

Varieties and Ecotypes—None. Selection trials are being conducted by the USDA Soil Conservation Service, Pullman Plant Materials Center, Pullman, WA, for a cultivar adapted to the northern Intermountain region.

Family Rhamnaceae

Ceanothus species

Introduction—Numerous species of Ceanothus occur in the Western United States. Munz (1974) described over 75 species in California. Considerably fewer species occur in the Intermountain region (Harrington 1964; Welsh and others 1987). However, many species common to the Southwest, northern California, Oregon, and southern Washington have been tested in the Intermountain area. Species that have been entered into adaptation trials were selected from sites with somewhat similar climatic and edaphic conditions.

Different species of Ceanothus possess important traits and have been planted in an attempt to enhance wildlife, range, watershed, or horticultural resources in areas outside their natural range. Although a number of species have been initially screened for adaptability to the Intermountain region, the species discussed in this chapter have been the most promising.

In general, species of Ceanothus have a number of attributes that are important for revegetation. Seeds are easily cleaned and planted. Small seedlings are vigorous and young plants grow rapidly; only a few other shrubs grow as quickly as Ceanothus. Species of Ceanothus are capable of nitrogen fixation and most are well adapted to infertile soils. Most are excellent forage plants, yet recover well from grazing.

Family Rhamnaceae

Ceanothus cuneatus Wedgeleaf ceanothus

Description—Wedgeleaf ceanothus (fig. 36) is an evergreen shrub (Munz 1974) distributed from Mexico to California, Nevada, Oregon, and southern Washington (Munz 1974; Peck 1941). It is a highly palatable evergreen species, and is heavily browsed as a winter forage (Conard and others 1985; Gibbens and Pieper 1962; Gibbens and Schultz 1963). It is an upright shrub ranging in height from 3 to 23 ft (0.9 to 7 m) (Munz 1974) and forming dense thickets (Stubbendieck and others 1986).

Ecological Relationships and Distribution—Collections from Butte, Shasta, and Siskiyou Counties in California, and Jackson County, OR, have been planted throughout the Intermountain area. Selections from approximately 2,000 ft (610 m) elevation, growing on granitic and basalt soils, have been planted in Utah, Idaho, Nevada, Wyoming, and Colorado. This species occurs as an understory in a number of ponderosa pine communities; outplantings have primarily been confined to ponderosa pine or mountain brush sites in the Intermountain area. Various collections have also been used to treat disturbed sites in southern California (Fessenden 1979).

Figure 36—Capsules of wedgeleaf ceanothus must be harvested when green as they dehisce explosively when dry.

Plant Culture—Seeds of the approximately 12 collections tested in the Intermountain area express similar features. They are small with 49,000 to 54,000 cleaned seeds per lb (108,000 to 119,000 per kg) (Reed 1974; Van Dersal 1938). Plants established in the Intermountain area usually produce good seed crops annually from healthy bushes. Few seedlings have appeared from natural spread in any study site, although some sites are frequently cultivated, which would result in seed burial.

Seeds germinate and establish well from late fall and early winter seedings. Rodents gather ripened seeds from trial plantings and native stands (Conard and others 1985). Consequently, late fall plantings are advised to reduce rodent damage to new plantings. Wedgeleaf ceanothus seeds germinate abundantly after fires (Reed 1974; Sampson and Jespersen 1963); seeds also benefit after being treated with boiling water (Grisez and Hardin 1967). Seeds placed in boiling water for 1 to 3 minutes germinated rapidly and more uniformly than untreated seeds. This response has been recorded for numerous collections. Seeds that are fall seeded following hot water treatment are generally adequately wet prechilled and germinate well in the spring.

New seedlings are quite vigorous and grow rapidly. Growth exceeds that of big sagebrush, antelope bitterbrush, and other commonly seeded shrubs. Young plants are able to recover following some browsing, but Medin and Ferguson (1980) reported that developing stands established by seeding and transplanting on winter game ranges in Idaho ultimately succumb to continued heavy grazing by big game, small mammals, grasshoppers, and to winter injury. Plants are very palatable (Gibbens and Schultz 1963; Scrivner and others 1988) and are heavily used by game and livestock.

Plantings conducted within the Intermountain area exhibit adaptation to a wide array of sites. The species does express broad amplitude (Detling 1961). Of the selections being tested, few exhibit adaptation to calcareous soils common in Utah and Nevada. Plants have established on these basic soils, but normally succumb in 4 to 6 years. Plantings established in central Idaho on granitic neutral or slightly acidic soils have survived quite well. However, collections from central California and Oregon have suffered winter damage. Normally portions of the crown are killed in a single season; however, some plants have persisted for over 30 years. This species cannot be recommended for use on wildlands outside its natural range. However, within its natural range it could be used for watershed protection and wildlife. It can be used for low-maintainance landscaping in areas within its natural range and on similar sites elsewhere.

Uses and Management—The species demonstrates usefulness for seeding disturbed watersheds; it grows rapidly and furnishes excellent ground cover. It also provides cover on open, wind-blown game ranges. This species' ability to fix nitrogen also contributes to its usefulness in range, watershed, and disturbed land plantings.

Varieties and Ecotypes—None.

Family Rhamnaceae

Ceanothus greggii
Desert ceanothus

Description—Desert ceanothus is a low-growing to erect shrub 1 to 6.5 ft (0.3 to 2 m) tall, with thick, persistent, entire leaves (Welsh and others 1987). Desert ceanothus grows in mixed desert shrub communities including pinyon-juniper, ponderosa pine, chaparral, and mountain brush sites in Nevada, California, Arizona, New Mexico, Texas, and Mexico (Kearney and Peebles 1960; Thornburg 1982; Welsh and others 1987). It occurs at elevations between 4,000 and 9,400 ft (1,220 to 2,870 m) in southern Utah (Welsh and others 1987).

Ecological Relationships and Distribution—Only a limited number of collections, primarily from southern Utah, have been used in wildland seedings. Collections acquired from scattered stands growing on rocky slopes, and from nearby pure stands, have been tested. Although this species grows on a variety of soil types (Carmichael and others 1978; Plummer 1977; Stark 1966; Thornburg 1982), collections obtained from basic to coarse-textured soils have been the only ones tested. This species is well suited to arid sites and provides an opportunity to enhance plantings where few shrubs are adapted and most species are difficult to establish. Desert ceanothus has been incorporated into a few range and wildlife improvement projects in central and southern Utah.

Plant Culture—Seedlings establish best from late fall and winter seedings. Seeds are small, yet larger than most other species of Ceanothus. There are approximately 23,000 cleaned seeds per lb (50,700 per kg) (Reed 1974). Seeds are borne in capsules that split and disperse the seeds from the bush. Hot water treatments effectively improve germination. Untreated seeds require approximately 42 days of wet prechilling to initiate germination (Stark 1966).

Good seed crops are not produced each year, even from bushes grown under cultivation. Generally, commercially harvestable crops are produced once every 3 to 4 years. Only about one-half the seeds acquired from arid native stands and wildlife plantings in Utah are viable. Keeley (1977) reported similar numbers of

viable seeds from wildland collections at other locations. Plants flower in April and May; seeds ripen in July (Reed 1974; Van Dersal 1938) and can be hand collected by stripping the capsules. Like other species of Ceanothus, desert ceanothus seeds disseminate as they ripen. Seeds must be collected when slightly green and stored to allow drying.

Uses and Management—Desert ceanothus is a valuable browse species for big game (Bradley 1965; Gullion 1964; Leach 1956; Pase and Pond 1964; Powell 1988), and is a particularly important winter forage (Conard 1987; Van Dersal 1938) and summer browse for livestock (Boles 1987).

This shrub establishes quickly and is well adapted to fresh disturbances. Horton (1949) reported that plants survive well on road disturbances on coarse-textured soils at elevations near 5,350 ft (1,630 m) in California, and recommended planting container stock or direct seeding in spots to control erosion. Desert ceanothus recovers following fire because seeds stored in the soil are fire activated. Resprouting from root crowns does occur, but only infrequently.

Varieties and Ecotypes—None.

Family Rhamnaceae

Ceanothus integerrimus
Deerbrush ceanothus

Description—Deerbrush ceanothus is a spreading, erect, deciduous shrub that grows rapidly (Cronemiller 1959; Hitchcock and Cronquist 1973; Munz 1974; Van Dersal 1938). Leaves are large and oblong-ovate in shape (Cronemiller 1959); some remain on the bush throughout the winter (Cronemiller 1959; Munz 1974; Van Dersal 1938). Like other species of Ceanothus, it is able to fix nitrogen (Biswell 1960; Harvey and others 1980).

Plant Culture—Seeds ripen in midsummer and are dispersed as the capsule dries and dehisces (Keeley 1987). The seeds are smaller than those of most other Ceanothus species with about 70,000 cleaned seeds per lb (154,300 per kg) (Reed 1974). Seeds are long-lived and may persist in the soil for decades (Cronemiller 1959; Pase and Brown 1982; Quick and Quick 1961). Seedcoats are impermeable to water, and embryo dormancy also exists (Heit 1967a). Seed germination can be enhanced by heat pretreaments (Shmida and Barbour 1982), and is best induced by boiling the seeds for 1 to 3 minutes followed by wet prechilling (Quick and Quick 1961). Viability of deerbrush ceanothus seed lots usually is higher than for seed lots of other species of this genus. Over 85 percent of cleaned seeds are often viable (Van Dersal 1938). Empty or immature seeds are difficult to separate from filled seeds using a gravity table or by flotation.

Ecological Relationships and Distribution—Deerbrush ceanothus is widely distributed in the Cascade Mountains of Oregon and Washington southward to southern California, Arizona, and New Mexico (Conard and others 1985; Kearney and Peebles 1960; Munz 1974; Peck 1941). It grows as the dominant understory in a number of tree and shrub communities (Conard 1987; Conard and others 1985; Gratkowski 1961a; Hartesveldt and others 1975). It is also well suited to open, dry slopes with and without shade (USDA Forest Service 1937). Based on its range of adaptation and rapid growth, this species has been evaluated for watershed and wildlife habitat improvement projects in central Idaho (fig. 37). Plantings have established well from fall and winter seeding or transplantings of bareroot stock. Young plants grow rapidly; yearly growth rates have exceeded 30 inches (76 cm). In addition, the shrub exhibits an ability to persist with understory grasses and herbs. The species sprouts aggressively following clipping. Although stem layering was reported by Biswell and Gilman (1961), this attribute has not been observed from plantings in Idaho. Deerbrush ceanothus grows well on fertile soils, but collections currently under study are not especially drought tolerant.

Uses and Management—Collections from California and Oregon have been evaluated for their ability to control erosion and restore wildlife habitat on logging roads and related disturbances where ground cover is essential. The plants form extensive, fibrous root systems when nursery grown. The root system provides excellent soil stability, and plants effectively stabilize erodible slopes and unstable banks. Plantings established at numerous sites in Idaho have been

Figure 37—Deerbrush ceanothus in south-central Idaho plantings provide excellent wildlife habitat and watershed protection.

seriously weakened and thinned by cold winter temperatures. The plants are not cold tolerant and serious dieback occurs each year. Less than 20 percent have survived on these plantings. Winter losses have also been noted from 1-year-old stock growing in nursery beds. The shrub has failed when planted on mine disturbances and infertile sites in Idaho, Utah, Nevada, and Wyoming, although Biswell (1960) and Harvey and others (1980) reported the plant is able to fix nitrogen and has been successfully planted on disturbed sites in the Southwest. It has not done well throughout the Intermountain region on disturbances lacking topsoil. It does well on road fills created in the Idaho Batholith, but not on mine wastes.

Although game animals utilize the shrub on research plantings and the plant provides considerable cover, it is not native to the Intermountain region, and replacement of other shrubs with this species is not advisable. It is not sufficiently winter tolerant to persist within the Intermountain region.

Varieties and Ecotypes—None.

Family Rhamnaceae

Ceanothus lemmonii
Lemmon ceanothus

Description—Lemmon ceanothus is a low, evergreen, spreading shrub that attains a height of 1.5 to 3 ft (46 to 91 cm); leaves are alternate, elliptical, 0.5 to 1.2 inches (13 to 30 mm) long, bright green and waxy above. Flowers are pale blue and abundant; seeds form within capsules (Munz and Keck 1959; Sampson and Jespersen 1963).

Ecological Relationships and Distribution—Lemmon ceanothus is a less widely distributed shrub than other species of Ceanothus. It is primarily confined to ponderosa pine communities from the base of the Sierra Nevada Mountains from Tuolumne and Eldorado Counties northward, and in the inner Coast Ranges from Lake and Yuba Counties north to Humboldt and Shasta Counties, California (Munz and Keck 1959). Although regionally adapted, it is an important deciduous shrub for wildlife (Sampson and Jespersen 1963).

Plant Culture—Seeds of lemmon ceanothus have an impermeable seedcoat and embryo dormancy. Heat scarification reduces seedcoat impermeability and hastens germination. Following heat treatment, wet prechilling for approximately 2 months is required to relieve embryo dormancy. Young seedlings are vigorous and can survive some herbaceous competition.

Uses and Management—Research with this species for revegetation plantings in the Intermountain region has been limited. Plantings have been established on wildlife and watershed sites in the Interior Western States. Plant materials acquired from northern California have been the primary source for most plantings.

The species is best adapted to sites receiving 15 to 25 inches (380 to 640 mm) of annual precipitation. It has not proven adapted to basic soils, and it is not winter hardy. Less than 10 percent of all plants have survived for more than 5 years in plantings in the Intermountain region.

This species has received considerable use by big game. Its rapid rate of growth is an impressive feature. It is an attractive shrub, particularly when in bloom (fig. 38). The flowers are abundant and cover the bush with a dark blue blanket. Seed production is erratic. Plants are easily cultivated and have considerable potential for horticultural uses. They can also be used in low maintenance plantings and on recreational sites. This species cannot be recommended for use outside its natural range. However, within its area of adaptation the shrub can and should be used to restore disturbed communities and provide wildlife forage and watershed protection.

Varieties and Ecotypes—None.

Family Rhamnaceae

Ceanothus prostratus
Prostrate ceanothus

Description—Prostrate ceanothus is a low decumbent or prostrate, evergreen, layering shrub most prevalent in California (fig. 39). It grows 2 to 6 inches (5.1 to 15.2 cm) in height; stems root at the nodes,

Figure 38—Lemmon ceanothus is covered by masses of tiny blue flowers in spring.

Figure 39—Plants of prostrate ceanothus form a dense, low ground cover on an unstable granitic slope in central Idaho.

spreading to form dense mats 2 to 8 ft (0.6 to 2.4 m) across. Leaves are opposite, dark green, smooth above and sometimes gray green beneath. The margins usually have coarse teeth near the tip. Flowers are blue and borne in umbels. Fruits are roundish capsules (Sampson and Jespersen 1963).

Ecological Relationships and Distribution—Prostrate ceanothus occur in California on open flats and in pine forests at elevations from 3,000 to 6,500 ft (910 to 2,000 m) from Calaveras and Alpine Counties northward to Modoc County, and west to Siskiyou and Trinity Counties. It also occurs in Washington, Oregon, and western Nevada (Hitchcock and Cronquist 1973). It grows in mountain shrub, ponderosa pine, and red fir forests of higher mountain regions, usually forming carpets (Sampson and Jespersen 1963). A disjunct population occurs near Council, ID.

Plant Culture—Seeds are large, ranging from 37,500 to 44,500 per lb (82,700 to 98,100 per kg). However, they are difficult to collect from the low-growing plants. Seeds must be hand collected by picking small groups of fruits before the capsules are fully ripe. When dry, the capsules dehisce and scatter the seeds.

Seeds persist for many years in the soil, and can be stored under warehouse conditions for long periods without loss of viability. Seed germination is fire dependent. Treatment of the seeds with boiling water for 0.5 to 3 minutes hastens germination (Reed 1974). Seedlings develop well from fall and late winter seeding.

Nursery-grown bareroot stock establishes well as do rooted cuttings. Container stock can be propagated from seed or from stem cuttings (USDA Forest Service 1976). However, transplants must be dormant when field planted. If plants begin growth before field planting, they are susceptible to frost and drought. Seedlings and young plants are vigorous but grow slower than most other ceanothus species. New seedlings and transplants survive well on disturbed soils (Brown and others 1971; Tiedemann and others 1976).

Uses and Management—Prostrate ceanothus has been widely used for soil stabilization (Brown and others 1971; Tiedemann and others 1976; USDA Forest Service 1976), conservation (Plummer 1977), and horticultural plantings (Van Rensselaer and McMinn 1942), particularly in central California. Extensive transplanting projects have been employed to treat harsh, erodible sites. Prostrate ceanothus has attractive evergreen leaves and has been used to provide ground cover and serve as background plants to complement floral plantings and mixed shrub beds.

Prostrate ceanothus has been successfully used to control erosion and stabilize roadways, and logging and mine disturbances in the Intermountain area. Its ability to fix nitrogen (Delwiche and others 1965; Stewart 1967) possibly contributes to its success on infertile soils. Collections from Oregon and California have been widely used and are well adapted to mountainous areas dominated by forested communities. Most of these collections are tolerant of both shaded and open planting sites. The planting stock is widely adapted to infertile soils, exposed substrata, and mine wastes. Townsend (1966) reported this species recovers quickly following fires, and is one of the first species to reoccupy disturbances.

Prostrate ceanothus does not persist well with other plants. It spreads to provide a dense ground cover intermixed with few other plants. Prostrate ceanothus grows very slowly, and it spreads by stem layering. Numerous shallow roots are formed along the spreading stems. Prostrate ceanothus is able to persist and spread when buried by unstable soil. It is particularly useful for stabilizing steep banks, roadcuts, and unstable surfaces; however, it does grow slowly. Wildlife have made little use of the shrub on roadway plantings in Idaho, which allows it to be used on steep sites where animals may cause damage. However, Sampson and Jespersen (1963) reported that the shrub is browsed heavily by deer in California. Kufeld and others (1973) reported, from a summarization of studies in California, that the species is moderately used in all seasons.

This species provides attractive cover and has been used to landscape recreational sites and wildland areas where low maintenance is provided.

Varieties and Ecotypes—Various ecotypes and collections of prostrate ceanothus have been developed for horticultural uses. Stock can be purchased from wildland nurseries. A collection acquired near Council, ID, is particularly adapted to more arid sites,

surviving in areas receiving 15 to 20 inches (38 to 51 cm) of annual precipitation. It does well in open areas, and is better adapted to sites supporting other shrubs and some herbs than most other collections.

Family Rhamnaceae

Ceanothus martinii
Martin ceanothus

Description—Martin ceanothus is a low, rounded to spreading, unarmed shrub, between 8 and 32 inches (20 to 81cm) tall (Welsh and others 1987). The leaves are alternate and deciduous with short petioles. Blades are green on both sides, 0.3 to 1.2 inches (7.6 to 30.5 mm) long, 0.2 to 0.8 inch (5.1 to 20.3 mm) wide, elliptic to oval, ovate, or obovate, and entire or serrulate except at the base. The inflorescence is corymbose with numerous white flowers (fig. 40). The fruit is a three-lobed capsule 0.16 to 0.2 inch (4 to 5 mm) thick. Seeds are shiny brown and 0.1 inch (3 mm) long. Sutton and Johnson (1974) reported the plant is evergreen, although plants may retain their leaves until late into winter when most are shed.

Ecological Relationships and Distribution—Martin ceanothus is much more limited in distribution than most other species of ceanothus in the Intermountain region. It occurs in Utah, Nevada, Colorado, and Wyoming, at elevations between 6,000 and 9,500 ft (1,800 and 2,900 m) (Welsh and others 1987). Kearney and Peebles (1942) reported the plant grows in the Kaibab Plateau and Grand Canyon areas at about 7,500 ft (2,300 m).

Martin ceanothus grows in small patches or as scattered plants in pinyon-juniper, mountain brush, big sagebrush, ponderosa pine, Douglas-fir, aspen, and bristlecone pine communities in Utah. Youngblood and Mauk (1985) reported that Martin ceanothus occurs in limited areas within the conifer forest types of central and southern Utah. The plant is not highly shade tolerant, but is able to persist beneath Gambel oak, mountain maple thickets, and ponderosa pine overstories, and it responds quickly to burning or other methods of clearing. It is noticeably absent from the aspen communities in Utah described by Mueggler and Campbell (1986), possibly due to the dense overstory provided by this tree species. Where it grows with other shrubs, particularly Gambel oak, it is most prevalent in small, open areas where overstory species do not occur.

At lower elevations Martin ceanothus normally grows as scattered plants with big sagebrush, skunkbush sumac, antelope bitterbrush, and rubber rabbitbrush. Populations occur as somewhat isolated stands on very harsh sites that also support green ephedra, Wyeth eriogonum, mountain ash, and bristlecone pine. It exists as a minor component in Gambel oak, creeping barberry, and gray horsebrush communities. It seldom forms thickets. It often occupies ridgetops and exposed south and west slopes where few other species exist. It is well adapted to rocky, well-drained soils (Van Dersal 1938), and frequently occurs as the dominant plant in these situations.

This shrub is fire tolerant, but would not be considered a seral species in most situations. Although it recovers quickly following fire, it does not spread rapidly to occupy extensive areas. Other mountain brush species also recover well and are able to maintain their postfire position in these communities following burning.

Plant Culture—Plants begin growth early in spring, and leaves normally appear by early April. Flowers are formed in clusters on short stalks that often overtop the leaves and foliage. Under wildland conditions not all plants flower profusely each year. Good seed crops normally occur about once every 3 years, but even during periods of low production, some bushes produce considerable seed. Grazing by big game and livestock normally restricts seed production on many wildland sites. Plants established at protected nursery sites in Utah and Idaho have developed good seed crops nearly every year. Plants reach seed-bearing age in about 4 years if protected from grazing. Thereafter, annual seed production increases for about 3 years or until plants attain full stature.

When plants are in full bloom, the bushes are very attractive and colorful. Flowering occurs in May and June, and seeds mature from mid-July to mid-August (Plummer and others 1968). Flowering generally occurs late enough in spring that seeds are not damaged. Flowers are insect pollinated and attract large numbers of insects. Developing seed crops are frequently

Figure 40—Martin ceanothus receives extensive use by wildlife and livestock.

damaged by insects, causing some to abort. Seeds are formed in three-lobed capsules that are gummy and sticky when green. As the fruit ripens, the capsules split open and seeds are dispersed 1 to 6 ft (0.3 to 1.8 m) from the plant. Rodents eagerly gather the ripening fruits and cache the seeds. The seeds or fruits are difficult to harvest for commercial sale. Hand collection, a slow process, is required to remove the fruits from the bush. The fruits must be collected when slightly green before the seeds are dispersed. When green, the fruits adhere tightly to the plant and are not easily dislodged by beating or flailing. Once the fruit is collected, it is air dried to allow the capsules to dehisce. During drying, fruits should be covered with a light screen to prevent the seeds from being thrown off the drying tables. Seeds can be separated from the debris using fanning mills or screens. After screening, empty seeds can be removed on a gravity table or by floating the seeds in water. Cleaned seeds can be stored in open warehouses for 10 to 15 years without loss of viability (Plummer and others 1968).

Fresh collected seeds are dormant. Germination can be aided by immersion in hot water. The most effective treatment has been to place the seeds in boiling water for 1 to 2 minutes. The water is then allowed to cool to room temperature, and the seeds are removed and dried. Seeds are then fall seeded or wet prechilled for approximately 30 to 90 days before germination begins.

Martin ceanothus seeds should be fall seeded in a firm, weed-free seedbed. Seeds are relatively small, round, and easily planted. They should be planted 0.25 to 1 inch (0.6 to 2.5 cm) deep. Rodents will gather planted seed; consequently, late fall seeding is recommended. Seedlings appear early in the spring and are tolerant of frost. Young seedlings grow moderately well, but are not able to withstand competition from herbaceous plants. Martin ceanothus should not be seeded directly with herbs, but in separate spots or strips. Seedlings are well adapted to harsh sites, and survive well from plantings on well-drained, infertile soils free of herbaceous competition.

Transplants are easily cultured as bareroot nursery stock or container material. Bareroot and container stock must be dormant when field planted. If plants are lifted from the nursery bed and field planted after vegetative growth begins, serious losses will occur.

Uses and Management—Martin ceanothus is one of the most promising and useful shrubs for rehabilitation of big game winter ranges. It is well adapted to big sagebrush and mountain brush communities. It occupies some of the most critical wintering areas in Utah, including open south and west aspects, and it has established well when planted in these situations. Seedlings are sensitive to drought and must be planted in areas free of weeds. They grow at a moderate rate and can withstand heavy grazing even as young plants.

The shrub survives well on mine wastes and associated disturbances. It spreads slowly by natural recruitment, but it is persistent and long lived. It is adaptable to open slopes where big game may concentrate throughout the winter. The shrub has a low, rounded growth habitat; its forage is usually available to grazing animals.

Herbage quality is quite high, particularly for native stands in central Utah. Deer, elk, and livestock browse this species heavily (Diebert 1968). Tueller (1979), however, reported only minimal use by big game in Nevada. When planted on mine sites and on big game habitat improvement projects in Utah, the plants are heavily browsed by big game and livestock. Use can often be severe enough to reduce stand establishment. Big game animals seek areas occupied by the shrub in late fall and winter. Both leaves and stems are grazed during that season.

Seed production and harvesting are problems preventing the wide use of this species. Plants grown under protection and in nursery conditions produce abundant seed crops, but fruits are located amid the twigs in small clusters that are difficult to reach and detach. Plants are low growing and relatively uniform in size and shape. Consequently, mechanical harvesters could be developed to dislodge and collect the fruits. If such equipment were developed, use of this species would be greatly enhanced.

Varieties and Ecotypes—Collections of Martin ceanothus from Sanpete County in central Utah have proven well adapted to wildlife habitats throughout the State. This ecotype is a good seed producer, and is heavily browsed by big game. It appears well suited to infertile sites, including mine disturbances. Small seed production fields have been established, but seed yields are not sufficient to meet current demands. Commercial production should be encouraged.

Family Rhamnaceae

Ceanothus sanguineus
Redstem ceanothus

Description—Redstem ceanothus is an erect, deciduous, nonrhizomatous shrub, 5 to 10 ft (1.5 to 3.0 m) tall (fig. 41); with purple or reddish, flexible, glabrous twigs (Hitchcock and Cronquist 1973; Munz and Keck 1959). The leaves are thin, broadly elliptical to ovate or obovate, rounded or subcordate at the base, 0.4 to 3.9 inches (1.0 to 10 cm) long, subglabrous, and glandular-serrulate (Munz and Keck 1959). The flowers are numerous, white, and borne in showy compound clusters 2 to 4 inches (5 to 10 cm) long from previous year's wood (Kartesz and Kartesz 1980; Munz and Keck 1959). The fruit is a slightly lobed, 3-celled capsule about 0.2 inch (4 mm) long with one seed per cell.

Figure 41—Redstem ceanothus resprouts rapidly following logging in central Idaho.

Ecological Relationships and Distribution—Redstem ceanothus is distributed from British Columbia and Montana south to Washington, Oregon, Idaho, and California (Hitchcock and Cronquist 1973; Munz and Keck 1959; Reed 1974). This species is best adapted as an understory species in open or partially shaded areas (USDA Forest Service 1937). It occurs at mid to low elevations to 2,400 ft (730 m) in Montana (Dittberner and Olsen 1983), and 4,000 ft (1,200 m) in California (Munz and Keck 1959). It is most abundant throughout much of the Pacific Northwest at mid elevations in burned forest communities (Mueggler 1965). It is a principal component of extensive brush fields that develop after fires, logging, or clearing (Halpern 1988). The shrub is most prevalent in early seral stages of grand fir, Douglas-fir, western hemlock, and mixed conifer forests (Armour and others 1984; Conard and others 1985; Dahlgreen 1984; Franklin and Dyrness 1973; Schoonmaker and McKee 1988). It also grows as a scattered understory in mesic, open sites with ponderosa pine in central Idaho and the Northwest (Franklin and Dyrness 1973). Miles and Meikle (1984) reported that within the dry submontane Douglas-fir subzone, redstem ceanothus favors sites with low evapotranspiration.

Redstem ceanothus is less shade tolerant than other species that coexist in brush fields of the Northwest (Hooker and Tisdale 1974). It is often replaced by oceanspray and chokecherry as tree canopies close (Conard and others 1985), yet its presence with other shrubs provides extensive brush fields for 25 to 50 years (Morgan and Neuenschwander 1988). Miles and Meikle (1984) reported successional dieoff as a result of combined factors including drought stress, severe frost, utilization, and shade. Although the density of this species may decline rapidly as shade increases (Antos and Shearer 1980), it reestablishes quickly following disturbances and becomes a dominant cover (Zamora 1975). Nearly closed stands may develop within 3 to 5 years (Morgan and Neuenschwander 1988).

Like other species of Ceanothus, redstem ceanothus is primarily fire dependent for natural regeneration (Antos and Shearer 1980; Mitchell 1983; Wittinger and others 1977). Heat scarification stimulates seed germination (Lyon and Stickney 1976), and new seedlings flourish following wildfires or controlled burns. The species is capable of resprouting following burning and crown damage by deer (Miles and Meikle 1984). However, mature plants can disappear as shade increases. Periodic reburning maintains the species as an "obligate pioneer" (Laursen 1984). The shrub survives with 10- to 15-year intervals between burning (Lyon and Stickney 1976).

Plant Culture—Redstem ceanothus shrubs are normally robust and healthy plants, but abundant seed crops are infrequent. Individual plants may develop heavy seed crops, and the better bushes are normally "high graded" during seed collection. Most plants are tall, and hand stripping is difficult. Fruits are not easily dislodged from the plant by beating or shaking the stems. Seeds are dispersed as the capsule ripens; thus, capsules must be collected when still green and allowed to dry. Seeds are fully developed before the capsule dries; thus, seed quality or viability is not adversely affected by harvesting green capsules shortly before they dry. Rodents actively gather the ripening seeds (Conard and others 1985) and will collect entire seed crops as the fruits ripen.

Seedbanks develop through annual accumulation of seeds in the soil (Kramer 1984; Morgan and Neuenschwander 1985). Although seeds are eagerly eaten by rodents (Conard and others 1985), numerous seeds may accumulate in the soil and may remain dormant for decades (Furniss and others 1978). Seed densities ranging from 1.9 to 107 per ft^2 (20 to 1,150 per m^2) have been reported in Idaho (Kramer 1984).

Large amounts of redstem ceanothus seeds have not been collected for commercial sales. The shrub usually recovers satisfactorily by natural seedings so artificial planting is generally not necessary. However, seeds are easily cleaned for storage or seeding. Seeds are approximately 0.08 inch (2 mm) in diameter; smaller than those of most Ceanothus species. There are about 130,000 cleaned seeds per lb (287,000 per kg). Seed cleaning is quite simple. The capsules are allowed to air dry, causing them to break apart and propel the seed. Consequently, the capsules should be covered with a screen to prevent loss of seeds as fruits ripen. Seeds and debris can be separated using an air screen fanning mill.

Seeds have a hard, impermeable seedcoat and a dormant embryo (Heit 1967a; Kramer 1984). They

require a heat treatment to open the seedcoat or hilar fissure (Furniss and others 1978). Immersing the seed in boiling water at temperatures between 190 and 212 °F (88 and 100 °C) (Heit 1967a; Niering 1981) for 1 to 3 minutes, followed by cooling in the standing water, reduces seedcoat imposed dormancy. Heat-treated seeds require wet prechilling for approximately 60 days to enhance germination (Heit 1967a; Reed 1974). Radwan and Crouch (1977) reported germination after 1 month of wet prechilling, but 4 months was the optimum period. Miles and Meikle (1984) suggested seeds collected from different aspects and elevations have different optimum wet prechilling periods. Seeds can be stored for many years in an open warehouse, but may be damaged by chalcids. Gratkowski (1973) and Radwan and Crouch (1977) recommended storage at 37 to 69 °F (3 to 21 °C) to reduce insect infestations.

Heat-treated seeds should be planted in fall in a firm, well-prepared seedbed at depths between 0.25 and 0.5 inch (6.4 and 12.7 mm). Broadcast seeding on a loose, rough seedbed or surfaces with considerable litter also is successful. When seeding on a bare mineral surface, seeds should be incorporated into the soil and not left on the surface. Lyon (1971), and Youngberg and Wollum (1976) found that seedling survival by natural recruitment was much higher following fall burning than spring burning. Most seedlings developing from spring burning emerged a year following the burn; thus, they were subjected to considerably more herbaceous competition. Leege and Hickey (1975) found that the amount of precipitation received from May through August had a significant effect on seedling survival.

Natural recovery following wildfire is often dramatic, as seedlings are able to establish with little site or surface preparation. A considerable number of seedlings naturally succumb the first or second year after disturbance (Lyon 1971; Youngberg and Wollum 1976). However, seedlings of this species are quite vigorous and can persist on exposed sites. High seedling losses from natural seeding is to be expected as seedlings compete for limited resources. Although less than 4 percent may remain after two growing seasons (Orme and Leege 1976), sufficient plants often survive to fully occupy the site.

Natural thinning is not as evident where controlled seedings are conducted. If sites are not overseeded, little dieoff or thinning will occur. Once seedlings attain 1 to 2 years of age, they are often of sufficient size and vigor to persist with herbaceous competition.

Redstem ceanothus is capable of nitrogen fixation (Torrey 1978), which enriches the biomass and density of associated species. Thus, this shrub serves as an important nurse plant in many situations (Rose and Youngberg 1981; Scott 1970). It has been particularly useful in seeding fresh disturbances where few other species are initially able to establish. Under many situations where little or no vegetation exists, redstem ceanothus can be seeded with herbs to provide a mixed composition of plants. The shrub competes with other herbs without serious loss of young seedlings.

Transplants are easily grown as bareroot or container stock. Bareroot plantings survive as well as container seedlings and are much cheaper and easier to transplant. Transplanting is a useful method of establishing the shrub on selected sites and locations. Transplants grow rapidly and furnish a rapid-developing cover, particularly if plants are inoculated with nitrogen-fixing organisms. Even when planted on mine or roadway disturbances, redstem ceanothus is an aggressive early developer.

Uses and Management—Redstem ceanothus is an important forage and cover plant for big game and other wild animals. In the Okanogan Valley of Washington and British Columbia, redstem ceanothus is one of two browse plants that provide 60 to 70 percent of the winter forage consumed by deer (Miles and Meikle 1984). Although it provides 11 percent of the available winter forage, it supplies 52 percent of the herbage consumed by big game.

In many burned or cleared sites, redstem ceanothus is often heavily grazed, and all annual growth is utilized. This species is particularly important for use by elk during the winter months (Kufeld 1973; Leege 1972; Leege and Hickey 1975). It is grazed in summer by both deer and elk, although the amount and period of use may vary (Conard and others 1985; Keay 1977; Keay and Peek 1980; Thilenius 1960). Game animals are frequently attracted to burned sites where this species is abundant. Important wintering ranges are dependent on burning and logging to maintain this shrub (Leege and Hickey 1975).

Redstem ceanothus is particularly palatable to wildlife. It furnishes considerable herbage in areas where the plant is not abundant or the dominant species. Grazing animals seek and utilize the new growth (Gaffney 1941; Leege 1968; McCulloch 1955; Thilenius 1960). Scattered plants growing in riparian areas and forest openings are selectively used at all seasons.

The age of the plant and seasonal period of grazing affect its palatability. Leege (1968) reported that new growth is much more palatable than older twigs, and following burning, the nutritional value decreases with age (Asherin 1973; Leege 1969; Leege and Hickey 1971). However, Miles and Miekle (1984) did not recommend burning to regulate or enhance the forage value of this shrub.

The protein content of this plant during winter is about 10.1 percent; this provides the protein level necessary for deer maintenance (Miles and Miekle

1984). In addition, the average fiber content is a relatively low 34.7 percent. Livestock also are attracted to plants with high nutritive quality and make considerable use of this species.

Redstem ceanothus provides important cover for wildlife including big game, small mammals, and birds. It is particularly important in winter. It is also an important ground cover, and provides soil stability on burned slopes where erosion potential is high. It provides protection for streambanks and moist areas. Following fires it recovers quickly and provides ground cover and soil stability on areas where slumping and surface runoff are common.

Seedling establishment is very good when redstem ceanothus is planted on disturbances; consequently, this species is utilized to seed abandoned roadway and logging disturbances. Both direct seedings and transplantings have been successful in conservation plantings to control erosion. The species, however, is not well adapted to mine wastes, and has been slow to invade road and logging disturbances where vehicle activity has occurred and soils are compacted. It has been very useful for restoring riparian disturbances, and withstands livestock use. However, grazing of young plants can weaken developing stands.

This shrub is able to establish with seeded herbs. It can be seeded with herbs or transplanted into new grass/forb seedings. It can be used as a pioneer species to restore harsh sites, and provides favorable areas for other plants to establish.

Varieties and Ecotypes—None.

Family Rhamnaceae

Ceanothus velutinus
Snowbrush ceanothus

Description—Snowbrush ceanothus is a low-spreading, many-stemmed, evergreen shrub (fig. 42) (Countryman 1982; Welsh and others 1987; Zamora 1982) with olive-green to reddish brown bark. It attains heights of 3 to 9 ft (0.9 to 2.7 m) when growing in thickets or closed stands (Sutton and Johnson 1974). On open, windswept sites it may grow as low, rounded plants usually about 3 ft (0.9 m) tall; however, on fertile sites individual shrubs may be 12 ft (3.7 m) tall (Stanton 1974).

Leaves are 1.2 to 2.0 inches (3 to 5 cm) long with three main veins and a glossy dark-green surface (Miles and Miekle 1984; Stark 1966). They are alternate, thick, pubescent to glabrous, ovate to elliptic, and very fragrant (Sutton and Johnson 1974; Welsh and others 1987). The leaves often curl in drought conditions; this conserves water by reducing evapotranspiration (Miles and Miekle 1984).

The flowers are white, heavily scented, very abundant, and borne in more-or-less corymbose clusters on short branches (Mozingo 1987; Sutton and Johnson 1974). The fruit is a three-lobed capsule, with a single seed per locule. The seeds are small and dark brown or tan with shiny coats (Welsh and others 1987).

The plant forms a deep spreading root system, and nitrogen-fixing actinomycetes occur on the roots (Hickey and Leege 1970; Stanton 1974). Snowbrush ceanothus does not spread by layering or root suckering, but by resprouting from the crown. The plants have a distinct cinnamon odor if the leaves or stems are crushed (Welsh and others 1987).

Ecological Relationships and Distribution—Snowbrush ceanothus grows from the coastal ranges of California north to British Columbia and eastward to Alberta, Montana, South Dakota, and Colorado (Mozingo 1987; Reed 1974). Hitchchock and Cronquist (1973) reported that *C. v.* var. *hookeri* occurs on the west side of the Cascade Mountains from northern California to British Columbia. East of the Cascades, var. *velutinus* occurs in California, Nevada, Utah, Colorado, and South Dakota. In Utah, Wyoming, and Colorado, the species is less abundant and restricted to more specific communities. Goodrich and Neese (1986) reported the plant occurs primarily at elevations between 7,000 and 9,000 ft (2,100 and 2,700 m) in the Uinta and Blue Mountains and the west portion of the Tavaputs Plateau, where it is mostly confined to mountain brush, ponderosa pine, and aspen communities.

This shrub has a broad ecological amplitude and is considered a late seral species in some communities, and an early seral species in others. It is most often codominant with ponderosa pine and Douglas-fir. It

Figure 42—Snowbrush ceanothus is a common understory shrub in many ponderosa pine communities.

is also commonly encountered in various mountain brush, antelope bitterbrush, and forested shrub communities. It is a principal species in forested communities in Oregon and Washington (Franklin and Dyrness 1973) and Idaho (Steele and Geier-Hayes 1987, 1992). As an early seral species, it occupies Douglas-fir, white fir, grand fir, ponderosa pine, and lodgepole pine forests (Dyrness 1973; Franklin and Dyrness 1973; Halpern 1989; Schoonmaker and McKee 1988).

Although snowbrush ceanothus commonly grows on dry, open hillsides (Weber 1987), and is considered to be shade intolerant (Stanton 1974), it will persist as an understory in forested communities for considerable periods. Increasing closure of the canopy and competition affect removal of the shrub. The rate of succession is regulated by soil moisture, and snowbrush ceanothus can maintain a presence on xeric sites as an edaphic climax community (Miles and Miekle 1984). The shrub may persist as a midseral species with Douglas-fir, but if tree stands are somewhat open, it may remain as a permanent understory (Conard and others 1985).

The species responds well to disturbances, particularly fires (Halpern 1988). High-intensity fires are often followed by the rapid recovery and postfire dominance of this plant, usually within 1 year, if an adequate seedbank exists and climatic conditions favor establishment (Halpern 1989; Halvorson 1982). Seed germination is activated by burning (Halpern 1988; Marshall and Waring 1984; Mozingo 1987). This species is able to compete with pioneering herbs. Snowbrush ceanothus is, therefore, a major component of brush fields and shrubby communities that develop after wildfires (Gratkowski 1961b, 1978; Morris 1958). It is often a primary understory component on ponderosa pine sites. It may exist as a long-lived seral species or a climax dominant. Along with antelope bitterbrush, it forms important associations as a dominant climax shrub (Franklin and Dyrness 1973).

Snowbrush ceanothus grows across a wide elevational range from 3,500 to over 10,000 ft (1,100 to 3,000 m) (Mozingo 1987; USDA 1937). Aspect affects the distribution of the species due to increasing evapotranspiration demands on south and west slopes, particularly in pioneering systems (Miles and Miekle 1984). The shrub is unable to establish on south, southwest, or west aspects at elevations below 3,250 ft (990 m) in British Columbia because of xeric conditions. At high elevations it is not normally found on steeper east, northeast, or north aspects because of poor shade tolerance and competition (Miles and Miekle 1984).

Although snowbrush ceanothus is a fire-dependent pioneer species, successional dieoff is caused primarily by drought stress due to competition. Shading, frost damage, and utilization may hasten the process (Miles and Miekle 1984). Severe frosts frequently damage the shrub, particularly during years of low snow cover when the shrubs are exposed. Although plants may be killed to ground level, regrowth from the crowns can usually occur. Fires can damage and kill mature plants, but regrowth does occur, and stand regeneration is often accomplished with controlled burns.

Snowbrush ceanothus exists on a wide number of soil types and parent materials. It is able to grow on well-drained, coarse-textured soils (Stephens 1973), but water-holding capacity and nutrient availability greatly affect the presence of this shrub (Miles and Meikle 1984). Soils that contain sufficient moisture to sustain growth into July and August are important to its survival. Snowbrush ceanothus occurs on slightly acidic and neutral soils, and is particularly adapted to soils derived from granitic parent materials (Sutton and Johnson 1974; Watson and others 1980; Zavitkovski and Newton 1968).

Plant Culture—Plant growth and flowering are regulated by elevation. Vegetative growth normally begins by mid-April at lower elevations and as late as early June at higher sites (Noste and Bushey 1987). Flower development begins early in the season, often by mid-April. At higher elevations flowering may occur in June or July. Seed maturation occurs from July to August (Plummer and others 1968; Reed 1974; Stark 1966; Swingle 1939).

Plants usually produce a number of flowers each year, but viable seeds may not always mature. Seed production varies annually among wildland sites. Few areas produce abundant crops each year, but some shrubs will generally produce seed. Young plants that occur on open burn sites are not always better seed producers than those existing in mixed shrub/conifer forests. Normally, some sites will bear commercially harvestable crops each year, but sites must be located and inspected regularly.

Seed is harvested by hand stripping the fruits before they mature or the capsules dry. As capsules dry, seeds shatter immediately. Capsules ripen irregularly on the bush and fruits must be collected when still green. However, seeds are fully ripe before the capsules are dry, and harvesting of slightly green fruits does not diminish seed quality. Seed harvesting is slow and expensive, and is a principal deterrent to the wide use of this species.

Yields of 50 to 75 lb per acre (56 to 84 kg per ha) of cleaned seed have been obtained from sites in Idaho. Rodents actively gather the fruits and seeds, and will remove much of the seed as it matures. Nearly complete removal of the seed by rodents has been reported by Conard and others (1985).

Mature seeds have a hard impermeable seedcoat and a dormant embryo. Heat and wet prechilling are necessary for germination (Mozingo 1987). Soaking

the seed in boiling water for 1 to 3 minutes normally enhances germination. Seeds are then germinated in a cool, moist environment at 34 to 41 °F (1 to 5 °C) for 63 to 84 days (Reed 1974). Germination is usually completed in about 14 days (Quick 1935). Seed germination is usually very high, exceeding 70 to 80 percent (Reed 1974). Mozingo (1987) suggested that the optimum period of exposure to heat varies geographically among ecotypes, but differences have not been noted in separate collections obtained from central Idaho.

Seeds can be stored for long periods without loss of viability. Good stands have developed from planting in the fall at a depth of 0.5 to 0.75 inch (1.3 to 1.9 cm). Seedings also establish well by broadcasting seeds on a rough seedbed in the fall or early winter. Plantings on bare mineral soil or amid surface litter are both successful if the soil surface remains wet throughout the germination period. Miles and Miekle (1984) reported that natural seedings that germinate in the autumn, following late summer or fall burning, survived much better than those that germinate in spring after spring burning.

Snowbrush ceanothus seedlings establish well on fresh, open disturbances and compete favorably with pioneering herbs. The species establishes very well from artificial seedings and is particularly adapted to unstable sites. Sutton and Johnson (1974) and Miles and Meikle (1984) reported young plants grow slowly, but Scott (1970) found that nodulated seedlings produced 2.5 times more dry weight than non-nodulated plants. Results from plantings conducted in Idaho and Utah do not support reports that seedling growth is slow. In fact, plantings on forested roads and study sites are vigorous and aggressive. Seedlings and young plants develop well and are able to establish and persist with herbaceous competition. However, considerable differences between nodulated and non-nodulated plants were also noted on these sites.

A large number of natural seedlings can be expected to emerge on burn sites. Natural thinning normally occurs soon after emergence (Lyon 1971), but sufficient numbers usually survive to provide an adequate stand. Winter frost, grazing, and lack of soil water contribute to seedling losses.

Snowbrush ceanothus is easily grown as bareroot or container stock, and transplanting is an excellent method for stabilizing disturbances. Snowbrush ceanothus forms a symbiotic relationship with *Streptomyces ceanothii* to fix nitrogen (Hickey and Leege 1970). These organisms form clusters of modified short roots, not typical nodules (Furman 1959; Torrey 1978). Seedlings grown for field plantings should be inoculated with these nitrogen-fixing organisms.

Uses and Management—Snowbrush ceanothus is a particularly important species for restoring and enhancing soil fertility. Annual fixation of nitrogen ranges from 21 to 62 lb per acre (23.5 to 69.5 kg per ha) (Rose and Youngberg 1981; Tiedemann 1981; Zavitkovski and Newton 1968). Nodulated plants can improve growth of associated species. Scott (1970) reported Douglas-fir trees growing in the open were half the size of seedlings nourished by snowbrush ceanothus.

Snowbrush ceanothus has been particularly valuable as a pioneer species for improving poor soils and disturbed sites. It has been extensively used to revegetate logging roads, mine wastes, and other disturbances. It is particularly adaptable as a pioneer species capable of stabilizing and improving soil conditions that can then be used to enhance the establishment of associated species (Conard and others 1985; Geier-Hayes 1987; Steele and Geier-Hayes 1992). The shrubs improve soil fertility, which promotes early establishment and growth of other plants (Franklin and Dyrness 1973; Steele and Geier-Hayes 1987, 1992).

This shrub has been one of the most successful species used to revegetate roadways and unstable slopes in the Idaho Batholith, where erosion control is needed during the year of disturbance. Plants establish quickly, and small seedlings or transplants grow rapidly to furnish excellent ground cover. The plant can be seeded in mixtures with fast-developing herbs including western yarrow, fireweed, and Canada goldenrod, or it can be transplanted at various spacings to reduce wind erosion and runoff.

Ecotypes with different growth habits have been selected and used for erosion control. Plants obtained from windswept sites have dense, low-growing growth forms, and have demonstrated adaptability to a wide range of sites. These collections maintain a low, dense, leafy growth habit that provides excellent ground cover. One-year-old bareroot stock normally develops a crown spread of 18 to 30 inches (46 to 76 cm) during the year of establishment.

Plantings established along roadways have persisted following wildfires, and their extensive root system stabilizes roadfills. Regrowth occurs quickly and new shoots protect the soil surface. The evergreen growth habit of this shrub also aids in furnishing yearlong soil cover. The plant has been widely planted for erosion control in the West (Dietz and others 1980; Fessenden 1979; Monsen and Christensen 1975; Plummer 1977; Stark 1966).

Snowbrush ceanothus provides forage and cover for game and wildlife. It is regarded as a primary winter forage for big game, but use varies considerably among geographic regions (Martinka 1976; Stanton 1974; USDA Forest Service 1976). Undoubtedly, differences occur among ecotypes, and collections from some regions are much more heavily grazed than others. Miles and Miekle (1984) reported that

snowbrush and redstem ceanothus are the most important winter browse species for mule deer in the Okanogan Valley in British Columbia, and that 60 to 70 percent of the forage consumed in winter is supplied by these two shrubs. Plants in Idaho (Leach 1956), portions of Montana (Klebenow 1965; Youds and Herbert 1988), and some collections from central California received moderate to heavy use. Within the Great Basin this species receives much less use by big game (Tueller 1979). Although plants are browsed in winter, use is not excessive. Collections of this species have been assembled and field planted at various locations in Idaho. Collections from California, northern Idaho, and Oregon have received more use than most Intermountain region accessions. Use also varies by season (Martinka 1976; McCulloch 1955) and among big game animals (Kelbenow 1965; Peek 1974; Watson and others 1980).

Snowbrush ceanothus withstands considerable winter browsing and is able to recover without apparent loss in vigor. Snow cover and winter frost damage reduce both forage availability and animal use. Many sites are often covered with deep snow, and plants are unavailable for long periods (Miles and Miekle 1984).

Cattle generally make little use of this shrub (Curtis 1952). However, Miles and Miekle (1984) noted that they selectively used it in late fall and winter, thus competing with big game for winter browse. Sheep and goats browse new growth after fire (Stanton 1974).

Nutrient value varies among sites. In British Columbia, Miles and Miekle (1984) found snowbrush and redstem ceanothus were the only two native shrub species that provided maintenance level protein for deer in the winter months. Digestible energy was higher for snowbrush ceanothus than for all other native shrubs. The winter fiber content of snowbrush ceanothus was 26 percent, lower than any other shrub tested (Miles and Miekle 1984). This is due to the retention of leaves on the bush. This provided a much higher amount of forage with higher nutritive content than that of deciduous shrubs (Miles and Miekle 1984). In contrast, Dittberner and Olsen (1983) described protein and energy values for this shrub as poor. Blank (1984) and DeByle and others (1989) suggested that fire increases nutritive content, but Miles and Miekle (1984) concluded that the changes do not support the use of fire for nutrient enhancement.

The plant has considerable value in landscape and conservation plantings. Its growth habit, color, and evergreen features provide attractive cover. The plant is suited for extensive cultivation and will survive in organized plantings. In addition, it can be used in low-maintenance situations, and is particularly useful for restoring disturbances where native species are desired.

Varieties and Ecotypes—None. However, ecotypes with low growth forms, and selections that receive heavy browsing have been identified. These selections could quickly be advanced with more extensive seeding projects.

Family Salicaceae

Salix species
Willow

Introduction—There are about 300 species of willows worldwide; about 70 species are native to North America (Brinkman 1974i). Willows are constituents of many riparian zones in the Western United States. Their root systems stabilize streambanks, while stems and leaves dissipate flood energy and catch sediments. Willows contribute to the formation of overhanging banks that provide shade, cover, food, and travel corridors for a large number of vertebrates and invertebrates and microsites for establishment of many plant species (Clary and McArthur 1992; Kovalchik and Elmore 1992; Thomas and others 1979b).

Damage to many riparian ecosystems has resulted from improper grazing practices, logging, road construction, recreation, water impoundments, and other human activities. Land management efforts have recently centered on restoration and maintenance of these dynamic ecosystems. Research and riparian classification studies are rapidly providing knowledge of willow ecology and guidelines for management (Hansen and others 1988a,b, 1995; Kovalchik 1987; Manning and Padgett 1995; Padgett and others 1989; Szaro and Patten 1986; Youngblood and others 1985).

Natural regeneration processes and techniques for restoration of riparian communities have also received recent attention. Improvement of degraded riparian areas requires that factors causing degradation be addressed (Briggs 1995; Briggs and others 1994). Restoration efforts are unlikely to be successful unless the causes of degradation are first mitigated.

Most willow species are easily propagated; but little information is available for many individual species. General techniques for vegetative propagation and production from seed are provided below. Specific requirements, where known, are described in the plant culture chapter for each species.

Vegetative Propagation—Most willows can be propagated from hardwood cuttings. Techniques for harvesting and preparing cuttings are provided in Chapter 29 and in many books on plant propagation. Stems of most willows contain dormant, preformed root primordia. These are formed during the first year and quickly develop into roots when conditions are favorable (Haissig 1970, 1974). Upland species such as

Scouler willow do not produce root primordia. They root more slowly, and root initials appear only at the base of the cutting (Densmore and Zasada 1978).

Cuttings should be collected on or near the planting site whenever possible. Released varieties of some willow species are available from commercial nurseries, and can be used if restoration using local material is not an objective or if local material is unavailable (Carlson 1992; Darris and Lambert 1993; USDA Soil Conservation Service 1993a,b).

Unrooted cuttings may be used on sites with favorable planting conditions and long growing seasons. Dormant cuttings may be taken from fall through early spring. Densmore and Zasada (1978) found that cuttings taken in early spring rooted more readily than cuttings harvested in late fall. Rooted cuttings may be required for species that do not produce preformed root primordia and for plantings on sites with short growing seasons, rapidly declining water tables, or other factors that might slow establishment.

Rooted and unrooted cuttings should be planted in areas appropriate for each species. Cuttings or rooted stock should be planted at depths permitting the developing root system to remain in contact with the water table throughout the summer (Busch and others 1992). Plantings may be conducted in fall when water levels are low and appropriate planting areas exposed. This aids planters in placing the cutting base or root system at an adequate depth and permits early-spring root growth, but it also exposes cuttings or plants to spring runoff and flooding. Some plantings must be completed after spring runoff. Streams with artificially manipulated flows present special problems, as root growth may not be rapid enough to advance with a rapidly declining water table.

Survival and growth of willow plantings may require that vegetative competition be removed or reduced at the time of planting. Neiland and others (1981) found that competition with tall, dense grass stands adversely impacted survival. Svejcar and others (1992) and Conroy and Svecar (1991) obtained greater second-year survival of Geyer willow cuttings planted on bare ground than on Nebraska sedge/Baltic rush sites even though depth to the water table in midsummer was less on the Nebraska sedge/Baltic rush sites. They interpreted these results to represent an interaction of biotic and abiotic factors on willow establishment.

Large planting stock may be used when depressed water tables or browsing are problems (York 1985). Planting poles or dormant stubs permit the base of the cutting to be placed in the water table; foliage is produced beyond the reach of browsing animals, and cover and soil protection are obtained quickly. However, pole plantings are costly, and natural regeneration is generally unlikely to occur unless the water table is restored or browsing curtailed.

Willows may also be used to stabilize eroding streambanks and other disturbances. Such practices as wattling, brush matting, and branch packing are used to provide physical stability as vegetative cover develops (Gray and Leiser 1982; USDA Soil Conservation Service 1992). Live and dead plant materials including stems and branches are buried, planted, or placed on the soil to reduce soil movement, protect erosion control structures, and enhance vegetation development. Live willow cuttings used in these procedures often root, providing dense root systems and cover.

Propagation From Seed—Willows are dioecious; male and female flowers are borne on separate plants. Inflorescences are catkins or aments that, depending on the species, appear before, with, or after the leaves (Brunsfeld and Johnson 1985). The flowers are pollinated by bees. Fruits are capsules; each contains numerous tiny, hairy seeds. Seeds of most species ripen and are rapidly dispersed in early to midsummer (Brinkman 1974i). Dispersal may be timed to coincide with low water levels. Seeds are carried over long distances by wind and water. Hairs on the seeds may aid in dispersal; they may also function in the germination process (Martens and Young 1992). Summer-dispersed seeds may be viable for as little as 1 week (Densmore and Zasada 1983). They are nondormant and germinate rapidly, often in 24 to 48 hours, if deposited on wet, exposed substrates. Germination occurs rapidly over a wide range of temperatures. A requirement for exposure to light may ensure that germination occurs in areas free of vegetative competition. The ability to germinate over a wide range of temperatures may compensate for the short period of viability (Densmore and Zaszada 1983). Seed coats are transparent, and embryos contain chlorophyll. Consequently, germination and seedling development are rapidly initiated under favorable circumstances.

Wide dispersal enables willows to act as pioneer or early successional species following flooding, burns, or other disturbances that create suitable microsites for germination. Continued rapid growth enables seedlings to develop root systems that remain within reach of the declining water table in summer, compensate for the late period of germination, and withstand flooding during the succeeding spring.

Some arctic and high-elevation willows such as grayleaf willow mature seed in summer, but delay dispersal until fall (Densmore and Zasada 1983; Zasada and Viereck 1975). These seeds exhibit conditional dormancy; they are capable of germinating at high temperatures, but not at the lower ambient temperatures of the season. Embryos of late-dispersing species generally contain low amounts of chlorophyll. Wet overwinter chilling of these seeds releases dormancy, permitting seeds to germinate soon after snowmelt

and maximizing the period for seedling development during the short growing season.

Willow seeds may be hand harvested once the capsules begin opening, or recently dispersed seed may be collected from drifts (Brinkman 1974i). Use of a commercial shaker has been suggested for harvesting yellow poplar seed; the feasibility of using this system for collecting willow seed has not been assessed (Cech and Keys 1987). However, because ripening within stands, plants, and catkins is uneven, it is often advantageous to harvest entire catkins just as the capsules turn from green to yellowish or as the first capsules begin opening (Brinkman 1974i; Martens and Young 1992). Catkins can then be spread to dry in an enclosed area until the capsules open. With either method, it is imperative that maturation be monitored closely.

Seeds may be planted without cleaning, other than removal of twigs, leaves, and catkin branches. Martens and Young (1992) suggested that hairs not be removed from the seeds; their function is not fully understood. However, the hairs do cause the seeds to cling together. They may be removed by gentle carding (Atchley 1989) or by forcing air through a series of sieves containing the seeds (Fung and Hamel 1993; Harder 1970). Both techniques are rather slow if large quantities of seed are to be cleaned.

Brinkman (1974i) reported willow seed could be stored for only 10 days at room temperature, but viability could be maintained for 1 month if seed is stored wet in sealed, refrigerated containers. Zasada and Densmore (1977, 1980) found that seed of several summer and fall-dispersing willows could be stored for up to 3 years if dry seed was placed in doubled 3-mil polyethylene bags and stored at 14 °F (–10 °C).

Seeds may be sown directly into containers or onto wet soil surfaces. In the bareroot nursery, seed may be covered lightly using a roller (Brinkman 1974i). It is essential that the soil surface be kept wet and shaded, if possible. Seeds may be broadcast on appropriate sites if surfaces remain wet. Little information is available on production of planting stock from seed or direct seeding. Use of seed may be advantageous if local cutting material is not available. The ability to store seed for up to 3 years provides some flexibility in planning propagation and in timing direct seeding.

Family Salicaceae

Salix bebbiana
Bebb willow, beaked willow

Description—Bebb willow is a thicket-forming shrub or small tree growing to 33 ft (10 m) in height. Roots are shallow and dense. Twigs are reddish or grayish brown and hairy when young. Leaves are elliptic, obovate or oblanceolate, mostly 1.2 to 2.4 inches (3 to 6 cm) long and 0.4 to 1.2 inches (1 to 3 cm) wide with entire to shallowly toothed margins. Upper surfaces are green, and lower surfaces are glaucous with prominently raised veins. Catkins emerge and mature with the leaves. Staminate catkins are 0.4 to 0.8 inch (1 to 2 cm) long. Pistillate catkins are whitish yellow and 0.6 to 2.4 inches (1.5 to 6 cm) long. Floral bracts are narrow, pale yellow to light brown, and sparsely to densely hairy. Capsules are very loosely arranged and borne on stipes 0.08 to 0.16 inch (2 to 4 mm) long. They are ovoid conic, 0.2 to 0.3 inch (5 to 8 mm) long, short hairy, and long beaked. Stigmas are two lobed (Brunsfeld and Johnson 1985; Hitchcock and others 1964; Welsh and others 1987).

Plants begin flowering when 2 to 10 years old; optimum seed producing age is 10 to 30 years (Hansen and others 1988a,b; Rawson 1974). Bebb willow flowers from April to July or August (Gill and Healy 1974; ISTA 1966; Viereck and Little 1972). Fruits ripen and seeds are dispersed from May to August (Densmore and Zasada 1983; ISTA 1966).

Ecological Relationships and Distribution—Bebb willow is widespread in Canada and the United States, occurring from low to upper-middle elevations (Brunsfeld and Johnson 1985; Hitchcock and others 1964). It does not occur west of the Cascade Mountains or in California. At low elevations Bebb willow grows in broad meadows and on alluvial terraces and subirrigated slopes. It is most common on organic or mineral soils with textures ranging from silty to sandy or gravelly (Marchant and Sherlock 1984), and it will tolerate moderately alkaline to moderately acidic soils (pH 5.5 to 7.5) (Haeussler and Coates 1986). Water tables are usually within 3.3 ft (1 m) of the soil surface throughout the summer. Mottled or gleyed soils are common in the first 3.3 ft (1 m) (Hansen and others 1995). At upper elevations Bebb willow is found in drier riparian areas.

Uplands associated with Bebb willow may be dominated by Wyoming big sagebrush, mountain big sagebrush, Douglas-fir, or Engelmann spruce communities. Aspen, black cottonwood, and water birch are common overstory associates (Brunsfeld and Johnson 1985; Padgett and others 1989).

Bebb willow may dominate early seral willow communities along rivers and streams, overflow channels, or seeps (Boggs and others 1990). Seeds germinate on wet mineral substrates with full exposure to sunlight. Suitable seedbed microenvironments include recent alluvial deposits along streams and abandoned, silt-filled beaver ponds (Hansen and others 1988a). Seedlings colonize wet, exposed mineral soils following fires and have been noted to invade mine spoils in southwestern Canada (Marchant and Sherlock 1984; Watson and others 1980). Burned or otherwise damaged trees resprout readily. Plants may also develop

from detached branch segments (Watson and others 1980).

Bebb willow communities are relatively stable once established. They may persist for long periods due to the presence of high water tables or short periods of flooding (Hansen and others 1988a,b). Bebb willow requires full sun and lacks shade tolerance (Watson and others 1980); it may be replaced by taller species.

Plant Culture—Bebb willow may be propagated as rooted cuttings, but reports of rooting capability vary. In Alaska, cuttings harvested in autumn after leaf fall or in spring following leaf expansion failed to root (Densmore and Zasada 1978). In contrast, rooting success of current year's softwood, also harvested in Alaska, was 42 percent (Halloway and Zasada 1979). In Montana, Atchley (1989) obtained 40 percent rooting when cuttings of 4-year-old wood were harvested in May. Platts and others (1987) reported dormant cuttings rooted readily. Growth was initiated in about 10 days and shoot growth in 10 to 20 days. Roots were formed along the entire length of the stem.

For production of rooted cuttings in Saskatchewan, Cram (1976) recommended that 6-inch (15-cm) cuttings be harvested in early fall and immediately placed in cold storage at 34 °F (1 °C) for spring planting in a bareroot nursery. Rooted cuttings were subsequently outplanted as 1-0 stock. Watson and others (1980) reported 30 to 70 percent survival of 1-0 rooted hardwood cuttings on mine overburden in northern Alberta; most mortality resulted from rodent damage. Unrooted cuttings are sometimes used. Hansen and others (1988a,b, 1995) recommended use of early spring-harvested dormant cuttings 12 to 20 inches (30 to 50 cm) long with diameters greater than 0.4 inch (1 cm).

Bebb willow seeds must be harvested immediately when mature; seeds are dispersed in a period of 1 or 2 days (Marchant and Sherlock 1984). Fruits are green when preripe and yellowish when ripe (Watson and others 1980). Seeds may be hand harvested from trees or from recently dispersed drifts. Seeds may be used with or without cleaning (Brinkman 1974i). Atchley (1989) found that carding was more effective than the air-blowing technique described by Harder (1970) for removing the dense hairs from the seeds. Seeds vary in size and shape. Atchley (1989) found that viability was greater for plump, green seeds compared to small dark-brown seeds or wrinkled seeds. There are about 2,500,000 cleaned seeds per lb (5,500,000 per kg) (Brinkman 1974i). Bebb willow seeds collected in Alaska can be stored dry for at least 3 years in doubled 3-mil polyethylene bags at 14 °F (–10 °C) (Zasada and Densmore 1980).

Fresh seeds collected in Alaska are nondormant. Germination at temperatures from 41 to 77 °F (5 to 25 °C) exceeded 90 percent (Densmore and Zasada 1983; Zasada and Viereck 1975). This adaptation permits the short-lived seeds to germinate in highly variable environments during the short Alaskan growing season. By contrast, freshly harvested Montana seeds were highly germinable at 59 to 77 °F (15 to 25 °C) and less germinable at 41 to 50 °F (5 to 10 °C) (Atchley 1989). Thus, germination may be inhibited by cool seedbed microenvironments. Bebb willow seedlings can tolerate some shade (Atchley 1989).

Uses and Management—Watson and others (1980) described Bebb willow as being a rapid grower, capable of recovering rapidly after browsing, moderately aggressive on suitable sites, a relatively good soil stabilizer, and exhibiting low drought tolerance. Stands stabilize streambanks, providing protection from flooding. Bebb willow often occurs in clumps rather than continuous canopies (fig. 43). Thus, it provides shading for fisheries while permitting good access to recreational fishing sites. Campgrounds cannot be established within Bebb willow sites because the soils are generally wet early in the season.

Figure 43—Thickets of Bebb willow dominate many riparian communities from low to upper mid elevations in western mountain ranges.

Bebb willow provides a major source of highly productive and palatable browse for moose, deer, rabbits, elk, beaver, and bighorn sheep (Marchant and Sherlock 1984; Watson and others 1980). It is more tolerant of browsing than Geyer willow, Booth willow, yellow willow, and Drummond willow, and may increase at their expense following heavy browsing (Hansen and others 1995). Use of Bebb willow increases in late winter. It remains accessible in deep snow as branches are bent down and become accessible to browsing animals (Dorn 1970; Viereck and Little 1972). Song birds and game birds use the species for nesting and food.

Bebb willow communities are often adjacent to meadows grazed heavily by livestock (Boggs and others 1990; Dorn 1970). Trees are usually widely spaced, allowing for easy access (Tesky 1992). Consequently, deferring grazing until sites are dry may be required to reduce livestock trampling and soil compaction (Boggs and others 1990). Heavy livestock use may restrict Bebb willow seedling establishment, resulting in stand degeneration.

Prescribed burns can be used to rejuvenate degraded Bebb willow stands (Hansen and others 1988a,b; Tester and Marshall 1962). Burned plants sprout rapidly from basal stems. The small seeds are dispersed over considerable distances (Haeussler and Coates 1986; Kovalchik and others 1988). Establishment from seed depends on timing of the fire and availability of wet mineral soils to support germination and seedling establishment (Chrosciewicz 1988; Viereck and Little 1972; Viereck and Schandelmeirer 1980).

Bebb willow is used as a "diamond willow" for carving canes, lampposts, and furniture (Watson and others 1980). Wood of this species has also been used for baseball bats, charcoal, and gunpowder (Viereck and Little 1972) .

Varieties and Ecotypes—"Wilson" Bebb willow was released in 1985 by the Alaska Plant Materials Center (Wright 1989). It exhibits wide adaptability and a dense growth habit; it is useful for windbreaks, living fences, and screens.

Family Salicaceae

Salix boothii
Booth willow

Description—Booth willow is a highly branched, rounded shrub with numerous basal stems 10 to 20 ft (3 to 6 m) tall. Young twigs are yellow to dark brown and hairy, becoming glabrous at maturity. Mature leaves are elliptical to broadly lanceolate, thick, firm, and about 0.8 to 3 inches (2 to 8 cm) long. Margins are entire to toothed with fine, gland-tipped teeth. Both leaf surfaces are moderately pubescent when young. Upper surfaces of mature leaves are green; lower surfaces are paler, but not glaucous. Catkins expand with or slightly before the leaves. Staminate catkins are 0.4 to 1 inch (1 to 2.5 cm) long; pistillate catkins are 0.8 to 1.6 inches (2 to 4 cm) long. Floral bracts are brown to black and pubescent with long, curly, tangled hairs. Capsules are borne on stipes less than 0.08 inch (2 mm) long. They are 0.12 to 0.24 inch (3 to 6 mm) long, oblong ovate, and glabrous. Stigmas are nearly entire (Brunsfeld and Johnson 1985; Hitchcock and others 1964; Welsh and others 1987).

Ecological Relationships and Distribution—Booth willow occurs at midelevations from British Columbia to Alberta and south to northeastern California and Colorado (Brunsfeld and Johnson 1985). It may dominate or codominate early seral willow communities in fens, bogs, abandoned beaver ponds, wet meadows, and riparian sites, ranging from recently exposed rocky or gravelly deposits with high water tables to drier benches with deep sandy to clay-loam soils and water tables to 3.3 ft (1 m) below the soil surface (Brunsfeld and Johnson 1985; Manning and Padgett 1995; Padgett and others 1989; Youngblood and others 1985). Booth willow will tolerate moderately alkaline, but not strongly acidic or basic soils (Haeussler and others 1990).

Booth willow often grows in association with Geyer willow and whiplash willow in open bottom lands (fig. 44) and with Drummond willow in forested stream bottoms. Understory species range from beaked sedge and Nebraska sedge in wetter communities to various forbs and shrubs in drier areas. Kentucky bluegrass may be a dominant understory

Figure 44—Shrubby Booth willow is overshadowed by treelike whiplash willow.

species in areas with histories of grazing disturbances and dry surface soils (Hansen and others 1988a,b). Uplands associated with Booth willow support sagebrush, juniper, western spruce-fir, lodgepole pine, Douglas-fir, and alpine meadow communities (Esser 1992).

Booth willow resprouts following burning or mechanical damage. Resprouting is more vigorous if stem removal occurs during the dormant season (Kovalchik and others 1988). Booth willow is also tolerant of frost and flooding. Efficiency of gas exchange and root regeneration are increased by the presence of aerenchyma; adventitious rooting may occur above the level of flooded soil (Kovalchik 1992). However, growth is reduced by prolonged flooding above the level of the root crown.

Flowering occurs from May to June. Fruits ripen and seed is dispersed in late July and early August (Haeussler and others 1990; Zasada and Viereck 1975). Greatest quantities of seeds are produced by plants that are 2 to 10 years old (Brunsfeld and Johnson 1985; Haeussler and others 1990). Booth willow regenerates from short-lived seeds that are dispersed by wind or water. Suitable microsites for germination include wet sand or gravel surfaces receiving full sunlight (Hudak and Ketcheson 1992).

Plant Culture—Booth willow may be used to revegetate degraded riparian areas. Cuttings root readily and abundantly along the lower one-third of the stem (Platts and others 1987). New roots and stems are initiated in 10 to 15 days. Seedlings must be protected from browsing for at least 3 years to ensure establishment (Kay and Chadde 1992).

Fresh seeds harvested in Alaska germinated rapidly and nearly completely at constant temperatures ranging from 41 to 77 °F (5 to 25 °C) (Densmore and Zasada 1983). This behavior may be an adaptation to a short period of viability, the short growing season, and extreme variability in microsite conditions.

Uses and Management—Booth willow provides browse for moose, elk, deer, small mammals, birds, and other wildlife (Chadde and Kay 1988; Manning and Padgett 1995; Youngblood and others 1985). Excessive browsing can reduce Booth willow regeneration and seed production (Kay and Chadde 1992). Booth willow communities provide cover for many terrestrial species and shade and overhanging banks for fish (Brunsfeld and Johnson 1985; Manning and Padgett 1995). Streams in Booth willow stands may provide recreational fishing, but access is restricted by the dense canopies.

Palatability of Booth willow is fair for livestock and sheep; use increases late in the season (Manning and Padgett 1995; Padgett and others 1989; Youngblood and others 1985). Geyer willow, which is often abundant or dominant in Booth willow communities, is generally more palatable. Livestock use of both species should be restricted until soils are dry to avoid compaction (Hansen and others 1988a,b). Production of Booth willow stands is often high, while understory production is variable, depending on the amount of willow canopy present. Heavy use on sites with fine soils and palatable understory species must be avoided to preclude soil erosion and bank sloughing.

Prescribed burning may be used to rejuvenate decadent stands and increase sprouting for use by big game (Haeussler and others 1990; Manning and Padgett 1995). Plants also reestablish from offsite seed sources if burning occurs prior to seed dispersal and fires are severe enough to expose mineral seedbeds (Densmore and Zasada 1983; Zasada and Viereck 1975).

Varieties and Ecotypes—None.

Family Salicaceae

Salix drummondiana
Drummond willow, beautiful willow, blue willow

Description—Drummond willow is a multiple-stemmed shrub usually 10 to 13 ft (3 to 4 m) tall. Young twigs are finely hairy and yellow or green, later becoming glabrous and purple brown to yellow with a bluish glaucous bloom. Mature leaves are elliptic to lanceolate or oblanceolate, 1.6 to 3.5 inches (4 to 9 cm) long and 0.5 to 0.8 inch (1.3 to 2 cm) wide. Margins are entire and somewhat revolute. Leaf surfaces are dark green above and glaucous to strongly silvery pubescent beneath. Catkins expand before or with the leaves; flowering generally occurs in May (Dittberner and Olson 1983; Munz 1973). Staminate catkins are 0.4 to 1 inch (1 to 2.5 cm) long. Pistillate catkins are 0.6 to 1.6 inches (1.5 to 4 cm) long, densely flowered, and silvery pubescent. Floral bracts are black or dark brown, long hairy, and persistent. Capsules are 0.12 to 0.16 inch (3 to 4 mm) long and densely short hairy. Stigmas are lobed (Brunsfeld and Johnson 1985; Hitchcock and others 1964; Sutton and Johnson 1974; Welsh and others 1987).

Ecological Relationships and Distribution—Drummond willow occurs from Yukon and Saskatchewan south to California and New Mexico and east across southern Canada and the Northern United States. It occurs at mid to high elevations from the upper sage to the spruce-fir zone (Brunsfeld and Johnson 1985; Hansen and others 1995; Manning and Padgett 1995). It is found around springs, seeps, beaver ponds, lakes, ponds, and on flood plains and benches adjacent to swift, rocky, high gradient streams (fig. 45). At the lower edge of its range it generally

grows in wet, sandy or gravelly soils adjacent to streams. In cooler habitats at higher elevations it is more abundant and occurs across broad valley bottoms. In such areas it grows on moist, well-aerated mineral soils ranging from sandy to clayey loams. The water table may be near the surface in spring, but it drops below 3.3 ft (1 m) by late summer. Common associates are Booth willow and Geyer willow. Due to the similarity of their ecological requirements, community types in Utah, western Wyoming, and eastern Idaho dominated by either Drummond willow or Booth willow are classified as Booth willow types (Padgett and others 1989; Youngblood and others 1985). However, Goodrich (1992) noted that the dominance of this species and absence of Booth willow along rocky, high-elevation streams of the Uinta Mountains indicates a need to describe one or more riparian community types in which Drummond willow is the dominant woody species.

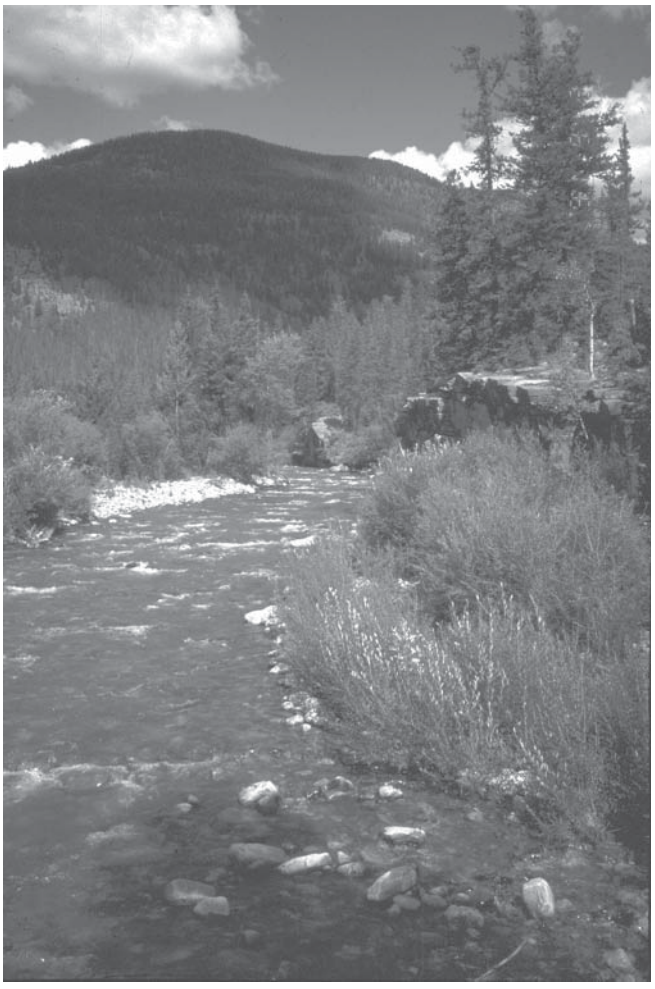

Figure 45—Drummond willow borders a high gradient stream in eastern Utah.

Plant Culture—Drummond willow is useful for stabilization of disturbed sites adjacent to streams and ponds. The species may be established from unrooted or rooted cuttings. Unrooted cuttings are most successful if planted on sites that remain wet throughout the growing season. Two to 4-year-old hardwood cuttings harvested in early spring root readily with root initials appearing along the length of the stem. Roots and shoots appear about 10 days after planting (Platts and others 1987). Seed biology of Drummond willow has not been studied. Seeds ripen in summer and remain viable for about 1 week (Uchytil 1991a).

Uses and Management—Drummond willow communities are long lived, but shade intolerant. Productivity is generally high. Stands provide stream stabilization, dense shade for fish, and habitat for beaver, birds, and other wildlife.

Moose and elk make heavy use of Drummond willow, particularly in winter (Peek 1974; Singer 1979; Stevens 1970). Plants in Yellowstone National Park have been stunted by moose and elk use (Chadde and Kay 1988; Patten 1968). In Oregon, Drummond willow is considered highly palatable to livestock, big game, and beaver (Kovalchik and others 1988). Heavy browsing by big game may lead to degradation or loss of this species. Loss of willows resulting from heavy use by beaver may result in an increase in graminoids, loss of beaver populations, and lowering of the water table.

Drummond willow communities stabilize streambanks and limit livestock access (Hansen and others 1988a,b). Heavy livestock use or trailing at streamside, particularly when soils are wet, however, may lead to highlining, dead clumps, stand loss, and bank compaction and sloughing. Decadent willows can recover rapidly if browsing is reduced. Excessive livestock grazing may also lead to a loss of palatable graminoids and their replacement by less palatable weedy species. Drummond willow stands may act as natural firebreaks in wet years, but during dry seasons they may burn (Crane 1982). Decadent Drummond willow stands may be rejuvenated using prescribed burning in late summer or early fall when sites have dried. Burning near streambanks should be carefully regulated. Livestock grazing must be curtailed for at least 2 or 3 years following burning. Plants recover by resprouting from the root crown following fire (Boggs and others 1990; Kovalchik and others 1988). Seed dispersed from unburned areas may germinate on exposed, wet mineral soils (Viereck 1982; Viereck and Schandelmeier 1980). Recovery from seed depends on seed availability, season of burning, and the presence of open, wet mineral soils.

Varieties and Ecotypes—"Curlew" Drummond willow was cooperatively released by the USDA Soil Conservation Service Pullman Plant Materials Center

in 1993 (USDA Soil Conservation Service 1993a). Curlew is valuable for inclusion in conservation plantings for streambank stabilization, erosion control, improvement of wildlife habitat, naturalized landscaping, and shelterbelts. It grows on wet, sandy to gravelly sites in areas receiving 20 to 25 inches (51 to 64 cm) of precipitation. The release originates from a native population growing near the Curlew River, Ferry County, Washington. It is propagated from seed or cuttings. Hardwood cuttings taken in late winter are most commonly used.

Family Salicaceae

Salix exigua
Coyote willow, dusky willow, narrowleaf willow, sandbar willow

Description—Coyote willow is a colonial shrub that spreads underground to form dense thickets. Stems develop from shoot buds on lateral roots. Stems are numerous, slender, and up to 16 ft (5 m) tall. Young twigs are thinly to densely hairy; older ones are glabrous and brown to reddish brown. Mature leaves are linear to oblong, entire to minutely toothed, 0.8 to 4.3 inches (2 to 11 cm) long, and 18 to 30 times longer than wide. Leaf surfaces are gray green to silvery white, and glabrous to densely pubescent. Catkins terminate the twigs and emerge and mature with or after the leaves. Staminate catkins are yellowish and 0.6 to 1.8 inches (1.5 to 4.5 cm) long. Pistillate catkins are 0.6 to 2.4 inches (1.5 to 6 cm) long. Floral bracts are yellowish and hairy. Capsules are 1.6 to 2.8 inches (4 to 7 cm) long, sessile, and glabrous to hairy. Stigmas are deeply lobed (Brunsfeld and Johnson 1985; Hitchcock and others 1964; Welsh and others 1987).

Flowering occurs from April to July (Dittberner and Olsen 1983). Fruits mature and seeds are dispersed from May to July (Brinkman 1974i; Noble 1979; Ware and Penfound 1949). Seed dispersal may correspond to low water levels (Youngblood and others 1985).

Ecological Relationships and Distribution—Coyote willow is widespread in North America, but occurs entirely east of the Cascade Mountains at low, or occasionally midelevations from the sagebrush to the spruce-fir zone. Coyote willow is one of the earliest pioneer species to colonize freshly deposited sand and gravel bars, which may be below the high water mark where it is subject to annual flooding, ice jams, and associated scouring and deposition (Hansen and others 1988a,b; Wasser and Hess 1982). It frequently occurs along streams and rivers in bottom lands, forming a narrow zone between the water's edge and adjacent cottonwood, water birch, thinleaf alder, or other willow communities (Kovalchik 1987; Szaro and Patton 1987; Youngblood and others 1985). It also grows on rocky, gravelly, and sandy lake and pond edges; wet, well-drained alluvial terraces and bottom lands that may have fine-textured soils (fig. 46); along irrigation ditches; and in wet areas along roadways (Brunsfeld and Johnson 1985). Soil surfaces in communities at the water's edge are often characterized by high percentages of exposed areas and rocky surfaces, and provide seedbeds for establishment of a wide array of annual and perennial herbaceous species (Youngblood and others 1985). Sandbar willow may continue to dominate repeatedly disturbed areas, regenerating by rootsprouting or establishing from seed. Stabilized communities of this shade-sensitive species may eventually be replaced by cottonwoods or other willow species.

Two subspecies of coyote willow are widespread in the Intermountain area; considerable variability occurs within each subspecies. *Salix exigua* ssp. *exigua* occurs primarily in the Wyoming big sagebrush zone of foothill areas and is distributed from southern British Columbia and Alberta to northern Mexico. This subspecies is characterized by entire or few-toothed, gray-green to silvery pubescent leaves; late-developing catkins; and narrow, acute floral bracts. *S. e.* ssp. *melanopsis* is distributed from Alberta to California and south to northern Colorado, and occurs at higher elevations than ssp. *exigua* (Hitchcock and others 1964). Subspecies *melanopsis* is distinguished by its toothed to subentire leaves that are glaucous beneath, glabrous capsules, and blunt floral bracts (Brunsfeld and Johnson 1985).

In addition to spreading by suckering, coyote willow produces numerous small seeds that are dispersed by wind and water (Arno and Hammerly 1977; Mozingo

Figure 46—Coyote willow forms a dense thicket along a dry streambed.

1987). Seeds germinate within 24 hours if exposed to freshly deposited, wet alluvium in full sunlight (Densmore and Zasada 1983). In the field, seeds generally do not remain viable for more than 1 week (Ware and Penfound 1949). Branches are flexible and resprout if buried in sediment. Plants may also regenerate vegetatively from broken stems and roots deposited on exposed, wet soils.

Plant Culture—Coyote willow is an excellent species for restoration of disturbed riparian areas and recently deposited sediments because of its early successional status, rapid growth, and ability to root sprout (Uchytil 1989a). Unrooted cuttings may be used successfully on low-elevation sites where the water table remains high throughout the growing season. Rooted stock should be used on sites with fluctuating water tables, high flooding potentials, or short growing seasons. Coyote willow cuttings develop roots along the entire length of the stem (Platts and others 1987). Roots and shoots appear in about 10 days.

There are about 10,000,000 cleaned seeds per lb (22,000,000 per kg) (Brinkman 1974i). At 72 °F (22 °C), Brinkman (1974i) obtained 83 percent germination in 4 days.

Uses and Management—Maintenance of coyote willow stands is important because of their ability to stabilize streambanks (Uchytil 1989a). Loss of this species as a result of browsing and human-caused disturbances can lead to serious erosion problems (Hansen and others 1988a,b).

Coyote willow is browsed by moose, elk, and to a limited extent, mule deer (Patten 1968; Van Dersal 1938). It is heavily used by beaver (Mozingo 1987). Thickets of sandbar willow provide valuable cover for birds and other wildlife species (Lindauer 1983). However, because of their upright growth habit, they provide only moderate amounts of shade for fish (Hansen and others 1988a,b). Dense stands of coyote willow bordering streams may limit access by fishermen. As such stands are seasonally flooded, they should not be used for campgrounds or roadways (Hansen and others 1988a,b). Coyote willow is used for forage and especially for cover by livestock (Van Dersal 1938). Forage production is low to moderate (Hansen and others 1988a,b).

Coyote willow communities often act as firebreaks due to their occurrence on sites with high water tables or near streams, but they may burn during unusually dry years. Burned plants may resprout from roots and spread from offsite seeds dispersed to wet mineral soils (Conrad 1987; Rowe and Scotter 1973; Zasada 1986).

Varieties and Ecotypes—"Silvar" coyote willow was cooperatively released by the USDA Soil Conservation Service, Pullman Plant Materials Center in 1993 (USDA Soil Conservation Service 1993b). The release originated from material collected on the Tucannon River, near Starbuck, Washington, at an elevation of 560 ft (170 m). It is recommended for use in conservation plantings for riparian area stabilization and restoration, wildlife habitat improvement, and shelterbelts. It is normally propagated from cuttings, but seed can be used.

Family Salicaceae

Salix geyeriana
Geyer willow

Description—Geyer willow is a large shrub or small tree with numerous slender, ascending stems 10 to 13 ft (3 to 4 m) in height arising from a tight basal cluster (fig. 47). The root system is deep, fibrous, and spreading (Sutton and Johnson 1974). Young twigs are densely hairy, but become glaucous; older twigs

Figure 47—Geyer willow forms clumps or corridors that provide cover and travel routes for big game.

are brownish purple and glabrous. Early leaves of the season are glabrous above with long, silky hairs beneath. Mature leaves are lanceolate to elliptical, entire to inconspicuously toothed, 1.2 to 3 inches (3 to 8 cm) long, and 0.3 to 0.5 inch (8 to 12 mm) wide. Surfaces are silvery to gray green above, glaucous below, and hairy on both sides. Catkins expand with the leaves on short, leafy branchlets. Staminate catkins are yellow to reddish and 0.3 to 0.6 inch (0.7 to 1.5 cm) long. Pistillate catkins are globose, reddish, 0.4 to 0.6 inch (1 to 1.5 cm) long, and loosely flowered. The persistent floral bracts are sparsely hairy and yellow to brown or blackish. Capsules are hairy, ovoid oblong, and 0.1 to 0.2 inch (3 to 6 mm) long. Stigmas are nearly entire (Brunsfeld and Johnson 1985; Hitchcock and others 1964).

Ecological Relationships and Distribution—Geyer willow occurs at low to upper elevations from British Columbia to Montana and south from California to Colorado. It grows in wet meadows and marshes, beaver ponds, valley bottoms along meandering streams, and on dry stream benches from the sagebrush to the spruce-fir zone (Brunsfeld and Johnson 1985; Uchytil 1991b). It most commonly grows on fine-textured silty to clay-loam soils that may contain some cobbles or gravels and have considerable organic material and mottling near the surface (Padgett and others 1989; Youngblood and others 1985). Plants usually grow in clumps, but may form a more or less continuous corridor near streamside. Communities in broad valleys are relatively stable and maintained by seasonal flooding and high water tables within 3.3 ft (1 m) of the surface. Associated willow species often include Bebb willow, Booth willow, yellow willow, plainleaf willow, Drummond willow, and Lemmon willow. The understory often includes a moderate to dense cover of graminoids and forbs.

Geyer willow flowers from May to August (Dittberner and Olson 1983; Munz 1973). In eastern Oregon seed dispersal begins in early July (Padgett 1981). Seedlings colonize wet, exposed, well-aerated mineral soils, but can withstand anaerobic conditions (Manning and Padgett 1995).

Plant Culture—Either unrooted or rooted Geyer cuttings may be used to revegetate disturbed sites. Cuttings form roots in about 10 days and shoots in about 10 to 15 days (Platts and others 1987). Conroy and Svejar (1991) and Svejcar and others (1992) found that establishment of Geyer willow was best if unrooted cuttings were planted with the base within 12 inches (30 cm) of the midsummer water table. Waterlogged conditions had no effect on growth of the cuttings.

Uses and Management—Geyer willow is used by moose and elk, especially in winter (Chadde and Kay 1988; Gaffney 1941; Padgett and others 1989). It is more palatable than Drummond willow, Wolf willow, and Booth willow (Boggs and others 1990). Geyer willow clumps and corridors provide excellent cover and travel routes for big game. Beaver use it for food and building material (Allen 1983). It also provides food and cover for birds and small mammals (Argus 1957). Roots of Geyer willow growing along streams contribute to formation of overhanging banks; the canopy provides shade for fish.

In eastern Oregon palatability of Geyer willow to livestock was rated as moderately high (Kovalchik and others 1988). Willows and understory species in these communities are often highly productive and may receive heavy use (Hansen and others 1988). Geyer willow communities provide easy access to livestock. Early season use by wild ungulates, livestock, or vehicles may adversely impact wet organic soils (Manning and Padgett 1995). Excessive use may lead to decreased willow vigor or stand loss, replacement of understory graminoids with less desirable species, lowering of the water table, erosion, and conversion to drier community types (Kovalchik 1987). Decadent Geyer willow can recover if released from browsing pressure.

Plants recover from burning or mechanical damage by sprouting or possibly by establishment of seedlings from offsite seed sources (Kovalchik and others 1988). Fires are infrequent in these areas, but may occur in dry years. Prescribed burning may be used to rejuvenate decadent stands. Areas must be protected from browsing until the stands recover (Boggs and others 1990; Kovalchik 1987).

Varieties and Ecotypes—None.

Family Salicaceae

Salix glauca
Grayleaf willow, glaucous willow

Description—Grayleaf willow is a low shrub 1 to 4 ft (0.3 to 1.2 m) tall. Young twigs are grayish and hairy, becoming reddish brown and glabrous as they mature. Bark of older plants may be rough and furrowed. Mature leaves are lanceolate to elliptical, entire to minutely serrulate, and up to 2.2 inches (5.5 cm) long and 0.3 to 0.9 inch (0.7 to 2.2 cm) wide. Mature leaf surfaces are pale green above and glaucous beneath. They are grayish hairy when young, becoming glabrous as they mature. Catkins expand with the leaves and remain on the plant through summer. Staminate catkins are 0.6 to 1.6 inches (1.5 to 4 cm) long. Pistillate catkins are 0.6 to 2 inches (1.5 to 5 cm) long and densely flowered. Floral bracts are persistent, hairy, and pale brown to black. Capsules are 0.2 to 0.3 inch

(5 to 7 mm) long, long beaked, and densely hairy, becoming nearly glabrous as they mature. Stigmas are bilobed (Brayshaw 1976; Brunsfeld and Johnson 1985; Hitchcock and others 1964; Viereck and Little 1972).

In Alaska and Yukon, grayleaf willow flowers in June. Fruits ripen in July and August and seeds are dispersed in late August and September (Densmore and Zasada 1983; Viereck and Little 1972).

Ecological Relationships and Distribution—Grayleaf willow is a circumboreal species, extending south in North America to alpine and subalpine sites in eastern Idaho, Utah, Montana, Wyoming, Colorado, and northern New Mexico. In the Intermountain area it occurs along streams and in other wet places, on talus slopes, and in snow concentration areas in alpine meadows and forest openings (Padgett and others 1989; Welsh and others 1987). It is found on soils ranging from well drained to poorly drained and usually waterlogged (Alaska Rural Development Council 1977). A low-growing form occurs in open, alpine situations (fig. 48); plants in somewhat protected, subalpine environments are more erect and shrublike (Dorn 1970). An early successional species, grayleaf willow pioneers fresh alluvial deposits, burns, and other disturbed areas with exposed mineral soils (Viereck and Little 1972).

Densmore and Zasada (1983) and Zasada and Viereck (1975) reported that grayleaf willow produces large numbers of small, lightweight seeds that remain on the plant through summer and are dispersed in fall. These seeds remain viable through winter and germinate in spring following snowmelt; this permits seedling development to occur over the entire growing season. Spring ripening populations, however, have been reported (Watson and others 1980). Grayleaf willow often becomes highly abundant following fire, establishing from seed sources in unburned areas (Foote 1983). Seedlings have been noted to invade disturbed sites in Arctic areas (Densmore and Zasada 1983; Viereck and Little 1972). Grayleaf willow sprouts following mechanical damage or burning (Haeussler and Coates 1986). It also spreads vegetatively through rooting of horizontal stems (Sampson and Jones 1977).

Figure 48—Grayleaf willow occurs in alpine areas and exhibits a low, spreading growth habit.

Plant Culture—Densmore and Zasada (1978) found that untreated cuttings of 2-year-old wood, taken in autumn following leaf fall or in spring following leaf expansion, produced few roots. Cuttings treated with rooting hormones produced few to moderate numbers of roots along the entire length of the cutting (Platts and others 1987). Roots and stems appeared in about 10 days. Cuttings have been used to plant unstable sand dunes in northern Alberta (Hardy BBT Limited 1989).

Seed may be used to propagate planting stock. Direct seeding may also be practical (Uchytil 1992). Densmore and Zasada (1983) and Zasada and Viereck (1975) found that fresh seeds were conditionally dormant. Germination increased with constant incubation temperatures from 41 to 77 °F (5 to 25 °C). Wet chilling for 90 days released dormancy; germination was initiated during wet chilling, and nearly all seeds germinated when incubated at constant temperatures in the 41 to 77 °F (5 to 25 °C) range. Environmental conditions may influence the level of seed dormancy; this was indicated by variability in germination of seeds by year of collection and geographic origin. Germination also varied among seeds from different catkins on the same plant.

Seeds may be stored at 14 °F (–10 °C) in doubled 3-mil polyethylene bags for up to 3 years without loss of viability (Zasada and Densmore 1980; Zasada and Densmore 1977). The initial dormancy of some seed lots is lost in storage.

Use and Management—Grayleaf willow is browsed by moose, but it is generally less palatable than other co-occurring willows (Milke 1969). Caribou make use of the species, primarily in summer; snowshoe hare use is concentrated in winter (Cody 1965; Smith and others 1988). Nutrient quality of grayleaf willow for ungulates is good in winter (Risenhoover 1987; Scotter 1972), but lower growing forms may be covered by snow. Plants are tolerant of heavy browsing. The cover value of grayleaf willow for large ungulates is also limited by its low-growing habit, but dense stands provide good cover for small animals (Uchytil 1992).

Erosion control value of grayleaf willow is considered moderate due to its intermediate growth rate (Alaska Rural Development Council 1977). Established plants, however, provide good soil stabilization.

Varieties and Ecotypes—There are no releases.

Family Salicaceae

Salix lasiandra var. *caudata* Whiplash willow

Description—*Salix lasiandra* plants growing in the Intermountain region belong to *S. l.* var. *caudata*, whiplash willow. Whiplash willow ranges from 10 to 20 ft (3 to 6 m) in height (fig. 49). It is treelike at lower elevations, becoming shrubby at higher elevations. Young twigs are finely hairy, becoming glabrous and yellowish with age. Large branches are yellow to red or brown in winter, while small branches are orangish (Sutton and Johnson 1974). Mature leaves are lanceolate to elliptic, widest at or below the middle, and serrulate. Leaf surfaces are green and glabrous. The lower surface is paler than the upper, but not glaucous. Petioles often bear glands on the upper side near the junction with the leaf blade. Catkins expand with the leaves. Staminate catkins are white to yellow and 0.6 to 1.8 inches (1.5 to 4.5 cm) long, with three to five stamens. Pistillate catkins are pale green to yellow or white and 0.8 to 2.8 inches (2 to 7 cm) long. Floral bracts are deciduous, yellow green, hairy on the lower part, and glabrous distally. Capsules are narrowly ovate, glabrous, and 0.16 to 0.3 inch (4 to 8 mm) long. Stigmas are lobed. Flowering occurs in April or May, and fruiting and seed dispersal from June to August (Brinkman 1974i; Hitchcock and others 1964).

Figure 49—Pistillate catkins of whiplash willow are conspicuous, white to green, and appear with the leaves.

Pacific willow (*S. l.* var. *lasiandra*) occurs mostly west of the Cascade Mountains, but also in wetter portions of eastern Washington, northern Idaho, and northwestern Montana. It is distinguished by the glaucous lower surface of its leaves (Brunsfeld and Johnson 1985).

Ecological Relationships and Distribution—Whiplash willow is distributed from Alaska to Saskatchewan and south from southern California to New Mexico at low to mid elevations (Welsh and others 1987). Associated uplands support communities ranging from Wyoming big sagebrush to pinyon-juniper, mountain big sagebrush, and Douglas-fir (Uchytil 1989b). Whiplash willow is commonly a pioneer or early seral species on alluvial sands and gravels adjacent to fluctuating streams and rivers or abandoned river channels (Brunsfeld and Johnson 1985). Stands are maintained by periodic flooding. Whiplash willow may maintain its dominance on stabilized sandbars, as they develop into benches within the flood plain, but it is eventually replaced by later seral willow or cottonwood species (Manning and Padgett 1995). It often occurs with coyote willow, another pioneer species; they form intermittent linear communities between the high water level and later successional woody species growing further from water. Whiplash willow exhibits high tolerance to deposition and flooding and low tolerance of drought and salty soils (USDA Soil Conservation Service 1992). Its productivity is generally low due to repeated flooding.

Whiplash willow spreads primarily from seeds that are dispersed by wind and water (Zasada 1986). Broken twigs or branches of whiplash willow transported downstream and deposited on wet alluvial surfaces may sprout, developing new plants vegetatively (Argus 1973).

Plant Culture—Whiplash willow is widely used for stabilizing streambanks due to its early seral status. It may also be used on appropriate sites to provide naturalized landscaping, screens, or windbreaks. Unrooted or rooted cuttings may be used. Unrooted cuttings are most successful in areas with high water tables throughout the summer and a long growing season. Whiplash willow roots readily along the entire length of the stem. Roots initiate growth in about 10 days and shoots in 10 to 15 days (Platts and others 1987).

Seeds are green when preripe and yellowish when ripe (Brinkman 1974i). There are about 11,500,000 cleaned seeds per lb (25,300,000 per kg). Brinkman (1974i) reported 25 percent germination at 72 °F (22 °C) in 3 days. Densmore and Zasada (1983) found that fresh seed collected in Alaska germinated rapidly and nearly completely at constant incubation temperatures ranging from 41 to 77 °F (5 to 25 °C).

Uses and Management—Whiplash willow colonizes and stabilizes recent alluvial deposits. Roots provide streambank stability; the canopy provides shade for fish. Consequently, management to maintain these stands is critical. Whiplash willow provides valuable habitat for deer and nongame birds (Argus 1973; Arno and Hammerly 1977; Bernard and Brown 1977; Gray and Greaves 1984). Although palatability of whiplash willow for wildlife is generally considered poor or fair, it is an important browse for mule deer (Sampson and Jespersen 1963; USDA Forest Service 1937). Beaver use it heavily in winter (Kindschy 1985).

Palatability of whiplash willow is greater for sheep than for cattle. On wet sites, healthy whiplash willow stands are not easily accessed by livestock because of the dense overstory. Therefore, these stands are only moderately susceptible to overgrazing, trampling, and compaction (Manning and Padgett 1995). Communities with coarse, dry surface soils and limited herbaceous cover are more vulnerable to heavy grazing. With prolonged heavy use, willow recruitment is decreased, mature plants are highlined, and plants become decadent or die. Willows may be replaced by more mesic shrubs, introduced grasses such as Kentucky bluegrass, or weeds (Hansen and others 1995). With reduction or elimination of browsing, existing plants often recover quickly.

The response of whiplash willow to burning has been poorly documented, and its resprouting capability is not known. Windblown seeds play an important role in reestablishing the species in burned or disturbed areas (Miller and Miller 1976; Shaw and Clary 1996; Zasada 1986).

Varieties and Ecotypes—"Nehalem" Pacific willow is a male clone released by the USDA Soil Conservation Service Corvallis Plant Materials Center in 1978 (Darris and Lambert 1993). It originated from a native population growing near the Nehalem River in northwestern Oregon. Nehalem was selected for its high basal stem density and attractive foliage. It may be used to stabilize streambanks, improve riparian and aquatic habitat for wildlife and fish, and provide natural area landscaping and screens. Nehalem is adapted to planting sites on sandbars, lakeshores, and riverbanks at elevations below 4,900 ft (1,500 m) on the west side of the Cascade Mountains from Washington to northern California. It may be planted on soils ranging from sandy loams to gravelly or rich, rocky soils where soil water is adequate. Nehalem is tolerant of flooding and may be planted in reservoir drawdown areas. Stands may be established from cuttings; suitable materials may be used for wattling, brush matting, and branch packing to provide slope protection.

"Roland" whiplash willow was released in 1985 by the Alaska Plant Materials Center (Wright 1989). It is used for landscaping and stream revegetation and protection throughout Alaska.

Family Salicaceae

Salix lasiolepis
Arroyo willow

Description—Arroyo willow is a shrub or small tree 13 to 20 ft (4 to 6 m) tall (fig. 50) with multiple stems, a large root crown, and a fibrous root system. Young twigs are hairy and yellowish olive to reddish. Mature leaves are coriaceous, oblong or oblanceolate, and entire or rarely minutely serrate with somewhat revolute margins. They are 0.6 to 1.6 inches (1.5 to 4.1 cm) long and 0.2 to 0.5 inch (5 to 13 mm) wide. Leaf surfaces are dark green, glabrous above, and glaucous beneath. Catkins expand before to slightly after the leaves. Staminate catkins are 0.9 to 1.8 inches (2.2 to 4.5 cm) long. Pistillate catkins are densely flowered and 0.9 to 1.8 inches (2.2 to 4.5 cm) long. The persistent floral bracts are purplish black and densely hairy. Capsules are ovate, glabrous, and 0.1 to 0.2 inch (3 to 5 mm) long (Hitchcock and others 1964; Welsh and others 1987).

In northern Arizona, arroyo willow flowers from mid-March to mid-April (Sacchi and Price 1992). Seeds are dispersed over a 3-week period from late April to mid-May.

Figure 50—Arroyo willow grows along washes, ditches, and well-drained sites along ephemeral streams.

Ecological Relationships and Distribution—Arroyo willow is distributed at low elevations from British Columbia to Idaho and south from Baja California to west Texas and northern Mexico. It occurs entirely east of the Cascade Mountains. Arroyo willow may be found growing along streams, ditches, and washes (Welsh and others 1987). It is adapted to well-drained, ephemerally wet riparian sites (Manning and Padgett 1995). In Nevada, arroyo willow occurs on streambenches with coarse-textured or dry surface soils, along incised or ephemeral streams, and near seeps (Manning and Padgett 1995).

Plant Culture—Arroyo willow may be propagated from cuttings. Rooting ability ranges from erratic (Platts and others 1987) to very good (USDA Soil Conservation Service 1992). Roots form from the callus and over the lower one-third of the stem (Platts and others 1987). Stem and root growth are initiated in about 10 days.

Seed biology of arroyo willow has received little study. Seeds are nondormant and remain viable in nature for only 1 to 3 weeks (Sacchi and Price 1992).

Uses and Management—Arroyo willow has good habitat value, high tolerance to flooding and sediment deposition, moderate drought tolerance, and low salt tolerance (USDA Soil Conservation Service 1992). Management to preserve arroyo willow communities in otherwise arid areas is critical; they provide important habitat for a wide range of invertebrate and vertebrate species.

Native seedlings of arroyo willow establish on fresh fluvial deposits and open or partially vegetated streambanks (Sacchi and Price 1992). High seedling mortality is associated with drying of the soil surface; competition and herbivory play minor roles. Seedling growth is reduced by shading, and small seedlings have low overwinter survival. Seedlings surviving for 3 growing seasons may be considered established.

Varieties and Ecotypes—"Rogue" arroyo willow was cooperatively released by the Corvallis USDA-SCS Plant Materials Center in 1990 for use in stabilizing streambanks of low velocity meandering streams, improving freshwater fish and wildlife habitat, naturalized landscaping, and windbreaks or screens in riparian or moist upland situations (Darris and Lambert 1993).

Rogue is a male clone derived from a population growing along the Rogue River in Curry County, OR (Darris and Lambert 1993). Plants are large, multi-stemmed or occasionally single trunked with spreading crowns. Rogue was selected for its rapid, early growth rate and low incidence of insect and disease pests. It is widely adapted to riparian areas and moist upland sites receiving greater than 35 inches (890 mm) of annual precipitation from Washington to northern California on the west side of the Cascade Mountains. The release is propagated from cuttings and can be used for wattling, brush matting, and branch packing in combination with mechanical site treatments (Darris and Lambert 1993).

Family Salicaceae

Salix lutea
Yellow willow, shining willow

Description—Yellow willow is a rounded shrub or rarely a small, usually multi-stemmed tree 10 to 20 ft (3 to 6 m) tall (fig. 51). Young twigs are sparsely hairy and yellowish to reddish, becoming glabrous and yellowish white, gray, or brownish with age. Mature leaves are lanceolate to elliptical, entire to serrulate, 0.8 to 2.2 inches (2 to 5.5 cm) long, and 0.4 to 0.8 inch (10 to 21 mm) wide. They are dark green to yellow green above and pale green and glaucous below. However, a nonglaucous form has been reported (Manning

Figure 51—A low- to mid-elevation species, yellow willow frequently occurs as an early seral species on periodically flooded streambars.

and Padgett 1995). Catkins expand slightly before or with the leaves. Staminate catkins are 0.8 to 2 inches (2 to 5 cm) long. Pistillate catkins are 0.8 to 2.8 inches (2 to 7 cm) long and densely flowered. The persistent floral bracts are hairy and brown to blackish red. Capsules are glabrous and 0.1 to 0.2 inch (3 to 6 mm) long, produced on stipes less than 0.1 inch (2.5 mm) long. Stigmas are often scarcely lobed (Brunsfeld and Johnson 1985; Hitchcock and others 1964; Welsh and others 1987).

Flowering and fruiting dates vary within and among populations (Martens and Young 1992). Catkins appear in late March or early April on stands near Reno, NV. Flowering has been reported to occur from May to June in California (Munz 1973). Capsules ripen about a month following flowering (Martens and Young 1992). Catkins on a single branch vary in phenological development, and flowering within each catkin is indeterminate. Consequently, fruit ripening is not uniform. Seeds are dispersed by wind and are buoyant in water. Hairs on the seed may aid in dispersal, but they may also be important in germination and seedling establishment (Martens and Young 1992).

Ecological Relationships and Distribution—Yellow willow is distributed from Washington to Manitoba and south from California to Nebraska (Brunsfeld and Johnson 1985). A common species within its range, it grows along streams and ditches in valleys and canyon bottoms. It generally occurs at low to mid elevations, but may be found at higher elevations, particularly in the southern portion of its range. Associated upland communities include mountain big sagebrush, pinyon-juniper, mountain mahogany, Jeffrey pine, or lodgepole pine (Uchytil 1989c).

Yellow willow is capable of withstanding prolonged inundation and often occurs as a pioneer or early seral species on periodically flooded streambars. On such sites it may occur with, or replace, whiplash willow or coyote willow. Understory cover on such sites is often sparse. Yellow willow stands also occur on wet alluvial benches or terraces with well-developed, usually fine-textured soils. Water tables are generally high, but may fall below 3.3 ft (1 m) in summer. Understory species include beaked sedge, Nebraska sedge, bluejoint reedgrass, and other graminoids (Hansen and others 1995; Manning and Padgett 1995; Youngblood and others 1985). Understory productivity and accessibility to livestock depend on the extent of willow canopy. Yellow willow communities may occur in mosaics with other riparian community types dominated by cottonwoods, Booth willow, or Drummond willow.

With excessive livestock grazing in yellow willow communities, the water table falls, surface soils dry, and streams may become incised (Hansen and others 1995; Manning and Padgett 1995). Associated species may be shifted to shrubs such as Woods rose, mesic forbs, or with prolonged excessive grazing, Kentucky bluegrass and other weedy and exotic species.

Plant Culture—Yellow willow may be planted as unrooted or rooted cuttings. Unrooted cuttings are better able to establish on sites with a high water table that persists throughout the summer and allows roots to develop. Roots are initiated along the entire length of the stem, but are most abundant along the lower one-third. Under greenhouse conditions, new roots and stems are initiated in about 10 days (Platts and others 1987). Although cuttings root rapidly, only moderate numbers of roots are produced.

Seed of yellow willow may be collected by harvesting the inflorescences as the capsules begin to open (Martens and Young 1992). Developing fruits should be monitored carefully because seed is dispersed quickly when mature. Harvested catkins can be spread to dry in a warm room until capsules open, releasing the seed.

Fresh yellow willow seed harvested near Reno, NV, exhibited greatest germination in the dark at 50 to 77 °F (10 to 25 °C) (Martens and Young 1992). Germination at 36 °F (2 °C) exceeded 10 percent; no seeds germinated at 95 to 104 °F (35 to 40 °C). When germinated in the dark at 55 alternating temperature regimes, utilizing temperature combinations between 32 and 104 °F (0 and 40 °C) (8 hrs/16 hrs), greatest germination (52 percent) occurred at 50/36 °F (10/2 °C). Temperatures corresponding to very cold, cold, and moderate seedbed conditions enhanced germination; alterations corresponding to warm and warm/fluctuating seedbed conditions reduced germination.

Yellow willow seeds can be stored for short periods of time (Martens and Young 1992). Seeds exhibited some viability after 7 weeks when stored in water at 36 °F (2 °C), in paper bags at 32 °F (0 °C), or at room temperature (Martens and Young 1992). Viability of seeds stored in a desiccator over calcium chloride at 32 °F (0 °C) declined from 25 to 2 percent after 2 weeks.

Uses and Management—The USDA Soil Conservation Service (1992) described yellow willow as having good habitat value, good rooting ability, moderate tolerance of flooding, moderate drought tolerance, and low salt tolerance. Yellow willow often forms a thick corridor that provides streambank stabilization. The fibrous root system contributes to the development of overhanging banks; the canopy provides shade and litter, enhancing fish habitat.

A dense canopy cover of yellow willow provides food and cover for big game, beaver, birds, and other wildlife. Moose and elk use yellow willow in summer and winter. Excessive browsing, however, can result in stand opening or loss of willows (Gaffney 1941; Hansen and others 1995; Van Dersal 1938).

Livestock may make heavy summer and fall use of palatable understory species associated with some yellow willow stands. Heavy livestock use of willows may reduce their vigor, or if prolonged, result in stand loss. Wet soils are easily damaged by livestock trampling early in the season, resulting in soil compaction, early drying of the soil surface, and bank sloughing. Decadent stands resulting from excessive browsing by livestock or big game will regenerate if browsing pressure is reduced. Fire may also be used to rejuvenate decadent stands (Hansen and others 1995). Recreation and travel within these communities require careful consideration due to the dense willow canopy and early season wet soils (Hansen and others 1995). Campsites and trail or road routes should skirt these areas when possible.

Varieties and Ecotypes—None.

Family Salicaceae

Salix planifolia
Plainleaf willow

Description—Plainleaf willow is a shrub growing to 13 ft (4 m) in height. Twigs are glabrous and black to purplish black, exfoliating in translucent flakes. Mature leaves are elliptical, entire, dark green, shiny above, strongly glaucous beneath, and not permanently pubescent on both sides (fig. 52). Veins are prominent and partially parallel. Catkins expand before or with the leaves. Staminate catkins are 0.4 to 1 inch (1 to 2.5 cm) long. Pistillate catkins are densely flowered and 0.8 to 1.6 inches (2 to 4 cm) long. Floral bracts are persistent, black, and long hairy. Capsules are short hairy and 0.1 to 0.3 inch (3 to 7 mm) long. Stigmas are lobed (Hitchcock and others 1964).

Figure 52—Plainleaf willow is a small- to medium-sized shrub with dark green elliptical leaves that are shiny above and glaucous beneath.

Three varieties are recognized. *Salix planifolia* var. *planifolia* ranges from 6.6 to 13 ft (2 to 4 m) in height with elongate leaves 1.4 to 3.1 inches (3.5 to 8 cm) long. The leaves are usually red tinged and sparsely hairy. The other two varieties are generally less than 6.6 ft (2 m) in height. *S. p.* var. *monica* is usually 3.3 ft (1 m) or less in height with leaves that are 1 to 1.4 inches (2.5 to 3.5 cm) long. *S. p.* var. *pennata* is 3.3 to 6.6 ft (1 to 2 m) tall with leaves 1.8 to 2.6 inches (4.5 to 6.5 cm) long (Brunsfeld and Johnson 1985; Hitchcock and others 1964).

Ecological Relationships and Distribution—Plainleaf willow is circumboreal and extends southward in North America from California to New England (Welsh and others 1987). It is found along streams, around the margins of lakes and ponds, and in other wet areas.

Salix planifolia var. *planifolia* occurs east of the mountains in Western Canada and the Northwestern United States at low to moderate elevations. In the United States, it is distributed from the upper sagebrush to the Douglas-fir zone in northern Idaho, Montana, and Wyoming (Uchytil 1991c). It grows on mineral soils with textures ranging from gravelly to sandy or clayey. Water tables on these sites may fall below 3.3 ft (1 m) by midsummer. Associated species often include other tall willows such as Bebb willow, Booth willow, or Geyer willow.

Salix planifolia var. *monica* occurs in valley bottoms at high elevations and on wet, open, subalpine slopes from central Idaho to west-central Montana, and south from the Sierra Nevada Mountains of California to New Mexico. It often occurs in upper cirque basins with cold air drainages (Brunsfeld and Johnson 1985). It usually grows on wetter sites than *S. p.* var. *planifolia*. *S. p.* var. *monica* is often associated with Wolf willow, but grows on saturated soils with finer textures. Soils on *S. p.* var. *monica* sites usually have an organic surface horizon overlying alluvial sands, silts, clays, or sometimes gravels. Soils are often gleyed near the upper horizon (Youngblood and others 1985). Soil pH is generally slightly to strongly acidic (pH 4.4 to 6.3). Stands may be flooded in spring, and the water table generally remains within the rooting zone throughout the growing season. Lowering the water table may lead to an increase in Wolf willow. *S. p.* var. *pennata* is more narrowly distributed. It occurs in the Cascade Mountains from northern Washington to northern Oregon.

Plant Culture—Rooted or unrooted plainleaf willow cuttings may be planted. Unrooted cuttings root rapidly, but rooted cuttings are recommended for high-elevation sites with short growing seasons and rapidly drying soils. Stems produce low to moderate numbers of roots along their entire length (Platts and

others 1987). Root formation is initiated in about 10 days; shoots require 10 to 15 days to develop under greenhouse conditions.

Densmore and Zasada (1983) found that seeds collected in Alaska were nondormant at maturity. Germination was rapid and nearly complete at constant temperatures ranging from 41 to 77 °F (5 to 25 °C).

Uses and Management—Roots of plainleaf willows growing in riparian areas contribute to the formation of overhanging banks. Plants also furnish shade for fish habitat. Beaver use the plant for food and building materials. Stem pieces not consumed may sprout and develop into new plants (Cottrell 1995). Big game use plainleaf willow communities for forage, cover, and as travel corridors (Hansen and others 1995; Manning and Padgett 1995; Padgett and others 1989). Moose make heavy winter use of *S. p.* var. *planifolia*, but use by elk and mule deer is low (Dorn 1970; Mattson 1984; Van Dersal 1938). Winter use of *S. p.* var. *monica* may be limited due to its low stature. However, in some areas, moose browse all branches that are accessible in winter. Plainleaf willow communities also provide valuable cover and food for small mammals and birds (Douglas and Ratti 1984; Finch 1987).

Open stands of *S. p.* var. *planifolia* provide moderate amounts of forage for livestock (Hansen and others 1995) compared to other willow communities. Production of these communities is moderate. Palatability of *S. p.* var. *planifolia* to cattle is low (Dorn 1970), but palatability of some associated understory species is high. Early season or season-long use by livestock should be avoided as trampling of saturated sites will damage plants and soils (Manning and Padgett 1995). Short growing seasons and continually wet soils usually limit livestock use to late summer and early fall (Hansen and others 1995). The grazing value of sites dominated by *S. p.* var. *monica* is limited due to its small stature, low productivity, and association with wet soils.

Subalpine and alpine areas occupied by plainleaf willow provide an array of recreational opportunities including hiking, wildlife viewing, and fishing (Hansen and others 1995). These communities, particularly the wetter *S. p.* var. *monica* sites, are easily damaged by hikers, livestock, horses, and offroad vehicles. Heavy use can cause soil compaction, rutting, loss of vegetation, formation of multiple trails or roads, streambank erosion, and other long-term damage that cannot be easily repaired. Travel should be restricted to existing trails or roads, and these carefully maintained. New travel routes should be constructed on adjacent uplands.

Response of the species and its varieties to burning and its ability to resprout have not been examined (Hansen and others 1995). Short-term productivity of understory sedges can be increased by burning. Protection from grazing by livestock during the growing season leaves a thick cover of dry vegetation that burns well in spring before new growth is initiated. Burns along streambanks should be conducted with caution to avoid loss of the bank stabilization provided by these communities. Burned sites should be protected from grazing for 2 to 3 years to prevent overuse of recovering plants.

Varieties and Ecotypes—None.

Family Salicaceae

Salix scouleriana
Scouler willow, fire willow, black willow, mountain willow, nuttall willow

Description—Scouler willow is a shrub or multistemmed tree arising from a massive root crown and a deep, spreading root system. Mature trees may be 5 to 60 ft (1.5 to 18 m) tall. Young twigs are gray and short hairy, becoming dark reddish brown and glabrous. The crushed bark has a distinctive skunklike odor. Mature leaves are oblanceolate to lanceolate or ovate, entire to crenate or serrate, 0.8 to 2.4 inches (2 to 6 cm) long, and 0.4 to 1.2 inches (1 to 3 cm) wide. Leaf surfaces are dark green and glabrous above and sparsely reddish hairy beneath. Leaves turn yellow in autumn. Catkins usually expand before the leaves and are soon deciduous. They are nearly sessile. Staminate catkins are yellowish white, 0.6 to 1.4 inches (1.5 to 3.5 cm) long, and about as long as wide. Pistillate catkins are reddish, densely flowered, 0.8 to 2.4 inches (2 to 6 cm) long, and 0.5 to 0.7 inch (1.3 to 1.7 cm) wide. Floral bracts are brown to black and long hairy. Capsules are hairy, 0.2 to 0.3 inch (5 to 8 mm) long, and more or less long beaked. Stigmas are entire to bilobed (Brunsfeld and Johnson 1985; Hitchcock and others 1964).

Scouler willow is one of the earliest willows to flower. Flowers appear from April to July (Orme and Leege 1980); fruits ripen and seeds disperse from May to July (Brinkman 1974i). Seeds remain viable for only about 1 week (Densmore and Zasada 1983).

Ecological Relationships and Distribution—Scouler willow is distributed from Alaska to Manitoba and south to California, South Dakota, and New Mexico (Brunsfeld and Johnson 1985). At low to mid elevations, it occurs in valley bottoms, along streams, and around springs, where it attains a treelike stature. Scouler willow, however, is generally an upland species, growing on well-drained slopes at higher elevations, where it occurs as a minor understory species in late seral Douglas-fir, subalpine fir, western hemlock, and western red cedar forests (Arno and Hammerly 1977; Froiland 1962). It is slightly tolerant of shade

and capable of persisting on these sites at low frequencies (Cooper and others 1987; Steele and Geier-Hayes 1989, 1992). Scouler willow may be found on mineral soils of varying textures and on peaty soils (fig. 53). It is tolerant of acidic, but not salty, soil conditions.

Scouler willow proliferates following disturbance. It often becomes widespread following stand-destroying wildfires, slash burning, clearcutting, road building, or other disturbances that expose mineral soil and provide suitable sites for seed germination and establishment of seedlings (Arno and others 1985; Steele and Geier-Hayes 1989, 1992, 1995). It is particularly abundant where soils have been disturbed in such a manner as to trap water. Some broadcast burn operations and wildfires that leave 50 percent or more of the preburn overstory intact, however, do not provide suitable seedbeds for Scouler willow, and an increase in snowbrush ceanothus may be favored (Forsythe 1975; Steele and Geier-Hayes 1995).

High seedling densities on exposed, wet mineral soils may result from heavy seed rain originating from unburned areas (Lyon 1971; Stickney 1986). Scouler willow seeds sown on burns of differing severities on upland black spruce sites in Alaska germinated only on moderately (organic soil layers partially consumed) and severely (ash layer present, organic material in soil consumed or nearly so to mineral soil) burned seedbeds (Gruell and others 1982; Lyon and Stickney 1976). Germination was greatest and seedlings survived after 3 years only on severely burned sites.

Burned Scouler willow plants resprout vigorously from the rootcrown; multiple sprouts sometimes appear a few days after a fire (Foote 1983). Some plants regenerate even following burns that destroy the entire canopy (Lyon and Stickney 1976). Regenerating trees grow rapidly, particularly during the first two growing seasons (Leege and Hickey 1971; Lyon 1971). Vegetative spread occasionally occurs through rooting of branch segments (Watson and others 1980).

Figure 53—Generally an upland species, Scouler willow grows on dry slopes as an understory in conifer forests.

Dense stands of Scouler willow seedlings and regenerating plants may form shrub fields following fire. These may persist for varying periods of time with willow coverage decreasing as conifers mature (Steele and Geier-Hayes 1995).

Plant Culture—Scouler willow has been used to stabilize cut-and-fill areas along logging roads and other disturbed upland areas, but cuttings do not root as readily as those of many other willows (Monsen 1975; Plummer 1976). Roots develop in moderate numbers from the callus area; they do not develop along the length of the stem. Formation of roots normally requires about 10 to 15 days under greenhouse conditions (Platts and others 1987). Densmore (1978) found that total percent and rate of rooting were greater for cuttings of second-year wood harvested in the spring following leaf expansion (10 percent in 30 days, 1 root each) than for dormant cuttings harvested in the fall (4 percent in 60 days, 4.5 roots each). Second-year wood was collected from a population near Fairbanks, AK.

In a field test, 8- to 10-inch (20- to 25- cm) dormant cuttings of 2- to 3-year-old-wood harvested near Fairbanks, AK, were stored fully imbibed at 14 °F (–10 °C) until planted soon after soil thaw. Cuttings were planted vertically with 0.8 to 2 inches (2 to 5 cm) of stem above ground. Survival following one growing season was 17 percent. Nearly 100 percent of all stem cuttings collected in late fall and early winter from sites in Idaho stored in a moist cold environment, and spring planted in nursery beds, rooted and produced healthy plants. Plants grown under nursery conditions for one season developed large, robust root systems. When outplanted, the rooted plants established quickly and provided cover on road cuts and fill slopes.

Scouler willow may also be propagated from seed. There are about 6,500,000 seeds per lb (14,300,000 per kg) (Brinkman 1974i). Germination of seeds incubated at 85/70 °F (29/21 °C) reached 95 percent in 1 day. Densmore and Zasada (1983) obtained rapid and nearly complete germination of an Alaskan collection when seeds were incubated over a range of constant temperatures from 44 to 71 °F (5 to 25 °C).

Uses and Management—Scouler willow is a highly valued browse species for big game. Seral brush fields of Scouler willow and other shrubs are important winter ranges (Leege 1968). Moose, elk, white-tailed deer, and mule deer use the species throughout the year, but primarily in winter (Kufeld 1973; Kufeld and others 1973; Singer 1979; Smith 1953). In south-central Alaska, moose sometimes remove the bark (Viereck and Little 1972). Recent sprouts are most palatable; greatest production may

occur on branches browsed the previous year. Much of the browse on mature plants is unavailable because plants are quite tall. Scouler willow also provides cover for birds and small mammals (Steele and Geier-Hayes 1992; Vories and Sims 1977). In seral brush fields Scouler willow provides excellent cover for big game. Isolated plants in late-seral coniferous stands are not as effective. Scouler willow is highly palatable to cattle and sheep (Dayton 1931). It may receive greater use than other willow species due to the high accessibility of the willow clumps.

Prescribed burning in fall or spring has been used to stimulate sprouting of Scouler willow shrub fields that have grown beyond the reach of big game (Leege 1968, 1969, 1979a). Spring burning may be preferable; fall burning destroys winter browse. Considerable growth may occur during the first growing season following spring burning. Leege (1979a) found that sprouts 5 ft (1.5 m) long were produced following a spring burn in Idaho. Burning at 5-year intervals did not decrease productivity (Leege 1968). Plant nutritive value increases only slightly after burning, but new shoots are within reach and more palatable than older shoots.

Scouler willow in clearcuts may enhance shade-tolerant spruce and Douglas fir establishment by protecting plants from wind and temperature extremes (Steele and Geier-Hayes 1989, 1992). In the absence of a conifer overstory, Scouler willow's growth habit is altered from a narrow, upright form to a more shrublike form with a broad, rounded canopy. These vigorous plants compete strongly with shade-intolerant seedlings of ponderosa pine. Because the two species have similar growth rates for the first 6 to 8 years, the pine seedlings may not survive to overtop the willow. Mechanical treatments to remove Scouler willow are generally impractical due to the plants' deep, spreading root system. Consequently, plantations of Douglas-fir are more likely to be successful.

Scouler willow has been recommended for use in watershed plantings (Monsen 1975). Rooted cuttings establish quickly when planted on road fills and other disturbances. They grow quickly and provide excellent ground cover on exposed unstable slopes. They also may be used in naturalized landscaping to provide screens or background plantings.

Varieties and Ecotypes—None.

Family Salicaceae

Salix wolfii
Wolf willow

Description—Wolf willow is a low-statured shrub 2 to 5 ft (0.6 to 1.5 m) tall with a fibrous, spreading root system. Young twigs are yellow to orange and more or less persistently thin hairy, becoming chestnut brown when mature. Mature leaves are entire, elliptical to lanceolate or oblanceolate, 0.5 to 1.6 inches (1.2 to 4.2 cm) long, and 0.2 to 0.5 inch (0.5 to 1.3 cm) wide. They are gray green to silvery and sparsely to densely hairy on both sides. Catkins expand with the leaves. Staminate catkins are yellowish and 0.2 to 0.6 inch (0.5 to 1.5 cm) long. Pistillate catkins are globose, fuzzy, white, densely flowered, and 0.4 to 0.8 inch (1 to 2 cm) long. Floral bracts are persistent, long hairy, and blackish or pale at the base. Capsules are 0.1 to 0.2 inch (3 to 5 mm) long and glabrous or rarely hairy. Stigmas are lobed (Hitchcock and others 1964; Sutton and Johnson 1974; Welsh and others 1987).

Ecological Relationships and Distribution—Wolf willow is distributed from northeastern Oregon south to Nevada and east to Montana and Colorado (Brunsfeld and Johnson 1985). In central Idaho it occurs from cooler sites at mid elevations in the Douglas-fir zone to subalpine areas, where it grows along streams and around lakes and ponds. Wolf willow community types in southeastern Idaho, northern Utah, western Wyoming, and Montana occur in broad meadows, on alluvial terraces, around seeps, and in old beaver ponds at mid to upper elevations (Hansen and others 1995; Padgett and others 1989; Youngblood and others 1985). Wolf willow often dominates a low shrub overstory, although scattered taller willows may be present. At high elevations, Wolf willow may occur in pure stands (fig. 54). Wolf willow occurs on soils with a relatively thick organic surface horizon that develops from deposition of leaves and twigs. Some sites with lower amounts of organic matter have fine mineral soil with high water-holding capacity. Oxygen is provided by lateral movement of water through such soils. The water table is generally within

Figure 54—Wolf willow forms dense patches of low-statured shrubs in narrow valley bottoms at high elevations.

3.3 ft (1 m) of the surface throughout the growing season. Stream channels in Wolf willow communities are often small and meandering. Streambanks are stable due to the high density of willow roots in the soil. Overland flow is common during snowmelt.

Plant Culture—Wolf willow may be used to revegetate streambanks and ponds, although growth may be slow. Rooted cuttings are advised for use on high-elevation sites with short growing seasons. Hansen and others (1995) recommended use of dormant 2- to 4-year-old wood. Cuttings should be 12 to 20 inches (30 to 50 cm) long and 0.4 inch (1 cm) or more in diameter. Rooting is erratic; few to a moderate number of roots normally form along the length of the stem (Platts and others 1987). Ten to 15 days are required for root and stem initiation. The seed biology of Wolf willow has not been studied.

Uses and Management—Wolf willow communities should be managed to maintain willows along stream margins and provide vegetative cover throughout the community. Wolf willow communities provide valuable streambank stabilization (Hansen and others 1995). The low overstory and diversity of plant species often present in these communities provide cover for birds, small mammals, and other small vertebrates and invertebrates. Cover value for big game is fair. Biomass production of Wolf willow is moderate. The species is palatable to sheep, beaver, and big game. Winter use is minimal when plants are leafless and snow covered. Understory graminoids and forbs vary in palatability. Species such as water sedge or tufted hairgrass may receive heavy use by cattle, but accessibility may be restricted by the dense shrub overstory. Excessive grazing may lead to replacement of the understory by less palatable species. Grazing and equipment use should be restricted until soils are dry as they are easily compacted and become erodible if the vegetative cover is lost. The response of Wolf willow to fire has not been documented (Hansen and others 1995).

Varieties and Ecotypes—None.

Family Saxifragaceae

Philadelphus lewisii
Lewis mockorange

Description—Lewis mockorange (fig. 55), known as syringa, Lewis syringa, mockorange, or Indian arrowwood was named for Captain Meriwether Lewis, who first collected it on the Clark Fork River near Missoula, MT, on July 4, 1806. Plants are long-lived perennials, ranging from open to densely branched, erect to rounded, fibrous rooted shrubs 3 to 12 ft (0.9 to 3.7 m) in height (Carson and Peek 1987; Dittberner and Olsen 1983). Clusters of arching stems develop on older specimens. Young branches are divaricate and glabrous to pubescent with red to chestnut brown bark. Conspicuous transverse cracks develop in the bark during the second season; the bark later turns gray and eventually exfoliates. The light green leaves are opposite, sessile, or short petiolate and ovate to oblong with acute to acuminate tips. They are 1 to 3 inches (2.5 to 7.6 cm) long and 0.4 to 1.6 inches (1.0 to 4.1 cm) wide. The thin blades are entire, 3 to 5 veined, usually glabrous above, but pubescent around the edges and along veins beneath.

Attractive terminal cymes of attractive white flowers develop on lateral branches, each with 3 to 11 perfect, regular flowers. Flowers arise from the axils of gradually reduced leaves. There are four white petals, 20 to 60 unequal stamens with conspicuous yellow anthers, and three to five persistent styles that are more or less connate. Fruit is a woody capsule with four cells attached to the persistent calyx. The light brown fusiform seeds are numerous (Hitchcock and others 1961; Welsh and others 1987). Flowering occurs from late May to July. Fruits develop from July to September or October when the capsules dehisce and seeds are wind and gravity dispersed (Orme and Leege 1980; Young and Young 1986).

Lewis mockorange exhibits a high degree of local variation in floral and vegetative characteristics. This variability has been assigned taxonomic status by some workers (Hitchcock and others 1961).

Ecological Relationships and Distribution—There are about 50 species of *Philadelphus* in North America, Mexico, Asia, and central Europe. Only two species, Lewis mockorange and littleleaf mockorange (*Philadelphus microphyllus*), occur in the Intermountain region. Lewis mockorange is distributed from

Figure 55—Lewis mockorange survives on a low foothill site following many years of excessive grazing.

British Columbia south to northern California and east to Montana (Hitchcock and others 1961; Lackschewitz 1986). It grows from near sea level to 7,000 ft (2,100 m), but is most common at midelevations. It is a dominant shrub in some climax ponderosa pine communities and a common shrub in some seral ponderosa pine communities (Wright 1978). It is also found in sagebrush deserts, lodgepole pine forests, and coastal Douglas-fir and redwood forests. It commonly occurs in foothills and low mountains on all aspects, but primarily on northern and eastern slopes (USDA Forest Service 1937). The species grows on soils ranging from dry, rocky, gravelly loams on open hillsides, to deep, rich alluvial humic loams near riparian zones (USDA Forest Service 1937). It generally occurs in small scattered clumps in moist, open, or partially shaded transitional areas along gullies, canyon bottoms, riparian areas, and seeps (Carson and Peek 1987; Hopkins and Kovalchik 1983). It also grows on cliffs, talus slopes, and rocky hillsides with other shrubs such as serviceberry and ocean-spray (Carson and Peek 1987; Franklin and Dyrness 1973).

Plant Culture—Seeds may be collected by hand stripping the capsules from the plants after maturity, but before the valves begin to open. Dried capsules are crushed to release the seeds, and trash is removed with an aspirator or fanning mill. There are 3,500,000 to 8,000,000 seeds per lb (7,716,000 to 17,637,000 per kg) of clean seed (Stickney 1974b). Seed fill is often low. Seeds may be stored in airtight containers for periods of up to 1 year. They require an 8-week wet prechilling at 41 °F (5.0 °C) to release embryo dormancy (Stickney 1974b). Germination is tested at 72 to 79 °F (22 to 26 °C).

Seeds may be broadcast seeded on a rough seedbed and covered lightly or spot seeded in selected, prepared areas. They may also be surface seeded using a Brillion seeder or similar device. Best results are obtained if seeds are planted in well-drained sites free of herbaceous competition. Seeds may be mixed with other shrub seeds that require shallow or surface planting.

Bareroot stock may be produced by fall seeding or by seeding wet prechilled seeds in spring. The tiny seeds may be diluted by mixing them with rice hulls to improve uniformity of seeding. Seeds should be covered very lightly. Seedlings develop rapidly and can be transplanted as 1-year-old stock. Container stock may also be grown from seeds.

Due to a lack of commercial seed sources and ease of vegetative propagation, planting stock is frequently grown from cuttings. Dormant 3 to 4 inch (7.6 to 10.2 cm) hardwood cuttings may be planted in a closed cold frame with bottom heat for rooting. Softwood cuttings gathered in early summer or early fall are also easily rooted in a cold frame (Doran 1957; Marchant and Sherlock 1984). Digging rooted suckers and dividing the crown of mature plants with a sharp spade or axe are alternate means of vegetative propagation.

Lewis mockorange is a valuable plant for transplanting on disturbed steep, rocky, unstable slopes where it provides soil stabilization and vegetative cover. Seedlings or larger stock are recommended for such sites. Lewis mockorange is also useful for planting in transitional areas of degraded riparian zones.

Uses and Management—Lewis mockorange is not normally grazed heavily by livestock, but in some areas it does receive fair amounts of use by cattle and sheep (Leege 1968; USDA Forest Service 1937). It frequently occurs with other species that are more palatable to big game and, consequently, it may receive little use, except under severe conditions. However, in some areas it does provide good browse for deer and elk, especially on winter ranges (Kufeld 1973; Leege 1968; Marchant and Sherlock 1984; Stubbendieck and others 1986). New growth is generally highly palatable to big game (Leege 1968). Leege (1969) reported that elk use of Lewis mockorange increased by 30 percent following a spring burn. The plants provide cover for birds and other small animals.

Lewis mockorange is classified as a fire resistant or survivor species (Fischer and Bradley 1987). Although shoots may be consumed by fire, Lewis mockorange is capable of resprouting from the root crown or caudex during the first season following burning (Fischer and Bradley 1987; Rowe 1983). Consequently, it is found in early to late seral as well as in climax communities. Lewis mockorange is not as prolific a sprouter as cooccurring shrubs (Leege 1969). Leege and Hickey (1971) found that spring-burned Lewis mockorange in northern Idaho seral brush fields (grand fir/pachistima habitat type) resprouted within 1 or 2 months, while fall-burned shrubs did not resprout until the following spring. Sprouts were more numerous following fall burning. The historic burn interval in climax ponderosa pine communities is thought to be 6 to 22 years; thus, Wright (1978) prescribed burns at 10 to 15 year intervals to enhance shrub growth.

Lewis mockorange is the state flower of Idaho and is one of the more extensively used native shrubs for landscaping (Marchant and Sherlock 1984). It is valued for its showy white flowers; the fruits and leaves are less attractive. Dense branches and foliage make it suitable for hedges. Native Americans used the long woody shoots for arrow shafts (USDA Forest Service 1937).

Lewis mockorange seedlings establish well, but should be protected from competition and browsing. Landscape plants should be pruned after flowering because flowers are produced on twigs of the previous year. The species is normally free of insect and disease problems, but seedlings are sometimes susceptible to damping off.

Varieties and Ecotypes—The Colfax germplasm of Lewis mockorange originated from the Colfax, WA, area. St. Maries germplasm originated from St. Maries, ID. Several commercial cultivars of Lewis mockorange have been developed. "Waterton," selected from the Waterton Lakes area of Alberta, is a hardy, bushy shrub with flowers scattered over the crown of the plant (Marchant and Sherlock 1984). *Philadelphus coronarius*, introduced from Europe, is the commonly cultivated mockorange (Welsh 1987).

Littleleaf mockorange is a smaller, short-lived shrub, growing from 3 to 7 ft (0.9 to 2.1 m) in height and 4 ft (1.2 m) in width. Shrubs have ascending stems and a rounded crown with reddish-tan exfoliating bark. Leaves are narrower than those of Lewis mockorange, and flowers are solitary or in clusters of three. Littleleaf mockorange occurs from Utah to Wyoming and south to Texas in pinyon-juniper, mountain brush, aspen, lodgepole pine, and Douglas-fir/white fir forests (Goodrich 1985; Sutton and Johnson 1974; Welsh and others 1987). Littleleaf mockorange receives some use by mule deer (Patton and Ertl 1982) and other wildlife. Littleleaf mockorange may be propagated from seed or cuttings. It is easily transplanted and is a strikingly attractive ornamental (Sutton and Johnson 1974).

Family Saxifragaceae

Ribes aureum
Golden currant

Description—There are more than 100 species of *Ribes*, primarily occurring in the temperate and colder regions of the northern hemisphere and the Andes mountains of South America. They are particularly common in the Western United States (Pfister 1974; Welsh and others 1987). Species with jointed pedicels, several flowers per raceme, and glabrous to glandular berries that are generally unarmed are grouped as currants. The remaining species, usually armed with spines, are referred to as gooseberries (Hitchcock and others 1961).

Golden currant is an unarmed, irregularly shaped, multiple-stemmed shrub 3 to 10 ft (0.9 to 3.0 m) tall (Welsh and others 1987) that spreads by suckering (fig. 56). The reddish bark of young twigs turns gray with age. Leaves are alternate, deciduous, and petiolate. Blades are ovate with a cuneate to chordate base, usually glabrous, and palmately three-lobed with the lobes entire, toothed, or lobed. Ascending bracteate racemes occur on the ends of lateral spur branches with two to 15 flowers (Harrington 1964). Flowers are complete and regular with a spicy odor (Stark 1966). The hypanthum is cylindrical with five spreading calyx lobes alternating with five shorter, erect petal lobes. Young flowers are golden yellow, but turn reddish with age. The edible fruit is a globose, glabrous, many-seeded berry. Fruit color varies from yellow to red orange or black. The minute embryo is embedded in a large amount of endosperm (Goodrich and Neese 1986; Hitchcock and others 1961; Munz and Keck 1959; Pfister 1974; Welsh and others 1987).

Ecological Relationships and Distribution—Golden currant is distributed from north-central Washington to Saskatchewan and South Dakota and south to California and New Mexico (Welsh and others 1987). Hitchcock and Cronquist (1973) reported that the shrub occurs along streambanks and washes, and from grasslands and big sagebrush deserts to ponderosa pine forests throughout the Pacific Northwest. In California it grows along moist streambanks and in bottom lands at elevations between 2,500 and 7,800 ft (760 and 2,400 m) (Munz and Keck 1959). Golden currant occurs in many Utah riparian and palustrine habitats in greasewood-shadscale, sagebrush, pinyon-juniper, mountain brush, ponderosa pine, and Douglas-fir communities at 4,395 to 8,490 ft (1,340 to 2,600 m) (Goodrich and Neese 1986; Welsh and others 1987). It occupies similar areas in Colorado and New Mexico, and is common in the plains and foothills of South Dakota and Saskatchewan (Harrington 1964).

Golden currant is generally not widely abundant (Wasser 1982); it occurs as scattered plants, patches, clumps, and in corridors along waterways. It does not occur as even a minor component of aspen or conifer forests in the Intermountain area (Mueggler 1988; Steele and Geier-Hayes 1987; Youngblood and Mauk 1985), but it does grow in aspen/chokecherry communities. It normally grows on fertile, well-drained sites such as moist streambanks, washes, ditches, seeps, and springs. It has been widely cultivated as an

Figure 56—Golden currant planted as a low-maintenance species in a recreation site.

ornamental (Goodrich 1985; Pfister 1974), and now occupies drier sites within abandoned farmlands, ranches, and wildland areas.

Although considered a species for moist sites (Thornburg 1982), golden currant is found on well-drained soils receiving in excess of 16 inches (40 cm) of annual precipitation. It usually occurs on sandy to silty loam soils (Thornburg 1982), but is also adapted to clay-loam soils. Plants generally grow in full sun to partial shade on soils ranging from slightly acidic to slightly basic (Dittberner and Olsen 1983; Wasser 1982).

Plant Culture—Golden currant flowers appear with or slightly before the leaves in April or May. Fruits ripen in June or July and are dispersed by birds and mammals (USDA Forest Service 1948). In central Utah berries may ripen as late as mid-August (Plummer and others 1968).

Fruits or berries are hand harvested by stripping them from branches or by flailing them into containers as soon as they ripen; this reduces losses to birds (Pfister 1974). Few wildland stands are large enough to produce many pounds of seed; consequently, cultivated ecotypes are usually the sources sold for wildland plantings. Native stands are capable of producing good seed crops, but only about 4 lb (1.8 kg) of clean seed are extracted from 100 lb (45.4 kg) of fruits (Pfister 1974). Seed collection costs are high, and tend to restrict use of the shrub in large-scale seeding projects. However, viable seed crops are usually produced each year at most locations, and local ecotypes can be collected and propagated for specific plantings. Most seeds are harvested from cultivated plantings, fence-line plantings, or irrigated seed fields. Plants in these situations generally produce more consistent and abundant crops. In addition, the bushes are more uniform in stature, and are closely spaced, which aids in harvesting.

Collected fruits should not be allowed to overheat prior to extraction. Fruits are processed by maceration using a Dybvig cleaner and water to separate the berry or pulp from the seeds (Plummer and others 1968). Dried fruit should be soaked in water to aid cleaning or maceration. Pulp and empty seeds may be separated from sound seeds by flotation. There are 200,000 to 285,000 seeds per lb (441,000 to 628,000 per kg) (Pfister 1974).

Heit (1971) recommended that tetrazolium chloride staining be used for testing viability, but embryo excision is difficult. Seed viability is generally quite high, usually in excess of 75 percent. Seeds retain good viability for 5 to 17 years if stored dry in sealed containers (Pfister 1974) or in open warehouses (Plummer and others 1968; Stevens and others 1981a). Seed may remain dormant in the soil for many years (Moss and Wellner 1953; Quick 1954).

The degree of dormancy varies among seedlots and among seeds within a seedlot; this provides an adaptive advantage. However, this characteristic reduces the effectiveness of seed pretreatments. Most seeds require a long period of wet prechilling to break embryo dormancy. Germination can be hastened and increased by wet prechilling at low temperatures. A wet prechilling of 60 to 90 days at 28 to 36 °F (–2.2 to 2.2 °C) is often used to release embryo dormancy (Pfister 1974). Stidham and others (1982) recommended that seeds be prechilled on blotters moistened with potassium nitrate.

Seeds should be fall planted to provide a cold, moist period for wet prechilling. Spring plantings should use only prechilled seeds. Seeds are small, round, and easily dispensed through most seeders. Golden currant can be seeded alone or in mixtures with selected shrubs and forbs. It should not be seeded directly with grasses or broadleaf herbs that germinate and grow rapidly. Seeds are usually sown at a rate of 0.25 to 2 lb per acre (0.3 to 2.2 kg per ha), depending on the method of seeding and row spacings. Wildland seedings are usually conducted using seed-dribblers mounted on tractors. Seeds are often hand planted in selected areas. Only a small portion of an area is actually planted using these techniques.

Under nursery conditions, seeds are usually sown at a rate of 60 to 80 seeds per ft^2 (650 to 860 per m^2) or 40 viable seeds per linear ft (130 per linear m) of row (Pfister 1974). Seeds should be planted 0.25 inch (6 mm) deep on a firm seedbed. Planting on sites having some surface mulch or debris aids in germination and seedling establishment. Adding mulch to the soil surface is recommended for nursery beds subject to rapid drying and crusting.

Seed germination is usually only moderate or fair. However, seeds that germinate often do so uniformly, and initial emergence is usually very good even under range or wildland conditions. Compared with most shrubs, seedlings of golden currant are very persistent. Seedlings grow rapidly and generally attain heights in excess of 6 to 12 inches (15 to 30 cm) the first growing season. Although natural thinning occurs, seedlings are vigorous; normally enough survive to provide a full stand. Seedlings of few other shrubs are as vigorous as this species.

Planting sites should be cleared of competition to improve shrub seedling success. Golden currant seedlings and young plants are able to compete and establish with some competitive understory. The shrub is more sensitive to competition when planted along streams or in moist situations, yet seedlings of this species are able to compete well with aggressive herbs that exist in riparian communities. New seedlings appear from natural seeding throughout native ranges, which attests to the survival attributes of this species.

Bareroot or container-grown transplants can be quickly grown, although overseeding is usually recommended to assure emergence of the desired number of seedlings. Planting beds are normally thinned to the proper spacing and density. One-year-old transplants develop a dense, well-branched root system, and field survival of 1-0 transplants is usually very high. Transplants establish very well on harsh disturbances due, in part, to the well-developed root system of young plants. Container stock is grown from seed or hardwood or softwood cuttings (Doran 1957).

Uses and Management—Golden currant has been widely planted for wildlife habitat (Patton and Ertl 1982), ground cover, watershed protection, and conservation plantings (Pfister 1974). It establishes with good success in most wildland plantings; consequently, it is often used to assure the establishment of a desirable species.

Golden currant is a highly preferred spring and midsummer browse for big game, and is recommended for planting in mountain brush, pinyon-juniper, big sagebrush, and wet meadow communities that receive more than 20 inches (51 cm) of annual precipitation (Plummer and others 1968; Wasser 1982). Kufeld and others (1973) reported moderate summer use, but only light fall use by big game animals. The plant is eagerly grazed in early spring and summer, and can be planted on riparian sites and upland ranges to provide seasonal grazing by birds and big game.

Golden currant is commonly planted with a combination of other species to furnish diversity, early developing forage, fruits, and habitat for big game and birds. It provides preferred roosting and nesting cover for several songbirds (Johnson and Anderson 1980). Chukar partridge feed on the ripe fruits (Gullion 1964). Dayton (1931) reported that this shrub species has about average palatability for domestic livestock. Although Dittberner and Olsen (1983) reported considerable variation in palatability among golden currant populations in the West, this species produces an excellent amount of herbage annually.

Golden currant is an excellent species for stabilization of roadways (Wasser 1982) and other disturbances, particularly if transplant stock is used. Both bareroot and container-grown transplants establish and survive well on most disturbances. Transplants grow rapidly and furnish excellent ground cover in 2 to 3 years. If planted at close spacings, 3 to 4 ft (0.9 to 1.2 m) apart, an effective cover can develop quickly. Plants are reasonably adapted to disturbances where portions of the topsoil remain or where the topsoil has been mixed with the planting media. Disturbed areas that lack good fertility and consist of coarse fragments are less likely to sustain this shrub. However, golden currant is quite drought tolerant and can persist on harsh mine sites. Ferguson and Frischknecht (1985) recommended use of this species to reclaim coal fields in south-central Utah. The species prefers fertile, well-drained, neutral, loamy soils (Dittberner and Olsen 1983; Wasser 1982). Haeussler and Coates (1986) reported the plant grows best on soils supplied with humus.

Golden currant is widely used for hedges, windbreaks, and conservation and landscape plantings (Cook 1981; Wasser 1982). It is usually planted in combination with other woody species, particularly evergreens or less open deciduous species. It is often planted as a conservation or wildlife habitat species, but other shrubs provide more acceptable forage for birds (Miller and others 1948). This species is commonly planted in rows or hedges to provide berries for jam and jelly.

Golden currant is widely distributed along streambanks, floodplains, and drainageways (Hitchcock and others 1961; Wasser 1982). It can be used to reclaim riparian disturbances, particularly moist sites where the water table has been lowered by erosion and downcutting of gullies.

Golden currant is moderately fire tolerant (Hopkins and Kovalchik 1983; Rowe 1983), and recovers by resprouting or natural seeding (Rowe 1983). Pfister (1974) reported that golden currant seedlings establish well on mineral soils where the organic duff is removed by fire. Currants are subject to defoliation by the western tent caterpillar (Furniss and Barr 1975); they are also an alternative host for white pine blister rust (Quick 1954).

Varieties and Ecotypes—None.

Family Saxifragaceae

Ribes cereum
Wax currant

Description—Wax currant (fig. 57) is a spreading, unarmed, multicrowned, deciduous shrub, usually 2 to 5 ft (0.6 to 1.5 m) tall with puberulent and more or less stipitate glandular young branches (Hitchcock and others 1961; Welsh and others 1987). Leaves are fragrant, clustered on short spurlike branches (Sampson and Jespersen 1963), usually shallowly three- to five-lobed. The upper surface of the leaves is subglabrous to shiny, and the lower surface is waxy glandular dotted (Stubbendieck and others 1986). The inflorescence is pubescent and sticky glandular. Two or three flowers occur in short drooping clusters. Flowers are greenish white to pink (Welsh and others 1987). Fruits are dull to bright red, glandular to glabrous, and usually between 0.2 to 0.3 inch (6 to 8 mm) long.

Ecological Relationships and Distribution—Wax currant is found from British Columbia to southern California on the east slopes of the Cascade and

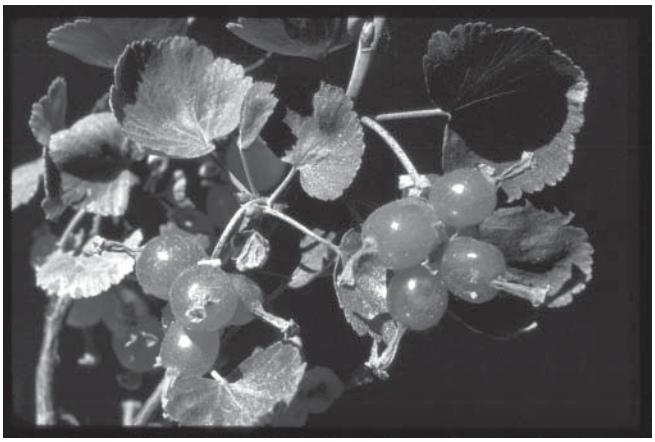

Figure 57—Wax currant growing on a rocky outcrop above timberline.

Sierra Mountains, and eastward to Montana, Nebraska, and New Mexico (Hitchcock and others 1961). It is one of the most widely distributed of all western currants, because it occurs from sagebrush deserts to alpine areas (Great Plains Flora Association 1986; USDA Forest Service 1937). *Ribes cereum* var. *cereum* is found from British Columbia to southern Arizona and southern California, and east to central Montana, Idaho, and western Nevada. The *R. c.* var. *inebrians* is more common eastward from central Idaho and Montana, south and east to Nebraska, New Mexico, Utah, and eastern Nevada. Welsh and others (1987) reported that most plants in Utah are *R. c.* var. *inebrians*, but intergradation of morphological features is common, and no geographical correlation is apparent in Utah. *R. c.* var. *colubrinum* is confined to the Snake River Canyon and related tributaries in Idaho, Washington, and Oregon (Hitchcock and others 1961).

Goodrich and Neese (1986) reported the plant is common and widespread in mountainous communities between 6,500 and 11,000 ft (2,000 to 3,400 m) in Utah. Sampson and Jespersen (1963) reported that wax currant is more widely distributed in California than sticky currant, although their distributions overlap. Wax currant is common in various plant communities, but not as a dominant species. It is often associated with antelope bitterbrush in the Central Rocky Mountains (USDA Forest Service 1937). It is prevalent in various ponderosa pine/Douglas-fir forest types in Colorado and several lodgepole pine associations in Oregon (Volland 1985b). It occurs in aspen communities (Mueggler 1988) and conifer forests of Utah (Youngblood and Mauk 1985) and Idaho (Steele and Geier-Hayes 1987), but only as a minor species.

Plant Culture—Wax currant plants flower from April to June; fruits ripen in August (Pfister 1974). Fruits are harvested by hand picking or flailing the bush to dislodge the berries. Fruits are macerated to remove the seed; the material is then dried, and seeds are separated from the dry pulp using a fanning mill. Seeds are quite small (Vories 1981), averaging about 251,000 per lb (553,400 per kg) (Pfister 1974). Seed production from wax currant is generally lower than from golden currant and sticky currant. In addition, seed germination is usually low and a longer period of wet prechilling is required to overcome dormancy. Pfister (1974) recommended that seeds be wet prechilled for 120 to 150 days at 28 to 32 °F (–2.2 to 0.0 °C).

Seeds should be fall sown at a depth of 0.2 to 0.5 inch (6 to 13 mm) on a firm seedbed. Haeussler and Coates (1986) recommended seeding on moist mineral soils with high percentages of organic matter. Plummer and others (1968) reported that seeds of this species have low seed germination, and the initial establishment of new seedlings is only fair. Young plants grow slower than golden currant seedlings, but persistence of established plants is excellent. Plants spread well from natural seeding. It is less successfully established by transplanting than golden currant. Wax currant is easily cultured in nursery beds.

Seeds of wax currant may be spread by birds or small mammals (Kramer 1984) or by being deposited directly below the shrub (Moss and Wellner 1953). Seeds may remain viable for a long period (Lyon and Stickney 1976). Pfister (1974) reported seeds retained good viability after 27 years of storage.

Although seeds are relatively thin walled and can be destroyed by severe fires (Kramer 1984), they benefit from fire scarification (Morgan and Neuenschwander 1985; Young 1983). New seedlings often appear following low-severity fires that remove little surface litter (Rowe 1983). Plants have large and deeply buried root crows that resprout from belowground tissue if not destroyed by fire (Bock and Bock 1984).

Uses and Management—Wax currant is somewhat less palatable throughout the entire year than golden currant (Plummer and others 1968). Kufeld and others (1973) reported that big game made only light use of the shrub in the spring and fall, but Plummer and others (1968) reported it was heavily browsed during all seasons.

Palatability of wax currant is low for livestock, but it is an important browse due to its abundance, productivity, and availability (Dittberner and Olsen 1983; Mueggler and Stewart 1980; Sampson and Jesperson 1963). This shrub has been principally used for wildlife habitat improvement, although limited plantings have been established for watershed and groundcover protection. It is an important shrub for use in restoration of mountain brush, aspen, and subalpine communities (Plummer and others 1968).

Wax currant has not been widely used for control of severe erosion problems or disturbed land plantings. It has been used to stabilize watersheds, small gullies, and moist streambanks in aspen and conifer forests if topsoil is present. Plants are adapted to disturbances related to fire and logging. Natural regeneration frequently occurs after these disturbances, and this species provides considerable ground cover and herbage. It can be seeded and transplanted on areas exposed by logging or fires with acceptable success. The shrub grows well with understory herbs, and can be planted with a number of species to control erosion and protect unstable sites. It does not spread rapidly to occupy harsh disturbances, and has not performed well as a pioneer species on mines, roadways, or similar disturbances. This shrub grows well with some overstory trees, and can be used to plant campgrounds and recreation sites where a dense tree cover may be desired. This species could be more widely used to restore native communities.

Varieties And Ecotypes—None.

Family Saxifragaceae

Ribes viscosissimum
Sticky currant

Description—Sticky currant (fig. 58) is a spreading, unarmed, uneven, aromatic shrub, mostly 3.3 to 6.6 ft (1.0 to 2.0 m) tall. Stems, leaves, inflorescences, and fruits are sparsely to thickly glandular (Welsh and others 1987). Leaf blades are orbicular, three- to seven-lobed with the main lobes crenate or dentate, round in outline, heart shaped at base, and hairy or glandular on both surfaces (Sampson and Jespersen 1963). Flowers are green, white, or pink, with three to 12 flowers occuring in a cluster. Berries are 0.4 to 0.5 inch (10 to 13 mm) long, black, rather dry, and glandular (Welsh and others 1987).

Figure 58—Sticky current generally occurs above timberline on windswept ridges.

Ecological Relationships and Distribution—This species is common from British Columbia to California on the east side of the Cascade and Sierra Nevada Mountains, and extending east to Montana and Arizona (Hitchcock and others 1961; Sampson and Jespersen 1963; Welsh and others 1987). Hitchcock and others (1961) divided it into two intergrading geographic races. *R. v.* var. *hallii* is distinguished by its glabrous ovaries and glaucous berries; it occurs throughout the eastern Cascades south of Mt. Rainier and the Sierras. *R. v.* var. *viscosissimum* has glandular and more or less pubescent ovaries and nonglaucous berries; it occurs over the remainder of the species' range. Welsh and others (1987) concluded that plants occurring in Utah are unique; the herbage has dense stipitate-glandular and nonglandular hairs and long, broad hypanthia.

Sticky currant grows in shady woods and rocky places in the Sierra Nevada Mountains at elevations between 6,000 and 9,000 ft (1,800 and 2,700 m) (Sampson and Jespersen 1963). Goodrich and Neese (1986) reported the species is common throughout the Uinta Basin in Utah, existing with aspen and conifer woods at 7,500 to 10,000 ft (2,300 to 3,000 m). Welsh and others (1987) reported that this shrub occurs throughout most of north, central, and eastern Utah, growing in the shade of aspen, fir, Douglas-fir, lodgepole pine, and spruce woodlands, but is less common in mountain brush and open meadows. Steele and Geier-Hayes (1987) reported sticky currant as a principal species with grand fir in central Idaho where it is often an early seral shrub, and may be the first shrub to dominate scarified sites following logging. These authors concluded that plants have a low tolerance for shade and begin to decline as a canopy taller than their own develops. Sticky currant plants attain mature stature within 5 years following logging. Their canopy is sparse, and the shrub does not seriously compete with the establishment of tree seedlings (Steele and Geier-Hayes 1987). However, plants of sticky currant remain longer than some species of ceanothus as overstory shade develops. Sticky currant is not a principal species in any conifer forest (Youngblood and Mauk 1985) or aspen type (Mueggler 1988) in Utah.

Plant Culture—Sticky currants flower in May or June, and fruits ripen in August or September (Pfister 1974). Fruits are harvested by hand picking or beating the bush to dislodge the berries onto canvas or other collection tarps. Fruits are cleaned by maceration using a Dybvig separator. Filled seeds will sink or settle in water, and the pulp and empty seeds can be decanted (Pfister 1974). Following maceration, large

seedlots can also be dried and the seeds separated from the debris using fanning mills (Plummer and others 1968). There are 255,000 to 349,000 cleaned seeds in 1 lb of cleaned seed (562,000 to 769,000 per kg) (Pfister 1974).

Most plants produce some fruits each year. New or young stands produce the most consistent crops. Although fruits are large, seed collection is slow and costly. Seed costs and poor availability discourage the use of this species in large projects. Enough seeds can be economically harvested most years from specific locations to supply seeds for rearing transplant stock. Seeds can be stored for extended periods, exceeding 17 years (Pfister 1974), if kept in dry sealed containers. Steele and Geier-Hayes (1987) reported seed buried in soil and duff remain viable long after the parent shrubs disappear.

Seeds require a wet prechilling period of 140 days at 28 to 32 °F (–2.2 to 0 °C) to initiate germination (Pfister 1974). Seed germination is only moderate. Seeds gathered from different collection sites can exhibit variable germination patterns. Plummer and others (1968) reported that initial establishment was only fair because of poor germination and relatively slow growth of small seedlings. Growth of young plants is somewhat slow, but improves as plants attain mature stature. However, plants that reach 2 to 3 years of age may succumb under adverse conditions; final establishment of seeded plots is only moderate or good. Plants are not rhizomatous, and natural spread is slow unless sites are cleared by logging, fires, or related disturbances.

This species can be produced as bareroot nursery stock or container material. Initial establishment is poor even under controlled rearing conditions; replanting is often required to produce full stands. Once established, nursery stock grows well, and when transplanted to range or wildland sites, survives quite well.

Uses and Management—Sticky currant is recommended for planting aspen, Douglas-fir, spruce woods, and less commonly mountain brush communities (Plummer and others 1968). It has been used to enhance wildlife habitat (Pfister 1974; Plummer and others 1968). Plants have only fair or poor palatability, but are quite tolerant of grazing. In Utah the plant is most commonly used during spring and summer periods by big game (Plummer and others 1968); heavy browsing may occur during these periods. Sampson and Jespersen (1963) reported that plants in California produce abundant herbage, which is heavily cropped by sheep and deer, particularly in fall.

Sticky currant grows well with other species, and frequently occurs with many other shrubs and herbs. It can be planted to stabilize disturbances following fire and logging. It grows well on undisturbed soils, but is less vigorous and poorly adapted on sites where the topsoil is disrupted or removed. The species is more site specific than other shrubs in its genus. Planting unadapted ecotypes on disturbances reduces survival; however, site factors affecting adaptation are not well understood.

The plant can be used as a nurse crop to improve seedling establishment of tree seedlings. It is also relatively abundant in localized areas and should be maintained for game habitat and ground cover. This species frequently increases following logging and becomes important for watershed protection.

Varieties and Ecotypes—None.

Family Scrophulariaceae

Penstemon fruticosus
Bush penstemon

Description—Bush penstemon is one of approximately 230 species of *Penstemon* that occur in Western North America (Hylton 1974). Most are herbaceous plants, but the list includes a few suffrutescent or woody shrubs. Bush penstemon is a woody species that normally reaches a height of 2.5 ft (76 cm). Plants form a persistent, woody crown that is usually wider than tall. They develop into wide, dense clumps when young and spread by stem layering, but natural dieback leaves the center open. Stems are erect, and clusters of leaves form at the base of current year's stems (Hitchock and Cronquist 1976). Leaves are mostly lustrous, evergreen, lanceolate or oblanceolate to elliptic, entire or serrulate or denticulate, 0.4 to 2 inches (1 to 5 cm) long, and 0.2 to 0.6 inch (5 to 15 mm) wide. Flowers are bright lavender blue, 1 to 1.5 inches (25 to 38 mm) long, 0.3 to 0.5 inch (7 to 12 mm) wide (Davis 1952). Three varieties were described by Hitchcock and Cronquist (1973); they differ in regard to leaf length, width, margins, and size of flowers. *Penstemon fruticosus* var. *serratus* is mainly confined to the Snake River Canyon of Oregon and Idaho; *P. f.* var. *scouleri* occurs in northeastern Washington, northern Idaho, and adjacent British Columbia; and *P. f.* var. *fruticosus* is more widespread and variable, but generally does not occupy the range of the two other varieties (Hitchcock and Cronquist 1973).

Ecological Relationships and Distribution—Bush penstemon generally occurs at elevations over 4,000 ft (1,200 m) on rocky slopes in forest openings from the Cascades of Washington and Oregon across Idaho to the Rocky Mountains of Montana and Wyoming (Davis 1952). Although widespread, this species is not particularly abundant. It is not a principal understory with any forest community in the Intermountain region (Mueggler 1988), northern Idaho (Cooper and others 1987), or eastern Washington

(Daubenmire and Daubenmire 1968). Plants normally occur on ridge crests, talus slopes, and forest openings. They invade roadcuts and are noticeable on abandoned disturbances. Bush penstemon is encountered in scattered stands of ponderosa pine and Douglas-fir. At higher elevations it exists in openings with subalpine fir. It does not occur in dense shrub fields or mixed grass/herb communities.

Plant Culture—Bush penstemon usually occurs as scattered plants on rocky outcrops (fig. 59). Following disturbances or clearing of overstory species, this shrub flourishes. It invades openings and forms patches dominating small rocky areas. Young plants are vigorous and robust. Disturbances often become excellent seed production centers.

Plants are evergreen; a high percentage of leaves remain on the shrub throughout the winter. New growth begins early in spring before most other plants initiate growth. Leaves develop rapidly to form a dark green clump.

Plants usually produce a profusion of flowers each year. Flowering begins in early June and may continue for nearly 1 month. Seeds ripen from mid-August to late September. Numerous seeds develop each year, but not all are viable. Seed quality varies widely among collection sites and years. Although the plant flowers for an extended period, seeds ripen fairly uniformly and remain in the capsule for nearly a month before shattering.

Seeds are collected by hand stripping the dry capsules, or by clipping the inflorescences. They must be harvested soon after the capsule dries, but before it opens and seeds shatter. Sites that are good seed producers have remained so for nearly 20 years. Most plants within a stand produce good seed crops each year. Seeds are easily harvested and can be cleaned by allowing the capsules to dry and dehisce, releasing the seeds. Seeds are small, but can be separated from the debris using a fanning mill or gravity table.

Figure 59—Bush penstemon, a low-growing mounding shrub, generally grows on rocky outcrops.

Some seeds will germinate soon after harvesting if exposed to favorable conditions, but a period of afterripening and wet prechilling is normally required to assure uniform germination. Seeds that are fall seeded receive natural wet prechilling and germinate uniformly in spring. Bush penstemon seedlings are vigorous and normally grow rapidly.

New seedlings spread quickly from existing plants. Although seedlings increase rapidly, the young plants are not highly competitive with grasses and broadleaf herbs. New seedlings are well adapted to harsh sites and compete well with other species under these conditions, but they are not able to compete with grasses and broadleaf herbs on deep, fertile soils.

Seedlings establish well by broadcast seeding on a rough seedbed or by drill seeding at shallow depths, about 0.24 inch (6 mm) on a firm seedbed. Seed germination and establishment occur uniformly; erratic stands are uncommon.

Bush penstemon is well adapted to drill or broadcast seeding. The seeds can be planted separately or in mixtures with most drills or broadcast seeders. The seeds are small and need not be planted at rates exceeding 2 to 3 lb per acre (2.2 to 3.4 kg per ha). Seeding at a rate of 2 to 4 lb per acre (2.2 to 3.4 kg per ha) is recommended for drill seeding. Broadcast seeding on unprepared road disturbances may be increased to 4 to 6 lb per acre (4.5 to 6.7 kg per ha), depending on whether other species are seeded and the condition of the seedbed. This is one species that responds well to the amount of seed sown. Increasing the seeding rate usually results in an increase in the number of plants to establish. Thus, plant density of this species can be regulated by adjusting the seeding rate. If seeded concurrently with species having larger seeds, it is recommended that the smaller seeds of bush penstemon be planted in separate drill rows to better regulate planting depth.

Small seedlings are quite vigorous. When seeded in barren openings, bush penstemon matures within 2 to 3 years. When grown in competition with grasses, the young plants can be seriously stunted. However, bush penstemon can be planted with certain grasses and forbs. Germination and seedling emergence of this shrub occur at about the same time as most herbs. Consequently, bush penstemon seedlings are able to compete favorably with many native grasses and broadleaf forbs. Bush penstemon seedlings are not able to persist when seeded with a dense cover of aggressive

grasses, including smooth brome, intermediate wheatgrass, or timothy.

Bush penstemon grows quickly from direct seeding or transplanting. Transplants can be reared as bareroot nursery stock, greenhouse-grown container stock, or rooted stem cuttings.

Bush penstemon seedlings begin growth early in spring, often before nursery lifting is completed. If bareroot stock initiates growth prior to lifting, field survival of the transplants declines significantly. Fall lifting and overwinter storage may be most practical. Plants stored in bags or crates should have the tops exposed. Plants can be fall lifted and planted in sawdust or other media for overwinter storage in open lath houses. Bareroot stock transplants very well and can provide effective ground cover within 1 to 2 years.

Bush penstemon is easily grown from seed or stem cuttings. However, plants grow rapidly and can be easily stunted if reared in containers that are too small. Container stock grows best in a well-drained, neutral potting media. Stem cuttings taken in midwinter and early spring root readily.

Uses and Management—Bush penstemon is well adapted for revegetation of road disturbances, mine sites, and other drastic disturbances (Hungerford 1984; Monsen and Christensen 1975; Plummer 1977; Tiedemann and others 1976). From roadway plantings in northwestern Montana, Hungerford (1984) rated bush penstemon as the second most useful species for revegetation of forest roads. Only Woods' rose exceeded this species in overall usefulness. The plant is extremely vigorous, matures quickly, and spreads rapidly by natural seeding and crown spread (Hungerford 1984; Monsen and Christensen 1975). It provides excellent ground cover due to its dense, low-profile growth habit. It furnishes effective protection throughout the entire year, as plants are evergreen, and provides aboveground protection at all seasons. It is able to persist and spread when buried by shifting soil. It is one of few species that is well adapted to both rocky, shallow soils, as well as deep, well-developed soils. This species can be successfully seeded or transplanted on rocky roadcuts. It establishes very well from broadcast seedings with minimal soil coverage. Few other species, including most grasses or broadleaf herbs, establish as successfully from broadcast seeding as this shrub.

Bush penstemon is an attractive shrub that flowers throughout most of the summer and provides an attractive leafy cover. It is able to spread and occupy rocky sites, providing an interesting pattern of ground cover. Both the flowers and leaves furnish an attractive background for other species. The shrub can be used to treat roadways, mine sites, and recreational areas where aesthetic values are important. It has considerable usefulness for formal plantings in landscaping commercial or residential sites. Its evergreen growth habit suggests this native shrub would be particularly useful for planting around summer homes and dwellings to prevent the spread of wildfires.

This species is also an important plant for wildlife habitat. It occupies sites that are open and exposed during midwinter. Game animals are often confined to these sites and rely heavily on this shrub. It has considerable promise for many situations, and could be more widely used in restoration programs if seeds were more available.

Varieties and Ecotypes—None.

Family Ulmaceae

Celtis reticulata
Netleaf hackberry

Description—*Celtis* is a large genus of about 70 species of shrubs and trees of the Northern Hemisphere. Netleaf hackberry is a variable taxon, and includes varieties that are difficult to separate due to the many intergradations encountered (Harrington 1964). Netleaf hackberry, also known as hackberry, western hackberry, and palo blanco, is a large deciduous shrub to small globose tree growing to 30 ft (9.1 m) in height and 6 to 12 inches (15 to 30 cm) in diameter, depending on available water (Bonner 1974a; Hitchcock and others 1973). Crowns are open and irregular with stout, ascending branches. Young twigs are glabrous to pubescent. Bark of older branches is reddish gray with prominent ridges and furrows. Plants develop a spreading and fibrous root system. Leaves are short petiolate and leathery with scabrous surfaces and entire to serrate margins. They are ovate or ovate-lanceolate, usually somewhat acuminate and acute to chordate at the base, 1 to 4 inches (2.5 to 10.2 cm) long and 0.74 to 1.5 inches (1.9 to 3.8 cm) wide. Leaf surfaces are dull green to yellow green, but paler with conspicuous reticulate veinlets below. They are three nerved near the base and short pilose along the veins. Foliage turns yellow in fall (Hitchcock and others 1973; Welsh and others 1987).

Plants are polygamo-monoecious with greenish flowers that emerge with the leaves clustered on short shoots of the current season. Flowers develop on slender, pubescent pedicels. Lower flowers are mostly staminate and several per axil. Upper flowers are one or two per axil and mostly perfect, but some may be pistillate. Perfect flowers consists of five membranous perianth segments, five stamens, and a one-seeded ovary with spreading style tips. Fruit is an orange-red to yellow, thin-walled, globose drupe with a datelike flavor (Treshow and others 1970).

Ecological Relationships and Distribution—Netleaf hackberry grows on dry foothills, open slopes, rocky bluffs, watercourses, and canyons from the Snake River drainage of the Northwestern States, east to Colorado, and south to west Texas and southern California (Bonner 1974a; Preston 1968; Thornburg 1982). It grows at elevations ranging from 2,000 to 6,000 ft (610 to 1,800 m) (Sutton and Johnson 1974; Thornburg 1982) on well-drained soils ranging from silty to rocky, shallow to deep, and neutral to calcareous (Sutton and Johnson 1974; Thornburg 1982; Van Dersal 1938). Plants grow in full sunlight and are drought tolerant and wind resistant (fig. 60). Netleaf hackberry is well adapted to watercourses and canyons where it may grow on limestone and gravelly and rocky soils (Thornburg 1982).

Netleaf hackberry occurs as scattered plants in big sagebrush and mountain brush communities at 3,000 to 5,000 ft (910 to 1,500 m) in Utah (Welsh and others 1987). It is prevalent on steep south and west slopes with pinyon-juniper, antelope bitterbrush, Stansbury cliffrose, and other mountain brush species throughout the Wasatch Mountains. It is particularly important on exposed slopes with other persistent species.

Plant Culture—Flowering occurs in March and April; fruits ripen in late fall, and seed disperses in fall and winter (Swingle 1939). Fruits persist on the trees for several months after ripening, providing a prolonged period for collection. Although this plant often grows in harsh environments, some seeds are usually produced every year. They are gathered by hand or by knocking them onto tarps. Collection may be easier in winter after leaves have fallen (Bonner 1974a). Drying may not be required if seeds are collected late in the season, but seeds are more difficult to remove from dry fruits. Twigs and other debris are removed by fanning. Extraction of the pulp by macerating the fruits in water apparently aids in improving germination. Bonner (1974a) reported that fermenting the fruits for 3 days at room temperature prior to depulping and wet prechilling improved germination. Approximately 80 lb (36.3 kg) of seed may be recovered from 100 lb (45.4 kg) of fruits; there are about 4,870 cleaned seeds per lb (10,736 per kg) (Swingle 1939). Dry fruits or cleaned seed may be stored in sealed containers at 41 °F (5.0 °C). Seeds require either fall sowing or a 120-day laboratory wet prechilling at 41 °F (5.0 °C) prior to spring sowing in the nursery (Hartmann and others 1990).

Germination is usually quite low as seed from most wildland collections has poor fill (Bonner 1974a). Undeveloped seeds are difficult to separate and remove during cleaning.

Seedlings grow slowly and are sensitive to competition from herbs. Nursery grown transplants and rooted cuttings are often recommended for field plantings to reduce problems associated with establishment from seed. Nursery or container-grown stock develops well, and field survival is excellent. One or 2-year-old planting stock is recommended for outplantings.

Seed and planting stock are rarely available on the commercial market; thus, it is necessary to arrange for collection of seed or propagation of seedlings. Although extensive testing of different ecotypes has not been reported, considerable differences in vegetative traits and areas of occurrence would suggest that planting success is dependent on the use of an adapted seed source.

Uses and Management—Netleaf hackberry currently receives limited use in artificial plantings. However, it is one of the tallest native species on sites within its range of adaptation, and provides important habitat for wildlife. It occupies exposed windblown slopes where big game animals concentrate, providing important cover and protection. The shrub is considered fair to good forage for deer and livestock (Sampson and Jespersen 1963). It frequently grows as clumps or in groups to furnish pockets of cover where few other shrubs are able to grow.

The species grows as a border along riparian zones and significantly enhances these communities. It is particularly adapted to steep slopes and well-drained sites aligning stream bottoms. Fruits persist on the tree well into the winter and provide food for birds (Thornburg 1982). Montezuma quail reportedly eat the seeds during winter months (Bishop and Hungerford 1965). Gambel quail also forage on the fruits (Gullion 1964; Martin and others 1951), as do various small mammals (Bailey 1936).

This species has established well from plantings on big game ranges in central and south-central Utah when planted on shallow soils and exposed slopes within the lower mountain brush zone. It has been

Figure 60—Netleaf hackberry growing on a dry, open slope protected by a rocky outcrop.

planted in groups or patches to provide concealment and winter cover in areas where upright vegetation is required. Game animals and livestock may graze new plantings, but not seriously enough to adversely affect plant growth. This species has survived years of drought without appreciable reduction in plant size and vigor. Once established, the young plants are very hardy and persistent. They are able to compete and grow with understory herbs.

Netleaf hackberry can be used to provide shade in recreation sites, and for windbreaks, shelterbelts, or domestic landscaping. It can be used on sites receiving at least 14 to 16 inches (36 to 41 cm) of annual precipitation. It does not require maintenance in landscape plantings, and could be more widely used in these situations.

Young plants do not grow rapidly. More rapidly developing species are recommended for unstable watershed or mine disturbances. This plant provides important ground cover on sites where high-intensity summer storms may occur. Plants are generally very hardy and long lived. Twigs and leaves are frequently infested by insect galls (Welsh and others 1987), but vigor is not seriously affected. Plants are not especially fire tolerant, and can be killed by wildfires, although resprouting does occur. Many native stands persist on rocky sites that provide some protection from wildfires. Plants that do survive fires usually recover slowly. Plants do not spread rapidly by natural seeding. Few new seedlings appear following fires or other disturbances. Seedlings appear to require shading, but seedbed requirements are not well understood.

Improved Cultivars and Other Species—None. In the Midwest, "Oahe," a released cultivar of *Celtis occidentalis*, has been used as substitute for Siberian elm, Russian-olive, and green ash, although vigor and ease of establishment are lower (Soloman 1985). The cultivar has received little testing in the Intermountain region.