Taxaceae—Yew family

Torreya Arn.

torreya

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Growth habit, occurrence, and uses. The genus *Torreya* includes 7 species of conifer trees found in North America and eastern Asia (Little 1979; Price 1990). These species of limited distribution represent a genus that in earlier geologic times was widespread in the Northern Hemisphere—Europe, Greenland, Alaska, British Columbia, Oregon, Colorado, Virginia, North Carolina (Abrams 1955; Boeshore and Gray 1936; Florin 1963; Schwartz and Hermann 1993a). Two species are native in the United States: Florida torreya is endemic to a small area in Florida and Georgia, and California torreya to central California (table 1). Little genetic variability has been found among populations of Florida torreya in contrast to those of California torreya (Schwartz 1993). Although growing in markedly different climates, the 2 species responded similarly in water stress tests (Schwartz and others 1995).

California torreya is a slow-growing, medium-sized tree found along streams and in canyon bottoms and other moist locations (Griffin and Critchfield 1976; Storer and Usinger 1963). In its shrub form, it is found on serpentine soils and in chaparral (Sudworth 1908). In elevation, California torreya ranges from coastal lowlands to almost 2,130 m in the southern Sierra Nevada. Under very favorable conditions, trees may grow to 23 m or more in height and 60 to 90 cm in diameter (Sudworth 1908). The tallest tree now on record is 29.3 m tall and 638 cm in circumference at 137 cm above ground (AFA 2000).

Florida torreya, also a slow-growing tree, is an endangered species found only at low elevations on ravine slopes 12 to 45 m above constant running streams on the east bank of Florida's Apalachicola River and tributaries and in a colony on low flat land that is 10 km west of the river (Kurz 1938; Nicholson 1990; Schwartz and Hermann 1993a & b). Florida torreya is commonly associated with seepage locations on soils ranging from coarse or fine sand to clay with limestone pebbles (Kurz 1938; USFWS 1986). In their native habitat, mature trees have reached 15 to 20 m in height and 30 to 60 cm in diameter (Harrar and Harrar 1962; Nicholson 1990; Schwartz and others 1995). However, due to severe population decline since the 1950's (the primary cause of this decline is unknown), the 1,500 or fewer immature survivors are generally less than 2 m tall (Bronaugh 1996; Schwartz and Herman 1999; Schwartz and others 1995). The tallest existing trees are found in several plantings outside of the species' endemic habitat; the largest, in North Carolina, measures 13.7 m tall and 277 cm in circumference (AFA 2000).

Because of their low availability, uses of both species of torreya are limited. Their wood is aromatic, rot-resistant, fine-grained, and excellent for cabinet-making (Burke 1975; Peattie 1953). Both species have been used locally for such purposes as shingles, fence posts, and firewood.

They grow satisfactorily outside of their native range and have received moderate use as ornamentals (Burke 1975; Sargent 1875; Wilson 1938). Fruits of California torreya were collected for food by native Californians, and the characteristics of its oil compare favorably with those of pine-nut oil for cooking purposes (Burke 1975). Squirrels have been observed eating fruits and seeds of Florida torreya and antler-rubbing scars provide evidence of use by deer (Bronaugh 1996; Nicholson 1990; Schwartz and Hermann 1993a).

Flowering and fruiting. Torreyas are dioecious. The male flowers are small, budlike, and clustered on the under sides of twigs in axils of leaves produced the previous year (Abrams 1955; Jepson 1925; Sargent 1933; Sudworth 1908). The female flowers are less numerous and occur on the lower sides of the current year's twigs. After fertilization, they develop singly into sessile, thin-fleshed arils that mature during the second season as green to purplish drupes 25 to 44 mm long (figure 1). When mature, the leathery cover eventually releases a 25- to 30-mm yellow-brown seed (Munz and Keck 1959) (figure 2). The thick woody inner seedcoat is irregularly folded into the white endosperm, and the embryo is minute (figure 3).

Both species flower in March and April, with some flowers of Florida torreya appearing as early as January and some of California torreya extending into May (Rehder 1940; Sargent 1933; Stalter 1990; Weidner 1996*)*. Under favorable growing conditions, Florida torreya produces male and female flowers about age 20 (Stalter 1990*)*; in greenhouse conditions*,* 5-year-old sprouts produced pollen (Schwartz 1996).

Information on the fruit production characteristics of both torreya species is sparse and inadequate. Fruits mature from August till November (Mirov and Kraebel 1939; Rehder 1940; Stalter 1990). At the Alfred B. Maclay Gardens in Tallahassee, Florida, fruit production from 8 trees was low and varied by tree and year. No fruits were produced in 4 years, and more than 100 fruits were available in 1985, 1986, 1987, and 1989 (Weidner 1996).

Collection, extraction and storage. Collection of Florida torreya fruits from the endemic population is not possible now because there are only scattered sexually mature male trees and no mature females (Bronaugh 1996; Schwartz and Hermann 1993a; Schwartz 1996). Trees in cultivation include less than 2 dozen reproductive females (Bronaugh 1996), so extraordinary diligence is required to collect any seeds that are produced. Fruits have been picked slightly green to gather them before the squirrels do and then held in open storage until the outer cover turned dark; then the pulp was softened in water and removed by rubbing fruits against hardware cloth (Weidner 1996).

Fruit production of California torreya is common and widespread enough to forestall concerns about shortage; several hundred pounds may be collected in single commercial collections (Callahan 1996). The fruits are generally picked from the trees, but seeds are sometimes collected after the fruits have been shed. Seed extraction is about the same as for Florida torreya, with the softened pulp removed by water pressure and some hand rubbing (Callahan 1996). Care is needed to avoid damage to the relatively tender seedcoat. Seed quality of California torreya is generally good and can be improved sometimes by separating light seeds through flotation.

Storage experience is short-term and fragmentary because torreya seeds are generally used as available. Based on incidental observations, the seeds may be recalcitrant, as high moisture content appears necessary to maintain their viability. California torreya has been stored in moist vermiculite or sphagnum moss at 2 to 7 EC for up to 3 years (Callahan 1996). Some seeds of both

species will germinate in lengthy cool or warm stratification (Callahan 1996; Weidner 1996).

Seeds of California torreya averaged 324/kg (147/lb) with a range of 243 to 421/kg (110 to 1991/lb) in 3 samples (Roy 1974). Florida torreya had 496 seeds/kg (225/lb) in 1 sample at a moisture content of 8.6% (Roy 1974).

Pregermination treatments and germination tests. Standard germination test procedures have not been developed yet for torreya seeds. Both species require lengthy after-ripening and stratification, but efforts made to date have not identified methods for timely germination testing of fresh or stored seeds.

As available, fresh seeds of Florida torreya have been tested at Alfred B. Maclay State Gardens according to the 9 variations of methodology specified in the recovery plan for the species (USFWS 1986). Warm stratification in a half and half mixture of Canadian peat and coarse sand for 6 months in a greenhouse at 13 to 18 EC has produced the best results. Gentle cracking of the distal end of the seedcoat before warm stratification produced somewhat higher germination than a preliminary 20-minute soak in 10% chlorine bleach or stratification alone (table 2) (Weidner 1996).

Germination averaged lowest for sowings made directly into outdoor beds. The germination results indicate that seedcrop quality or other factors differed from year to year, and results were also not very consistent for the same pretreatment and germination sequence.

Procedures have been prescribed for determining viability of torreya seeds quickly by a tetrazolium (TZ) test on excised embryos (Moore 1985). Seed preparation involves puncturing the seedcoat, soaking the seeds in water for 18 hours, and then cutting them open to expose nutritive tissue and the distal end of the embryo. The prepared seeds are soaked in a 1% TZ solution for 24 to 48 hours, depending on temperature; nutritive tissue and embryo are then further exposed and evaluated. Viable seeds have a completely stained embryo and nutritive tissue.

Nursery practices. Torreya germination is hypogeal. Both California and Florida torreyas can be reproduced from seeds but quantities grown are so small and infrequent that nursery practices are underdeveloped.

The protocols specified in the recovery plan (USFWS 1986) and the germination resulting therefrom (table 2) are evidently the most recent, systematic, and successful attempts to produce Florida torreya seedlings for outplanting. Seedlings are slow growing and very susceptible to damping-off, so repeated fungicide drenches are necessary.

Seeds of California torreya sown untreated in the fall will germinate late the next summer or in the second spring. Germination can be obtained by April of the first season by sowing in the fall and keeping the seedbed at 7 to 10 EC (Callahan 1996). Seeds generally have high viability—90 to 98% germination. In a test of seeds stratified for 3 months, 92% germinated in 232 days after sowing (Mirov and Kraebel 1939). Two growing seasons are required to produce seedlings 15 to 25 cm tall (Callahan 1996; Wilson 1996).

Both species sprout from stumps or root crowns and can be propagated vegetatively. Metcalf (1959) described sprouting of California torreya as vigorous "like redwood." Stalter (1990), Godfrey (1988), and others indicated that the current endemic Florida torreya population probably originated largely from vegetative propagation, but Schwartz and Hermann (1993a) concluded that most originated from seeds.

The urgency of conserving Florida torreya has stimulated development of its reproduction by cuttings (Bailo and others 1998; Nicholson 1988, 1993). Up to 91% of cuttings collected in

November from trees throughout the species' native range rooted in a pumice−peat−perlite mixture. The cuttings were potted and grown for 2 years and then shipped to botanic gardens and research institutions. A database on living Florida torreya material is maintained by The Center for Plant Conservation, headquartered at the Missouri Botanical Garden, St. Louis, Missouri.

References

Abrams L. 1955. Illustrated flora of the Pacific states: Washington, Oregon, and California. Volume I. Stanford, CA: Stanford University Press. 538 p.

AFA [American Forestry Association]. 2000. The national register of big trees 2000−2001. American Forests 106(1): 22−64.

Bailo BG, Determann R, Nicholson R, Sojkowski S. 1998. The *ex situ* conservation of stinking cedar. Public Garden 13(3): 9−11.

Boeshore I, Gray WD. 1936. An upper cretaceous wood: *Torreya antiqua.* American Journal of Botany 23: 524−528.

Bronaugh W. 1996. Champions on the brink. American Forests 102(1): 16−19.

Burke JG. 1975. Human use of the California nutmeg tree, *Torreya californica,* and of other members of the genus. Economic Botany 29: 121−139.

Callahan F. 1996. Personal communication. Central Point, OR: Callahan Seeds.

Florin R. 1963. The distribution of conifer and taxad genera in time and space. Acta Horti Bergiani 20(4): 121−312 [*Torreya* found on 262−266].

Godfrey RK. 1988. Trees, shrubs, and woody vines of northern Florida and adjacent Georgia and Alabama. Athens, GA: University of Georgia Press. 734 p.

Griffin JR, Critchfield WB. 1976. The distribution of forest trees in California. Res. Pap. PSW-82 (reprinted with supplement). [Berkeley], CA: USDA Pacific Southwest Forest and Range Experiment Station. 118 p.

Harrar ES, Harrar JG. 1962. Guide to southern trees. 2nd ed. New York: Dover. 709 p.

Jepson WL. 1925. A manual of the flowering plants of California. Berkeley: University of California. 1238 p.

Kurz H. 1938. *Torreya* west of the Apalachicola River. Proceedings of the Florida Academy of Sciences 3: 66−77.

Little EL Jr. 1979. Checklist of United States trees, native and naturalized. Agric. Handbk. 541. Washington, DC: USDA Forest Service. 375 p.

Metcalf W. 1959. Native trees of the San Francisco Bay region. Berkeley: University of California Press. 72 p.

Mirov NT, Kraebel CJ. 1939. Collecting and handling seeds of wild plants. For. Publ. 5. Washington, DC: USDA Forest Service, Civilian Conservation Corps. 42 p.

Moore RP, ed. 1985. Handbook on tetrazolium testing. Zurich: International Seed Testing Association: 73.

Munz PA, Keck DD. 1959. A California flora. Berkeley: University of California Press. 1681 p.

Nicholson R. 1990. Chasing ghosts: the steep ravines along Florida's Apalachicola River hide the last survivors of a dying tree species. Natural History 12/90: 8, 10−13.

Nicholson R. 1993. Rooting *Torreya taxifolia*, an endangered conifer of the Florida panhandle. Botanic Gardens Conservation News 2(2): 1−3.

Nicholson RG. 1988. Propagation of some woody endemic plants of eastern North America. Combined Proceedings of the International Plant Propagators' Society 37: 468–473.
Peattie DC. 1953. A natural history of western trees. Boston: Houghton Mifflin. 751 p.
Price RA. 1990. The genera of Taxaceae in the southeastern United States. Journal of the Arnold Arboretum 71: 69–91.
Rehder A. 1940. Manual of cultivated trees and shrubs hardy in North America. 2nd ed. New York: Macmillan. 996 p.
Roy DF. 1974. *Torreya* Arn., torreya. In: Schopmeyer CS, tech coord. Seeds of woody plants in the United States. Agric. Handbk. 450. Washington, DC: USDA Forest Service: 815–816.
Sargent CS. 1933. Manual of the trees of North America (exclusive of Mexico). 2nd ed. Cambridge, MA: Riverside Press. 910 p.
Sargent HW. 1875. A treatise on the theory and practice of landscape gardening adapted to North America. New York: Orange Judd Company. 592 p.
Schwartz MW. 1993. Allozyme variation of the endangered Florida torreya (*Torreya taxifolia).* Canadian Journal of Forest Research 23: 2598–2602.
Schwartz MW. 1996. Personal communication. Davis: University of California.
Schwartz MW, Hermann SM. 1993a. The continuing population decline of *Torreya taxifolia* Arn. Bulletin of the Torrey Botanical Club 120(3): 275–286.
Schwartz MW, Hermann SM. 1993b. The population ecology of *Torreya taxifolia*: habit evaluation, fire ecology, and genetic variability. Final Report. Tallahassee: Florida Game and Fresh Water Fish Commission, Nongame Wildlife Program. 76 p.
Schwartz MW, Hermann SM. 1999. Is slow growth of the endangered *Torreya taxifolia* (Arn.) normal? Journal of the Torrey Botanical Society 126(4): 307–312.
Schwartz MW, Hermann SM, Vogel CS. 1995. The catastrophic loss of *Torreya taxifolia*: assessing environmental induction of disease hypotheses. Ecological Applications 5(2): 501–516.
Stalter R. 1990. *Torreya taxifolia* Arn., Florida torreya. In: Burns RM, Honkala BH, tech. coords. Silvics of North America. Agric. Handbk. 654. Volume 1, Conifers. Washington, DC: USDA Forest Service: 601–603.
Storer TI, Usinger RL. 1963. Sierra Nevada natural history. Berkeley: University of California Press. 374 p.
Sudworth GB. 1908. Forest trees of the Pacific slope. Washington, DC: USDA Forest Service. 441 p.
USFWS [USDI Fish and Wildlife Service]. 1986. Florida torreya (*Torreya taxifolia*) recovery plan. Atlanta: USDI Fish and Wildlife Service. 42 p.
Weidner B. 1996. Personal communication. Tallahassee: Florida Department of Environmental Protection, Alfred B. Maclay State Gardens.
Wilson A. 1938. The California nutmeg tree in cultivation. Madroño 4: 166–167.
Wilson B. 1996. Personal communication. San Luis Obispo, CA: Los Pilitas Nursery.

Figure 1—*Torreya taxifolia*, Florida torreya: the fruit is sessile and druplike, 1H.

Figure 2—*Torreya,* torreya: *T. californica*, California torreya (left) and *T. taxifolia*, Florida torreya (right), large seeds, H 1.

Figure 3—*Torreya californica*, California torreya: longitudinal section through a seed showing the folds of the inner seedcoat extending into the endosperm, H 3.

Table 1—*Torreya,* torreya: nomenclature and occurrence

Scientific name & synonyms	Common name	Occurrence
***T. californica* Torr.** *T. myristica* Hook. *Tumion californicum* (Torr.) Greene	**California torreya,** California-nutmeg, stinking-yew, stinking-cedar	Central California—scattered in the coast ranges and on western slopes of the Cascades & Sierra Nevada
***T. taxifolia* Arn.** *Tumion taxifolium* (Arn.) Greene	**Florida torreya,** Florida-nutmeg, stinking-cedar	E bank of Apalachicola River & tributaries from Decatur Co., Georgia, to Liberty Co., Florida, & an outlying population in Jackson Co., Florida

Sources: Griffin and Critchfield (1976), Kurz (1938), Little (1979), Stalter (1990), Sudworth (1908).

Table 2—*Torreya,* torreya: germination of *T. taxifolia* seeds

Pre-germination treatment*	Germination by seed year			
	1985	1990	1993	Average
6 mon of warm stratification	69	13	80	54.0
Bleach + 6 mon of warm stratification	77	0	85	54.0
Cracking + 6 mon of warm stratification	100	25	86	70.3
3 mon of warm, then 3 mon of cold stratification	85	38	58	60.3
Bleach + 3 mon of warm, then 3 mon of cold stratification	77	25	44	48.7
Cracking + 3 mon of warm, then 3 mon of cold stratification	62	38	35	45

Source: Weidner (1996).
* Stratification temperatures: warm = 13 to 18 EC, cold = 2 to 7 EC.