CupressaceaeCCypress family

Chamaecyparis Spach

white-cedar

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Growth habit, occurrence, and use. The genus *Chamaecyparis* occurs naturally on the Atlantic and Pacific Coasts of North America and in Japan and Taiwan. Three species are native to North America, 2 to Japan, and 1 to Taiwan (Sargent 1965). The North American species (table 1) are long-lived evergreens that attain large size. Port-Orford-cedar, the largest, has reached diameters of more than 1 m and heights of near 70 m in old-growth stands (Zobel 1990a). Branching is distinctive with the many-branched twigs and small paired scalelike leaves arranged in fernlike sprays. Another common name is Afalse-cypress@ (Little 1979); they are not true cedars (*Cedrus* spp.). Because of their somber beauty and variety of form, white-cedars are often used for ornamental plantings, hedges, and windbreaks (Rehder 1940). They produce valuable timber, the wood being sought for poles, posts, construction timbers, specialty items, and other uses where durability is desired. Atlantic white-cedar wood is especially popular for boats, outdoor furniture, posts, and utility poles (Kuser and Zimmerman 1995).

Geographic races and hybrids. Two geographic races of Atlantic white-cedar have been proposed: var. *henryae* (Li) Little in Georgia, Florida, Alabama, and Mississippi and var. *thyoides* in the area from South Carolina to Maine (Little 1966). Great variation exists within the genus, and numerous horticultural selections have been made of the 3 North America species as well as the Asian ones (Dirr and Heuser 1987; Harris 1990; Little and Garrett 1990; Zobel 1990a). Both interspecific and intergeneric crosses have been successful with certain of the cedars. Alaska-cedar and 2 of the Asian species have been crossed (Yamamoto 1981), and Alaska-cedar has also been crossed with several species of *Cupressus* (Harris 1990). The most well-known of these crosses is with *Cupressus macrocarpa* to produce the widely planted Leyland cypress (*Cupressocyparis* × *leylandii*).

Flowering and fruiting. White-cedars are monoecious. Their tiny inconspicuous yellow or reddish male pollen-bearing flowers and greenish female flowers are borne on the tips of branchlets (Harris 1974). Staminate flowers of Atlantic white-cedar, for example, are about 3 mm long, and the pistillate flowers are approximately 3 mm in diameter (Little and Garrett 1990). Pollination occurs generally from March to May, and cones ripen in September to October. Cones are slow to open fully, and seed dispersal occurs from fall into the following spring (table 2). Cones of Port-Orford-cedar and Atlantic white-cedar mature the same year that they are pollinated, whereas cones of Alaska-cedar, in most of the species=s range, take a second year to complete maturation (Harris 1974, 1990). In the extreme southern portion of the range of Alaska-cedar, cones may mature in only 1 year (Owens and Molder 1975). This condition even occurs on trees from more northern origins or from higher elevations when established in seed orchards in warm, southern, coastal sites (El-Kassaby and others 1991). The seeds from these 1-year cones are of equal size and germination quality to seeds from 2-year cones.

The white-cedars bear cones at an early ageC5 to 20 for Port-Orford-cedar (Zobel 1990a) and 3 to 5 for Atlantic white-cedar (Little and Garrett 1990). Sprays of gibberellin (primarily GA_3) will induce flowering in even younger seedlings of Port-Orford-cedar and Alaska-cedar (Owens and Molder 1977; Pharis and Kuo 1977). The use of GA_3 and supplemental pollination on container-grown Port-Ordford-cedar trees 4 to 6 years from rooting or grafting has shown good potential to produce a large amount of seeds in a short period (Elliott and Sniezko 2000). Mature cones are 6 to 12 mm in diameter, spherical, and are borne erect on branchlets (figure 1). Cones have from 6 to 12 scales, each bearing from 1 to 5 seeds with thin marginal wings (figures 2 and 3) (Harris 1974). Average seeds per cone are 7 for Alaska-cedar (Harris 1990) and 8 for Atlantic white-cedar, but less than a third of these may be filled. With controlled crosses in a seed orchard, Port-Orford-cedar averaged as high as 8.6 filled seeds per cone (Elliott and Sniezko 2000). Cone ripeness is normally determined by their exterior color (table 3) and is illustrated in the color plates for 2 species.

Seed crops of both western white-cedars can be damaged by larvae of the seedworm *Laspeyresia cupressana* (Kearfott) feeding on seeds in the cones. Larvae of the incense-cedar tip mothC*Argyresthia libocedrella* BusckCmine the cones and seeds of Port-Orford-cedar and can destroy practically the entire seed crop (Hedlin and others 1980).

Collection of cones. Cones may be collected by hand or raked from the branchlets of standing or felled trees. As with many species, cone production is usually less in dense stands, although local conditions cause lots of variation (Zobel 1979), and open stands should be favored in collections from natural stands. In a North Carolina study, 8-to 10-year-old plantations of Atlantic white-cedar produced good seed crops that were easy to collect (Bonner and Summerville 1999). When collecting cones of Alaska-cedar in the northern part of the range, precautions are needed to limit the collection to mature, second-year cones. The smaller, greenish-blue, immature, first-year cones are often present with the yellow-brown mature cones on the same branches (Harris 1974).

Extraction, cleaning, and storage of seeds. Cones of cedars may be dried by spreading in the sun or in a warm room, or they may be kiln-dried at temperatures below 43 °C (Harris 1974). Over 90% of the seeds can be recovered from cones of Atlantic white-cedar dried at 35 to 40 °C if 2 or 3 cycles of drying, interspersed with re-wetting of the cones, are used (Bonner and Summerville 1999). Each time the cones are redried, they open a little more. Mature cones of all white-cedars open when dried properly, and their seeds may be extracted by gentle shaking or tumbling. The thin-coated seeds of all species are easily injured and de-winging should not be attempted (Harris 1974).

Cleaning seeds of white-cedars to high puri y values is difficult because the small, scalelike leaves are similar to the seeds in size and weight. For lots of Atlantic white-cedar, large trash can be removed with round-hole screens, and small trash can be blown off with any number of pneumatic cleaners or seed blowers. These same blowers can be used to upgrade Atlantic white-cedar lots by removing many of the empty seeds that occur naturally in this species. Separation is not absolute, of course, and many smaller filled seeds will be lost. With care, however, purities above 90% and filled seed percentages close to 90% can be obtained (Bonner and Summervillel 1999). Similar data on the other 2 species are not available. Numbers of cleaned seed per weight are listed in table 4.

Seeds of the white-cedars are orthodox in storage behavior. They should be stored at or below freezing at a seed moisture content of 10% or below (Allen 1957; Harris 1974). Seeds of Port-Orford-cedar from several origins stored at –15 °C lost no germination capacity over an 11-year period (Zobel 1990b). There are no comparable storage data for Alaska-cedar or Atlantic white-cedar, but the latter species is known to survive at least 2 years of similar storage without loss of viability (Bonner and Summerville 1999). Atlantic white-cedar seeds will also survive for at least 2 growing seasons in natural seedbeds (Little 1950).

Pregermination treatments and germination tests. Germination of cedar species is reported to be extremely variable and usually low, but this is due primarily to the naturally low percentages of filled seeds and the failure of seed managers to remove these empty seeds from the seed lots. Port-Orford-cedar germinates readily in the laboratory without pretreatment, and cold stratification does not appear to even improve germination rate (Zobel 1990b). Alaska-cedar exhibits a dormancy that can be somewhat overcome by warm incubation followed by cold stratification, but optimum schedules have not been determined (Harris 1990). In laboratory testing of germination, stratification of 21 days at 3 to 5 °C has been recommended (ISTA 1993). In nursery sowing, however, environmental conditions are seldom as favorable as those in the laboratory, so longer pretreatments are usually beneficial. One promising pretreatment schedule is moist stratification for 30 days at alternating temperatures of 20 and 30 °C, followed by 30 days at 5 °C (Harris 1974). The beneficial effect of warm incubation suggests that many of the seeds are not quite fully matured, and the incubation period enhances maturation in the same manner as warmer temperatures were shown to speed up cone ripening (Owens and Molder 1975).

Atlantic white-cedar has a variable dormancy also, although probably not as deep as that in Alaska-cedar. Some lots will germinate completely in the laboratory without any pretreatment (table 5). Recent tests with samples from North Carolina indicate that maximum germination in 28 days at good rates requires 4 weeks of moist stratification at 3 °C. Official test prescriptions (ISTA 1993) call for 90 days of stratification at 3 °C for germination within the same time period. Extremely slow germination has been reported in nursery beds in New Jersey (Little 1950), so some stratification would certainly be recommended. Germination is epigeal.

Nursery practice. For all 3 species of North American white-cedars, spring sowing of stratified seeds is recommended. Port-Orford-cedar has the least dormancy and may only require 30 days of cold stratification. In England this species is normally not stratified at all (Aldous 1972). Alaska-cedar and Atlantic white-cedar have deeper levels of dormancy, and more extended pretreatments are necessary. Warm incubation at alternating temperatures, followed by cold stratification (as described in the previous section), has been recommended for both of these species (Dirr and Heuser 1987). Seeds from the more southern sources of Atlantic white-cedar seem to be not so dormant, and 30 to 60 days of cold stratification alone may be sufficient. Experience with Port-Orford-cedar in western nurseries suggests covering the sown seeds with 3 to 6 mm (1/10 to 1/4 in) of soil and calculating sowing rates to produce 320 to 530 seedlings/m^2 (30 to 50/ft^2). One kilogram of Port-Orford-cedar seeds should produce approximately 284,000 plantable seedlings (Harris 1974). Shading the seed beds until midseason of the first year may also be beneficial. For field planting, 2+0 stock is commonly used in the western United States, although 2+1 transplants are favored for Port-Orford-cedar in England (Harris 1974). For Atlantic white-cedar, 2+0 seedlings are used in New Jersey and 1+0 seedlings in North Carlina (Kuser and Zimmerman 1995).

All white-cedars can be propagated vegetatively and are commonly produced this way for the ornamental market. Port-Orford-cedar cuttings should be taken between September and April, treated with indole butyric acid (IBA) powder (3,000 to 8,000 ppm), and placed in peat or perlite with mist and bottom heat (Dirr and Heuser 1987). Zobel (1990a) suggests taking cuttings from tips of major branches from lower branches of young trees. Alaska-cedar cuttings need 8,000 or more ppm of IBA, and cuttings should be taken in late winter to early spring (Dirr and Heuser 1987). After 4 years, growth of outplanted rooted cuttings was equal to that of seedlings in British Columbia (Karlsson 1982). Atlantic white-cedar cuttings taken in mid-November and treated with auxins also root very well (Dirr and Heuser 1987). With auxins and bottom heat in mistbeds, 90% rooting can be expected. Early comparisons show that growth of seedlings and stecklings (rooted cuttings) to be about the same (Kuser and Zimmerman 1995).

References

Aldhous JR. 1972. Nursery practice. For. Comm. Bull. 43. London: Forestry Commission. 184 p.

Allen GS. 1957. Storage behavior of conifer seeds in sealed containers held at 0 °F., 32 °F., and room temperature. Journal of Forestry 55: 278B281.

Bonner FT, Summerville KO. 1999. Production and quality of Atlantic white-cedar seed in coastal North Carolina. In: Shear TH, Summerville KO, eds. Symposium, Atlantic white-cedar: Ecology and Management. 1997 August 6B7; Newport News, VA. Gen. Tech. Rep. SRS-27. Asheville, NC: USDA Forest Service, Southern Research Station. 76B79.

Dirr MA, Heuser CW Jr. 1987. The reference manual of woody plant propagation: from seed to tissue culture. Athens, GA: Varsity Press. 239 p.

Elliott L, Sniezko RA. 2000. Cone and seed production in a Port-Orford-cedar containerized orchard. In: Hansen EM, Sutton W, eds. Phytophthora diseases of forest trees. IUFRO WP7.02.09. Proceedings, 1st International Meeting on Phytophthoras in Forest and Wildland Ecosystems. 1999 Auugust 30BSeptember 3; Grants Pass, OR. Corvallis: Oregon State University: 105B106.

El-Kassaby YA, Maze J, MacLeod DA, Banerjee S. 1991. Reproductive cycle plasticity in yellow cedar (*Chamaecyparis nootkatensis*). Canadian Journal of Forestry Research 21: 1360B1364.

Harris AS. 1974. *Chamaecyparis* Spach, white-cedar. In: Schopmeyer CS, tech. coord. Seeds of woody plants of the United States. Agric. Handbk. 450. Washington, DC: USDA Forest Service: 316320.

Harris AS. 1990. *Chamaecyparis nootkatensis* (D. Don) Spach, Alaska-cedar. In: Burns RM, Honkala BH, tech. coord. Silvics of North America. Volume 1, Conifers. Agric. Handbk. 654. Washington, DC: USDA Forest Service: 97B102.

Hedlin AF, Yates HO III, Tovar DC, Ebel BH, Koerber TW, Merkel EP. 1980. Cone and seed insects of North American conifers. FAO North American Forestry Commission, Study Group on Forest Insects and Diseases. Ottawa: Canadian Forestry Service. 122 p.

ISTA [International Seed Testing Association]. 1993. International rules for seed testing. Rules 1993. Seed Science and Technology 21 (Suppl.): 1B259.

Karlsson I. 1982. Propagation of Alaska yellow cedar (*Chamaecyparis nootkatensis* [D. Don] Spach.) by rooted cuttings for production planting. Proceedings of the International Plant

Propagators= Society 31(1981): 112B116.
Korstian CF, Brush WD. 1931. Southern white cedar. Agric. Tech. Bull. 251. Washington, DC: U.S. Department of Agriculture. 75 p.
Kuser JE, Zimmerman GL. 1995. Restoring Atlantic white-cedar swamps: techniques for propagation and establishment. Tree Planters= Notes 46(3): 78B85.
Little EL Jr. 1966. Varietal transfers in *Cupressus* and *Chamaecyparis*. Madrono 18(6): 161B167.
Little EL Jr. 1979. Checklist of United States trees (native and naturalized). Agric. Handbk. 541. Washington, DC: USDA Forest Service. 375 p.
Little S Jr. 1940. Seed fall of Atlantic white-cedar. Tech. Note 26. Philadelphia: USDA Forest Service, Allegheny Forest Experiment Station. 1 p.
Little S Jr. 1950. Ecology and silviculture of white-cedar and associated hardwoods in southern New Jersey. Yale University School of Forestry Bulletin 56: 1B103.
Little S Jr, Garrett PW. 1990. *Chamaecyparis thyoides* (L.) B.S.P., Atlantic white-cedar. In: Burns RM, Honkala BH, tech. coord. Silvics of North America. Volume 1, Conifers. Agric. Handbk. 654. Washington, DC: USDA Forest Service: 103B108.
Ouden PD. 1965. Manual of cultivated conifers. The Hague: Martinus Nijhoff. 526 p.
Owens JN, Molder M. 1975. Pollination, female gametophyte, and embryo and seed development in yellow cedar (*Chamaecyparis nootkatensis*). Canadian Journal of Botany 53: 186B199.
Owens JN, Molder M. 1977. Cone induction in yellow cypress (*Chamaecyparis nootkatensis*) by gibberellin A3 and the subsequent development of seeds within the induced cones. Canadian Journal of Forest Research 7: 605B613.
Pharis RP, Kuo CG. 1977. Physiology of gibberellins in conifers. Canadian Journal of Forest Research 7: 299B325.
Rehder A. 1940. Manual of cultivated trees and shrubs hardy in North America. 2nd ed. New York: Macmillan. 996 p.
Sargent CS. 1965. Manual of the trees of North America (exclusive of Mexico). 2nd ed., corrected and reprinted. New York: Dover Publications. 934 p.
Swingle CF, comp. 1939. Seed propagation of trees, shrubs, and forbs for conservation planting. SCS-TP-27. Washington, DC: USDA Soil Conservation Service. 198 p.
Van Dersal WR. 1938. Native woody plants of the United States: their erosion-control and wildlife values. Misc. Publ. 303. Washington, DC: USDA. 362 p.
Yamamoto C. 1981. [Possibilities of interspecific hybridization between *Chamaecyparis lawsoniana* and some other *Chamaecyparis* species; in Japanese, English summary.] Journal of the Japanese Forestry Society 63: 311B319.
Zobel DB. 1979. Seed production in forests of *Chamaecyparis lawsoniana*. Canadian Journal of Forest Research 9: 327B335.
Zobel DB. 1990a. *Chamaecyparis lawsoniana* (A. Murr.) Parl., Port-Orford-cedar. In: Burns RM, Honkala BH, tech. coord. Silvics of North America. Volume 1, Conifers. Agric. Handbk. 654. Washington, DC: USDA Forest Service: 88B96.
Zobel DB. 1990b. Effects of low temperature, seed source, and seed age on germination of *Chamaecyparis lawsoniana*. Canadian Journal of Forest Research 20: 1053B1059.

Figure 1C*Chamaecyparis nootkatensis*, Alaska-cedar: mature cones, × 2.

Figure 2C*Chamaecyparis,* white-cdar: seeds, × 8.

Figure 3C*Chamaecyparis lawsoniana*, Port-Orford-cedar: longitudinal section through a seed, × 8.

Table 1C *Chamaecyparis,* white-cedar: nomenclature and occurrence

Scientific name & synonym(s)	Common name	Occurrence
***C. lawsoniana* (A. Murr.) Parl.** *Cupressus lawsoniana* A. Murr.	**Port-Orford-cedar,** false cypress, Lawson cypress, Oregon-cedar, Port-Orford white-cedar	SW Oregon (Coos Bay) S to NW California (Klamath River)
***C. nootkatensis* (D. Don.) Spach** *Cupressus nootkatensis* D. Don	**Alaska-cedar,** yellow-cedar, Alaska yellow-cedar, Nootka yellow-cypress, Sitka cypress, yellow cypress	Pacific Coast region from Prince William Sound, Alaska, SW to W British Columbia & W Washington, & S in Cascade Mtns. to W & NW & SW British Columbia to California; local in NE Oregon
***C. thyoides* (L.) B.S.P.** *Cupressus thyoides L.*	**Atlantic white-cedar,** white-cedar, swamp-cedar, southern white-cedar	Narrow coastal belt from S Maine to N Florida, W to S Mississippi

Source: Little (1979).

Table 2C *Chamaecyparis,* white-cedar: phenology of flowering and fruiting

Species	Location	Flowering dates	Cone ripening dates	Seed dispersal dates
C. lawsoniana	Oregon	March	SeptBOct	SeptBMay
C. nootkatensis	Pacific Coast	AprBMay	SeptBOct*	OctBspring
C. thyoides	Atlantic Coast	MarBApr	SeptBOct	Oct 15BMar 1

Sources: Harris (1974), Little (1940).

* Cones require 2 years to reach maturity in the northern part of the range.

Table 3C*Chamaecyparis,* white-cedar: height, seed-bearing age, seed crop frequency, and color of ripe cones

Species	Height at maturity (m)	Year first cultivated	Minimum seed-bearing age (yrs)	Interval between large seed crops(yrs)	Color of ripe cones
C. lawsoniana	to 73	1854	5B20	3B5	Greenish yellow to red brown
C. nootkatensis	to 53	1851	C	4 or more	Yellow brown to red brown
C. thyoides	12-27	1727	3B20	1 or more	Greenish with glaucous bloom to bluish-purple & glaucous, finally red brown

Sources: Little (1950), Korstian and Brush (1931), Ouden (1965), Rehder (1940), Sargent (1965).

Table 4C*Chamaecyparis,* white-cedar: seed yield data

	Seed wt/cone wt		Cleaned seeds/weight			
			Range		Average	
Species	kg/100 kg	lb/100 lb	/kg	/lb	/kg	/lb
C. lawsoniana	20	20	176,400B1,323,000	80,000B600,000	463,000	210,000
C. nootkatensis	C	C	145,500B396,900	66,000B180,000	238,140	108,000
*C. thyoides**	20	20	926,100B1,102,500	420,000B500,000	1,014,300	460,000

Sources: Harris (1974), Korstian and Brush (1931), Swingle (1939).
* 1.64 kg of seeds were obtained from 1 bushel of cones (Van Dersal 1938).

Table 5C*Chamaecyparis,* white-cedar: stratification periods and germination test conditions and results

	Test conditions					Test results				
	Stratification (days)		Temp. (°C)		Duration	Germ. energy		Germ. capacity	Soundness	
Species	Warm*	Cold	Day	Night	(days)	(%)	(days)	(%)	(%)	Samples
C. lawsoniana	0	0	30	20	28	44	14	48	48	9
	0	0	30	20	60	24	34	52	C	60
C. nootkatensis	58	30	30	20	22	10	11	12	51	1
	0	30B90	30	20	41	0	C	0	57	3
	0	0	30	20	28B55	0	C	0	54	8
C. thyoides	0	0	30	20	60	C	C	84	C	11
	0	90	30	20	28	C	C	C	C	C

Source: Harris (1974).

* At alternating temperatures of 30 and 20 °C.
H At 5 °C.
I Seeds were exposed to light during the warm period.
' A constant temperature of 20 °C is also suitable (ISTA 1993).