CupressaceaeCCypress family

Calocedrus decurrens (Torr.) Florin

incense-cedar

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Synonyms. *Libocedrus decurrens* Torr., *Heyderia decurrens* (Torr.) K. Koch.

Other common names. California incense-cedar, pencil cedar, pecky cedar.

Growth habit, occurrence, and uses. Incense-cedar was once classified as the only species in the genus Libocedrus native to the United States (Harlow and others 1979; Little 1979), but recent taxonomic changes have included it as 1 of 3 species in the genus *Calocedrus* Kurz. Regional genetic variation within incense-cedar is small, but 12-year growth of trees from southern California was less than that of trees from more northerly regions (Rogers and others 1994). Recognized cultivars under the former classification include *L. decurrens aureovariegata* Beissner, *L. decurrens* cv. *columnaris* Beissner, *L. decurrens* cv. *compacta* Beissner, and *L. decurrens* cv. *glauca* Beissner (Harrison and Dallimore 1966; Rehder 1940).

Mature trees of this evergreen conifer vary in height from 15 to 46 m and from 0.3 to 2.13 m in diameter (Jepson 1910; Sargent 1961; Sudworth 1908). A maximum circumference of 11.73 m (AFA 1996) and a maximum height of 68.6 m have been reported (Stein 1974). Young trees generally have dense pyramidal to columnar crowns; older trees are characterized by more open, irregular crowns; rapidly tapering trunks with buttressed bases; and deeply furrowed and ridged bark.

The range of incense-cedar spans about 15 degrees of latitude from the southeastern slopes of Mount Hood in Oregon southward within and adjacent to the Cascade, Siskiyou, Coastal, and Sierra Nevada ranges to the Sierra de San Pedro Martir in northwestern Mexico (Griffin and Critchfield 1976; Sudworth 1908). It extends eastward from the coastal fog belt to arid inland parts of central Oregon, northern California, and westernmost Nevada. In elevation, incense-cedar is found from 50 to 2,010 m in the north and from 910 to 2,960 m in the south (Peattie 1953; Powers and Oliver 1990; Sudworth 1908). Incense-cedar grows on many kinds of soil and is one of the most prominent conifers on serpentine soils. Typically, it is a component of mixed conifer forest and may make up as much as 50% of the total stand (Powers and Oliver 1990).

Trees are harvested primarily for lumber and for round or split wood products. The wood is variable in color, durable, light, moderately soft, uniformly textured, easy to split and whittle, and finishes well. Incense-cedar is also used as a pulp additive and for making a variety of specialty items, the best known being the wooden pencil (Betts 1955; Panshin and others 1964). Boughs, particularly those bearing staminate cones, are harvested commercially for decorations (Schlosser and others 1991), and young trees are a minor component of the Christmas tree trade.

First cultivated in 1853, ornamental specimens with shapely crowns have grown well in many places outside of their native range in the Pacific NorthwestCNew England and the mid-Atlantic region of the United States and western, central, and southern Europe (Edlin 1968; Harrison and Dallimore 1966; Jelaska and Libby 1987; Sargent 1961). Within its native range, incense-cedar is commonly planted for highway landscaping, screenings, and home-site improvement.

Young incense-cedars are sometimes browsed extensively (Stark 1965), but in general, the species rates low to moderate in value as wildlife browse (Longhurst and others 1952; Sampson and Jespersen 1963; Van Dersal 1938). Its seeds are eaten by small mammals (Martin and others 1951) but are not a preferred food of chipmunks (Tevis 1953). Dense understory incense-cedars provide an important source of cover and food for overwintering birds in the western Sierra Nevada (Morrison and others 1989).

Flowering and fruiting. Yellowish green staminate flowers develop terminally on twigs as early as September even before current-year cones on the same twigs have opened (Stein 1974). These flowers, 5 to 7 mm long, are prominently present A...tingeing the tree with gold during the winter and early spring...@ (Sargent 1961). The inconspicuous pale yellow ovulate flowers also develop singly at tips of twigs. Flowering has been reported to occur as early as December and as late as May (Britton 1908; Hitchcock and others 1969; Mitchell 1918; Peattie 1953; Sargent 1961; Sudworth 1908), but it is not clear how well observers distinguished between flower appearance and actual pollen dissemination. Unopened staminate flowers and open or nearly open ovulate flowers were present on branches collected in the first week of April west of Klamath Falls, Oregon (Stein 1974).

Single cones (figure 1), each containing up to 4 seeds, are scattered throughout the crown, and mature in 1 growing season. As they ripen, their color changes from a medium green to a yellowish green or yellow tinged with various amounts and shades of brown. During opening, the cone becomes reddish brown and acquires a purplish cast. Insect-attacked cones are among the first to change color. Generally, cones of many color shades are found on a tree as opening commences.

Seed dispersal may extend over a lengthy period, from late August through November or later (Fowells and Schubert 1956; McDonald 1992; Mitchell 1918; Powers and Oliver 1990; Sudworth 1908). For example, in 1937 and 1940, respectively, 11 and 32% of the seed had fallen by early October at 1 or 2 California locations, yet 47 and 66% of the total fell after November 11 (Fowells and Schubert 1956). Cutting tests have shown that 14 to 65% of the naturally dispersed seeds appear sound, with higher values coincident with heavy crops (Fowells and Schubert 1956).

The oft-repeated generalization that incense-cedars bear some seeds every year and abundant crops frequently (Betts 1955; Mitchell 1918; Sudworth 1908; Van Dersal 1938) has not been confirmed by systematic observations made in 3 locations. During a 35-year period on the Stanislaus National Forest in California, incense-cedars bore a heavy or very heavy crop in 7 of those years, a medium crop in 11 years, and a light crop in 17 years (Schubert and Adams 1971). On the Challenge Experimental Forest in central northern California, there were 1 medium to heavy and 9 light to very light crops in 24 years (McDonald 1992). During 15 years on the South Umpqua Experimental Forest in southwest Oregon, there were 2 abundant crops, 1 medium crop, and 12 years with light or no crops (Stein 1974). Generalized statewide reports for California and Oregon show that incense-cedar cone crops are often light and that there is wide geographic variability in crop abundance (Schubert and Adams 1971). During years when crops are reported as light or a failure, scattered cones (even an occasional heavily loaded tree) may be found somewhere.

Flowers and young cones may be damaged or killed occasionally by adverse climatic factors, and squirrels cut some mature cones (Fowells and Schubert 1956). Losses are also caused by sawflies (*Augomonoctenus libocedrii* Rohw.), juniper scale (*Carulaspis juniperi* Bouche), and leaf-footed bugs (*Leptoglossus occidentalis* Heidemann) that feed on developing cones and seeds (Furniss and Carolin 1977; Koerber 1963).

Collection of cones. Cones are generally hand-picked from standing or felled trees. Stripping cones or using a cone rake will expedite collection because cones hang dispersed over the crown. The ideal time for collection is the short period when cleavages appear between the scales of many cones on a tree. If large quantities of seeds are needed, both collecting them fromn plastic sheets spread beneath or enclosing the tree and vacuum-harvesting seeds from the ground merit consideration. Dispersed seeds should be collected promptly to minimize heat damage. To facilitate later seed cleaning, foliage intermixed with cones or seeds should be removed during collection or shortly afterward, before it dries and crumbles.

Cones are normally handled and transported in partly filled open-mesh sacks that facilitate cone expansion and air exchange. Good aeration should be provided around each sack to prevent heating of cones while in storage.

Extraction and storage of seeds. To maintain high seed viability, cones should not be exposed to high temperatures. Under warm, dry conditions, cones will air-dry outdoors or indoors in 3 to 7 days if layered thinly in trays or on sheeting or tarps. Turning or stirring layered cones will facilitate drying and opening. They may also be kiln-dried at 27 °C or lower (Lippitt 1995).

Seeds separate readily from well-opened cones; moderate tumbling or shaking is helpful. Whether done by improvised methods or in commercial machines, tumbling or shaking should be done gently, preferably at less than 27 °C, because seedcoats of incense-cedar are thin and easily broken.

The winged seeds are about 2.5 cm long and nearly one-third as wide (figure 2). Although appearing to have

only 1 wing, each seed actually has 2 wingsCa long, wide wing extending lengthwise beyond the seed on one side and a narrow, much shorter wing barely merging alongside the first from the opposite side. The wings are persistent and project past the narrow radicle end of the seed rather than from the cotyledon end as in many other conifers (figure 3).

The persistent wings should be left intact. When seeds are run through mechanical de-wingers, the narrow radicle ends may break off along with the wings. This type of damage was the probable cause of the very low viability observed in some lots of de-winged seeds. Damaging effects should be evaluated before using any proposed hand or mechanical de-winging technique.

Small particles of debris can be removed from among winged seeds by screening. Sensitive adjustment of an air stream or gravity separator will permit further cleaning and adequate separation of empty from full seeds with wings intact. Purities of 85 to 98% or more have been obtained (Lanquist 1946; Lippitt 1995; Rafn 1915; Toumey and Korstian 1942).

Thirty-five liters (1 bu) of cones weigh 18 to 23 kg (40 to 50 lbs) and yield from 0.45 to 1.36 kg (1 to 3 lb) of seeds (CDF 1969; Tillotson 1925; Toumey and Korstian 1942). A minimum of 14,110 and a maximum of 63,930 seeds/kg (6,400 and 29,000 seeds/lb) were found among 55 samples from northern California weighed by Show in 1918. More recent collections indicate that seed weights differ by seed zone (Lippitt 1995):

Region & seed zone series no.	Seeds/wt Average /kg	/lb	Range /kg	/lb	Samples
Siskiyou Mtns. & inland north Coast Range (#300)	27,270	12,368	24,820B29,960	11,260B13,588	41
Sierra Nevada (#500)	31,820	14,433	21,540B45,330	9,768B20,562	36
Southern California & Central Valley (#900)	33,420	15,160	24,120B38,760	10,940B17,583	5

Reported averages representing collections made largely in northern and central parts of the species- range vary from 27,270 to 44,450 seeds/kg (12,368 to 20,160 seeds/lb) (CDF 1969; Lanquist 1946; Lippitt 1995; Mitchell 1918; Rafn 1915; Show 1918; Stein 1963; Sudworth 1900; Tillotson 1925; Toumey and Korstian 1942). The smaller averages are probably most realisticCsamples weighed by several investigators contained only 60 to 67% full seeds either winged or wingless (Lanquist 1946; Show 1918).

Incense-cedar seeds do not keep well in dry storage at room temperature (Shaw 1918), but high viability can be maintained for several years in cool storage. In limited tests, 2 lots retained 98% and 74% viability after storage in closed metal containers at 5 °C for 2 and 3 years, respectively, but lost all viability after 8 years (Schubert 1954). It is now common practice to store incense-cedar seeds dried to low moisture contents near - 18 °C in cloth or plastic bags or in plastic-lined fiberboard containers. Mature, undamaged lots of seed have retained viability in cold storage for 10 years at 5 to 9% moisture content (Lippitt 1995); maximum duration before such lots begin losing viability has not been determined.

Pregermination treatments and germination tests. Standard procedures prescribed by the Association of Official Seed Analysts (1998) for testing incense-cedar seeds include prechilling them for 30 days at 2 to 5 °C. Comparison tests showed that prechilling markedly improved total germination and rate of germination of some but not all lots (Stein 1974). Short of making a paired test, there is no way to identify which lots benefit from prechilling and which ones do not. To prepare them for prechilling, seed samples are either (1) placed on a moist substratum in a closed dish; (2) placed in a loosely woven bag or screen surrounded by moist peat, sand, or vermiculite; or (3) soaked for 24 hours in tap water at room temperature, drained, and then placed in a glass or plastic container.

Following prechilling, germination of incense-cedar is determined by subjecting seeds for 28 days to alternating temperaturesC16 hours at 20 °C and 8 hours at 30 °C with 750 to 1250 lux (75 to 125 foot-candles) exposure to cool-white fluorescent illumination at least during the high-temperature period (AOSA 1998). Tests should be carried out on cellulose paper wadding or blotters in closed germination boxes. Germination for 85 lots now in storage at one nursery has averaged 72% following 8 weeks of naked stratification (Lippitt 1995).

The viability of incense-cedar seeds can also be determined by a tetrazolium test (ISTA 1996). The preparation sequence involves removal of wings from dry seeds followed by soaking in water at room temperature for 6 to 18 hours (overnight). Shallow longitudinal cuts are then made on both ends of the seed to expose the embryo. Cut seeds are immersed in a 1% tetrazolium solution and kept in darkness for 6 to 18 hours at 30°C. Seeds having a completely stained embryo and a completely stained endosperm are considered viable. Viability determined by the tetrazolium test reveals the seeds= maximum potential and generally is somewhat higher than indicated by a germination test.

Nursery practice and seedling development. Soil fumigation of outdoor beds to combat damping-off and other diseases may or may not be necessary before sowing incense-cedar seeds. Maintenance or replacement of endomycorrhizal fungi is of concern if beds are fumigated. Spring sowing is now most common even though fall-sown seeds germinated earlier and more uniformly than those sown in the spring and resulting seedlings grew larger in the first season if they escaped damage by late spring frosts (Show 1930). An intermediate approach is to prepare seedbeds in the fall to facilitate early sowing in February or March. Before sowing, seeds are usually stratified naked or in a moist medium at 2 to 5 °C for 30 to 60 days (Lippitt 1995). Well-timed spring sowings of unstratified seeds have produced satisfactory crops (Show 1930; Stein 1974), but results are less certain. Some spring-sown seeds may hold over to produce seedlings the following spring (Show 1930).

The winged seeds are usually hand-sown in rows. They should be covered about 6 to 12 mm (3 to 2 in) deep (Show 1930). Burlap mulch proved satisfactory to keep seedbeds moist (Show 1930); sawdust or other mulch material and frequent sprinkler irrigation are currently used.

Incense-cedar can readily be grown in containers to plantable size in one season. Containers about 15 cm (6 in) deep with a volume of 165 to 215 cm^3 (10 to 13 in^3) are recommended. The seedlings may be started about February in a greenhouse and moved outdoors after 4 to 8 weeks or germinated and grown entirely outdoors.

Germination is epigeal and the radical emerges from the narrow winged end of the seed (figure 4). Young seeds usually have 2, rarely 3, cotyledons (Harlow and others 1979). Leaves about 1.2 cm (0.5 in) long develop along the epicotyl (figure 5). On the first branches, awl-shaped transitional leaves grade into the normal scalelike leaves (Jepson 1910). Seedlings grow 5 to 20 cm (2 to 8 in) tall in the first season and develop a well-branched root system. Young seedlings are fairly resistant to frost and drought (Fowells and Stark 1965; Pharis 1966; Stone 1957). They are preferentially attacked by cutworms, however, and need protection from damping-off (Fowells 1940; Fowells and Stark 1965; Show 1930; Stein 1963). In the north-central Sierra of California, they grew about as well unshaded as with one-fourth shade (Show 1930). In current practice, both bareroot and container seedlings are grown without shade. They should be watered regularly but not to excess. Beds may be weeded entirely by hand or with mechanical and chemical assistance.

Seedbed densities of 270 to 325 seedlings/m^2 (25 to 30/ft^2) are satisfactory for producing 1+0 stock. Densities of 160 to 215 seedlings/m^2 (15 to 20/ft^2) are used for 2+0 stock. Tree percents range from 20 to 75 (Show 1930; Stein 1974). Generally, 2+0 bareroot seedling stock is used for outplanting, but 1+0, 1+1, 2+1, and 1+2 transplants have also been used. Some of the target sizes now used for producing stock include 1+0 (stem caliper 3 mm and top length 13 cm), 2+0 (stem caliper 3.5 cm and top length 20 cm), and 1+1 (stem caliper 4 mm and top length 25 cm). Spring outplanting proved best in long-ago tests (Show 1930) and continues to be favored.

Incense-cedar also can be reproduced from cuttings started in November (Nicholson 1984), and responds better than most conifers to cell and tissue culture (Jelaska and Libby 1987).

Literature Cited

AFA [American Forestry Association]. 1996. 1996B97 national register of big trees. American Forests 102(1): 20B51.

AOSA [Association of Official Seed Analysts]. 1998. Rules for testing seeds. Lincoln, NE: Association of Official Seed Analysts. 123 p.

Betts HS. 1955. Incense-cedar (*Libocedrus decurrens*). American Woods Series. Washington, DC: USDA Forest Service. 4 p.

Britton NL. 1908. North American trees. New York: Henry Holt. 894 p.

CDF [California Division of Forestry]. 1969. Seed production and test data provided. Davis, CA: Davis

Headquarters Nursery.
Edlin HL. 1968. A modern sylva or a discourse of forest trees. Quarterly Journal of Forestry 62: 145B154.
Fowells HA. 1940. Cutworm damage to seedlings in California pine stands. Journal of Forestry 38: 590B591.
Fowells HA, Schubert GH. 1956. Seed crops of forest trees in the pine region of California. Tech. Bull. 1150. Washington, DC: U.S. Department of Agriculture. 48 p.
Fowells HA, Stark NB. 1965. Natural regeneration in relation to environment in the mixed conifer forest type of California. Res. Pap. PSW-24. Berkeley: USDA Forest Service, Pacific Southwest Forest and Range Experiment Station. 14 p.
Furniss RL, Carolin VM. 1977. Western forest insects. Misc. Pub. 1339. Washington, DC: USDA Forest Service. 654 p.
Griffin JR, Critchfield WB. 1976. The distribution of forest trees in California. Res. Pap. PSW-82 (reprinted with supplement). Washington, DC: USDA Forest Service, Pacific Southwest Forest and Range Experiment Station. 118 p.
Harlow WM, Harrar ES, White FM. 1979. Textbook of dendrology. 6th ed. New York: McGraw-Hill. 510 p.
Harrison SG, Dallimore EA. 1966. A handbook of Coniferae and Ginkgoaceae. 4th ed. London: Billings and Sons. 729 p.
Hitchcock CL, Cronquist A, Ownbey M, Thompson JW. 1969. Vascular plants of the Pacific Northwest: Part 1. Seattle: University of Washington Press. 914 p.
ISTA [International Seed Testing Association]. 1996. Rules amendments 1995. Seed Science and Technology 24(suppl. 1): 1B115.
Jelaska S, Libby WJ. 1987. Control of morphogenesis in *Calocedrus decurrens* tissue culture. In: Hanover JW, Keathley DE, eds. Genetic manipulation of woody plants. Basic Life Sciences Series 44. New York: Plenum Press: 377B388.
Jepson WL. 1910. The silva of California. Berkeley: The University Press. 480 p.
Koerber TW. 1963. Leptoglossus occidentalis (Hemiptera, Coreidae), a newly discovered pest of coniferous seed. Annals of the Entomological Society of America 56: 229B234.
Lanquist KB. 1946. Tests of seven principal forest tree seeds in northern California. Journal of Forestry 44: 1063B1066.
Lippitt L. 1995. Personal communication. Davis: California Department of Forestry and Fire Protection, Lewis A. Moran Reforestation Center.
Little EL Jr. 1979. Checklist of United States trees, native and naturalized. Agric. Handbk. 541. Washington, DC: USDA Forest Service. 375 p.
Longhurst WM, Leopold AS, Dasmann RF. 1952. A survey of California deer herds, their ranges and management problems. Bull. 6. Sacramento: California Department of Fish and Game. 136 p.
Martin AC, Zim HS, Nelson AL. 1951. American wildlife and plants. New York: McGraw-Hill. 500 p.
McDonald PM. 1992. Estimating seed crops of conifer and hardwood species. Canadian Journal of Forest Research 22: 832B838.
Mitchell JA. 1918. Incense cedar. Bull. 604. Washington, DC: USDA Forest Service. 40 p.
Morrison ML, Dahlsten DL, Tait SM, Heald RC, Milne KA, Rowney DL. 1989. Bird foraging on incense-cedar and incense-cedar scale during winter in California. Res. Pap. PSW-195. Berkeley: USDA Forest Service, Pacific Southwest Forest and Range Experiment Station. 10 p.
Nicholson R. 1984. Propagation notes on *Cedrus deodara* ›Shalimar- and *Calocedrus decurrens*. Plant Propagator 30(1): 5B6.
Panshin AJ, De Zeeuw C, Brown HP. 1964. Textbook of wood technology. Vol. 1, 2nd ed. New York: McGraw-Hill. 643 p.
Peattie DC. 1953. A natural history of western trees. Boston: Houghton Mifflin. 751p.
Pharis RP. 1966. Comparative drought resistance of five conifers and foliage moisture content as a viability index. Ecology 47: 211B221.
Powers RF, Oliver WW. 1990. *Libocedrus decurrens* Torr. Incense-cedar. In: Burns RM, Honkala BH, tech coords. Silvics of North America. Volume l, Conifers. Agric. Handbk. 654. Washington, DC: USDA Forest Service: 173B180.

Rafn J. 1915. The testing of forest seeds during 25 years, 1887B1912. Copenhagen: Langkjaers Bogtrykkeri. 91 p.

Rehder A. 1940. Manual of cultivated trees and shrubs hardy in North America. 2nd ed. New York: Macmillan. 996 p.

Rogers DL, Harry DE, Libby WJ. 1994. Genetic variation in incense-cedar *(Calocedrus decurrens*): 1. Provenance differences in a twelve-year-old common-garden study. Western Journal of Applied Forestry 9(4): 113B117.

Sampson AW, Jespersen BS. 1963. California range brushlands and browse plants. Pub. 4010. Berkeley: University of California, Division of Agriculture and Natural Resources. 162 p.

Sargent CS. 1961. Manual of the trees of North America (exclusive of Mexico). Volume 1, 2nd corrected edition. New York: Dover. 433 p.

Schlosser WE, Blatner KA, Chapman RC. 1991. Economic and marketing implications of special forest products harvest in the coastal Pacific Northwest. Western Journal of Applied Forestry 6(3): 67B72.

Schubert GH. 1954. Viability of various coniferous seeds after cold storage. Journal of Forestry 52: 446B447.

Schubert GH, Adams RS. 1971. Reforestation practices for conifers in California. Sacramento: California Department of Conservation, Division of Forestry. 359 p.

Show SB. 1918. The relation of germination in the greenhouse and nursery. Journal of Forestry 16: 319B328.

Show SB. 1930. Forest nursery and planting practice in the California pine region. Circ. 92. Washington, DC: U.S. Department of Agriculture. 74 p.

Stark N. 1965. Natural regeneration of Sierra Nevada mixed conifers after logging. Journal of Forestry 63: 456B457, 460B461.

Stein WI. 1963. Comparative juvenile growth of five western conifers. PhD thesis. New Haven, CT: Yale University. 194 p.

Stein WI. 1974. *Libocedrus decurrens* Torr., incense-cedar. In: Schopmeyer CS, tech coord. Seeds of woody plants in the United States. Agric. Handbk. 450. Washington, DC: USDA Forest Service: 494B499.

Stone EC. 1957. Dew as an ecological factor: 2. The effect of artificial dew on the survival of *Pinus ponderosa* and associated species. Ecology 38: 414B422.

Sudworth GB. 1900. The forest nursery: collection of tree seeds and propagation of seedlings. Bull. 29. Washington, DC: USDA Division of Forestry. 63 p.

Sudworth GB. 1908. Forest trees of the Pacific slope. Washington, DC: USDA Forest Service. 441 p.

Tevis L Jr. 1953. Stomach contents of chipmunks and mantled squirrels in northeastern California. Journal of Mammalogy 34: 316B324.

Tillotson CR. 1925. Growing and planting coniferous trees on the farm. Farm. Bull. 1453. Washington, DC: U.S. Department of Agriculture. 38 p.

Toumey JW, Korstian CF. 1942. Seeding and planting in the practice of forestry. 3rd ed. New York: John Wiley & Sons. 520 p.

Van Dersal WR. 1938. Native woody plants of the United States, their erosion-control and wildlife values. Misc. Pub. 303. Washington, DC: U.S. Department of Agriculture. 362 p.

Figure 1—*Calocedrus decurrens*, incense-cedar: cones hang singly from branch tips well-dispersed over the crown and contain up to 4 seeds each, × 0.75.

Figure 2—*Calocedrus decurrens*, incense-cedar: each seed has 2 wings, a long wide wing on 1 side and a narrow, much shorter one on the other side, × 3.

Figure 3—*Calocedrus decurrens*, incense-cedar: longitudinal section showing radicle located at narrow end of seed, × 8.

Figure 4—*Calocedrus decurrens*, incense-cedar: germinating seed with radicle and hypocotyl emerging from the winged end, × 3.

Figure 5—*CalLibocedrus decurrens*, incense-cedar: seedling development 4, 7, 10, and 17 days after germination.