Styracaceae—Storax family

Halesia carolina L.

Carolina silverbell

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Other common names. opossum-wood, silverbell, snowdrop-tree.

Growth habit, occurrence, and uses. Carolina silverbell—*Halesia carolina* L.—is a small, deciduous tree found naturally from West Virginia and southern Illinois south to South Carolina, northwestern Florida, and Alabama, with small pockets as far west as Arkansas and Oklahoma (Sargent 1965; Sluder 1990). It has been successfully planted in Massachusetts and California and also to some extent in northern and central Europe. Carolina silverbell was first cultivated in 1756 (Bonner and Mignery 1974). It is highly valued as an ornamental, and its fruits are a source of food for wildlife.

Flowering and fruiting. The perfect, white (sometimes pink), bell-shaped, axillary flowers of Carolina silverbell are borne in fascicles of 1 to 5 in March to May (Brown and Kirkman 1990; Sluder 1990). The species is precocious and seedlings may flower when only a little over 1 m in height (Dirr and Heuser 1987). The fruit, which matures in August and September, is an oblong or oblong-ovate, dry, 4-winged, reddish brown, corky drupe 2.5 to 5 cm long. The ovary is a 4-celled ellipsoid stone, 13 to 16 mm long, usually containing only 1 seed (figures 1 and 2) (Bonner and Mignery 1974; Brown and Kirkman 1990; Sluder 1990). The fruits are persistent on the branches, and dispersal occurs well into the winter.

Collection, extraction, and storage. Carolina silverbell fruits may be collected from the trees in late fall and early winter. De-winging can be done mechanically (Thornhill 1968) and is recommended to reduce bulk and facilitate handling. Complete extraction of stones from the fruits is not necessary. Bonner and Mignery (1974) found about 2,600 to 5,500 de-winged fruits/kg (1,200 to 2,500/lb) using 2 samples. Although no data on long-term storage are available, dry cold storage of cleaned fruits has been recommended (Chadwick 1935).

Figure 1—*Halesia carolina*, Carolina silverbell: fruits.

Germination tests. The seeds are extremely dormant and they response best to warm stratification followed by cold stratification. Moist stratification at 13 °C for 60 to 120 days, then 60 to 90 days at 1 to 5 °C, has worked for seeds from many sources (Bonner and Mignery 1974), although more northern collections may require more than 90 days of cold (Dirr 1977). Other sources, however, seem to need only cold stratification (Chadwick 1935). Stratified seeds can be germinated in flats of sand or sand–peat mixtures for 60 to 90 days with 30 °C day and 20 °C night temperatures. Seven samples germinated in this manner averaged 53% germination (Bonner and Mignery 1974). Germination is epigeal (figure 3).

Nursery practice. Because of uncertain response to stratification, the most practical method of propagation from seeds may be to plant in the fall and allow 2 years for full germination (Dirr and Heuser 1987). Stratified seeds should always be used for spring-sowing. Some growers in the North have planted seeds in flats of soil and have kept them in a greenhouse during the early winter months. In January,

Figure 2—*Halesia carolina*, Carolina silverbell: longitudinal section through 2 embryos of a stone.

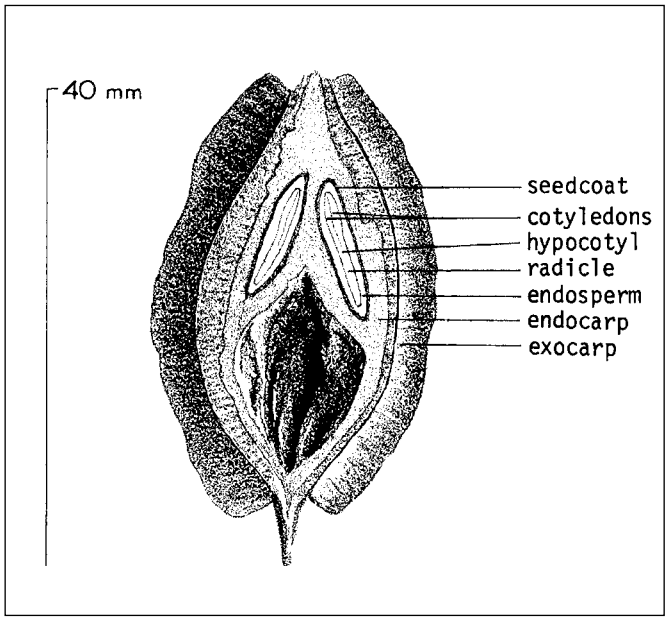
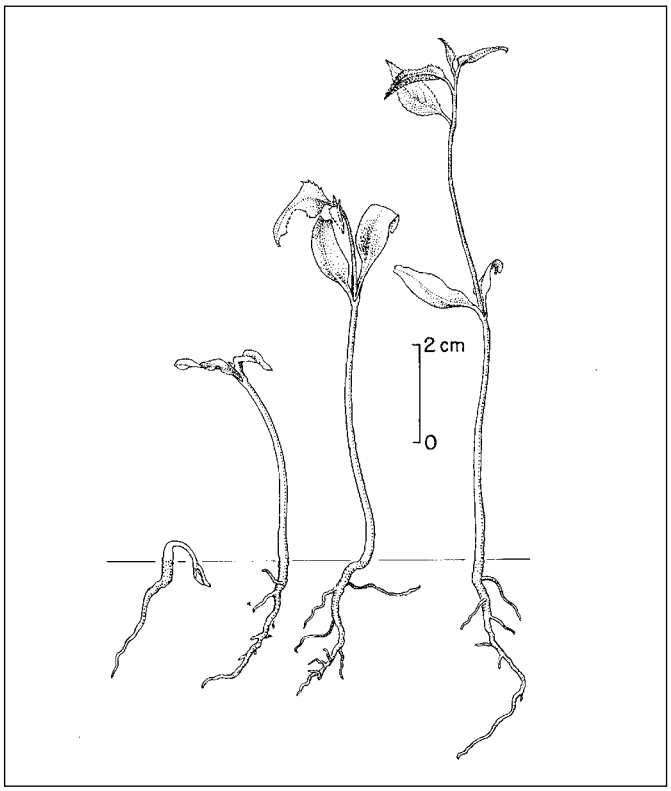


Figure 3—*Halesia carolina,* Carolina silverbell: seedling development after 1, 4, 16, and 40 days.



the flats are then moved to an outdoor cold frame for the cold part of the after-ripening treatment. The flats are protected by mulch or by board covers on the coldframes (Bonner and Mignery 1974).

Carolina silverbell can also be propagated by cuttings taken in mid-summer after shoot elongation has ceased but before fall hardening sets in. It is best to treat cuttings with 2,500 or 10,000 ppm indole butyric acid (IBA) solution and place them in peat or perlite under mist. Rooting success at levels of 80 to 100% can be expected (Dirr and Heuser 1987; Sluder 1990). Micropropagation techniques are also under study (Brand and Lineberger 1986).

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Hamamelidaceae—Witch-hazel family

Hamamelis L.

witch-hazel

Jill R. Barbour and Kenneth A. Brinkman

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Growth habit, occurrence, and use. Witch-hazels are deciduous shrubs or small trees that attain heights of 2 to 10 m (table 1). American witch-hazel is native from Nova Scotia to southeastern Minnesota, south to Missouri, southeastern Oklahoma and Texas, and east to central Florida (Little 1953). First cultivated in 1736 (Rehder 1940), American witch-hazel is used in environmental plantings largely because it flowers in late autumn. The species provides seeds for birds and browse for wildlife (Van Dersal 1938). Bark, leaves, and twigs have been used medicinally in the form of extracts. Another species—Ozark witch-hazel—is a shrub of the Ozark region of Missouri, Arkansas, and Oklahoma but is seldom planted. Japanese and Chinese witch-hazels are popular introduced ornamentals that bloom in the spring. *Hamamelis* × *intermedia* 'Arnold Promise', a hybrid of Japanese and Chinese witch-hazels, was first produced at the Arnold Arboretum (Hora 1981).

Flowering and fruiting. The spider-like yellow or rusty red flowers of American witch-hazel open in September or October, but the ovules are not fertilized until the following May. The fruits ripen early the next autumn (Rehder 1940; Van Dersal 1938). Members of the witch-hazel family have catkins for flowers and they are wind-pollinated (Johnson 1973). Ozark witch-hazel flowers from midwinter to spring (Fernald 1970). Capsules (figure 1) burst open when dry, each discharging 2 shiny black seeds (figure 2). There is limited dispersal by birds. Annual fruit production is highly variable, with abundant fruit crops occurring 1 out of 4 years (DeSteven 1982).

Developing witch-hazel seeds are the larval food of the beetle *Pseudanthonomus hamamelidis* Pierce (Curculionidae) (DeSteven 1982). Weevil eggs are laid on the fruits from mid-June to early July and the newly hatched larvae feed on the fruits from mid-July to September. Lepidopteran caterpillars may also consume the seeds. The 2 most abundant species are in the families Gelechiidae and Pyralidae, and 3 other "occasional" species are in the families Nolidae,

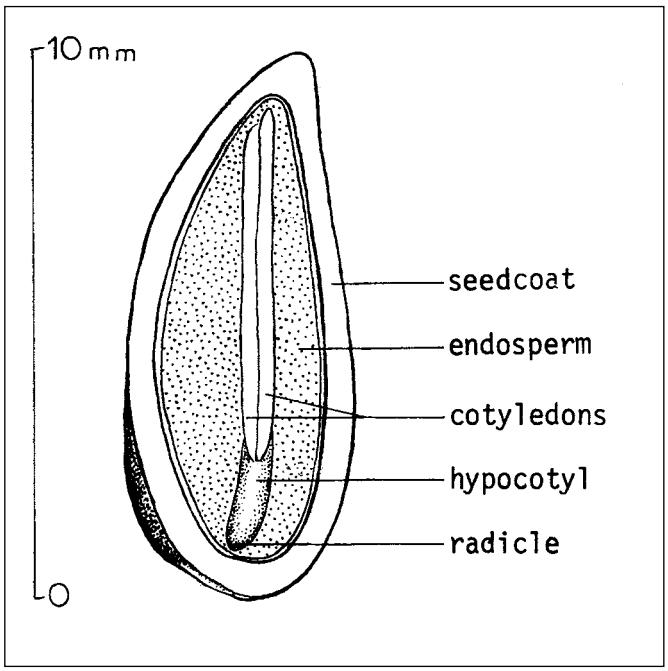
Figure 1—*Hamamelis virginiana,* witch-hazel: fruits (capsules) before and after seeds were discharged.

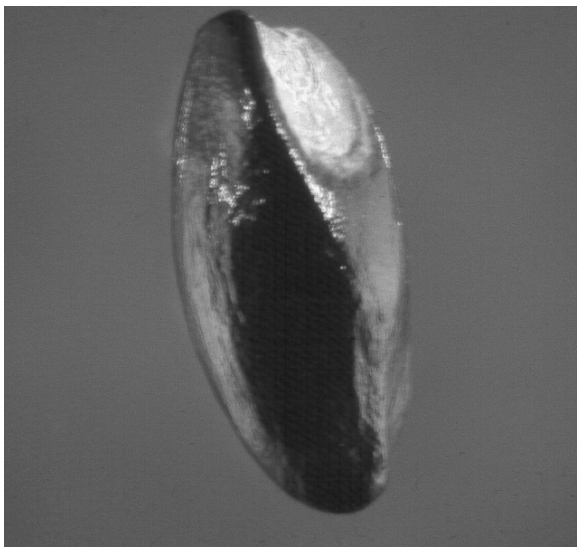
Table 1—*Hamamelis,* witch-hazel: nomenclature and occurrence

Scientific name	Common name	Occurrence	Height (m)
***H. japonica* Siebold & Zucc.**	**Japanese witch-hazel**	Japan	10
***H. mollis* D. Oliver**	**Chinese witch-hazel**	W central China	10
***H. vernalis* Sarg.**	**Ozark witch-hazel**	Ozark Mtns of Missouri & Arkansas	2
***H. virginiana* L.**	**American witch-hazel**	E US & Canada	7–10

Sources: LHBH (1976), Hora (1981).

Figure 2—*Hamamelis virginiana*, witch-hazel: longitudinal section through a seed (**top**) and exterior view (**bottom**).





Phalaenidae, and Geometridae (DeSteven 1982). Small mammals begin feeding on the seeds once they mature in the autumn. Only 14 to 16% of the seeds survive the predation by insects and mammals (DeSteven 1982)

Collection, extraction, and storage. Witch-hazel fruits should be picked in early autumn before they split open and discharge their seeds. Ripe fruits are dull orange-brown with blackened adhering fragments of floral bracts, but the seeds apparently mature as early as August before the fruit coat is fully hardened (Sandahl 1941). Fruits should be spread out to dry so the seeds may be separated from the capsules by screening. Two samples had 19,200 and 24,000 seeds/kg (8,727 and 10,909 seeds/lb) (Brinkman 1974). Fresh seeds can be stored dry in sealed containers at 5 °C for at least 1 year without loss of viability. For overwinter storage before spring-planting, seeds should be stratified in a 1:1 mixture of dampened sand and peat moss at 5 °C. The stratification medium should be 2 to 3 times the volume of seeds (Fordham 1976).

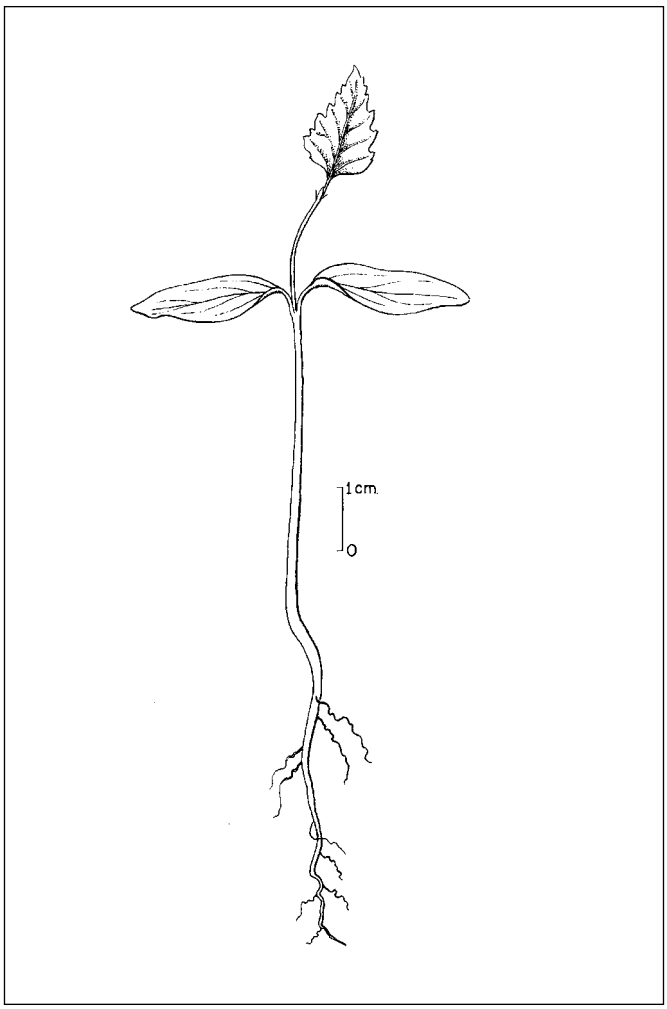
Germination and seed testing. Some stratified seeds germinate in the first spring but many remain dormant until the following year. Dormancy is due to conditions in both seedcoat and embryo, but satisfactory methods for overcoming dormancy have not been found. Rivera and others (1937) subjected witch-hazel seeds to pressures of 2,070 to 413,700 kN/m^2 (300 to 60,000 lb/in^2) at temperatures of 0, 25, and 50 °C and found that none of these conditions resulted in germination. In a series of tests, Brinkman (1974), stratified seeds for 60 days at 30 °C (day) and 20 °C (night) plus 90 days at 5 °C. When tested in sand at 30 °C (day) and 20 °C (night), 17% of these seeds germinated in 60 days.

Work in England on American witch-hazel seeds stratified for 2 months of warm and 2 months of cold, then 2 months of warm and 4 months of cold, produced 88% germination. The same seeds stratified for 2 months of warm and 1 month of cold, then $^1/_2$ month of warm and 4 months of cold, produced 84% germination. Chinese witch-hazel seeds stratified for 3 months of warm and 3 months of cold resulted in 88% germination. Ozark witch-hazel seeds germinated 70% after 3 months of cold stratification; 75% after 3 months of warm and 3 months of cold; 81% after 4 months of warm and 3 months of cold; and 85% after 5 months of warm and 3 months of cold (Dirr and Heuser 1987). A study at the Arnold Arboretum showed that Ozark witch-hazel germinated about as well after cold stratification only as it did after 2 stages of pretreatment (Fordham 1976). The Arnold Arboretum has found that 5 months of warm stratification followed by 3 months of cold treatment was satisfactory for witch-hazel seeds (Fordham 1991).

Chemical staining with 2,3,5-triphenyl tetrazolium chloride (TZ) is the preferred laboratory method for testing the viability of witch-hazel (Moore 1985). One-fourth of the seed opposite the radicle is clipped off to allow for the seed to imbibe the chemical. After staining, the seed is cut longitudinally to expose the embryo for observation. The average viability of 19 samples of witch-hazel seeds was 59% with a range of 0 to 97% (Brinkman 1974).

Nursery practice. Witch-hazel seeds may be fall-sown in the nursery as soon as collected, or stratified seeds may be sown in the spring. Limited trials show that seeds collected as early as August and sown by early October results in as much as 90% germination the following spring (Heit 1968; Sandahl 1941). Fall-sowing is recommended; the seedbeds should be mulched over winter and uncovered at germination time in the spring. For spring-sowing of stratified seeds, seedbeds should be prepared as early as soil conditions permit. Sowing in drills spaced 20 to 30 cm (8 to 12 in) apart will facilitate weeding and cultivating. Secondary leaves may develop on a seedling within 21 days after germination (figure 3). Propagation by layering also is possible.

Figure 3—*Hamamelis virginiana*, witch-hazel: seedling at 21 days after germination.



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Asteraceae—Aster family

Ericameria parishii (Greene) Hall

Parish goldenweed

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Synonyms. *Haplopappus parishii* (Greene) Blake, *Aplopappus parishii* (Greene) Blake, *Bigelovia parishii* Greene, *Chrysoma parishii* Greene.

Other common names. Parish goldenrod, Parish goldenbush, Parish heathgoldenrod.

Growth habit, occurrence, and uses. An erect shrub, Parish goldenweed has a mature height of 1 to 2.5 m (Jepson 1951). Plants 15 years old have attained heights of 2 m and crown spreads of 1.2 m (Everett 1957). Parish goldenweed occurs in the lower parts of the chaparral belt between 460 and 2,130 m of elevation in the mountains of southern California and Baja California (Munz and Keck 1959). Frequently, it is found on outwash fans and exposed hillsides. The primarily value of this species is for erosion control on dry slopes (Ratliff 1974). Since the final writing of this manual, several sections of the genus *Chrysothamnus* (see table 1) have been transferred to the genus *Ericameria*.

Flowering and fruiting. Parish goldenweed will flower and bear seeds at 2 years of age and produce seeds each year thereafter (Everett 1957). Flowering takes place from July to October (Munz and Keck 1959), and ripe seeds may be collected in October and November (Mirov and Kraebel 1937). The fruit of Parish goldenweed is a single-seeded achene (figure 1) that is handled as a seed. The achenes are about 2 mm long (figure 2), and there are about 3,600 cleaned achenes/g (101,900/oz) (Mirov and Kraebel 1937).

Collection, cleaning, and storage. Achenes are usually collected by hand and separated from their bristles by rubbing and blowing (Ratliff 1974). There are no known studies of storage, but the seeds are probably orthodox and can be easily stored at low temperatures and moisture contents.

Figure 1—*Ericameria parishii*, Parish goldenweed: achene with pappus removed.

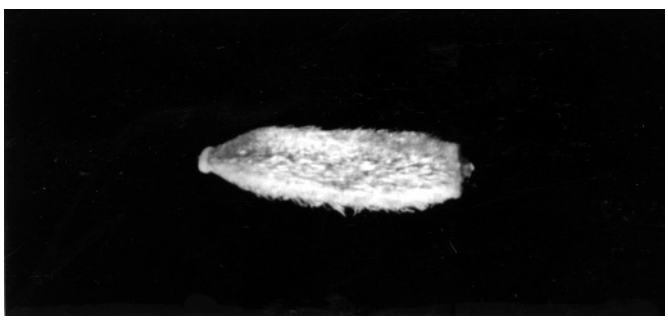
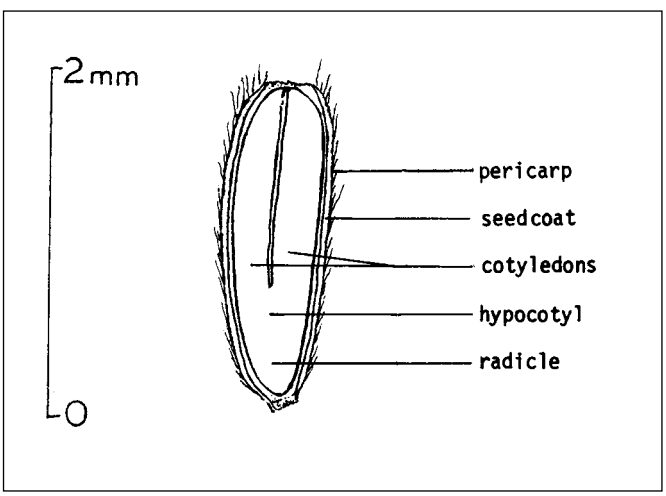


Figure 2—*Ericameria parishii*, Parish goldenweed: longitudinal section through an achene.



Germination. Parish goldenweed seeds are not dormant, and no pretreatments are required to stimulate germination (Emery 1964). Seeds sown on sand began germinating in 4 days, and a maximum of 95% was obtained (Mirov and Kraebel 1937). Germination is, however, usually much lower (about 20%) because of a high percentage of defective seeds (Ratliff 1974). Parish goldenweed may also be propagated by cuttings (Jepson 1951).

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Rosaceae—Rose family

Heteromeles arbutifolia (Lindl.) M. Roemer

Christmasberry

Susan E. Meyer

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Growth habit, occurrence, and uses. The genus *Heteromeles* has only a single species—*H. arbutifolia* (Lindl.) M. Roemer, also known as *H. salicifolia* (K. Presl.) Abrams (Phipps 1992). It is closely related to the large tropical genus *Photinia* Lindl., to which it has sometimes been referred. Christmasberry, also known as toyon, California-holly, and hollywood, is a long-lived shrub or small tree, 2 to 10 m in height, that sprouts freely after fire from a subterranean burl. It has shiny, leathery, evergreen leaves that are sharply toothed along the margins. A common constituent of chaparral vegetation throughout California and Baja California, it is usually found on less harsh, more mesic microsites. Christmasberry is useful for erosion control, is a source of honey, and has leaves and fruits that provide food for wildlife. It has also been widely planted in California as an ornamental for park, freeway, and home landscape use (Magill 1974). The attractive foliage and fruits are cut and used for their decorative value.

Flowering and fruiting. Unlike many chaparral shrubs, Christmasberry is summer-flowering (Magill 1974). The numerous, small flowers are borne in flat-topped or convex terminal inflorescences. The flowers are perigynous and have 5 separate petals, 10 stamens, and a 2- to 3-carpellate ovary. The fruits are bright red to orange, 2- or 3-seeded juicy pomes that are 6 to 10 mm in diameter. They ripen from October through January and are dispersed by birds. Good crops are reported to occur yearly (Keeley 1992).

Seed collection, cleaning, and storage. Christmasberry fruits may be clipped or stripped from the branches once they have attained a bright red or orange color (Magill 1974). They should be soaked in water and allowed to ferment slightly. (However, too-long a soaking period can damage the seeds, which have soft, pliable seedcoats.) The seeds (figure 1 and 2) may then be separated from the pulp by passage through a macerator, followed by flotation to remove the pulp. Small lots can be hand-rubbed through a large-holed screen. The seeds may then be allowed to dry. Once dry, any flat, unfilled seeds can be removed by screening.

Figure 1—*Heteromeles arbutifolia,* Christmasberry: seeds.

Christmasberry seed weight is apparently highly variable. Magill (1974) reported a mean seed weight of 19 mg and count of 52,630 seeds/kg (23,900/lb), whereas Keeley (1991) reported a seed weight of 5.5 mg and count of 181,820/kg (82,500/lb). Martineja and Bullock (1997) examined Christmasberry seed weight as a function of habitat variables. They found no correlation with latitude or annual precipitation but did find a significant increase in seed weight with increasing elevation. Overall mean seed weight for their 12 Christmasberry populations was 36 mg and seed count was 27,800 seeds/kg (12,600/lb), with weight ranges of 28 to 49 mg and counts of 20,400 to 35,700 seeds/kg (9,200 to 16,200/lb).

Christmasberry seeds have limited longevity at room temperature, but they are probably orthodox in storage behavior. Keeley (1991) reported a shelf life of less than 1 year in laboratory storage. The seeds were also damaged or killed by high temperature treatments. One hour at 70 °C reduced viability from 99 to 33%, and 5 minutes at 120 °C resulted in essentially complete mortality (Keeley 1987). Magill (1974) recommended sealed storage at low tempera-

Figure 2—*Heteromeles arbutifolia*, Christmasberry: longitudinal section through a seed.

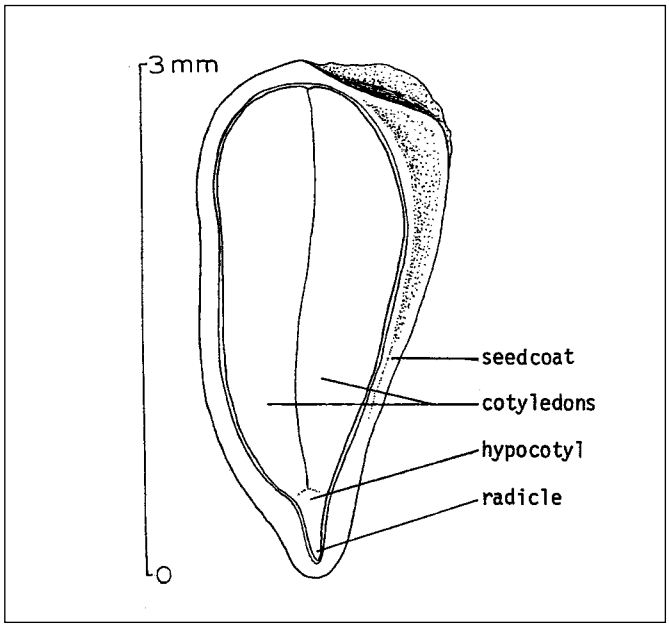
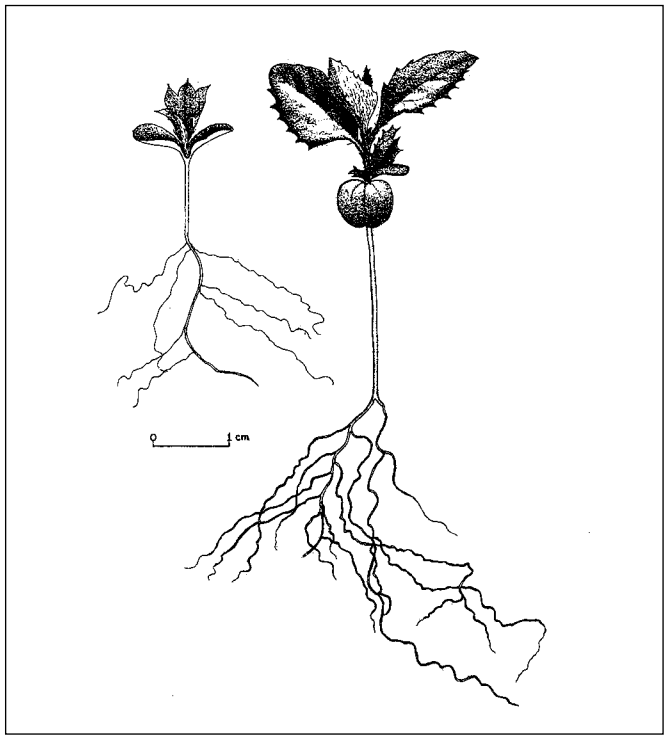


Figure 3—*Heteromeles arbutifolia*, Christmasberry: young seedling (**left**) and older seedling (**right**).



ture but did not give any data on viability retention under these conditions.

Germination and seed testing. Christmasberry seeds are reported to be nondormant at dispersal (Emery 1988; Keeley 1987; Magill 1974), whereas seeds that have been stored are rendered secondarily dormant and require 3 months of chilling at 3 to 5 °C in order to germinate. Under field conditions, Christmasberry seeds germinate within a few months of dispersal and do not form a persistent seedbank (Parker and Kelly 1989). Germination is epigeal (figure 3). Recruitment of new individuals is rarely observed. Although winter seedling emergence is a common occurrence, the seedlings almost invariably die, either from herbivory or summer drought (Parker and Kelly 1989). Because of the transient seed bank, there can be no recruitment after fire, and new recruitment is in fact restricted to chaparral stands that have been free of fire for at least 50 years (Keeley 1992). The seedlings are not very drought-tolerant and seem to need the shade and the deep litter that develops under adult shrub canopies in old stands in order to survive.

Recently harvested lots of Christmasberry seeds that are well-cleaned to remove unfilled seeds generally have high fill and high viability. Keeley (1987) reported germination of 99% at 23 °C. Such lots should be relatively easy to evaluate, either with a germination test or with tetrazolium staining. A 3-month chill at 5 °C followed by a germination test of 28 days at 20 or 25 °C should give maximum germination. Christmasberry seeds have no endosperm, and the embryo completely fills the seed cavity (figure 2). A procedure similar to that used for apple (*Malus* spp.) or bitterbrush (*Purshia* spp.) can be used for tetrazolium evaluation. The seeds should be soaked in water overnight, then clipped at the cotyledon end. The embryos can then be gently squeezed out, immersed in 1% tetrazolium chloride for 6 hours at room temperature, and examined for staining patterns. Older seedlots that have begun to lose viability and germinate sporadically will probably also have ambiguous tetrazolium staining patterns.

Field seeding and nursery practice. Christmasberry would probably be difficult to direct-seed in a wildland setting because of its establishment requirements (Keeley 1992). The seedlings require shady, moist conditions and deep litter, so they would have difficulty getting established on the open disturbances that characterize most wildland seeding projects. Christmasberry is easily propagated from seeds in a nursery setting, however. The seeds maybe planted in flats in sand or soil. If freshly harvested seeds are used, no pretreatment is necessary, and seedlings emerge over a period of 10 to 40 days (Magill 1974). Emergence of 73% has been reported in one case. The seeds may also be planted outdoors in nursery beds. Chilling before spring-planting is recommended (Magill 1974). Greever (1979) reported 100% emergence from March sowing in sand and that there was little difference in seedling size between December and March sowings by May. Propagation by grafting or cuttings is also practiced (Greever 1979; Magill 1974).

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Elaeagnaceae—Oleaster family

Hippophae rhamnoides L.

common seabuckthorn

Richard T. Busing and Paul E. Slabaugh

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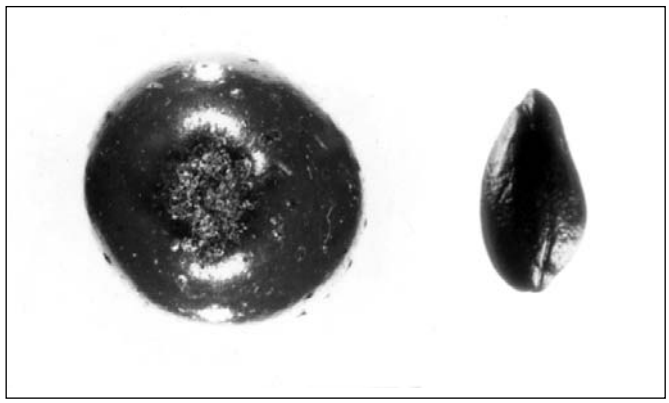
Other common names. Sandthorn, swallow-thorn.

Growth habit, occurrence, and use. Common seabuckthorn—*Hippophae rhamnoides* L.—is native to northwestern Europe through central Asia to the Altai Mountains, western and northern China, and the northern Himalayas. Of the 2 species in the genus, only common seabuckthorn is widely cultivated (Rehder 1940). A very hardy deciduous shrub or a small tree, common seabuckthorn is used primarily for ornamental purposes. In Europe and Asia, it is used to form hedges and, because of its nitrogen-fixing symbionts, serves to enrich and protect soils (Bogdon and Untaru 1967; Kao 1964; Stewart and Pearson 1967). A tendency to form thickets by root suckering limits its use in shelterbelts. In Asia, the plant has a variety of medicinal uses (Ma 1989). The berries, which are a rich source of vitamins (Stocker 1948; Valicek 1978; Zhmyrko and others 1978), have been used in making a cordial and jam in Siberia (Hansen 1931). The plant stems bear many sharp, stout thorns and provide protection, cover, and food for various birds and small rodents (Hansen 1931; Pearson and Rogers 1962).

Flowering and fruiting. The species is dioecious; its very small, yellowish, pistillate flowers appear in March or April before the leaves (Pearson and Rogers 1962; Slabaugh 1974). Orange-yellow, drupelike acidic fruits about the size of a pea (figure 1) (Rehder 1940) ripen in September or October (Hoag 1965; Hottes 1952) and frequently persist on the shrubs until the following March. Each fruit contains a bony, ovoid seed (figures 1 and 2). Seedcrops are borne annually.

Collection, extraction, and storage. Common seabuckthorn fruits are soft and cling tenaciously to the brittle twigs (Demenko and others 1983). Fruits may be picked from the bushes at any time between late fall and early spring. However, germination may vary with the time that seeds were extracted from the ripe fruits (Eliseev and Mishulina 1972). Seeds may be extracted by running the wet fruits through a macerator and floating off the pulp. Prompt cleaning and drying is advantageous because germination rate is very low for seeds left too long in the fruits (Eliseev and Mishulina 1977; Rohmeder 1942). From 45 kg (100 lb) of fruits, 4.5 to 14 kg (10 to 30 lb) of cleaned seeds may be extracted. Soundness of 85% and purity of 97% have been reported (Slabaugh 1974). The average number of cleaned seeds determined on 10 samples is 88,000/kg (40,000/lb), with a range of 55,000 to 130,000/kg (25,000 to 59,000/lb) (Slabaugh 1974). Smaller seeds, numbering 258,000 to 264,500/kg (117,000 to 120,000/lb), were reported in Romania (Enescu and Stegaroiu 1954). The seeds are orthodox and store easily at low moisture contents and temperatures. Dry seeds have been kept satisfactorily for 1 to 2 years at room temperature (Slabaugh 1974). Viabilty of 60% has been reported for seeds stored 4 to 5 years (Smirnova and Tikhomirova 1980).

Figure 1—*Hippophae rhamnoides*, common seabuckthorn: fruit and seed.



Germination. Internal dormancy in seeds of seabuckthorn can be broken by stratification in moist sand for 90 days at 2 to 5 °C (Cram and others 1960; Pearson and Rogers 1962). Stratification for 15 days is sufficient if seeds are sown in the autumn (Grover and others 1962). Germination tests may be run in 40 days on stratified seeds

Figure 2—*Hippophae rhamnoides*, common seabuckthorn: longitudinal section through a seed.

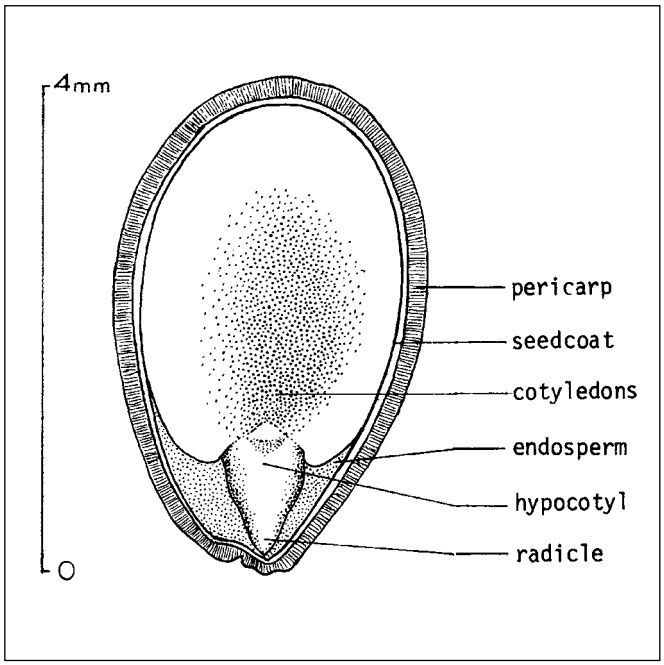
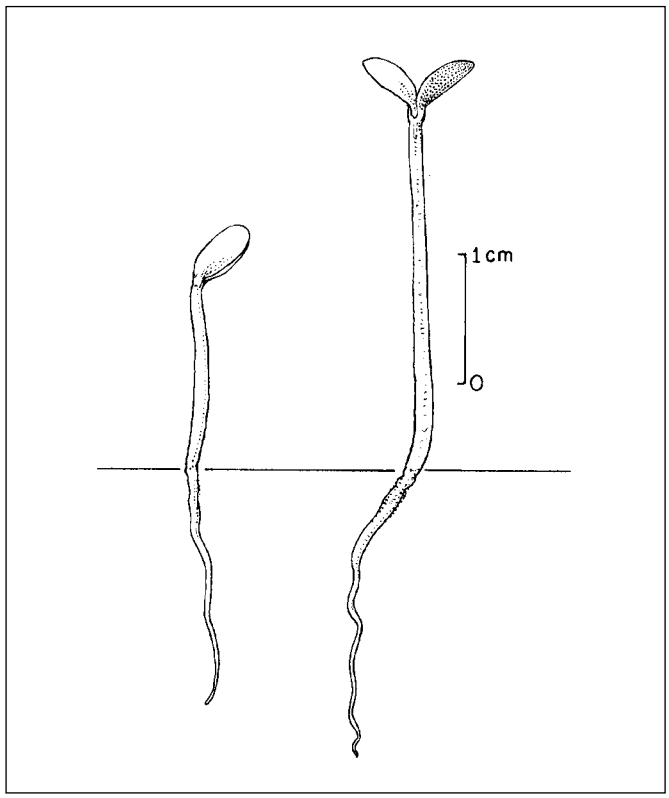


Figure 3—*Hippophae rhamnoides*, common seabuckthorn: seedling development at 1 and 7 days from germination.



in sand flats at diurnally alternating temperatures of 20 and 30 °C (Slabaugh 1974). Germination was increased slightly by exposure to light intensities up to 2,150 lumens/m^2 (Pearson and Rogers 1962). Soaking seeds in solutions of gibberellic acid, sulfuric acid, or other compounds, such as potassium iodide (KI), zinc sulfate ($ZnSO_4$), manganese sulfate ($MnSO_4$), or cobalt sulfate($CoSO_4$), may also increase germination (Avanzanto and others 1987; Eliseev and Mishulina 1972). Germination of untreated seeds ranged from only 6 to 60% after 60 days (Slabaugh 1974). Tests in Romania and England gave results of 75 to 85% and 95 to 100% (Enescu and Stegaroiu 1954; Pearson and Rogers 1962). Germination is epigeal (figure 3).

Nursery practice. Untreated seeds may be used for fall-sowing (Grover and others 1962), but stratified seeds are needed for spring-sowing (Cram and others 1960). Either broadcast or drill sowing is satisfactory if seeds are covered with about 6 mm ($^1/_4$ in) of soil. Shading during the early stages of germination is beneficial (Hansen 1927). This species can be propagated by layers, suckers, and root cuttings as well as by seeds (Avanzanto and others 1987; Papp 1982, Varga and Foldesi 1985). It grows best on moist, neutral to basic, sandy soils (Pearson and Rogers 1962).

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Rosaceae—Rose family

Holodiscus (K. Koch) Maxim.

ocean-spray

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Growth habit, occurrence, and use. *Holodiscus* is a taxonomically complex genus including about 6 species of western North America and northern South America (Hitchcock and others 1961; Ley 1943). The 2 generally recognized North American species (table 1)—creambush ocean-spray and gland ocean-spray—are deciduous, multistemmed shrubs with simple, alternate, deciduous, toothed to shallowly lobed, exstipulate leaves.

Creambush ocean-spray grows from 1 to 6 m in height, with slender, arching branches and grayish red exfoliating bark. It is a prolific root sprouter, capable of recovering from fire, grazing, or mechanical damage by resprouting from perennating buds in the root crown. Growing at elevations from sea level to 2,150 m, it is most abundant in coastal areas from British Columbia to southwestern California. It also occurs eastward to Montana in drier conifer types of the interior Pacific Northwest. A dominant shrub in a number of forested communities, creambush ocean-spray is also common in riparian areas and on rocky talus slopes (Halversen and others 1986; Topik and others 1986). Remnant stands are found on higher peaks of Great Basin mountain ranges (Hitchcock and others 1961; USDA FS 1937).

Gland ocean-spray is a low, intricately branched shrub that is 0.1 to 3 m tall (Harrington 1954). It differs from creambush ocean-spray in its more compact growth habit, leaves with decurrent petioles, and leaf lobes or teeth without secondary teeth. Gland ocean-spray grows east of the Cascade Mountains and the Sierra Nevada, from north central Oregon to Chihuahua, Mexico, at elevations ranging from 1,400 to 3,350 m (Harrington 1954; Mozingo 1987; USDA FS 1937). Although gland ocean-spray is found in a variety of plant communities, its most characteristic habitats are talus slopes, rock outcrops, slickrock plateaus, and dry, rocky desert areas.

Palatability and forage value of both ocean-spray species vary geographically but are generally low for livestock and big game. However, in the absence of more palatable shrubs, substantial quantities are browsed by deer (*Odocoileus* spp.) and by elk (*Cervus elaphus*) on low-elevation winter ranges. In some areas, ocean-sprays are important year-round (USDA FS 1937). Both shrubs may increase on summer ranges where other forage species are browsed preferentially (Ferguson 1983). Gland ocean-spray is browsed in summer by bighorn sheep (*Ovis canadensis*) and both species are browsed by rabbits (Sutton and Johnson 1974; Todd 1975; Van Dersal 1938).

Ocean-spray has considerable potential for revegetating a variety of disturbed areas. Populations capable of growing on dry, rocky, well-drained sites may be particularly useful

Table 1—*Holodiscus,* ocean spray: nomenclature and occurrence

Scientific name & synonym(s)	Common name(s)	Occurrence
***H. discolor* (Pursh) Maxim.** *Spiraea discolor* Pursh *Spiraea ariaefolia* Smith in Rees *Schizonotus discolor* Raf. *Sericotheca discolor* Rydb.	**creambush ocean-spray,** creambush, creambush rockspirea, hardhack, Indian arrow-wood, ocean-spray	S British Columbia, Washington, Oregon, W Montana, N Idaho, NE Nevada, & California
***H. dumosus* (Nutt.) Heller** *Spiraea dumosa* Nutt. ex T. & G. *Spiraea discolor* var. *dumosa* Wats. *Schizonotus dumosus* Koehne. *Sericotheca dumosus* Rydb.	**gland ocean-spray,** bush ocean-spray, bush rockspirea, mountain-spray, rock-spirea, creambush	E & S Oregon, N central & S Idaho, NE California, Nevada, Utah, W & S Wyoming, Colorado, Arizona, New Mexico, & S to Chihuahua, Mexico

Sources: Archer (2000), Flessner and others (1991), Hitchcock and others (1971), Ley (1943), McMurray (1987b).

(Stark 1966; Sutton and Johnson 1974). Ocean-spray has been recommended for use in nonintensive highway plantings, riparian areas, windbreaks, erosion control projects, wildlife habitat improvement projects, and conservation plantings (Antieau 1987; Atthowe 1993; Flessner and others 1992). Because of their growth habits, showy inflorescences, and fall coloration, both species are attractive ornamentals. Creambush ocean-spray was first cultivated in 1827 and gland ocean-spray in 1853 (Rehder 1940).

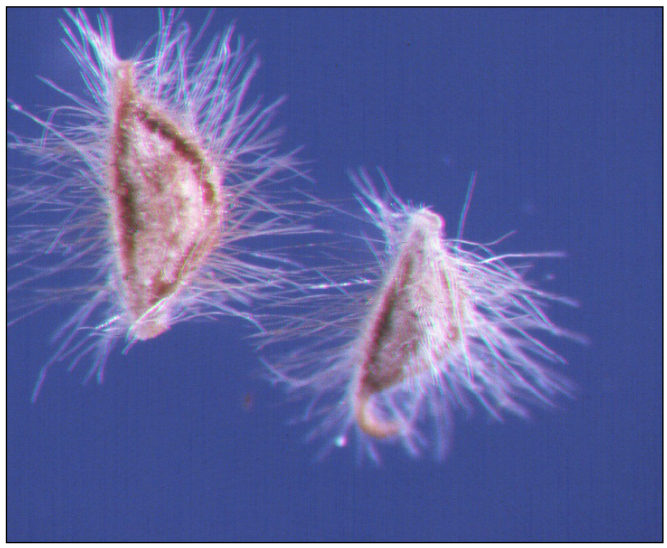
Native Americans made digging sticks and arrow shafts from the hard wood and straight branches of ocean-spray (Anderson and Holmgren 1969; Daubenmire 1970; Hopkins and Kovalchik 1983). Fruits of gland ocean-spray were eaten by Native Americans of the Great Basin, and pioneers made nails from its wood.

Both North American ocean-sprays are tetraploid, with 2X = n = 18 (Antieau 1986; Goldblatt 1979; McArthur and Sanderson 1985), and both exhibit considerable morphological variation. A genetic basis for variability in such characteristics as growth habit, growth rate, leaf morphology, and flower abundance in creambush ocean-spray is suggested by common garden studies (Flessner and others 1992).

Flowering and fruiting. Although the showy terminal panicles and floral buds of both species develop in early spring, flowering is delayed until late spring to mid-summer. Fruits ripen in late summer and are dispersed by wind and gravity through November (Hitchcock and others 1961; Stickney 1974) (table 2). The insect-pollinated flowers are small, creamy-white, perfect, and perigynous (Hitchcock and others 1961; McArthur 1984). The entire disk lining the hypanthium gives the genus its name (Greek: *holo* = whole and *diskos* = disk). Each flower produces 5 villous, light-yellow achenes that are about 2 mm long (figures 1 and 2). Seeds are broadly oblong and contain a thin endosperm and an embryo with ovate cotyledons (figure 2) (Ley 1943).

Collection, cleaning, and storage. Ocean-spray achenes are among the smallest of shrub fruits. Estimates of the number of cleaned achenes per weight exceed 11,000,000/kg (5,000,000/lb) for each species (King 1947; Link 1993). Achene collection is tedious, and supplies are rare and costly. In addition, the achenes are difficult to handle because of their pubescence and small size. Achenes are hand-stripped from inflorescences in late summer or autumn (table 2) (Monsen 1996). Large debris in air-dried collections can be removed with a fanning mill. Small lots may be cleaned by hand-rubbing and sieving (Link 1993).

Figure 1—*Holodiscus*, ocean spray: achenes of *H. discolor*, creambush ocean-spray.



Sound achenes are identified by examining imbibed achenes through a dissecting microscope for the presence of an embryo. Using this method, King (1947) found that only 7% of ocean-spray achenes collected were sound. In creambush ocean-spray from British Columbia, viability was greater for achenes collected in October or November than for those collected in August or September (Marchant and Sherlock 1984).

Storage requirements for ocean-spray have not been examined. The achenes appear to be orthodox in storage behavior and can probably be stored for several years at low water contents and temperatures.

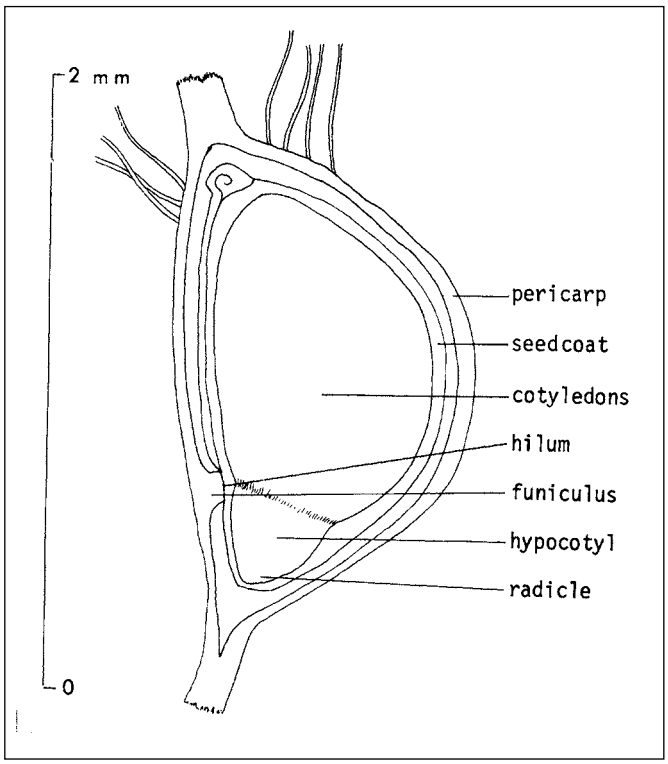
Germination. There are no official testing prescriptions for this genus. Germination of creambush ocean-spray seeds is enhanced by wet prechilling at 2 to 5 °C for 15 to 18 weeks (King 1947; Marchant and Sherlock 1984). King

Table 2—*Holodiscus*, ocean-spray: phenology of flowering and fruiting

Species	Location	Flowering	Fruit ripening	Seed dispersal
H. discolor	California	May–Aug	—	—
	N Idaho	July	Aug	—
	N Idaho	July	Late July–early Sept	Aug–Nov
H. dumosus	Great Basin	June–Aug	—	—
	Utah	June–Aug	—	—
	—	—	Aug	Aug

Sources: Drew (1967), Jorgensen (2004), Mozingo (1987), Munz and Keck (1973), Orme and Leege (1980), Welsh and others (1987).

Figure 2—*Holodiscus discolor*, creambush ocean-spray: longitudinal section through an achene.



(1947) obtained 84% germination in 22 days when seeds were chilled for 18 weeks before incubation at 20 to 24 °C.

Germination of gland ocean-spray has received little study. Link (1993) reported that 16 weeks of wet chilling failed to release dormancy in this species. Effective treatments have not been reported.

Viability of ocean-spray seeds may be tested by tetrazolium chloride staining. After 3 hours of imbibition in water at room temperature, seeds are excised from the achene and the seedcoat is pricked or slit near the center of the seed. Seeds are then allowed to imbibe a 1% tetrazolium chloride for 4 hours at room temperature. Stained embryos may be read in place, as the seedcoat is very thin (Hurd 1996; King 1947). Staining should be evaluated as described by Peters (2002) for Rosaceae III genera.

Nursery practice. Ocean-sprays may be propagated as bareroot or container stock (Everett 1957). Achenes should be fall-sown or artificially prechilled and spring-sown in bareroot nurseries (Flessner and others 1992). Marchant and Sherlock (1984) obtained successful plantings only by planting freshly harvested achenes in fall. Cleaned achenes of both species can be drilled at reasonably uniform spacings within rows (Shaw and Monsen 2004). They may also be broadcast and covered by dragging a lightweight chain over the seedbed. Seedlings develop slowly and may be lifted as 1+0 or 2+0 stock, depending upon size specifications and growing conditions.

Container seedlings are propagated by planting several wet-prechilled achenes in each container and thinning or by planting germinants. Kruckeberg (1982) reported that ocean-spray can be propagated by fall-sowing achenes in boxes outdoors and covering them lightly with soil. Flessner and others (1992) planted wet prechilled (4 months at 4 °C) creambush ocean-spray achenes in shallow flats in a greenhouse. Seedlings emerged after 16 to 30 days of incubation at a minimum temperature of 21 °C. Developing seedlings were fertilized and treated with a fungicide as necessary. After 2 months they were transferred to larger containers in a lathhouse and held overwinter for planting as 1+0 stock.

Kruckeberg (1982) reported that creambush ocean-spray planting stock is easily obtained by potting wildlings, which are often abundant. Morgan and Neuenschwander (1988) observed high densities of creambush ocean-spray wildlings following severe burns, but Wright and others (1979) and Stickney (1996) concluded that the species exhibits poor seedling regeneration following fire in sagebrush (*Artemesia* spp.) and conifer communities of the intermountain and northern Rocky Mountain regions.

Ocean-spray can be grown from cuttings, but rooting of both species varies widely among clones, cutting types, and propagation techniques (Antieau 1987; Link 1993). Softwood cuttings may be treated with rooting hormones and propagated in a greenhouse with a mist system (Antieau 1987; Marchant and Sherlock 1984). Success with semi-hardwood cuttings is variable (Everett and others 1978; Kruckeberg 1982). Fall-harvested hardwood cuttings are cut to 15-cm (6-in) lengths and treated with 0.8% indole-3-butyric acid (IBA) powder and a fungicide (Macdonald 1986). Hardwood cuttings stored in straw-bale bins or cold frames will develop calluses (Macdonald 1986; Marchant and Sherlock 1984). When fall-planted, these cuttings root rapidly. Layers and suckers have also been propagated successfully (Kruckeberg 1982).

Field practice. Fresh achenes broadcast over a rough seedbed in fall are covered by natural soil sloughing (Shaw and Monsen 2004; Van Dersal 1938). Achenes may be mixed with seeds of other shrub species, but they should not be sown with more competitive grasses or forbs. Planting areas should be selected carefully to make the best use of seed supplies, as seeding results are often erratic. Native creambush ocean-spray seedlings develop slowly and are poor competitors (Wright and others 1979).

Creambush ocean-spray can be established by transplanting. Youtie (1992) reported good survival of rooted cuttings on biscuit scablands in Oregon's Columbia River Gorge. Marchant and Sherlock (1984) found that planted seedlings grew slowly the first year. Low survival on western Montana roadcuts was attributed to poor soils and unhealthy planting stock (Hungerford 1984).

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Fabaceae—Pea family

Hymenaea courbaril L.

courbaril

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Other common names. jutaby, *cuapinol*, *algarrobo*.

Occurrence and growth habit. Courbaril—*Hymenaea courbaril* L.—is a large tree, about 45 m tall, relatively slow growing (about 1 m/year) with a well-formed clean trunk. It develops best on sandy, drained ridges and river banks (but not well in wetlands) and is normally found in open sites from southern Mexico, Central America, and the West Indies, to northern South America. It is found in a variety of soils, such as clay to sand, occurring predominantly in oxisols, with a pH range from 4.8 to 6.8. It grows best in areas with 1,900 to 2,150 mm of rainfall, and from sea level to about 900 m. It coppices well in cut-over areas except from large stumps and can also be propagated from cuttings. Courbaril is the most widespread of the 17 species in the genus *Hymenaea*; there is an African species and the remaining species are found in neotropical America. Courbaril readily forms forest associations in semi-deciduous, secondary, moist subtropics (Rzedowski 1981). It is also reported in nearly pure stands in Mexico (Weaver 1987).

Use. Courbaril's basic use is for timber. The wood is strong, hard, and tough; it is difficult to saw, machine, and carve but bends well after steaming. It is commercially useful for flooring, handles, sporting equipment, furniture, and railroad ties (Chudnoff 1984). Its heartwood has a specific gravity of about 0.70 g/cm^3. Although courbaril wood is resistant to white-rot fungi (less to brown-rot) and termites, it has little resistance to marine borers. It does not weather well and does require painting (Francis 1990; Longwood 1962). The tree has limited ornamental use for shade, parks, and streets because of its heavy legumes (pods) and the offensive odor of the broken legumes as seeds mature. Although it has a limited appeal, the seed pulp is a good dietetic source of sugar and high in fiber when eaten plain or toasted or drunk as a fermented beverage. It is also given to livestock. According to local folk medicine, a bark infusion is used as a laxative and the fruit pulp as an antidiarrheal (Liogier 1978).

Flowering and fruiting. Large trees with full, overhead light usually flower during spring and summer. Terminal racemes bear white flowers about 4 cm wide. Mature legumes (figure 1) measure 5 to 10 cm long, 2 to 3.5 cm wide, and 2.5 cm thick and fall during the following spring. The thick, hard legume does not open naturally, but protects 3 or 4 large seeds (figures 2 and 3) encased in a powdery, cream-colored pulp (Liogier 1978). Small animals—such as agouties (*Tayassu* spp.) and peccaries (*Dasyprocta* spp.)—open the legumes to eat the pulp and seeds. Legumes have a protective gum that delays rotting for several months, until the seeds begin to take up moisture for germination; otherwise the seeds would rot in their legumes (Jansen 1983).

Collection and storage. Seeds collected in Puerto Rico average about 253/kg (115/lb) (Francis 1990), whereas those collected in Brazil yield 475/kg (215/lb) (Pereira 1982). A single tree may produce 100 legumes per year but not necessarily each year. Because of the height of the trees, the legumes are usually picked manually from the ground, and seeds are obtained from fresh legumes that have fallen in spring (Jansen 1983). After-ripening causes an actual

Figure 1—*Hymenaea courbaril*, courbaril: legume.

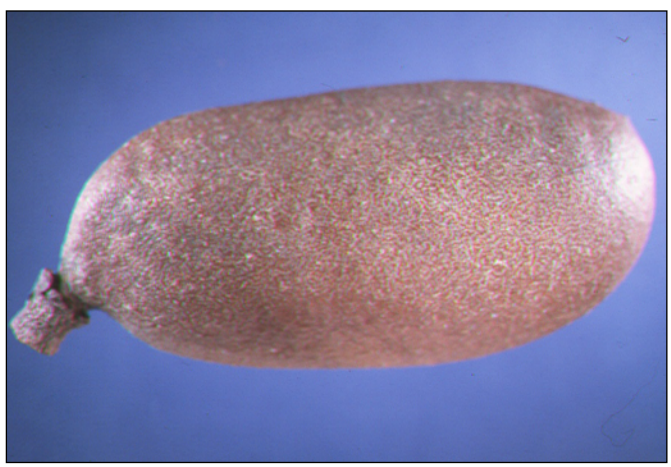


Figure 2—*Hymenaea courbaril*, courbaril: seeds.

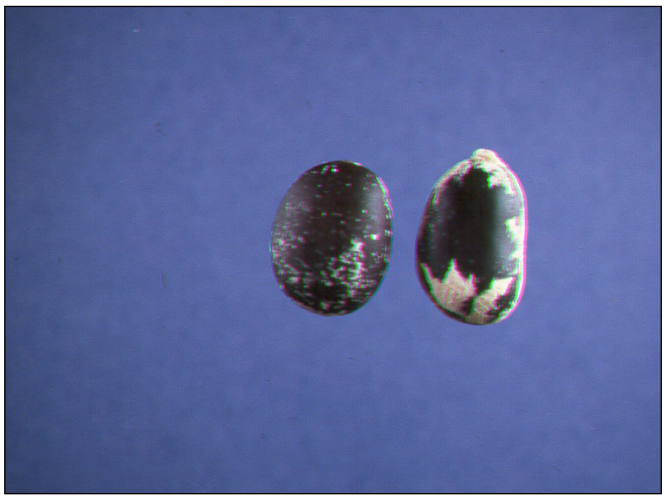
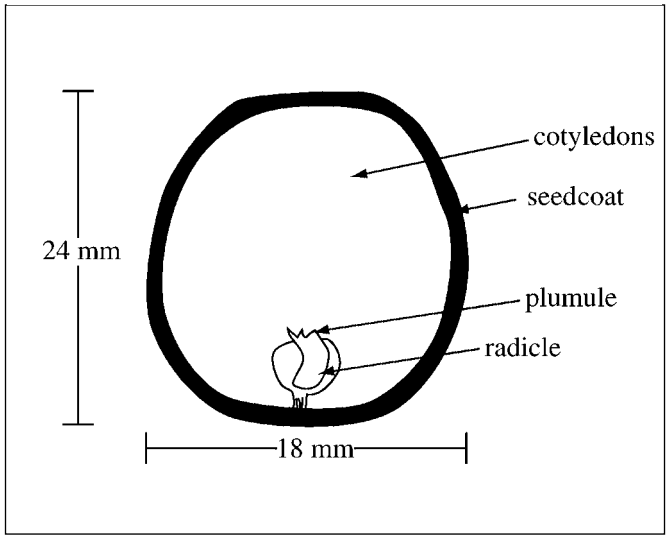


Figure 3—*Hymenaea courbaril*, courbaril: longitudinal section through a seed.



germination enhancement during the first 4 months after collection. This may also account for the long (9-month) period seeds remain in the legume on the tree before falling. Courbaril seeds are orthodox in storage behavior and store relatively well with acceptable germination for periods in excess of 1 year. However, the conditions for optimal storage changes with time. For the first year, sealed containers are preferable at ambient temperatures; after that, seeds should be refrigerated or kept in unsealed bags (Marrero 1943).

Germination. Simple scarification or an hour of soaking in sulfuric acid is necessary as a germination pretreatment (Marshall 1939). After imbibition, seeds may be germinated in potting mix for 14 to 21 days with up to 90% germination (Francis and Rodriquez 1993; Marrero 1949). Seeds can be germinated at ambient temperature in either potting mixture or sand placed in shallow trays or moistened filter or blotter paper in petri dishes.

Nursery practice. Container stock may be grown in either full sun or 50% shade. However, seedlings grown in full sun are ready for outplanting about 2 weeks earlier than seedlings grown in shade (Francis 1990; Pereira 1982). Although courbaril may be direct-seeded or underplanted, success is greater with containers unless seeds can be given greater protection. A large taproot with a well-developed fibrous net grows deeply and may or may not have associated nitrogen-fixing nodules (Allen and Allen 1981). Seeds may be infected by a bruchid beetle, *Pygiopachymerus* sp. (Decelle 1979); a weevil, *Rhinochenus* sp. (Jansen 1975); and an ant, *Atta* sp. (Jansen 1983).

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