1937). Elm seeds can be cleaned with an air-screen cleaner in a reverse procedure—blowing out the seeds, and catching the heavier leaves and twigs (Myatt 1996) with the air vents wide open on both sides of the cleaner. A large round-holed 9.9-mm screen (#25) is placed on top of the cleaner to separate the seeds from the leaves and a small round-holed 2.4-mm screen (#6) is placed on the bottom to separate the twigs from the seeds (Myatt and other 1998). Only 3 to 7% of the seeds blown out of the air chute in the back of the air-cleaner were good seeds (Myatt and others 1998).

Fruits usually are sown or stored with the wings attached. Elm seeds are orthodox in storage behavior and should be stored at low temperatures and moisture contents in sealed containers (table 4). Dessication of smoothleaf elm seeds to 3.3% moisture content did not reduce germination (Tompsett 1986). When the temperature of storage was increased at constant moisture contents, seed longevity was reduced within the range of –13 to 52 °C. Smoothleaf elm seeds stored at 22% moisture content (fresh-weight basis) died after 7 days at –75 C°, but seeds stored at 19% moisture content lost no germination ability. Lowering the storage temperature from –13 to –75 °C did not increase seed longevity. Tompsett (1986) found that a 5% moisture content and a temperature of –20 °C or lower maintains the long-term seed viability for smoothleaf elm seeds. Tylkowski (1989) reported that Russian elm seeds dried to 10% moisture could be stored at –1 to –3 °C for 5 years without losing any viability; however, after 6 years of storage, a 20% decrease in germination was observed. Siberian elm seeds with 3 to 8% moisture content have been stored at 2 to 4 °C in sealed containers for 8 years (Dirr and Heuser 1987). Air-dried Scots elm seeds stored at 1 to 10 °C were only viable for 6 months (Dirr and Heuser 1987).

Dried American elm seeds stored at 0, 10, and 20 °C declined from 65 to 70% germination before storage to less than 10% after 10.5 months of storage (Steinbauer and Steinbauer 1932). Another lot of dried American elms seeds stored at 20 °C exhibited a steady, continuous decline in germination when stored for 14 to 51 weeks compared to fresh seed germination values (Steinbauer and Steinbauer 1932). Barton (1939, 1953) found that a 75% germination value for American elm seeds was retained after 15 years of seed storage at –4 °C with a 3% seed moisture content .

Pregermination treatments. Under natural conditions, elm seeds that ripen in the spring usually germinate in the same growing season; seeds that ripen in the fall germinate in the following spring. Although seeds of most elm species require no presowing treatment, practically all the seeds in some seedlots of American elm remain dormant until the second season (Rudolf 1937). Dormant American elm seedlots should receive cold stratification for 2 to 3

Table 4—*Ulmus,* elm: seed storage conditions

Species	Seed moisture (%)	Storage temp (°C)	Viable period (yr)
U. alata	Air-dried	4	1
U. americana	3–4	–4	15
	Air-dried	4	2
U. crassifolia	Air-dried	4	1
U. glabra	Air-dried	1–10	0.5
U. laevis	Air-dried	22	0.5
U. parvifolia	10–15	0	0.5
U. pumila	3–5	2–4	8
U. thomasii	Air-dried	Cold	—

Sources: Barton (1939, 1953), Brinkman (1974), Heit (1967a&b), Kirby and Santelmann (1964), Rohmeder (1942), Sus (1925).

Table 5—*Ulmus,* elm: seed yield data

				Cleaned seeds (x1,000)/weight				
	Place	Fruit/vol		Average		Range		
Species	collected	kg/hl	lb/bu	/kg	/lb	/kg	/lb	Samples
U. alata	Mississippi	—	—	245	112	222–269	101–119	4
U. americana	—	5.8	4.5	156	71	106–240	48–109	14
U. crassifolia	Mississippi	—	—	147	67	130–135	59–61	5
U. glabra	Europe	4–6.5	3–5	88	40	66–99	30–45	12+
U. japonica	Japan	—	—	12.8	6	—	—	2+
U. laevis	Russia	—	—	140	63	117–205	53–93	20+
U. parvifolia	US, Japan	—	—	265	121	250–372	114–169	6+
U. pumila	—	—	—	158	72	88–261	40–119	35+
U. rubra	—	—	—	90	41	77–119	35–54	10
U. serotina	—	—	—	328	149	—	—	—
U. thomasii	—	7.7–10.3	6–8	15	7	11–15	5–7	5

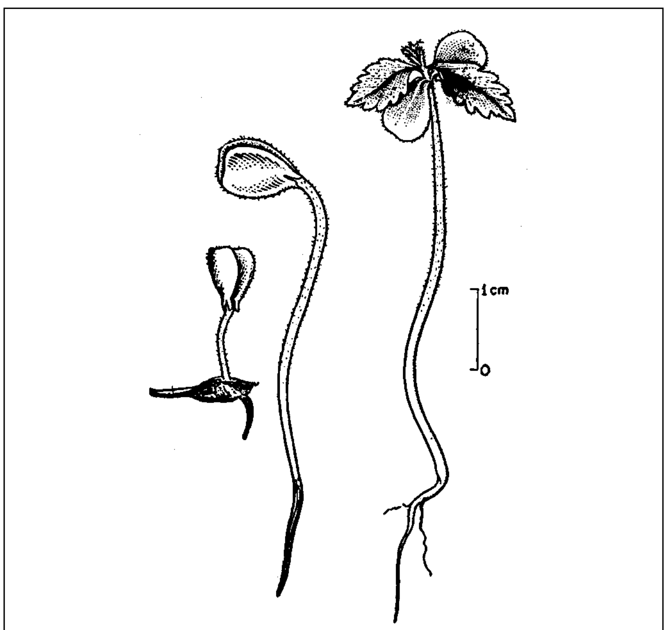
Sources: Asakawa (1969), Brinkman (1974), Engstrom and Stoeckeler (1941), Goor (1955), Gorshenin (1941), Heit (1969), Rafn and Son (1928), Stoeckeler and Jones (1957), Sus (1925), Swingle (1939), Taylor (1941), Van Dersal (1938), Wappes (1932).

months (Dirr and Heuser 1987). Seeds of slippery elm, especially from northern sources, also may show dormancy; 70% of fresh seeds germinated and 57% germinated after 2 months of cold, moist stratification (Dirr and Heuser 1987). Stratification at 5 °C for 60 to 90 days before sowing improves germination of cedar, smoothleaf, and September elms (Brinkman 1974; Dirr and Heuser 1987; Maisenhelder 1968).

Winged, Scots, Japanese, English, Russian, Siberian, and rock elms have no pregermination requirements (Dirr and Heuser 1987). Fresh seedlots of Scots elm germinated at 98%, but after 2 months of cold, moist stratification, only 88% germinated (Dirr and Heuser 1987). English elm rarely produces seeds, but fresh seeds will germinate at 100% with or without 2 months of stratification (Dirr and Heuser 1987). Fresh Siberian elm seeds germinated 96% and cold stratification did not improve germination (Dirr and Heuser 1987). Fresh lacebark elm seeds will germinate without pretreatment, but once dried they require 1 to 2 months of cold, moist stratification (Dirr and Heuser 1987).

Germination tests. Official testing rules for American elm call for alternating temperatures of 30 °C (day) for 8 hours and 20 °C (night) for 16 hours for 14 days on wet blotters and 10 days at a constant 20 °C for Chinese and Siberian elms (AOSA 2001). American elm seeds can also germinate well at alternating temperatures of 21 °C (day) and 10 °C (night) (Burns and Honkala 1990). The International Seed Testing Association (1999) suggests testing for 14 days on wet blotters for all 3 species. ISTA also suggests removal of the pericarp if germination is slow. Germination tests of most species may also be made on sand or peat in germinators at alternating temperatures of 30 °C (day) and 20 °C (night). Rock elm seeds germinated 70 to 80% in a peat moss medium (Burns and Honkala 1990). Light requirements may vary among species (table 6). American elm can germinate in darkness but germination is increased with the addition of light (Burns and Honkala 1990).

Figure 3—*Ulmus americana*, American elm: seedling development at 1, 3, and 21 days after germination.



Germination is epigeal (figure 3); it usually peaks within 10 days. Seedlots of stratified seeds complete germination in 10 to 30 days. With American elm seeds, germination can extend up to 60 days; seeds can lay on flooded ground for a month without adversely affecting germination (Burns and Honkala 1990). Radicles of rock elm emerge in 2 to 3 days in a petri dish and are 2.5 to 3.8 cm (1 to 1.5 in) long by the 5th day; cotyledons opened about the 5th or 6th day (Burns and Honkala 1990). Winged elms cotyledons are oval with shallowly notched apexes and heart-shaped bases and may persist 1 to 2 months on the seedling with primary leaves appearing 1 week after germination in natural forest conditions (Burns and Honkala 1990).

Nursery practice. Seeds of elm species ripening in the spring are usually sown immediately after collection, whereas seeds of fall-ripening species or of species requiring stratification are usually planted the following spring (table 7). Beds should be kept moist until germination is complete; shading is not usually necessary. From 5 to 12% of the viable cedar elm seeds sown can be expected to produce plantable stock (Burns and Honkala 1990). One-year-old seedlings usually are large enough for field planting. Rock elm seedlings have a persistent dormant bud, so seedlings rarely develop more than a single pair of true leaves in the first growing season (Burns and Honkala 1990). In northern Wisconsin, rock elm 1.5+0 nursery stock averaged 27 cm (10.6 in) in height 5 years after planting and 52 cm (20.5 in) in height 10 years after planting; first-year survival was 85% and 10th-year survival was 32% (Burns and Honkala 1990). To improve survival in semiarid regions, trees often are transferred into containers after 1 year in the seedbeds (Goor 1955). Slippery elm is commonly used as rootstock when grafting hybrid elms (Burns and Honkala 1990).

Table 6—*Ulmus,* elm: germination test conditions and results

Species	Germination test conditions*				Germinative energy	Germinative capacity			
		Temp (°C)			Amount	Period	Avg		Purity
	Medium	Day	Night	Days	(%)	(days)	(%)	Samples	(%)
U. alata	Soil	32	21	15	76	7	91	6	—
U. americana	Paper pads	30	20	14	—	—	—	—	—
	Kimpak	30	20	28	—	—	67	1	—-
	—	—	—	13–60	55	7	64	15	92
U. crassifolia	Soil	32	21	80	56	78	56	2	—
U. glabra	Germinator or sand	21–30	20–25	30–60	—	—	44	72+	—
U. laevis	Germinator or sand	21	21	30	—	—	65	22+	85
U. parvifolia	Paper pads	20–29	20	10–60	—	—	55	2+	64
U. pumila	Paper pads	—	—	10	—	—	—	—	—
	Kimpak	30	20	28	—	—	81	1	—
	Germinator or sand	20–30	20	30	55	10	76	48	90
U. rubra	Sand	30	20	60	21	10	23	5	94
U. serotina	Soil	32	21	30	68	20	72	1	—
U. thomasii	Sand or petri dish	30	20	30	77	8	81	11	95

Sources: Arisumi and Harrison (1961), AOSA (2001), Engstrom and Stoeckeler (1941), Gorshenin (1941), Heit (1967a&, 1968), ISTA (1999), Johnson (1946), Kirby and Santelman (1964), Maisenhelder (1968), McDermott (1953), NBV (1946), Rafn and Son (1928), Rohmeder (1942), Spector (1956), Stoeckeler and Jones (1957), Sus (1925), Swingle (1939), USDA FS (2002), Wappes (1932).

* Light for 8 hours or more per day is recommended for American elm (AOSA 2001; ISTA 1999; McDermott 1953). Light is neither required nor inhibitory for germination of winged elm (Loiseau 1945), and Chinese and Siberian elms (AOSA 2001; ISTA 1999).

Table 7—*Ulmus,* elm: nursery practice

Species	Sowing season*	Seedlings/area		Sowing depth		Tree	Out-planting
		/m²	/ft²	mm	in	percent	age (yrs)
U. alata	Summer	—	—	0–6.4	0–1/4	—	1
U. americana	Spring	5	2	6.4	1/4	12	1
U. crassifolia	Spring	—	—	0–6.4	0–1/4	—	1
U. glabra	Summer	—	—	0–6.4	0–1/4	—	—
U. laevis	Summer	—	—	0-6.4	0–1/4	6	1–2
U. parvifolia	Spring	25–30	2–3	4.8–6.4	3/16–1/4	12–20	1–2
U. pumila	Summer	—	—	6.4	1/4	3–7	1–2
U. rubra	Spring	25	2	6.4	1/4	—	1
U. serotina	Spring	—	—	0–6.4	0–1/4	—	1
U. thomasii	Spring	15–38	1–4	6.4	1/4	—	2

Sources: Baker (1969), Deasy (1954), Engstrom and Stoeckeler (1941), George (1937), Kirby and Santelman (1964), Rohmeder (1942), Stoeckeler and Jones (1957), Sus (1925), Swingle (1939), Toumey and Korstian (1942).

* Spring-sowing was preceded by stratification in sand or in a plastic bag at 4 to 5 °C for 60 days.

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Lauraceae—Laurel family

Umbellularia californica (Hook. & Arn.) Nutt.

California-laurel

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Growth habit, occurrence, and uses. The genus *Umbellularia* contains a single species—*Umbellularia californica* (Hook. & Arn.) Nutt.—that has many common names (Coombes 1992; Stein 1990), the best known being California-laurel, California-olive, Oregon-myrtle, myrtlewood, bay, laurel, and pepperwood. California-laurel is a broad-leaved evergreen that matures either as a shrub or tall forest tree. Over much of its range, it attains heights of 12 to 24 m and diameters of 46 to 76 cm, but near the ocean, in the chaparral, and on other severe or rocky sites it is confined to prostrate or shrub sizes (Harlow and others 1979; Jepson 1910). In the protected bottomlands of southern Oregon and northern California, mature trees are 91 to 305 cm in diameter and 30 or more m tall (Harlow and others 1979). A maximum circumference of 1,387 cm at 137 cm above ground (AFA 2000) and a maximum height of 53.3 m have been reported (Sargent 1961).

Several racial variations are recognized. *Umbellularia californic*a forma *pendula* Rehd. is an uncommon, broad-spreading tree distinctive for its pendulous branchlets that contrast strongly with typically ascending branch growth (Jepson 1910; Rehder 1940). *U. californica* var. *fresnensis* Eastwood has fine white down on the lower surfaces of leaves and branches of the panicle (Eastwood 1945). Several forms that Jepson (1910) describes—gregarious, rockpile, dwarf, and prostrate—may indicate other varietal differences.

The range of California-laurel spans more than 11 degrees of latitude, from near the 44th parallel in the Umpqua River Valley of Douglas County, Oregon, south beyond the 33rd parallel in San Diego County, California, nearly to the Mexican border. California-laurel is widely distributed in the coast ranges and less abundantly in inland valleys and the Siskiyou and Sierra Mountains (Sudworth 1908). It may be found from sea level to 1,220 m in much of its range, and from 610 to 1,520 m in southern California (Jepson 1910). Pure, dense stands of California-laurel develop in some areas, but more often it is intermixed with other tree and shrub species. It grows in many kinds of soils under both cool-humid and hot-dry atmospheric conditions (Stein 1990). In xeric climates, it is most prominent where soil moisture is favorable—on alluvial deposits or protected slopes, along watercourses, near springs and seeps—but in its shrub form, it also is found on dry slopes and is a common component of chaparral (Sampson and Jespersen 1963).

All parts of the tree have served human needs. Wood of this species compares favorably in machining quality with the best eastern hardwoods (Davis 1947) and is used for woodenware, interior trim, furniture, paneling, veneer, and gunstocks. Burls and other growths with distorted grain are especially prized for making the gift and novelty items that are marketed extensively as "myrtlewood." Dried leaves are used for seasoning meats and soups (McMinn 1970). In an earlier day, Hudson Bay Company trappers brewed a comforting tea from the leaves to overcome chill (Ross 1966). David Douglas learned that hunters made a drink from the bark and declared it "by no means an unpalatable beverage" (Harvey 1947). Native Americans ate substantial quantities of the fruit and seeds, made a drink from the bark of the roots, and used the leaves for several internal and external medicinal purposes, including vermin control (Chesnut 1902).

Extracts of the leaves, seeds, and wood have strong chemical properties and should be used with caution. Vapor from the aromatic leaves can cause sneezing, headache, sinus irritation, other severe discomforts, and even unconsciousness (Drake and Stuhr 1935; Peattie 1953). The leaves contain considerable menthol (Stein 1974) and the ketone umbellulone, which when extracted from the leaf oil, interferes strongly enough with respiration, heartbeat, and blood circulation to cause death in laboratory animals (Drake and Stuhr 1935). Umbellulone also has fungicidal and germicidal properties (Drake and Stuhr 1935). Oils from the wood, leaves, and seeds have been sold for pharmaceutical purposes such as treating catarrh, nervous disorders, rheumatism, meningitis, intestinal colic, and dyspepsia (Peattie 1953; Sargent 1895; Stuhr 1933).

California-laurel is used to a moderate extent as an ornamental evergreen. It has thick, glossy, medium-to-dark green persistent leaves that turn orange or yellow before they drop individually and contrasting pale yellow flowers. The very dense aromatic foliage often shapes naturally into a pleasing, symmetrical, rounded crown. Since it was first cultivated in 1829 (Rehder 1940), it has demonstrated the ability to grow well far outside its natural range (Stein 1958). It can be grown as a decorative potted plant for lobbies and patios and will tolerate moderate pruning (Kasapligil and Talton 1973).

California-laurel also has wildlife values—young sprouts are choice browse in spring and summer. Year-long use is rated by Sampson and Jespersen (1963) as good to fair for deer (*Odocoileus* spp.) and fair to poor for cattle, sheep, and goats. Longhurst and others (1952) list it as a principal browse species for deer in the north coastal ranges of California. Silver gray-squirrels (*Sciurus griseus*), dusky-footed wood rats (*Neotoma fuscipes*), and Steller's jays (*Cyanocitta stelleri*) feed on the seeds extensively (Bailey 1936; Van Dersal 1938). Hogs eat both seeds and roots (Jepson 1910; Van Dersal 1938).

Flowering and fruiting. California-laurel flowers regularly and often profusely. The small, pale yellow, perfect flowers grow on short-stemmed umbels that originate from leaf axils or near the terminal bud (figure 1). Flower buds develop early; those for the following year become prominent as current-year fruits are maturing. Within its long north–south range, California-laurel has been reported to flower in all months from November to May, beginning before new leaves appear (Jepson 1910; Kasapligil and Talton 1973; Rehder 1940; Unsicker 1974). The flowering period may stretch into late spring and summer with the occasional appearance of flowers originating in axils of the current year's developing leaves (Sargent 1895). California-laurel flowers at an early age; flowers have been observed on short whiplike shrubs and on 1-year-old sucker growth that originated on a long broken stub. Small insects appear to be the chief pollinaters (Kasapligil 1951).

Seedcrops are abundant in most years (Stein 1974). Although umbels bear 4 to 9 flowers each, generally only 1 to 3 fruits set (Jepson 1910). The age when a tree first bears fruit, the age for maximum production, and the average quantity produced have not been reported. Seeds are produced in abundance after trees are 30 to 40 years old (Harlow and others 1979). Damage to developing seedcrops by insects, birds, or diseases has not been reported.

Collection, extraction, and storage. The fruits—acrid drupes each containing a single, large, thin-shelled seed—ripen in the first autumn after flowering (Rehder 1940; Sargent 1895; Sudworth 1908). As the drupes mature, their thin, fleshy hulls change from medium green to speckled yellow green (Britton 1908; Sudworth 1908) (figure 1), pale yellow (Eliot 1938), or various other hues, ranging from yellow-green tinged with dull red or purple (Peattie 1953; Sargent 1895) through purplish brown (Jepson 1910; Kasapligil 1951) to purple (Kellogg 1882; Sargent 1892; Torrey 1856). Ripe drupes may be yellow-green on one tree and dark purple on an adjacent tree (Stein 1974).

Drupes fall stemless to the ground in late autumn or winter and are dispersed by gravity, wind, animals, and water (McBride 1969). Seeds are collected simply by gathering fallen drupes—if squirrels and other animals don't get there first. Shaking ripe drupes from the tree should provide a good means for making quick, efficient collections.

When soft, the fleshy hulls are readily removed from the seeds by hand. The hulls can also be removed easily by machines used for de-pulping drupes if quantity processing is required. Mirov and Kraebel (1937) obtained about 300 cleaned seeds (figure 2) from 0.45 kg (1 lb) of drupes. For 8 samples processed at Davis, California (Lippitt 1995), the seed count averaged 547/kg (248/lb) and ranged from 403 to 675/kg (183 to 306/lb).

Figure 1—*Umbellularia californica*, California-laurel: yellow-green mature drupe suspended from its conical capula.

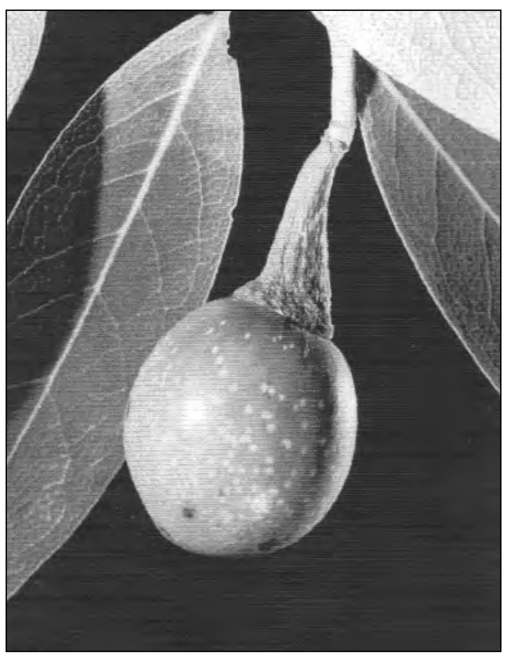


Figure 2—*Umbellularia californica*, California-laurel: exterior views of cleaned seeds.

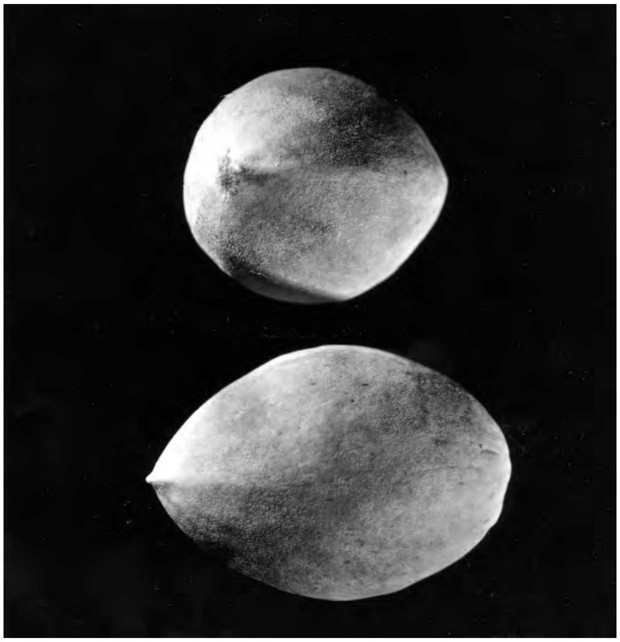
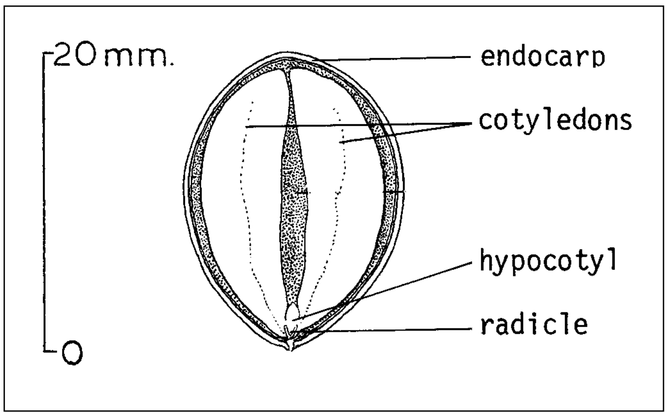


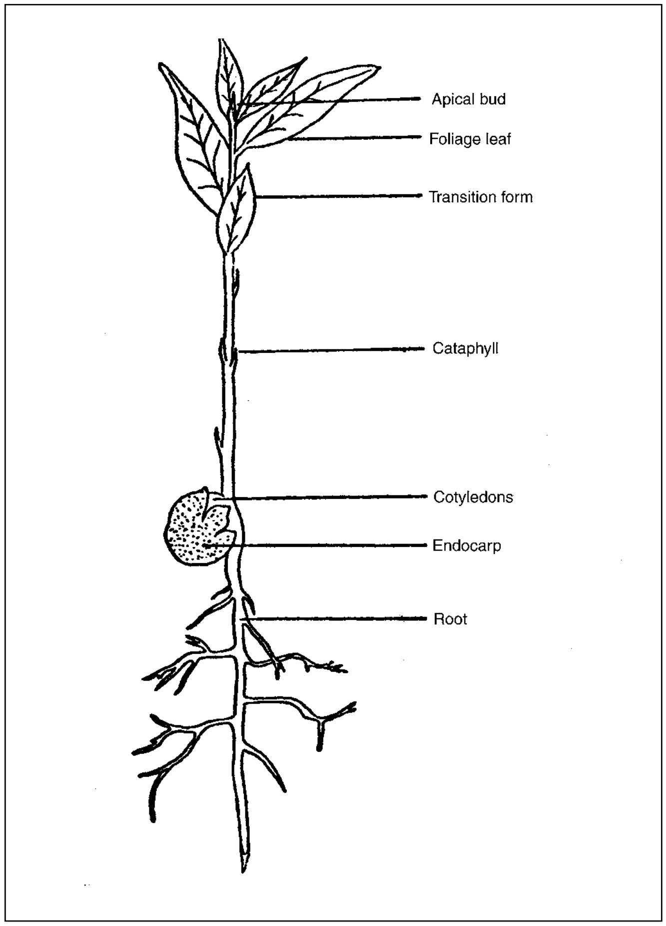
Figure 3—*Umbellularia californica*, California-laurel: tudinal section through a seed.



Seeds of California-laurel have lost viability in storage even at low temperatures, so yearly collection of fresh seeds is advised (Stein 1974). Viability has been maintained for 6 months when seeds were stored at 3 °C in wet, fungicide-treated vermiculite (McBride 1969). Storage trials have been very limited and tests of cool, moist storage at different moisture contents are needed. Highest germination (81%) was obtained from a seedlot with 32% moisture content (Lippitt 1995). Under favorable natural conditions, seeds on the ground retain their viability over winter, but under adverse conditions, viability may prove transient.

Seed treatment and germination. Fresh untreated seeds will germinate under room or outdoor conditions in peat moss, sawdust, vermiculite, or light-textured soil but may require 3 months or longer (Kasapligil 1951; Mirov and

Figure 4—*Umbellularia californica*, California-laurel: 4-month-old seedling (from Stein 1974, courtesy of Baki Kasapligil 1951).



Kraebel 1937; Stein 1974). Germination can be speeded by scarifying, cracking, or removing the endocarp or by stratifying the seeds, but it still may require about 2 months (Kasapligil 1951; McBride 1969; Stein 1974). In light soil, 20 to 25% of untreated seeds germinated; with stratification, germination nearly doubled (Stein 1974). In 16 lots of seeds collected in 1969 from Oregon and California sources, germination by the end of March ranged from 0 to 82% after January planting deep in pots of peat or vermiculite. Parts of seedlots held in a refrigerator at 4.4 °C from November to January germinated somewhat better than those immediately planted outdoors in a peat–vermiculite mixture. The better seedlots germinated equally well in several contrasting test conditions (Stein 1974).

In comparison tests made in petri dishes, California-laurel germination was highest in 30 days under a temperature regime of 16 °C day, 7 °C night, and when evaporative stress was minimal (McBride 1969). Germination did not appear affected by light level but was highest in soil with moisture tension at 4 to 10 atmospheres.

Seedling development and nursery practice. Under forest conditions, germination has been reported to take place in autumn soon after seedfall (Harlow and others 1979; Sargent 1895; Sudworth 1908) or in late winter and spring (Stein 1958, 1974). Covered seeds germinate best, but the large seeds do not bury readily without ground disturbance or silt deposition by high water. Seedling establishment is uncommon in the drier parts of California except in protected areas and where the ground is disturbed (Jepson 1910).

Germination is hypogeal, and the fleshy cotyledons remain within the endocarp and attached to the seedling until midsummer, when the plant may be 15 to 20 cm tall (Kasapligil 1951; Sargent 1895). Generally, there are 2 large cotyledons, sometimes 3, and no endosperm (figure 3) (Kasapligil 1951).

Young California-laurel seedlings appear flexible in their growth requirements. In the first 120 days, seedlings potted in vermiculite grew well at several levels of temperature, evaporative stress, soil moisture, and soil nutrients (McBride 1969). Seedlings grown at 18% or more of full sunlight produced the most dry weight. Seedlings produce leaves of several transitional forms as they develop (figure 4) and do not branch until they are 2 or 3 years old unless so induced by removal of the terminal bud (Kasapligil 1951). They soon develop a moderately stout taproot and are difficult to transplant if more than 1 year old unless grown in containers. Recovery after transplanting is often slow, and height growth may be limited for several seasons.

California-laurel may also be reproduced by cuttings (Stein 1974). Under field conditions, it sprouts prolifically from the root collar, stump, and fallen or standing trunk.

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Ericaceae—Heath family

Vaccinium L.

blueberry, cranberry

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Occurrence, growth habit, and uses. There are about 150 to 450 species (the number varies by authority) of deciduous or evergreen shrubs (rarely trees or vines) in *Vaccinium* (Huxley 1992b; LHBH 1976; Vander Kloet 1988). The majority of species are native to North and South America and eastern Asia (LHBH 1976; Vander Kloet 1988). Some of the more commonly cultivated North American species are listed in table 1. Like other members of the Ericaceae, *Vaccinium* species require an acidic (pH 4.0 to 5.2) soil that is moist, well drained, and high in organic matter (3 to 15%). Symptoms of mineral nutrient deficiency arise if soil pH exceeds optimum levels (LHBH 1976). Sparkleberry is one exception that grows well in more alkaline soils (Everett 1981). Many species of *Vaccinium* establish readily on soils that have been disturbed or exposed (Vander Kloet 1988).

Many species of *Vaccinium* are rhizomatous, thus forming multi-stemmed, rounded to upright shrubs or small trees ranging in height from 0.3 to 5.0 m (table 1). Cranberry forms a dense evergreen ground cover about 1 m in height (Huxley 1992b; Vander Kloet 1988).

Several species of *Vaccinium* are valued for their edible fruits. Historically, Native Americans consumed blueberries fresh or dried them for winter consumption (Vander Kloet 1988). In addition, they steeped the leaves, flowers, and rhizomes in hot water and used the tea to treat colic in infants, to induce labor, and as a diuretic (Vander Kloet 1988). Currently, most commercial blueberry production occurs in North America, where highbush blueberry accounts for more than two-thirds of the harvest (Huxley 1992a). Another species, rabbiteye blueberry, is more productive, heat resistant, drought resistant, and less sensitive to soil pH than highbush blueberry, but it is less cold hardy (Huxley 1992a; LHBH 1976). In more northern latitudes, the low-growing lowbush and Canadian blueberry bushes occur in natural stands. Their fruits are harvested for processing or the fresh fruit market (LHBH 1976).

Although cranberry has been introduced successfully into cultivation in British Columbia, Washington, and Oregon, Wisconsin and Massachusetts remain the largest producers; the crops for 2000 were estimated at 2.95 and 1.64 million barrels, respectively (NASS 2001).

Evergreen huckleberry grows along the Pacific Coast and is valued for its attractive foliage, which is often used in flower arrangements (Everett 1981). Species of *Vaccinium* also are prized as landscape plants. Lowbush forms are used to form attractive ground covers or shrubs. Two cultivars of creeping blueberry (*V. crassifolium* Andrews)—'Wells Delight' and 'Bloodstone'—form dense ground covers usually < 20 cm in height, varying only in texture and seasonal color change (Kirkman and Ballington 1985). Shrub-forming species add interest to the landscape with their attractive spring flowers and brilliantly colored fall foliage (Dirr 1990). Bird lovers also include *Vaccinium* spp. in their landscapes as the shrubs attract many birds when fruits ripen. In the wild, species of *Vaccinium* also serve as a source of food for many mammals (Vander Kloet 1988).

Geographic races and hybrids. Breeding programs have focused on improvement of species of *Vaccinium* since the early 20th century (Huxley 1992a). As a result, numerous hybrids and cultivars exist, each suited to specific growing conditions.

Flowering and fruiting. Perfect flowers are borne solitary or in racemes or clusters and are subterminal or axillary in origin (Vander Kloet 1988). White flowers, occasionally with a hint of pink, occur in spring or early summer, usually before full leaf development (table 2) (Dirr 1990). Rabbiteye and lowbush blueberries are generally self-sterile and must be interplanted to ensure fruit-set. Highbush blueberries are self-fertile, although yields can be improved by interplanting with different cultivars (Huxley 1992a). When mature, fruits of blueberries are many-seeded berries (figure 1), blue to black in color, often glaucous, ranging in size from 6.4 to 20 mm in diameter with a per-

Table 1—*Vaccinium,* blueberry and cranberry: nomenclature, plant height, and natural occurrence

Scientific name & synonym(s)	Common name(s)	Plant height (cm)	Occurrence
***V. angustifolium* Ait.** *V. lamarckii* Camp *V. nigrum* (Wood) Britt. *V. angustifolium* var. *hypolasium* Fern. var. *laevifolium* House var. *nigrum* (Wood) Dole var. *brittonii* Porter ex Bickn.	**lowbush blueberry,** late sweet blueberry, low sweet blueberry	18 ± 9	Labrador & Newfoundland; W to Manitoba & Minnesota; S to Illinois, Delaware, & Pennsylvania; mtns of Virginia & West Virginia
***V. arboreum* Marsh.** *V. arboreum* var. *glaucescens* (Greene) Sarg. *Batodendron andrachniforme* Small *Batodendron arboreum* (Marsh.) Nutt.	**sparkleberry,** farkleberry	311 ± 102	Virginia to central Florida, W to E Texas, central Oklahoma & SE Mississippi
***V. corymbosum* L.** *V. constablaei* Gray *V. corymbosum* var. *albiflorum* (Hook.) Fern. *V. corymbosum* var. *glabrum* Gray *Cyanococcus corymbosus* (L.) Rydb. *Cyanococcus cuthbertii* Small	**highbush blueberry,** American blueberry, swamp blueberry	230 ± 60	Atlantic Coast; W to E Texas & Illinois; absent from Mississippi, central Ohio, W Kentucky, W Tennessee, West Virginia, & central Pennsylvania
***V. macrocarpon* Ait.** *Oxycoccus macrocarpus* (Ait.) Pursh	**cranberry,** large cranberry, American cranberry	6 ± 3	Newfoundland, W to Minnesota, S to N Illinois, N Ohio, & central Indiana; Appalachian Mtns to Tennessee & North Carolina
***V. myrtilloides* Michx.** *V. angustifolium* var *myrtilloides* (Michx.) House *V. canadense* Kalm ex A. Rich. *Cyanococcus canadensis* (Kalm ex A. Rich) Rydb.	**Canadian blueberry,** velvet-leaf blueberry, velvetleaf huckleberry, sour-top blueberry	35 ± 14	Central Labrador to Vancouver Island, Northwest Territories SE to Appalachian Mtns
***V. ovatum* Pursh.**	**California huckleberry,** evergreen huckleberry, shot huckleberry	82 ± 42	Pacific Coast, British Columbia to California
***V. oxycoccos* L.** *V. palustre* Salisb. *Oxycoccus palustris* Pers. *Oxycoccus quadripetalus* Gilib.	**small cranberry**	2 ± 1	North American boreal zone to the Cascade Mtns in Oregon & to Virginia in the Appalachian Mtns
***V. virgatum* Ait.** *V. virgatum* var. *ozarkense* Ashe *V. virgatum* var. *speciosum* Palmer *V. parviflorum* Gray; *V. amoenum* Ait. *V. ashei* Rehd.; *V. corymbosum* var. *amoenum* (Ait.) Gray *Cyanococcus virgatus* (Ait.) Small *Cyanococcus amoenus* (Ait.) Small	**rabbiteye blueberry,** smallflower blueberry	300 ± 100	SE United States
***V. vitis-idaea* L.**	**lingonberry,** cowberry, foxberry, mountain cranberry	7 ± 3	New England & scattered throughout Canada; native to Scandinavia

Sources: GRIN (1998), Huxley (1992b), Vander Kloet (1988).

sistent calyx (table 3) (LHBH 1976). Cranberry fruits are many-seeded berries that are red at maturity and range from 1 to 2 cm in diameter (Huxley 1992b).

Collection of fruits, seed extraction, and cleaning. Small quantities of ripe fruits may be collected by hand-picking. Larger quantities, however, are usually harvested mechanically (Huxley 1992a). To extract seeds, fruits should be placed in a food blender, covered with water, and thoroughly macerated using several short (5-second) power bursts. More water is added to allow the pulp to float while the sound seeds (figures 2 and 3) settle to the bottom. Repeating this process several times may be necessary to achieve proper separation of seeds and pulp (Galletta and Ballington 1996). Seed weights are listed in table 3.