The genus Torreya:

With key to species

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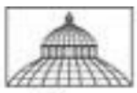

THE NEW YORK BOTANICAL GARDEN

Springer

Taxaceae: The Genera and Cultivated Species

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Source: *Botanical Review*, Oct. - Dec., 1998, Vol. 64, No. 4 (Oct. - Dec., 1998), pp. 291-322

Published by: Springer on behalf of New York Botanical Garden Press

Stable URL: https://www.jstor.org/stable/4354329

E. TORREYA

TORREYA Arn., Ann. Nat. Hist. 1: 130. 1838. Type species: *T. taxifolia* Arn., Ann. Nat. Hist. 1: 130. 1838. Common names: torreya, fetid-yew (Fig. 8).

Tumion E. Greene, Pittonia 2: 194. 1891.

Dioecious, occasionally monoecious, small or large trees 5–30 m tall; bark gray-brown to light brown or orange-brown, smooth when young, narrowly fissured with age; branches opposite or whorled; branchlets opposite or subopposite, green the first year, changing to dark red-brown, brown or gray by the third year; buds ovoid, acute, prismatic, 3–12 mm long, the scales persistent or deciduous, few, imbricate, lustrous, ovate, keeled. Leaves persistent 3–4

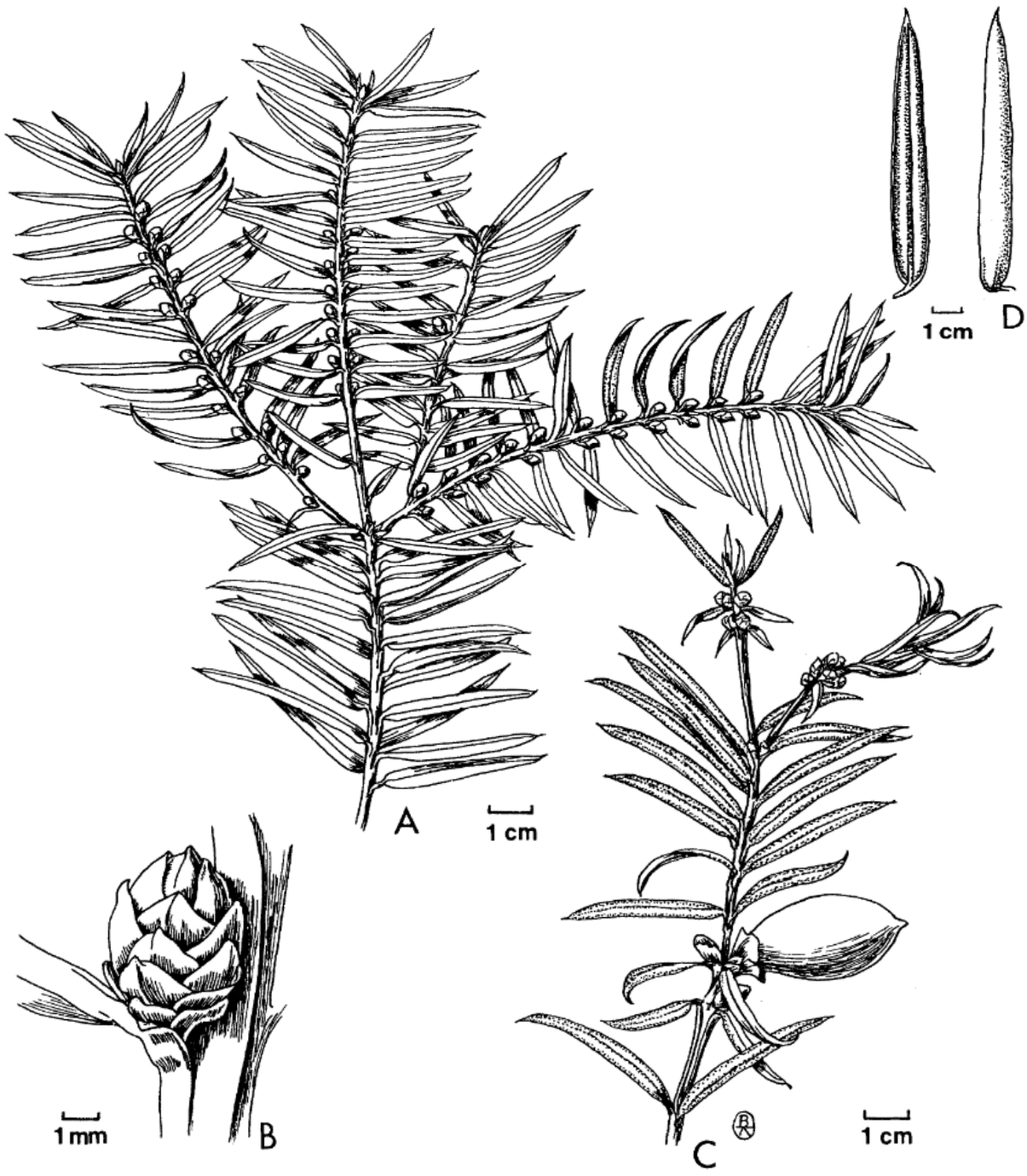

Fig. 8. *Torreya nucifera* (L.) Siebold & Zucc. **A.** Branchlets bearing pollen strobili. **B.** Pollen strobilus. **C.** Branchlet bearing young megastrobili with mature megastrobilus and aril. **D.** Adaxial (left) and abaxial (right) leaf surfaces. [From live material, *E. A. Cope 781* (BH) and *B. K. Boom 3224* (BH).]

years, spirally arranged but 2-ranked and appearing opposite by the twisting of the bases, linear-lanceolate, (1–)1.5–9 cm × 2–5 mm, often rounded at the base, acuminate to cuspidate with rigid, pale, spiny tips, petiole usually only distinguishable where it is decurrent on the branchlet, upper surface convex, often with a puffy appearance, sometimes with 2 thin longitudinal grooves, the midrib obscure or slightly impressed, lower surface broadly concave, the midrib raised, stomatal bands impressed or sunken, each much narrower than or equal to the

raised midrib, 0.2–1 mm wide, pale, becoming fulvous with age, resin canal 1, extending to the tip of the leaf in the center, below the vascular bundle, aromatic, fetid or odor lacking.

Pollen strobili simple, axillary, on the most recent year's branchlets, borne on minute recurved peduncles so that the strobili are most easily visible from the lower surface of the branchlet, 4–10 mm long, subtended by 12 or 16 keeled sterile scales arranged in 4 vertical rows; microsporophylls numerous (20–36), arranged in alternating whorls of 4, hyposporangiate (occasionally perisporangiate), dorsiventral, each with (3–)4(–6–7) microsporangia.

Ovules solitary, terminal on short shoots, the shoots paired on an abbreviated branchlet in the axil of a foliage leaf near the base of the current year's branchlet, entirely surrounded by and nearly completely adnate to the thin aril, subtended by 4 short (1–3 mm long) sterile scales, one ovule of the paired shoots often not developing; arils ovoid-oblong, drupe-like, (1.5–)2–3.5(–5) cm long, purple or tinged green, resinous, ripening the second season; seeds hard, woody, nearly as large as the aril, megagametophyte smooth to slightly or deeply ruminated. Chromosome number, n = 11.

Torreya is a genus of seven closely related species in North America and eastern Asia. Four of the species inhabit a band of eight provinces across central China. Of these, *T. jackii* Chun grows only in the eastern coast province of Zhejiang. The range of *T. grandis* Fortune from east to west includes Zhejiang, Fujian, Anhui, and Jiangxi to Hubei, where *T. fargesii* Franchet begins to appear. *Torreya fargesii* extends west through Sichuan to Yunnan, the province from which *T. yunnanensis* W. C. Cheng & L. K. Fu has been described. The morphological differences between these taxa are slight. *Torreya fargesii* and *T. grandis* are especially similar, distinguished principally by a ruminate megagametophyte in the seed in *T. fargesii* (Hu, 1927). There is overlap in other characters that have been used to distinguish species—e.g., grooves on the upper surface of the leaves, length of the spiny tips of the leaves, and branchlet color (Fig. 9). *Torreya jackii* is more readily discernable because of its longer, falcate leaves that terminate in a shorter, spiny tip. *Torreya yunnanensis* has recently been segregated from *T. fargesii* (Cheng et al., 1975) on the basis of the tendency of the former for longer, slightly less falcate, acuminate leaves and a different pattern of canals and ridges in the ruminate albumen. These species are not well known, as very little descriptive work has been published and only a few specimens are available in major herbaria.

A fifth Asian species, *T. nucifera* Siebold & Zucc. of Japan, is geographically separated from other species and is the most commonly cultivated species. Without this information identification is difficult, the only reasonably reliable feature being the color change of the branchlets in the third year of growth.

Torreya taxifolia Arn., the nearly extinct relict surviving in a tiny region in southeastern United States, and *T. californica* Torrey, a California endemic, show strong resemblance to the Asian torreyas but are easily distinguished from them. In contrast to torreyas from Asia, these species have a smooth or only slightly ruminate (irregular lobing, rippling or deeply grooved or channeled) megagametophyte in the seed, rather long, spiny leaf tips, and stomata that are only slightly sunken in the lower leaf surface. *Torreya californica* has considerably longer leaves than all other *Torreya* species except *T. jackii*, an endemic of a single province in China.

Torreya is unique in the Taxaceae in having embryogenesis with cleavage rather than simple polyembryony and a cell wall formed at the 4 or 8 nuclei stage (Doyle & Brennan, 1971; Tang et al., 1986), a purple aril that completely surrounds the seed, and a ruminate megagametophyte in the seed. The genus is distinguished from *Taxus* by its opposite or subopposite branchlets and lack of a prominent midrib on the upper surface of the leaf. *Torreya* is distinguished from *Cephalotaxus* by its sessile or subsessile arils, lack of a prominent mid-

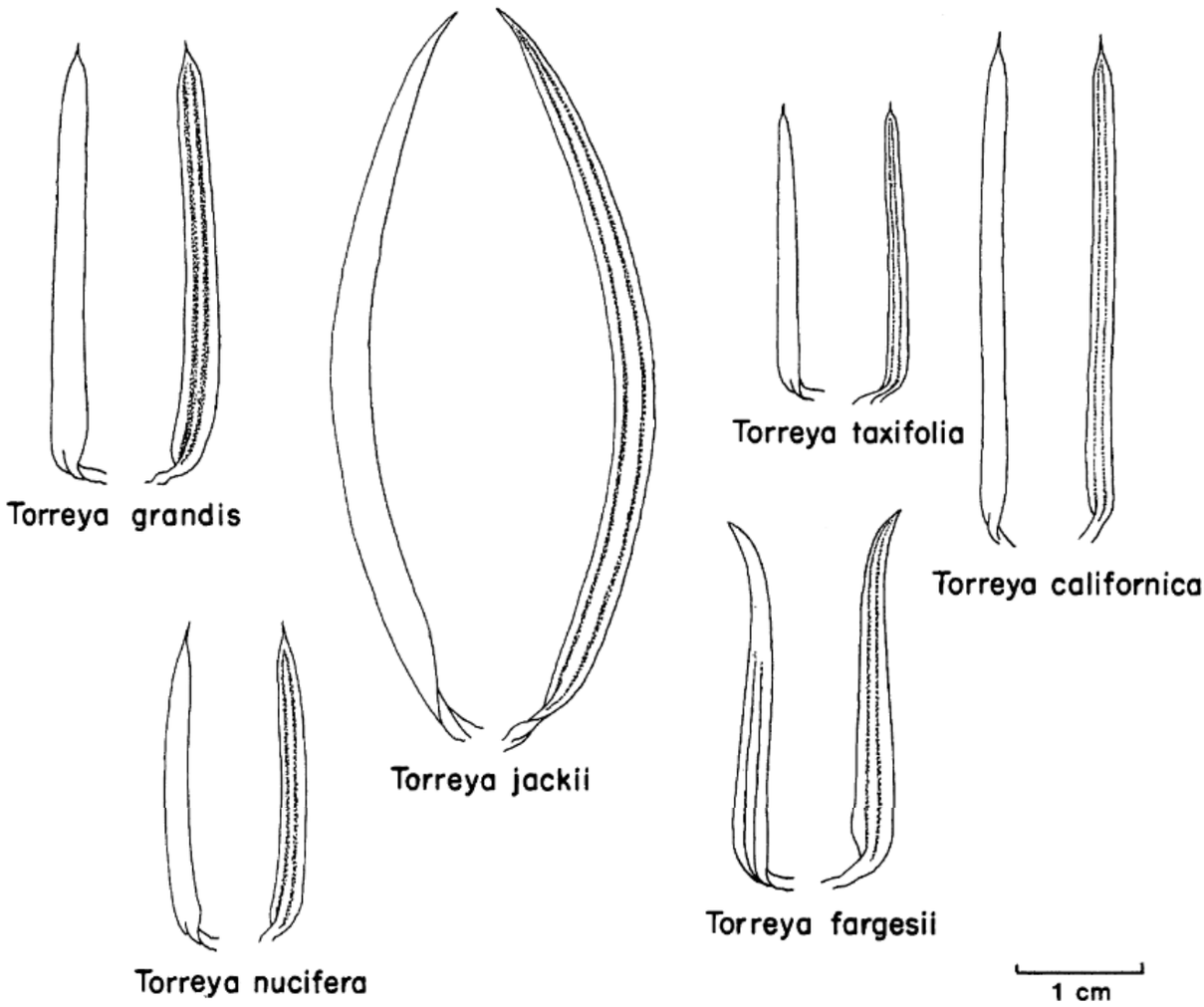

Fig. 9. Leaves of six species of *Torreya*. **Left:** Upper, adaxial surface. **Right:** Lower, abaxial surface showing stomatal bands (shaded).

rib, sunken stomatal bands that are narrower than or equal to the midrib and spine-tipped leaves.

Torreya is most closely related to *Amentotaxus*, with which it shares the characteristics of monocyclic stomata, foliar resin canal, absence of taxane alkaloids, long leaves, and large seeds (Hart, 1987; Janchen, 1950; Keng, 1969). It differs substantially from *Amentotaxus* in its simple pollen strobili, sunken stomatal bands, chromosome number, and the above-mentioned characteristics of the embryo.

Kayaflavone, which has not been found in other genera of Taxaceae, is the only biflavonoid that has been isolated from *Torreya* (He et al., 1983; Ma et al., 1985). Monoterpenes typical of other conifers and sesquiterpenes abound in the foliar resin of *Torreya*, the major components being limonene, alpha-pinene, and myrcene (He et al., 1985, 1986; Yatagai & T. Sato, 1986). Calcium oxalate is present in the bark (Chang, 1954) and the wood of *Torreya* contains resin (Bliss, 1918). The anti-cancer agent, taxol, present in *Taxus* and *Austrotaxus*, has not been identified in *Torreya*.

Torreya is rarely cultivated in this country, limited almost entirely to parks and arboreta. In China, the large oily seed is highly valued for food, and many trees have been propagated and planted for this purpose.

1. Species Not in Cultivation

T. YUNNANENSIS W. C. Cheng & L. K. Fu in W. C. Cheng et al., Acta Phytotax. Sin. 13: 87. 1975.

2. Representative Specimens

None seen.

3. Cultivated Species

Key to the cultivated species of *Torreya*

1. Leaves 3–9 cm long.
   2. Leaves falcate, to 9 cm long, the spiny tip <0.5 mm; megagametophyte ruminate . . . . *T. jackii*
   2. Leaves straight, <6.5 cm long, the spiny tip to 2 mm long; megagametophyte smooth or only slightly ruminate . . . . . *T. californica*
1. Leaves mostly <3 cm long.
   3. Megagametophyte deeply ruminate; leaves with 2 longitudinal grooves on upper surface, spines at leaf tips usually <1 mm long . . . . . *T. fargesii*
   3. Megagametophyte smooth or only slightly ruminate; leaves lacking longitudinal grooves (if present, extending only ⅓ of the distance toward tip) on upper surface, spines at leaf tips usually at least 1.5 mm long.
      4. Stomatal bands scarcely impressed on lower leaf surface; extremely rare; hardy only to Zone 8 . . . . . *T. taxifolia*
      4. Stomatal bands impressed on lower leaf surface; less rare; hardy at least to Zone 6.
         5. Branchlets dark red-brown or brown by the third year; spines at leaf tips usually 2 mm long . . . . . *T. nucifera*
         5. Branchlets light-colored or only gray by the third year; spines at leaf tips usually 1.5 mm long . . . . . *T. grandis*

TORREYA CALIFORNICA Torrey, New York J. Pharm. 1(3): 49. 1852. Common names: California torreya, California-nutmeg.

T. myristica Hook.f., Bot. Mag. 4780. 1854.

Tree, 5–30 m, conical or round-topped with slender, spreading, slightly pendulous branches; bark gray-brown to orange-brown, smooth, developing narrow furrows; branchlets green in the first year, turning brown by the third year; buds 8–10 mm long. Leaves stiff, 2.5–6 cm × 2–3 mm, acuminate or cuspidate with long (to 2 mm) spiny tips, dark green, midrib 1–1.5 mm wide; the stomatal bands 0.2–0.5 mm wide, narrower than the margins. Arils ovoid-oblong to ellipsoid, 2.5–3.5 cm long, green with purple markings; seeds 2.5–3.5 cm long, shallowly furrowed, the megagametophyte smooth or slightly ruminate.

A native of northern California, the California nutmeg is cultivated rarely in places other than parks and botanical gardens in the United States and Europe. It was introduced into cultivation in England in 1851. Zone 6.

Representative specimens: UNITED STATES: California, Mariposa Co., *W. J. Dress 4561* (BH), Butte Co., *R. T. Clausen 641* (BH). UNITED STATES (CULTIVATED): Pennsylvania, Philadelphia, 5 Aug 1969, *J. M. Fogg s.n.* (BH); Massachusetts, Jamaica Plain, Arnold Arboretum, 25 Nov 1921, *G. M. Merrill s.n.* (BH); California, San Francisco, Golden Gate Park, 28 May 1959, *E. McClintock s.n.* (BH).

TORREYA FARGESII Franchet, J. Bot. 13: 264. 1899. Common name: Farges torreya.

Tree to 25 m tall or shrub; bark gray-brown; branchlets green the first year, becoming yellow-green the second year and finally gray. Leaves 1.5–2.5 cm long, acuminate, the spiny

tips 0.5–1 mm long; upper surface with 2 distinct grooves on either side of the midrib, the stomatal bands narrower than the green margins, pale green. Arils 1.6–2.5 cm long; seeds 1.6–2.5 cm long, globose-ellipsoid, the megagametophyte deeply ruminate almost to the middle.

A native of central and western China, this torreya is cultivated only in its native region, if at all, and rarely in botanical gardens.

Representative specimens: CHINA: Hubei, Tang-hsien, *E. H. Wilson 2108* (A); Yunnan, Lienfu, Kakatung, between Mekong and Yangtze Rivers, *H. F. von Handel-Mazetti 7848* (A); Yunnan, *H. T. Tsai 57582A* (A); Yunnan, Weixi, Lipiting Range, *J. F. Rock 9396* (A); Sichuan, *A. Henry 7096* (A); Tibet, Tsarung, *J. F. Rock 22656* (A).

TORREYA GRANDIS Fortune, Gard. Chron. 1857: 788. 1857. Common names: Chinese torreya, grand torreya, tall torreya.

T. grandis Fortune ex Gordon, Pinetum: 326. 1858.
T. nucifera var. *grandis* Pilg. in Engl., Pflanzenr. 4: 107. 1903.

Shrub or occasionally tree to 25 m tall; bark gray-brown; branchlets green the first year, yellow-green the second year and gray by the third year. Leaves 1.2–3 cm × 3 mm, the apex usually more cuspidate than acuminate, the spiny tip usually ca. 1.5 mm long, nearly rounded at the base, dark yellow-green; 2 longitudinal grooves usually present on upper surface for ⅓–½ the length, lacking aromatic or fetid odor. Arils obovoid, oblong-ellipsoid or cylindrical, 2–3 cm long; seeds 2–3(–5) cm long, obovoid-oblong or ellipsoid to subglobose, brown or red-brown, mucronate, the megagametophyte smooth or only slightly ruminate.

H. H. Hu (1927) and Ching (1927) described two forms and four varieties of these species on the basis of nut and leaf size and mature tree habit. These have long been grafted and grown for their nuts. Cheng and Fu (1978) described one of these as the cultivar 'Merrillii' (more properly 'Merrill') and synonymized the others under *T. grandis*.

A native of five provinces in eastern China, the edible nuts or seeds are an important food source in China. Chinese torreya is cultivated rarely in botanical gardens, having been introduced to Britain in 1855. Zone 6.

Representative specimens: CHINA: Hubei, *B. Bartholomew et al. 584* (A); Anhui, Huang Sang, *F. Y. Yuan 31039* (A); Anhui, *R. C. Ching 3036* (A); Anhui, *A. N. Steward 7143* (A); Zhejiang, King-huan, *R. C. Ching 2346* (A); Zhejiang, Sula-am-hsien, *Y. L. Keng 808* (A); Zhejiang, Tien-mo-shan, *T. Tang & W. Y. Hsia 97* (A); Zhejiang, Chu-chi-hsien, *S. Chen 326* (A), *Y. L. Keng 1188* (A).

TORREYA JACKII Chun, J. Arnold Arbor. 6: 144. 1925. Common name: jack torreya.

Tree 8–12 m tall, the trunk ca. 20 cm diam., or shrub with numerous ascending branches; branchlets spreading, somewhat pendulous, green-brown the first year, red-brown the second year, gray thereafter. Leaves falcate, (3.5–)5–9 cm × 4–5 mm, acuminate or attenuate, the spiny tip <0.5 mm; midrib inconspicuous, slightly impressed, aromatic. Arils obovoid, sessile or subsessile, ≥2.5 cm long, glaucous; seeds 2.5–3 cm long, the megagametophyte ruminate.

A native of China, this torreya is cultivated extremely rarely in arboreta (Arnold Arboretum may contain the only specimen cultivated in North America).

Representative specimen: CHINA: ZheJiang, Chen-chian, Ga Fong Keng, *R. C. Ching 1779* (ISOTYPE: A).

TORREYA NUCIFERA (L.) Siebold & Zucc., Abh. Math.-Phys. Cl. Konigl. Bayer. Akad. Wiss. 4: 234. 1846. Common names: Japanese torreya, nut-bearing torreya, kaya.

T. ignensis Doi & Morik., Bot. Mag. (Tokyo) 42: 534. 1928.
T. macrosperma Miyoshi ex Morik., Bot. Mag. (Tokyo) 42: 534. 1928.

Tree to 10 m, occasionally to 25 m tall with oval crown; branches numerous, stout, horizontally wide-spreading; bark gray to gray-brown, smooth, fissured and scaling with age; branchlets green in the first two years, dark red-brown or brown by the third year; buds shining, 3 mm long, the scales stiff. Leaves (1–)2–3.8 cm × 3–4 mm, green to blue-green, more often cuspidate than acuminate, the spiny tips to 2 mm long, stomatal bands equal in width to the midrib, pale to nearly white. Arils ellipsoid, 2.5 cm long, green, striped or tinged purple; seeds (1.6–)2–2.5 cm long, the megagametophyte smooth or only slightly ruminate. Cultivars: 'Aurea Variegata', 'Prostrata'.

A native of central and southern Japan, Japanese torreya is cultivated in North America, Europe, and Asia. It was introduced as a cultivated plant in North America in 1860 and in England in 1764. This torreya has been used for ornament and furniture-making; the seeds have been used as food. Two additional species earlier described from Japan (Morikawa, 1928) are included here. Zone 6.

Representative specimens: KOREA: Kyung Nam Do, *Y. C. Oh 86* (BH). JAPAN: Kamata, Tokyo-fu, *R. K. Benttie & Y. Kurihara 10575* (BH). UNITED STATES (CULTIVATED): New York, Bronx, 8 Aug 1924, *K. R. Boynton s.n.* (BH); North Carolina, Biltmore, 28 Jul 1923, *W. H. Manning s.n.* (BH); California, Hollywood, 20 Jun 1916, *E. P. Bradbury s.n.* (BH).

TORREYA TAXIFOLIA Arn., Ann. Nat. Hist. 1: 130. 1838. Common names: Florida torreya, stinking-cedar, gopherwood.

Tree to 12 m tall with open pyramidal crown; branches slightly pendulous; bark brown to orange-brown, scaly, irregularly fissured; branchlets green or yellow-green the second year, brown or gray thereafter; buds acute, 1 cm long, brown. Leaves linear to linear-lanceolate, 2–3.7 cm × 3 mm, rounded at the base, acuminate with sharp, piercing, spiny tips 1.5–2 mm long, rounded at the base, glossy green, aromatic, the petiole sometimes distinguishable and ca. 1 mm long, stomatal bands scarcely impressed, narrower than the midrib. Arils obovoid, 2.5–3 cm long, dark purple; seeds 2–3 cm long, the megagametophyte smooth or only slightly ruminate.

Florida torreya is an endangered species. It is native only in Gadsden, Liberty, and Jackson Counties in Florida and Decatur County in southeastern Georgia. This species is cultivated in Florida and in botanical gardens in North America and Europe. It was introduced into cultivation in England in 1840. Zone 8. Cultivar: 'Argentea'.

Representative specimens: UNITED STATES: Decatur Co., Georgia, *R. F. Thorne et al. 3058* (BH); Liberty Co., Florida, *K. M. Wiegand & W. E. Manning 52* (BH). UNITED STATES (CULTIVATED): Leon Co., Tallahassee, Florida, *L. H. Bailey 6903* (BH).

IV. Acknowledgments

I am grateful to Dennis Stevenson of The New York Botanical Garden and to Jerry Davis and Melissa Luckow, both of the Bailey Hortorium, for their time and effort in bringing this paper to publication.