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Tree of the Year: *Torreya nucifera*

ERIC HSU

Just as the Europeans have worshipped the common yew (*Taxus baccata*) in ancient religions and valued its wood, the Japanese and South Koreans have sanctified the Japanese nutmeg (*Torreya nucifera*) and prized its wood and fruits. It is easy to see why these trees are venerated there when one has the opportunity to stand before a mature *Torreya nucifera* or even old groves. Their handsome lustrous needles, spreading branches, and pyramidal profiles bespeak a divine presence. The large number of specimen trees and groves in Japan and South Korea, as well as those in arboreta, botanic gardens, and public gardens make it fitting that *Torreya nucifera* is the 2019 Tree of the Year.

Introduction

Torreya is a genus of six species, four of which are native to eastern Asia (China and Japan) and two in North America. Three of the eastern Asian species, which comprise *Torreya fargesii* Franchet, *T. grandis* Fortune ex. Lindley, and *T. jackii* Chun are found in China. *Torreya fargesii* and *T. grandis* are widely distributed, with the former in Anhui, Fujian, Guizhou, Hunan, Jiangsu, Jiangxi and Zhejiang and the latter in Anhui, Hubei, Hunan, Jiangxi, Shaanxi, Sichuan, and Yunnan. *Torreya jackii* is confined to Zhejang Province. *Torreya nucifera* (Linneaus) Siebold & Zuccarini is present in central and southern Japan and Jeju Island, South Korea.

The two North American representatives include the Critically Endangered

Opposite, Bijarim Forest on Jeju Island, which lies approximately 60 km off the southern coast of South Korea.

Right, The fine lustrous needles of *Torreya nucifera* var. *radicans*, here growing at the US National Arboretum (see p. 56).

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(at US Federal level) *Torreya taxifolia* Arn. (Florida torreya) and the Californian endemic *Torreya californica* Torr. (California torreya). Restricted to the Apalachicola River in the Florida Panhandle and southern Georgia, *Torreya taxifolia* has declined significantly due to disease and post-glacial temperature changes (Schwartz et al., 2001). Its conservation now rests on assisted migration where plants now thrive outside of its native range. *Torreya californica* occurs scattered throughout the Coast Ranges and western slopes of the Sierra Nevada.

Torreya can be distinguished from *Taxus* on the account of its sharp, spiny leaf tips, narrow stomatal bands relative to the leaf midribs, and two axillary cones. The seed cones of *Taxus* have red fleshy arils that attract birds who disperse the seeds whereas those of *Torreya* have green to purple flushed flesh. Their maturation times differ too—six to nine months for the former, and 18 months for the latter.

The Scottish botanist George Walker Arnott (1838) honored John Torrey, an American botanist who produced several publications on plants collected during the expansion of the United States westwards in the Rocky Mountains by naming the genus after him. Arnott had chosen the Florida native *Torreya taxifolia* to be the type on which the genus was circumscribed. Engelbert Kaempfer, the German naturalist and physician, who travelled through Persia (now Iran), India, Russia, Japan, and south-east Asia, first described *Torreya nucifera* as *Taxus nucifera* in *Amoenitatum exoticarum* (1712). During his stint as a surgeon with the East India Company (1690–1692), Kaempfer had enjoyed unprecedented access to Japan, which had been previously secluded from the West. He was allowed to study and name Japanese plants, and was the first European to see and introduce *Ginkgo biloba*. The engraving of *Torreya nucifera* in *Amoenitatum exoticarum* (1712) is perhaps the earliest illustration. Carl Linneaus would adopt several of Kaempfer's names, including *Taxus nucifera* in *Species Plantarum* (1753).

Like Kaempfer, the German physican and botanist Philipp Franz von Siebold (1796–1866) was able to collect plant specimens and even created a small botanical garden at his Japanese home on Dejima Island. Siebold worked with the University of Munich's Professor of Botany, Joseph Gerhand

Probably the first illustration of *Torreya nucifera* published in 1712 in *Amoenitatum exoticarum*.

Zuccarini (1797–1848), to catalog and publish the accounts of Japanese plants, including *Torreya nucifera* in 1846. They had recognized the conifer's morphological differences from *Taxus*. However, the species has made several rounds under the genera *Caryotaxus*, *Foetataxus*, *Taxodium*, and *Tumion*.

Torreya nucifera is commonly known as the Japanese torreya or nutmeg-yew. In its native Japan, it is called *kaja* and *kaya*. Written as 榧, *kaya* is the Japanese word for 'yew', and the resemblance of *Torreya nucifera* to *Taxus* makes sense given the superficial similarity in the foliage. Like the Japanese word, its Korean name *bija* is derived from two Chinese characters 榧子 (Wonsoon Park pers. comm.). When these characters are interpreted separately, 非[bi:] reflects the leaf shape, and 木[mɔk] means a 'tree'. Therefore 榧[bi:] means the *bija* tree. 子[ja] basically means fruit.

Description

Torreya nucifera Siebold & Zucc.
Abh. Math.-Phys. Cl. Königl. Bayer. Akad. Wiss. 4(3): 232. 1846

Synonyms

Taxus nucifera L., Sp. Pl. 2: 1040 (1753). [1 May 1753]
Taxus nucifera Telfair ex Steud., *Nomencl. Bot.* [Steudel], ed. 2. 2: 664 (1841).
Taxus nucifera Wall., *Tent. Fl. Napal.* 2: 57, t. 44 (1826). [Sep–Dec 1826]

Right, the ellipsoidal fruit of *Torreya nucifera*: the single, edible seed is covered by a fleshy aril (above); **below**, the clusters of fruit at the tips of the branch.

photographs © Ben Jones

Torreya nuda (Pursh) Eaton, *Man. Bot.* (A. Eaton), ed. 5. 421 (1829). [Sep 1829]
Podocarpus nuciferus Loudon, Hort. Brit. [Loudon] 388 (1830).
Caryotaxus nucifera Zucc. ex Endl., Syn. Conif. 241 (1847). [May–Jun 1847]
Torreya ascendens Nakai ex Uyeki, Sci. Rep. Matsuyama Agric. Coll. No. 10 (Not. Pl. Lign. Sikok. 11.) 3 (1953).
Foetataxus nucifera J. Nelson, Pinaceae [Nelson] 168 (1866).
Taxus nucifera hort. ex Parl., Prodr. [A. P. de Candolle] 16(2.2): 439 (1868). [mid Jul 1868]
Tumion nuciferum (L.) Greene, Pittonia 2(10): 194 (1891). [15 Sep 1891]
Torreya macrosperma Miyoshi, Rep. Nat. Monuments Jap. No. 32, 2 (1922).
Torreya fruticosa Nakai, Tyosen Sanrin Kaiho No. 158 (Indig. Spec. Comf. & Taxads Korea & Manchur. 1.) 26 (1938).
Torreya igaensis Doi & Morik., Bot. Mag. (Tokyo) 42: 536 (1928).
Torreya nucifera Siebold & Zucc. var. *sphaerica* Kimura, Jap. J. Bot. 13(4): 519 (1948).
Torreya nucifera Siebold & Zucc. f. *sphaerica* (Kimura) Yonek., J. Jap. Bot. 80(6): 323 (2005). [Dec 2005]

Evergreen tree 15 to 25 m tall, crown symmetrical and pyramidal with spreading branches, subdioecious (male or female cones may dominate on individual plants, but within the presence of cones of opposite sex). Leaves

photograph © Harry Baldwin

The male strobili of *Torreya nucifera* on a tree at RBG Kew taken in mid April 2020. They appear during the winter in double rows along the underside of branches and can be present on different branches from female cones.

1.5–2.5 × 0.22–0.30 cm, linear, stiff, gradually tapering to short spinescent apices, deep green and lustrous, pale green underneath with two narrow pale yellow stomatal bands. Fruit ellipsoidal (to 1.5 in. long), dark green, ripening in the second year with purple blush, single seed covered by a fleshy aril.

Systematics

Species relationships within *Torreya* have been conflicting. In their phylogenetic study, Li et al. (2001) have revealed strong support for two clades or groupings: the North American group of *Torreya californica* and *T. taxifolia*; the Asian group of *T. jackii*, *T. grandis*, *T. fargesii*, and *T. nucifera*. Within the Asian clade, *Torreya jackii* and *T. grandis* were closely aligned with another group of *T. fargesii* and *T. nucifera*. Hao et al. (2008) confirmed the North American clade and the sister relationship with *T. fargesii* and *T. nucifera*, and discovered that *Torreya jackii* diverged early. The early divergence of *Torreya jackii* from other species and the subgrouping of *T. californica* and *T. taxifolia* is well supported (Leslie et al., 2012). Phylogenomic analysis of *Torreya* (Zhang et al., 2019) upheld this position of *Torreya jackii* and the sister relationship of *T. fargesii* and *T. nucifera*, but surprisingly revealed the second sister pair of *T. grandis* and *T. californica*. The same analysis indicated that *Torreya* diversified approximately 8.9 million years ago and China and eastern North America was the ancestral location. Li et al. (2001) attributed the current distribution of *Torreya* to a single vicariance event that separated the Old World and New World, and estimated the divergence between the Old World and New World species to be around 30 million years ago. The original division of the genus based on the embryo coat pattern was not borne out in the molecular studies (Li et al., 2001; Hao et al., 2008; Leslie et al., 2012; Jun et al., 2014; Zhang et al., 2019). Hu (1927) had

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Above, *Torreya nucifera* growing at Trompenburg Arboretum in Rotterdam, Netherlands (see p. 45). **Inset** is the deeply fissured bark of the tree.

organized the Old World *Torreya* into Sect. Ruminatae (*T. jackii* and *T. fargesii*) and Sect. Nuciferae (*T. nucifera* and *T. grandis*).

Within the Taxaceae, *Amenotaxus* is considered the sister genus to *Torreya* based on molecular (Chaw et al., 1997; Cheng et al., 2000; Quinn et al., 2002; Wang et al., 2002; Leslie et al., 2012; Lu et al., 2014; Zhang et al., 2019) and morphological evidence (Ghimire & Heo, 2014).

Conservation Status
Assessed as Least Concern.

Distribution and Habitat
Torreya nucifera occurs in southern parts of Japan and South Korea.

South Honshu, Kyushu, and Shikoku play host to *Torreya nucifera* which inhabits mixed broad-leaved conifer forests. Charles Sprague Sargent, the first director of the Arnold Arboretum, regarded this conifer as the most beautiful example of the genus, praising its majestic size, red bark and black-green needles after sighting old specimens on the bank of the Kisogawa River, near Agematsu in central Honshu (1894). Elwes & Henry (1913) reports seeing trees growing with *Abies firma*, *Tsuga*, and *Quercus* in forests on the slopes of Kirishima Mountain, southern Kyushu. Farjon (2010) notes that *Chamaecyparis obtusa*, *Podocarpus macrophyllus*, *Nageia nagi*, *Taxus cuspidata* and *Sciadopitys verticillata* are other conifers growing in vicinity of *Torreya nucifera*.

In South Korea, it is restricted to Jeju Island and Wando Island. Jeju Island is considered the home of the largest and oldest (approximately 200 to 400 years old, with the most ancient possibly 880 years) *Torreya* trees, and the Bijarim Forest itself is recognized as the Natural Monument No. 374 (Shin et al., 2017). Islanders call this forest *Gotjawal*, an amalagation of the Jeju dialect words *got* for 'forest' and *jawal* meaning 'rock'. This term acknowledges the island's geological history, evident in its uneven terrain caused when lava from the volcanic eruption spewed forth and ossified upon cooling. These rocks, the lava vestiges, gradually corroded as water permeated their cracks. Plants then colonized the pockets, becoming thickets and later forests. Because different microclimates were created within the 'bumpy' land, different plants coexist with each other in unique ecological arrangements. Sandwiched between two volcanoes Darangshioreum (382.4 m) and Dotoreum (284.2 m), the *Torreya* forest or Bijarim Forest contains 44.8 hectares (~110 acres), 1.4 km from the north to south and 0.6 km from east to west (Shin et al., 2017). Average temperatures range from 5.3 °C in January to 26.7 °C in August (mean annual temperature, 15.7 °C) while the average annual precipitation is 1774.2 mm, peaking in August (307.8 mm) (Korea Meteorological Administration, 2017). *Torreya nucifera* is associated with 276 plant taxa, such as *Mallotus japonicus*, *Machilus thunbergii*, *Orixa japonica*, and *Polystichum tripteron* (Korea Tree Health Association (KTHA), 1999; Lee, 2009; Shin et al., 2010; Choi & Lee, 2015).

photograph © Wonsoon Park

One of the champion *Torreya nucifera* is over 820 years old, photographed here in 2010 on Jeju Island in South Korea (see pp. 48–49).

Uses

The Japanese prized the seeds for their edible qualities, utilizing them as roasted 'nuts' and cooking oil. The cooking oil, produced in limited quantities, is rich in Vitamin E and has sciadonic acid, a fatty acid beneficial for lowering cholesterol and body fat (Kaya-no-Mori, 2019). Because of its subtle nutty flavor, the oil is prized within some culinary circles for tempura. In Akadomari, in the south of Sado Island (Sado Island Blog, 2019), the 'nuts' flavor deep-fried snacks unique to that region. However, the wood is more valuable, having endowed its rich yellow glow to Go boards. This demand has had an adverse effect on wild populations, necessitating conservation measures against logging; current regulations only permit removal of trees that have died from natural causes. Kurokigoishiten Co. Ltd. (2019), a Japanese company specializing in building and selling Go boards, considers the best trees for wood to be in the Miyazaki region, Kyushu Island since the climate there encourages consistently even and beautiful grain patterns. The log must be between 200 and 800 years old to be suited for making a Go board. A fine Go board with attached legs can fetch from US$2000 to US$100,000, given the time and labour required to source and treat the wood. However, if kept in good condition, Go boards can appreciate in value. In addition to being favoured for Go boards, the wood has been used for water pails and cabinetry (Wilson, 1916).

Koreans valued *Torreya nucifera* largely for the antiparasitic properties of its nuts. There is a prescription of seven nuts a day for a week recorded in the Joseon era (Yeong-woo, 2018). During the Goryeo dynasty, the state of Tamna (now Jeju Island) made a tribute payment of nuts to the royal court. King Sejong of the Joseon dynasty would accept nuts and timber as part of the annual tribute from Jeju as recorded in the *Sejong sillok jiriji* (Geographical Appendix to the Annals of King Sejong) (Yeong-woo, 2018). As described in a Chinese poem by Dasan, Baengynyeonsa Temple was required to supply a harvest of nuts from its grove to the government office (Yeong-woo, 2018). In fact, temples in the Joseon dynasty had to grow trees for producing the parasiticide.

Introduction of *Torreya nucifera* to cultivation

William Aiton (1813) documents *Torreya nucifera* as having been introduced to the UK in 1764 while Loudon recorded in 1820 (Elwes & Henry, 1906) and noted a tree at Whiteknights in Reading in 1834. Philipp Franz von Siebold had brought it to the Botanic Gardens Ghent in 1830. Although Ernest Henry Wilson saw trees at Mount Takao approximately 16 to 20 m tall with 1.3 to 2 m in girth and even measured one specimen in Yakushima with a trunk of 2.3 m wide, no living material appears to have been introduced, despite herbarium specimens being collected (1913). The Veitch Nurseries in Chelsea, London, UK offered *Torreya nucifera* in the 1911 catalogue of hardy ornamental trees and shrubs (1911).

Father Emile Joseph Taquet, a French missionary sent to Korea at the age of 24 in 1898, noted the occurrence of wild Korean populations in Jeju Island, sending back herbarium specimens collected in 1908 and 1911 to American, European, and Japanese institutions. Like his French missionary colleagues in China, Taquet broadened the understanding of the East Asian flora, especially that of Jeju Island where he lived for 11 years (*The Jeju Weekly* 2013; Kyung-ae, 2019). However, no mention was made whether seeds or living propagules from Jeju Island were shared.

No date has been precisely ascertained for the first appearance of *Torreya nucifera* in North America. Alfred Rehder (1927) indicated that the species was introduced to cultivation before 1764 although he did not differentiate this probable date for North America and Europe. The earliest mention of *Torreya nucifera* in North American literature appears in the sixth edition of Andrew Jackson Downing's *A Treatise on the Theory and Practice of Landscape Gardening* (1859) which included a supplement from Henry Winthrop Sargent. Andrew Jackson Downing (1815–1852) was considered the first well known American landscape architect and horticulturist; Downing befriended the New Yorker banker Sargent whose 22-acre country estate Wodenethe was across the river from Downing's residence above Fishkill Landing (now Beacon), New York. Sargent, like Downing, was an avid gardener who became enthusiastic about conifers and soon amassed one of the best collections in the north-east US. Large numbers of choice woody plants were imported from Europe and trialed for the first time in the East Coast US. Among these plants was *Torreya nucifera*, about which Sargent (1859) writes: 'This is out with us at Wodenethe, for the first winter, and we have no returns about it.' However, the overwintering fate of *T. nucifera* was not revealed. It is probable that Sargent's planting marked the first documented entry to North America.

A subsequent mention of *Torreya nucifera* in North American cultivation appears in Josiah Hoopes' *The Book of Evergreens* (1868). Josiah Hoopes and his brother Abner, fifth-generation Quakers, operated an enormously successful nursery whose nucleus of plants was imported from England in October 1853 (Jones, 2003). The nursery became one of the primary economic engines driving the plant nursery industry in West Chester, Pennsylvania. By the time Hoopes had published his book on conifers, the nursery had a third partner and accountant George Thomas, employed up to one hundred employees, and expanded to 44 acres (Jones, 2003). Hoopes (1868) confessed limited experience with *Torreya nucifera:* 'We have not tested it thoroughly in the open ground, but have grown it for a few years past as a pot plant, to our great satisfaction. Our own small experience would lead us to believe that it may be recommended for trial with excellent chances of success.'

With its branch offices in New York and London, Yokohama Nurseries may have been the primary means of acquiring seeds and plants since it strategically targeted the growing demand for Japanese plants in Western

gardens. Its 1915 catalog offers both seeds and plants of *Torreya nucifera* that would have permitted other nurseries to scale up production. A plant sourced from Yokohama nurseries in 1910 still grows at the Royal Botanic Garden Edinburgh (Tom Christian pers. comm.).

Hicks Nurseries, Westbury, New York, was one of the first nurseries to sell sizeable *Torreya nucifera*. This nursery was established in 1853 by a farmer and Quaker preacher Isaac Hicks. Isaac's son Edward later became known for developing specialized machinery to transplant large trees at time when grand estates on the Gold Coast of Long Island demanded them. Edward's son Henry Hicks, a 1892 college graduate of New York State College of Agriculture (now Cornell University) was instrumental and influential in utilizing his connections with botanists and horticulturists, especially the plant explorer Frank Meyer, to procure new and unusual plants for the business. Henry was especially interested in east Asian plants, and undertook breeding them. One of his most successful results, a cross between *Taxus baccata* (English yew) and *T. cuspidata* (Japanese yew) was *Taxus* × *media* 'Hicksii' which became popular for hedging. The addition of *Torreya nucifera* was certainly no happy accident, and Hicks described it as an 'evergreen tree with handsome dark green foliage' in the 1928 catalogue. Customers purchasing it were advised to plant it in sheltered locations. Two sizes, 6–12 in. [15 to 30 cm] and 6–8 ft [1.8 to 2.4 m], were offered respectively for $3.00 and $25.00. Hicks Nurseries' wealthy clients certainly had planted *Torreya nucifera*, and an inventory of exotic plants growing in several private estates (Grier & Grier, 1928) revealed its inclusion. Childs Frick, the son of the steel magnate Henry Clay Frick, amassed a significant collection of conifers, which was documented in the privately published *Pinetum Claytonense—A list of Coniferous Plants Growing at Clayton*, NY (1924).

The US Department of Agriculture's *Bureau of Plant Industry Inventory of Seeds and Plants Imported by the Office of Foreign Seed and Plant Introduction during the Period from July 1 to September 30, 1916*. No. 48 curiously lists seed of *Torreya nucifera* (Plant Introduction #43075) from the American consul general at Hankow, China, although the species is not native to China. Whether this seed was dispatched to the American consulate via Japan is uncertain, it seems plausible that a Chinese species would have been the source. There is no documentation of whether seeds were viable enough to produce plants.

The former Washington Park Arboretum (now University of Washington Botanic Gardens), curator Joe Witt, collected and introduced seed in 1982 from South Korea, although the mother trees themselves were cultivated. An October 1997 expedition, which included the participants Tony Avent of Plant Delights Nursery, Dan Hinkley of Heronswood Nursery, Darrell Probst of Garden Visions, Bleddyn and Sue Wynn Jones of Crûg Farm, and Song Ki Hun of Chollipo Arboretum, resulted in seeds being harvested in Jeju Island and introduced to the United States (Avent, 2019). Plants were sold in

the Heronswood Nursery catalog under HC 970328. The 2003 Royal Botanic Garden Edinburgh Japan expedition, 2005 Japanese expedition led by Howick Arboretum, Polly Hill Arboretum, Quarryhill Botanical Garden, and Royal Botanic Garden Edinburgh, and the 2007 expedition with the same institutions save for Quarryhill Botanical Garden, but including Morris Arboretum, have yielded new Japanese material to the collections.

Interestingly, the majority of *Torreya nucifera* in collections are descended from Japanese populations rather than South Korean populations, and perhaps future collections should focus on the latter for conservation.

Specimens in USA

The oldest, if not the tallest *Torreya nucifera* in North America may be the one in the nine-acre pinetum started in 1866 at the Hunnewell estate, Wellesley, Massachusetts. The estate is perhaps famous for its clipped topiary in the Italianate garden, which has been and is still dutifully maintained by each Hunnewell generation. A firm believer of nature as a universal benefit and garden-making a socially valuable pastime, Horatio Hunnewell significantly advanced the knowledge and development of the New England horticulture. He became well known for his woody plants, especially conifers and rhododendrons that were imported at great expense from England before plant quarantine laws tightened. Cut samples were often exhibited at the Massachusetts Horticultural Society shows, and Hunnewell often hosted eminent landscape architects, garden designers, and nurserymen on his estate. He was the benefactor of the Arnold Arboretum and Harvard University and Wellesley College's botany departments. Hunnewell was related to Henry Winthrop Sargent whose aforementioned estate Wodenethe had an arboretum of rare conifers.

Had Horatio Hunnewell not been determined to grow every imaginable conifer hardy in the New England climate, *Torreya nucifera* might not have entered the picture. Such were his efforts that the pinetum was an established collection before the Arnold Arboretum's founding in 1872. Charles Sprague Sargent took it upon himself to visit and survey the pinetum as a preliminary assessment of what was hardy at his incipient institution. Curiously Sargent was sceptical of *Torreya*'s potential as a sizeable tree, having said in *Forest Flora of Japan* (1894): 'The elevation above the sea at which it flourishes in Japan indicates that it will be hardy in the middle states, although we cannot expect to see it grow to any size in New England.' Donald Wyman suggests the tree would have been planted by 1885 and it was first mentioned in the Hunnewell diaries in 1905. By the time Ernest Henry Wilson saw the tree in 1913, it was 6 m tall. Sixteen years later, the same tree had reached 7.6 m and only gained an additional 30 cm at 7.9 m in 1949 (Wyman, 1952).

Polly Hill Arboretum, Martha's Vineyard, Massachusetts, is home to two plants, which were originally received as seedlings in 1960 by Polly Hill from

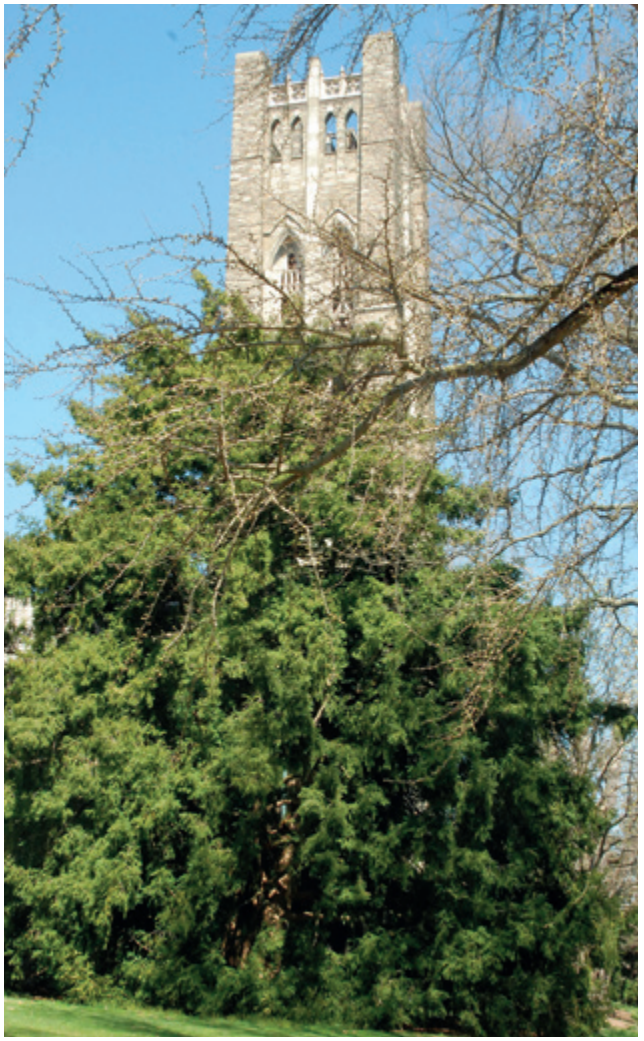
William Phelps. One tree (1960-054*A) 8.23 m tall near the Arboretum Centre has developed a more open and loose habit from its sheltered, semi-shaded location. The second tree, 6.55 m tall in the Conifer Row, is dense and thick from the exposed, full-sun position (Todd Rounsaville pers. comm.). During the 2007 BCJMMT Japan expedition, seeds were collected from populations in Honshu.

With its warm summers and moderate winters, the coastal mid-Atlantic US region (Delaware, Maryland, Pennsylvania, Virginia, western and southern New Jersey, District of Columbia) seems to be the ideal climate for *Torreya nucifera*. Morris Arboretum of University of Pennsylvania, New York Botanical Garden and Scott Arboretum of Swarthmore College all have sizeable trees. Morris Arboretum has the state champion located near the Swan Pond. Tony Aiello (pers. comm.) reported that it has a 107.5 cm trunk diameter, measured at 60 cm from the ground; the tree's provenance is uncertain, despite its accession number of 1932 and its uncertain link to a record of a plant acquired from the Yokohama Nursery in January 1912. The height, last measured in 2017, was 21 m with a spread of 15 m (Champion Trees of Pennsylvania, 2019). Aiello said that the tree is comparable in size to the Scott Arboretum's tree, which is not included in the champion tree survey. Awarded the 1999 champion trees in New Jersey, the Scott Arboretum tree (S01254*A) is currently 13 m with a spread of 9 m and a trunk diameter of 142 cm. Predating the Arboretum's founding, it was obtained from Hicks Nurseries.

New York Botanical Garden has three outstanding examples in the Native Plant Garden, once the site of the original pinetum in the nineteenth century. When last measured in 2013, they respectively had the spread of 10.6 m and dbh of 83 cm, 13.4 m and 66 cm, and 14.3 m and 104 cm (Kristine Paulus pers. comm.). Two more trees received in 1949 and 1950 and planted in the Benenson Ornamental Conifer Collection each have a spread of 9.9 m with 0.27 m dbh and 12 m with 0.73 m dbh.

Andrew Greller (pers. comm.) reported seeing seedlings and saplings near a large *Torreya nucifera* in the grounds of William Cullen Bryant Preserve at the Nassau County Museum of Art, Roslyn Harbor, New York. He did not provide measurements of the parent tree. Greller first documented this sighting in the January–March 2002 newsletter of the Long Island Botanical Society.

Dumbarton Oaks, Washington, DC has at least one large tree approximately 12 m tall with a 9 m spread in the west of the North Vista garden (Jonathan Kavalier pers. comm.). J. C. Raulston Arboretum, Raleigh, NC, has several trees represented in the collection, although they are from cultivated sources. One was from the North Carolina State Fairgrounds in 1995 while another tree was acquired from J. Sargeant Reynolds Community College. Juniper Level Botanic Garden nearby had a healthy specimen 6 m tall collected in South Korea 20 years ago; several of its trunks mysteriously died for unexpected reasons (Tony Avent pers. comm.). However, a root sprout approximately



Torreya nucifera at the Scott Arboretum, Swarthmore College. in Pennsylvania.

0.60 m will hopefully replace the original mother tree.

In the Midwest US, cold temperatures appear to be the limiting factor in successful cultivation. The trees at the Morton Arboretum, Lisle, Illinois, were killed to the ground during the winter of 2019 when temperatures plummeted to -30 °C (-23 °F), but they have resprouted from the roots (Matt Lobdell pers. comm.). At least one tree was 2.4–3 m tall before these temperatures.

The University of Washington Botanic Gardens, Seattle, Washington State, has four trees, two of which are of wild origin from South Korea. Joe Witt, the

garden's former curator, had visited South Korea in October 1982 and sent back seed from which two plants were produced. These two saplings were planted out in the garden ten years later in November 1992. Dan Hinkley (pers. comm.) planted the seedlings from the 1997 Korean expedition at Heronswood Garden, Kingston, Washington State, but they are not thriving due to the shade. Nearby in his private garden Windcliff, a specimen is about 3 m tall with 3.81 cm dbh, forced to compete with an encroaching *Phyllostachys dulcis*. The Hoyt Arboretum, Portland, Oregon, has two young accessions of wild-origin from South Korea as well. However, only one of these trees is currently alive (Vincent Parisi pers. comm.).

At the Huntington Botanical Garden near Los Angeles, California, two *Torreya nucifera* were planted in the Japanese Tea Garden in March 2016 (Kathy Musial pers. comm). The plants were propagated from seed distributed through the 1992 Chiba University Index Seminum from Okura (Tanzawa Mountains, Kanagawa Prefecture). They each are 1.24 m tall with a 100 cm spread and 1.88 m tall with a 1.93 cm spread (Daniel Goyette pers. comm.).

Torreya nucifera, specimen locations and details

NORTH AMERICA: USA

LOCATION	ACCESSION NUMBER / TREE #	HEIGHT + SPREAD (metres)	TRUNK DIAMETER (centimetres)	AGE	SOURCE	REFERENCE
Arnold Arboretum, MA	794-34*A	-	76.9 cm	-	-	-
Arnold Arboretum, MA	533-40*A	-	10.9 cm	-	Botanic Garden, Tokyo, Japan	-
Arnold Arboretum, MA	490-97*B	-	5.9 cm	-	-	-
Arnold Arboretum, MA	490-97*A	-	4.9, 4 cm	-	-	-
Arnold Arboretum, MA	454-90*B	-	9.8 cm	-	-	-
Arnold Arboretum, MA	454-90*A	-	10.1 cm	-	-	-
Arnold Arboretum, MA	453-90*A	-	14.6 cm	-	-	-
Arnold Arboretum, MA	15810*A	4	25.5 cm	-	Hunnewell	-
Atlanta Botanical Garden, GA	1994-0566	0.9 + 2	-	-	-	-
Atlanta Botanical Garden, GA	1994-0647	3 + 2	8 cm (breast height)	-	-	-
Atlanta Botanical Garden, GA	1998-0776	3 + 2	6 cm (breast height)	-	-	-
Atlanta Botanical Garden, GA	1997-1412	less than 1 m + 1	-	-	var. *ingaensis*	var. *ingaensis*
Dawes Arboretum, OH	D2002-0539.001	0.70 + 1.42	4.7 cm	-	Hidden Lake Gardens, MI	-
Dawes Arboretum, OH	D2002-0539.002	1.19 + 2.19	3.7 cm	-	Hidden Lake Gardens, MI	-
Dawes Arboretum, OH	D2006.0090.001	0.89 + 0.76	2.3 cm	-	US National Arboretum	-
Dawes Arboretum, OH	D2006.0090.003	0.71 + 1.20	2.2 cm	-	US National Arboretum	-
Dumbarton Oaks of Harvard University, Washington, D.C.	-	12	914 cm	-	-	-
Holden Arboretum, OH	81-574*A	3	-	-	-	-
Holden Arboretum, OH	81-574*C	4	-	-	-	-
Holden Arboretum, OH	57-361*A	4	-	-	-	-
Hunnewell Estate, MA	-	7.9	-	-	Wyman 1952	-
Huntington Botanical Gardens, CA	71509*1	1.24 + 1.00	91 cm	-	Chiba University Index Seminum 1992	-
Huntington Botanical Gardens, CA	71509*2	1.88 + 1.93	-	-	Chiba University Index Seminum 1992	-

Torreya nucifera, location and specimen details

NORTH AMERICA: USA–CANADA | EUROPE: BELGIUM

LOCATION	ACCESSION NUMBER / TREE #	HEIGHT + SPREAD (metres)	TRUNK DIAMETER (centimetres)	AGE	SOURCE	REFERENCE
Longwood Gardens, PA	1968-0612*A	5 + 6	20 cm	-	USDA	-
Longwood Gardens, PA	1968-0612*B	6 + 5	19 cm	-	USDA	-
Morris Arboretum, PA	1932-0786*A	21 + 15	107.5 cm @ 60 cm	-	-	-
New York Botanical Garden, NY	06789*A	12 + 11	114 cm (breast height)	-	Provenance unknown	-
New York Botanical Garden, NY	06789*B	13 + 16	70 cm (breast height)	-	Provenance unknown	-
New York Botanical Garden, NY	06789*C	15 + 13	137 cm (breast height)	-	Provenance unknown	-
New York Botanical Garden, NY	16/51*A	11 + 10.8	357 cm (breast height)	-	R. H. Montgomery	-
New York Botanical Garden, NY	118/49*A	14 + 12	84 cm (breast height) @ 61 cm	-	R. H. Montgomery	-
Polly Hill Arboretum, Martha's Vineyard, MA	1960-54*A	8.23 + 0.71	8.54 cm	Measured 2013	Garden of William Phelps (Guyencourt, Delaware)	-
Polly Hill Arboretum, Martha's Vineyard, MA	1960-54*D	6.55 + 5.34	6.55 cm	Measured 2013	Garden of William Phelps (Guyencourt, Delaware)	-
Scott Arboretum, PA	S01254*A	13	9	-	Hick Nurseries	-
Windcliff, Indianola, WA	-	3	3.81 cm (breast height)	-	1997 South Korea expedition	-
University of British Columbia Botanical Garden, Vancouver, BC	1972-0604	9	15 cm (breast height)	-	Ed Lohbrunner	-
University of British Columbia Botanical Garden, Vancouver, BC	1972-0604	6 + 7	15 cm (breast height)	-	Ed Lohbrunner	-
Arboretum Kalmthout, Belgium	00001628*A	14 + 10	116 cm @ 1.5 m	~120 years		-
Arboretum Wespelaar, Belgium	93112	4 + 4	10.2 cm (breast height)	-	-	-
Arboretum Wespelaar, Belgium	2553	3 + 2.2	3.8 cm (breast height)	-	Bonn Botanical Garden	-
Arboretum Wespelaar, Belgium	14322	2.1 + 2	3.8 cm (breast height)	-	Piet de Jong	-
Arboretum Wespelaar, Belgium	19358	0.6 + 1	-	-	Nikko Botanical Garden	-
Arboretum Wespelaar, Belgium	19337	0.66 + 1	-	-	Nikko Botanical Garden	-
Arboretum Wespelaar, Belgium	3296	4 + 3.2	6.4 cm (breast height)	-	Niehues, China	-

Specimens in Canada

Two plants, which came in 1972 from the late nurseryman and plantsman Ed Lohbrunner of Lakeside Gardens Nursery, Victoria, British Columbia, are in the David C. Lam Asian Garden. Heavy shade from neighbouring plants had affected their growth for several years, and one tree currently 9 m tall with a dbh of 15 cm has developed a pyramidal habit (Douglas Justice pers. comm.). The other tree was relocated in 2005 to a more open, sunnier location, and had its top removed in 2010 to maintain its size; this pruning encouraged multiple second shoots 5 m tall. With a spread of 7 m, it is currently 6 m tall with a 15 cm dbh trunk. No cones have been observed on either tree.

Specimens in Europe: Belgium

Torreya nucifera has not prospered at the Arboretum Wespelaar, showing chlorotic or unhealthy needles and bare branches (Joke Ossear pers. comm.). However, the Belgian national champion tree estimated to be 120 years old belongs to Arboretum Kalmthout where it is approximately 14 m high with

Torreya nucifera, location and specimen details

EUROPE: GERMANY–ITALY

LOCATION	ACCESSION NUMBER / TREE #	HEIGHT + SPREAD (metres)	TRUNK DIAMETER (centimetres)	AGE	SOURCE	REFERENCE
Botanische Gärten der Universität Bonn, Germany	XX-0-BONN-13371	18	191 cm	-	1920	-
Botanische Gärten der Universität Freiburg, Germany	-	4.5	28 cm (4 trunks)	-	-	-
Schlosspark Sanssouchi, Potsdam, Germany	-	15	107 cm	-	-	Monumental Trees 2019
Ricasoli Garden, Udine, Italy	-	20	334 cm @ 1.30 m	~209 years	-	Monumental Trees 2019

photograph © Abraham Rammeloo

Torreya nucifera at Arboretum Kalmthout in Belgium.

a spread of 10 m (Abraham Rammeloo pers. comm.). The larger of the two trunks is 116 cm at 1.5 m (dbh). The Kalmthout tree is thought to be the one that is mentioned in the 1903 booklet on the conifers of the Arboretum Kalmthout by the former director Antoine Kort; at that time, it was only 2 m tall (Abraham Rammeloo pers. comm.). Kort had reported fruiting and the resultant seedlings resemble *Torreya californica* more than *T. nucifera*; the nursery of Jacques Lombarts in Zundert, Netherlands, and the horticultural school near Ghent, Belgium were recipients of seed in 1949. Curiously the prodigious seed production noted by Kort has not been witnessed within the 20 years of Rammeloo's career at Kalmthout.

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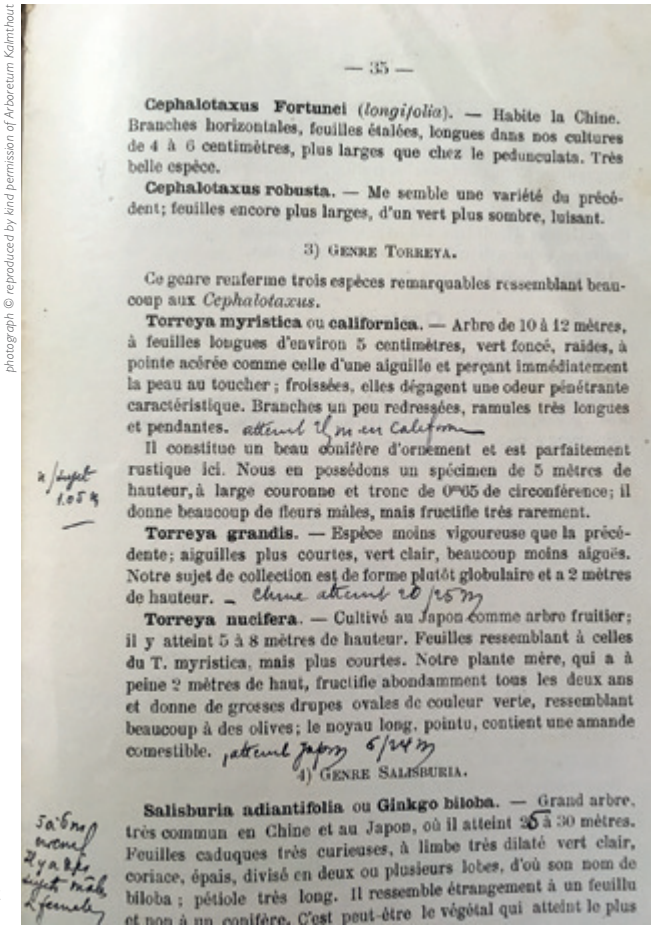


— 35 —

Cephalotaxus Fortunei (*longifolia*). — Habite la Chine. Branches horizontales, feuilles étalées, longues dans nos cultures de 4 à 6 centimètres, plus larges que chez le pedunculata. Très belle espèce.

Cephalotaxus robusta. — Me semble une variété du précédent; feuilles encore plus larges, d'un vert plus sombre, luisant.

3) GENRE TORREYA.

Ce genre renferme trois espèces remarquables ressemblant beaucoup aux *Cephalotaxus*.

Torreya myristica ou **californica.** — Arbre de 10 à 12 mètres, à feuilles longues d'environ 5 centimètres, vert foncé, raides, à pointe acérée comme celle d'une aiguille et perçant immédiatement la peau au toucher; froissées, elles dégagent une odeur pénétrante caractéristique. Branches un peu redressées, ramules très longues et pendantes. atteint 12m en Californie

Il constitue un beau conifère d'ornement et est parfaitement rustique ici. Nous en possédons un spécimen de 5 mètres de hauteur, à large couronne et tronc de 0m65 de circonférence; il donne beaucoup de fleurs mâles, mais fructifie très rarement.

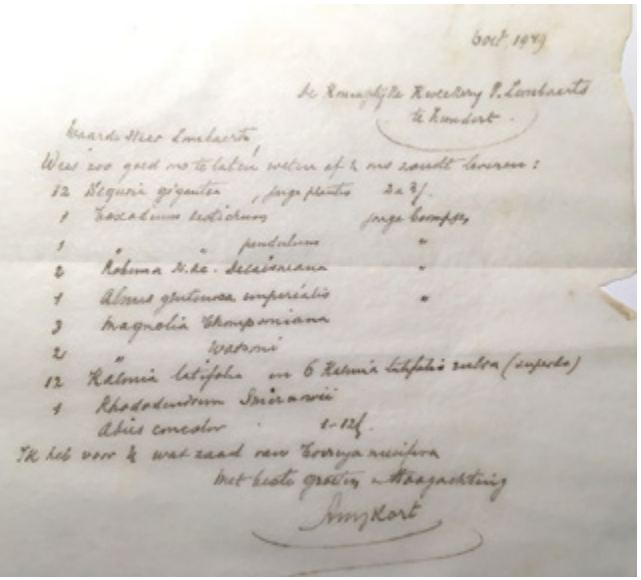
Torreya grandis. — Espèce moins vigoureuse que la précédente; aiguilles plus courtes, vert clair, beaucoup moins aiguës. Notre sujet de collection est de forme plutôt globulaire et a 2 mètres de hauteur. — Chine atteint 20/25m

Torreya nucifera. — Cultivé au Japon comme arbre fruitier; il y atteint 5 à 8 mètres de hauteur. Feuilles ressemblant à celles du T. myristica, mais plus courtes. Notre plante mère, qui a à peine 2 mètres de haut, fructifie abondamment tous les deux ans et donne de grosses drupes ovales de couleur verte, ressemblant beaucoup à des olives; le noyau long, pointu, contient une amande comestible. atteint Japon 6/24m

4) GENRE SALISBURIA.

Salisburia adiantifolia ou **Ginkgo biloba.** — Grand arbre, très commun en Chine et au Japon, où il atteint 25 à 30 mètres. Feuilles caduques très curieuses, à limbe très dilaté vert clair, coriace, épais, divisé en deux ou plusieurs lobes, d'où son nom de biloba; pétiole très long. Il ressemble étrangement à un feuillu et non à un conifère. C'est peut-être le végétal qui atteint le plus

A page from the 1903 booklet on conifers with Antoine Kort's personal annotations when he ran the nursery at Kalmthout in Belgium.



Left, 1949 letter from Antoine Kort at Arboretum Kalmthout to Lombarts nursery with supply, among other species, of *Torreya nucifera*.

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photograph © Ben Jones

Opposite, *Torreya nucifera*, planted in the late 1970s, at Harcourt Arboretum, Oxford.

Torreya nucifera, location and specimen details

LOCATION	ACCESSION NUMBER / TREE #	HEIGHT + SPREAD (metres)	TRUNK DIAMETER (centimetres)	AGE	SOURCE	REFERENCE
Reeburg Park, Vught, North Brabant, Netherlands	-	16	254 cm @ 1.30 m	-	-	Monumental Trees 2019
Trompenburg Arboretum, Rotterdam, Netherlands	-	-	99 cm @ 1.30 m	-	-	Monumental Trees 2019

Specimens in Germany

Botanische Gärten der Universität Bonn has two trees—the old tree (XX-0-BONN-13371), planted approximately around 1920, currently has a height of 18 m (59 ft) and a circumference of 191 cm (6 ft), but the other tree, a recent accession, is too small to be worth noting (Cornelia Löhne pers. comm.).

At Schloss Sanssouci, Potsdam, a tree planted in 1972 is around 14.50 m high and has a girth of 1.07 m (Monumental Trees, 2019).

Specimens in Italy

The Ricasoli Garden in Udine, Italy has a 20 m tree with a girth of 3.34 m at 1.30 m high; this tree is believed to have been planted around 1810, making it approximately 200 years old (Monumental Trees, 2019). Another tree with a girth of 2.46 m at 1.30 m can be seen in the Botanical Garden of Siena, Siena, Italy (Monumental Trees, 2019). Its height is unknown.

Specimens in Netherlands

National Tree Museum Von Gimborn Arboretum, Trompenburg Gardens & Arboretum, and Pinetum De Dennenhorst have *Torreya nucifera* in their collections. One of the two trees at the Von Gimborn Arboretum, Doorn, (1900ZG01293) produces viable fruits. These fruits from this tree yielded seed from which three seedlings were successfully raised in 1954 and planted in a grouping 5 to 7 m apart at Trompenburg Gardens & Arboretum (Fortgens pers. comm.). The Trompenburg trees are 10 to 17 m tall with a circumference breast height 75–105 cm, and they have been fecund in annual fruit production. In addition, 'Prostrata' planted in 1963 and 'Variegata' added in 1978 completes the *Torreya nucifera* representation.

There is also a tree 15.60 m tall with a girth of 2.54 m at 1.30 m in the Reeburg Park, Vught, North Brabant (Monumental Trees, 2019).

Torreya nucifera, location and specimen details

EUROPE: SWITZERLAND–UNITED KINGDOM

LOCATION	ACCESSION NUMBER / TREE #	HEIGHT + SPREAD (metres)	TRUNK DIAMETER (centimetres)	AGE	SOURCE	REFERENCE
Conservatoire et Jardin botaniques (CJB), Geneva, Switzerland	-	8	30-60 cm (3 trunks)	-	Boccard Nursery (1980)	-
Conservatoire et Jardin botaniques (CJB), Geneva, Switzerland	-	4	30-50 cm (3 trunks)	-	Boccard Nursery (1980)	-
Cambridge University Botanic Garden, Cambridge, UK	196437028	8.5 + 7	35 cm (breast height)	Measured 2016	Hilliers Nursery	-
Harcourt Arboretum (Oxford Botanic Garden), Oxford, UK	1978075.2	5 + 7	-	-	Hilliers Nursery 1978	-
Wakehurst Place, UK	1969-21338	16	49 cm (breast height)	Measured 2016	Source unknown	TROBI
Sir Harold Hillier Gardens, Hampshire, UK	1977.732	5.9	21.0 cm (breast height)	Measured 10/2001	-	-
Sir Harold Hillier Gardens, Hampshire, UK	1977.733	7	19.0 cm (breast height)	Measured 10/2001	-	-
Sotterley Hall, Suffolk, UK	Planted 1936	13	43 cm (breast height)	Measured 2016	-	TROBI
Bicton Park Botanical Gardens, Devon, UK	Tree I.D. 579	12	36 cm (breast height)	Measured 2013	-	TROBI
Bedgebury National Pinetum, Kent, UK	Tree I.D. 49958 Planted 1926	12	36 cm (breast height)	Measured 2015	-	TROBI
A private garden in Cardiff, Wales, UK	Planted 1944	12	36 cm (breast height)	Measured 2018	-	TROBI

Specimens in United Kingdom

The cool summers in northern United Kingdom have not been conducive to establishing *Torreya nucifera* in collections. Di Sparks (pers. comm.) mentioned that the Howick Arboretum on the east coast of Northumberland had mixed results with plants, with two lost within the first two years after planting. One tree (BBJMT 123), collected in 2005 at 280 m in Niigata Prefecture, Honshu, Japan is only 0.4 m by 0.4 m. Two older trees (CU 93/9) propagated from seed collected in Gunma Prefecture, Japan by Chiba University in 1994 have scarcely grown, topping at 1 m by 0.5 m and 2 m by 1.5 m. John Grimshaw (pers. comm.) has echoed the same experience at the Yorkshire Arboretum. The tree at the Royal Botanic Garden Edinburgh, sourced in 1910 from the Yokohama nurseries, was *ca*. 6 m × 0.4 m dbh in 2016.

At Cambridge University Botanic Garden, a tree obtained from Hilliers Nursery in 1964 has grown to a respectable 8.5 m with a spread of 7 m (Peter Atkinson pers. comm.). The botanic garden, being located inland north of London, enjoys a more continental climate that may have aided the tree's growth. Wakehurst Place, Haywards Heath, UK currently has the champion tree in UK, which is at present 16 m with 49 cm dbh (Ed Ikin pers. comm.).

The Royal Botanic Gardens, Kew also have trees although none are close in age and size to Wakehurst's tree. The Tree Register of the British Isles records 21 specimens in the UK and Ireland, but only nine of these exceed 10 m height, the most significant of which are listed in the table above.

Specimens in Australia

Mount Tomah Botanic Garden, the cool climate garden satellite of Royal Botanic Gardens Sydney in the Blue Mountains, has two accessions growing in the open shade of eucalyptus trees. They have formed wide-spreading shrubby habits, producing healthy new growth each year (Ian Allan pers. comm.). Mount Lofty Botanic Garden, the cool temperate outpost of Botanic Gardens of South Australia, has three trees 50 to 52 years old. They were propagated

Torreya nucifera, location and specimen details

AUSTRALIA–SOUTH KOREA

LOCATION	ACCESSION NUMBER / TREE #	HEIGHT + SPREAD (metres)	TRUNK DIAMETER (centimetres)	AGE	SOURCE	REFERENCE
Mount Lofty Botanic Garden, South Australia, Australia	G88874	5-8 + 1.5-1.8		~50-52 years	The Aritaki Arboretum, Japan.	-
Mount Tomah Botanic Garden, New South Wales, Australia	12390/1	3.6 + 4.50 (N) + 3.80 (S) + 4.10 (E) +2.10 (W)	14.9 cm @ 0.9 m (breast height)	-	Provenance unknown	-
Mount Tomah Botanic Garden, New South Wales, Australia	12390/2	3.4 + 2.90 (N) + 4.00 (S) + 4.60 (E) + 2.10 (W)	17.7 cm @ 1 m (breast height)	-	Provenance unknown	-
Bijarim Forest, Jeju Island, South Korea	-	14 + 15	6 m (breast height)	820 years or more		-
Gaecheonsa Temple, Hwasun, South Korea	-	16 +18.4	3.5 m (breast height)	~400 years	Natural Monument 483	-
Imhoe-myeon, Sangman-ri, Jindo, South Korea	-	12	6.35 m	~600 years	Natural Monument 111	-
Samin-ri, Gangjin, South Korea	-	11.5	5.8 m	~500 years	Natural Monument 39	-
Seongnae-ri, Sacheon, South Korea	-	19	3.85 m	~300 years	Natural Monument 287	-

from seed (Stock Number 86/66) received on April, 22 1966 from the Aritaki Arboretum, Japan (Stephen Kingdon pers. comm.). These trees have formed multi-trunked stems 5–8 m high from the base high, and have spread from 1.5 m to 1.8 m wide 1 m from the ground (Mark Devlin pers. comm.).

Specimens in South Korea

South Koreans hold *Torreya nucifera* in high regard, having planted large groves around temples.

Given that the Bijarim Forest in Jeju Island has the oldest and largest population, it is not surprising that the best trees are found there. The oldest tree, considered 820 years or more, is 14 m tall with a girth at breast height 6 m and a width of crown 15 m (Korea National Arboretum, 2015).

Several trees, including a few groves, on the main Korean peninsula have been accorded National Monument status. The Cultural Heritage Administration of South Korea (2006) have recognized eight National Monument distinctions, three of which are trees. The tree at Mount Naejangsan, Samin-ri, Gangjin, estimated to be 500 years old and is 11.5 m tall with a spread of 5.8 m. It has been designated a National Monument #39 in 1962. How this tree escaped logging has been attributed to two possible reasons. One reason was that its size and somewhat irregular habit was deemed unsuitable for building the lieutenant general's headquarters after King Taejong (1400–1418) chose the area for a military outpost. The locals had removed all other trees for timber, leaving the runty tree behind. The other reason was the value of the tree's fruit in treating parasitic infections, therefore people felt compelled to protect the tree from possible destruction. Nowadays the town of Samin-ri hosts an annual celebration on 15 January during which prayers for peace are held around the tree.

At Imhoe-myeon, Sangman-ri, Jindo a specimen approximately 600 years old, is 12 m tall with a girth of 6.35 m. This tree (Natural Monument #111) was once in the courtyard of the Guamsa Temple about 1,000 years ago, and villagers regarded it to be sacred. Another tree (Natural Monument #287) about 300 years old, with a height of 19 m and a girth of 3.85 m, can be seen in Seongnae-ri, Sacheon. The grove of trees planted around the Gaecheonsa Temple, Hwasun, itself given Natural Monument #483 status, has a 400-year-old tree 16 m tall, with a girth of 3.5 m at breast height and a crown of 18.4 m in width.

Baengnyeonsa Temple in Jangseong-gun (Natural Monument #153) is estimated to have over 5,000 trees between 8 and 10 m tall that the national Buddhist teacher Gakjinguksa was believed to have planted at the end of the Goryeo era (918–1392) (Yeong-woo, 2018). The forest of trees (Natural Monument #239) at Geumtapsa Temple at Cheondeungsan Mountain, which are largely 10 m tall, are supposedly planted from the sixth year reign of Queen Seondeok of Silla who oversaw Korea from 632 to 647.

Torreya nucifera, location and specimen details

JAPAN

NAME	PREFECTURE	HEIGHT (metres)	TRUNK WIDTH (metres)	ESTABLISHED AGE	LOCATION	LANDMARK STATUS (S - RECOGNIZED NATIONAL MONUMENT)
Nagoya Castle Kaya	Aichi	15	8.1	-	Nagoya Castle	-
Kaya of Imori Shrine	Ehime	-	5.5	-	Shikoku Chuo City	City-designated Natural Monument
Kaya of Mentuji Temple	Fukui	15	3.45	500	Mentuji Temple	S35 (March 5)
Shiganashika of Yugenji Temple	Gifu	18	3.7	-	Yugenji Temple	S46 (December 14)
Kyouya of Ryoinji Temple	Gifu	18	3.80	500	Ryoinji Temple	S45 (January 20)
Shohoji Precinct Kaya Tree	Gifu	34	4.28 (4.99)	-	-	H3 (November 22)
Hirono Daikaya	Gifu	19.5	3.90 (4.11)	-	Shirakawa	42 (May 9)
Ryusenji no Kaya	Gifu	20	3.15 (3.23)	-	Gero City	48 (May 30)
Hidakagaya of Hioki	Hyogo	20	4.0	600	Tamba Sasayama City	T14 (October 8)
Kasugae Kaya	Hyogo	20	5.0	-	Tamba Sasayama City	-
Kaya of Daishuji Temple	Hyogo	20	7.6	over 300	Mita City	S46 (April 1)
Hidari Makigaya	Hyogo	26	7.35	700 or more	Yabu City	S26 (June 9)
Shirakawa's stone dwelling kaya	Hyogo	20	4.5	350	Kobe City	H6 (February 4)
Engoji Kaya	Hyogo	26	5.30	-	Tamba City	S51 (October 12)
Kaya of Saiho-ji Temple	Hyogo	12	5.4	600	Tamba Sasayama City	H6 (March 23)
Great Kaya from Yamaguchi	Hyogo	20	5.5	600	Nishinomiya City	S48 (March 29)
Kaya of Ihara Hiyoshi Shrine	Hyogo	30	4.74	-	Tamba City	S51 (December 9)
Ayaoka Shrine Kaya	Hyogo	23	5.70	700	Tamba City	-
Jotokuji Temple	Hyogo	18.7	4.45	450	Kamikawa Town	H9 (October 8)
Kaya of Kayaji Temple	Hyogo	15	4.4	250	Kawasai City	S60 (November 29)
Kaya of Shounji	Hyogo	25	4.95	700	Kamiguncho	S61 (March 25)
Ono's Great Kaya	Hyogo	20	6.50	400	Sayo-cho	?
Kusunoki Kaya	Hyogo	15	3.2	-	Kobe City	-

Specimens in Japan

Torreya nucifera is frequently found growing on Japanese temple sites because the triangular shape of conifers projects divinity in its apex pointing upwards to the heavens (Peng et al., 2018). The trees on temple sites are often outstanding specimens with significant height and trunks of large girth, and their sacred association have protected them from being logged or simply removed. However, shrine sites, private residences, and agricultural lands also have large *Torreya* trees. The number of trees is too numerous to describe here in detail, but here are a few:

The Kaya at Yokomuro, Gunma Prefecture. This tree is considered one of Japan's top three, although its canopy has gained the craggy profile of mountain tops and the thick branches now require props for support. Considered over 1,000 years old and designated as a national Natural Monument, the tree is 24 m tall with a trunk circumference of 8.1 m.

The Kaya at Yono City, Saitama Prefecture. Yono City plays host to another major specimen 22 m tall with a trunk circumference of 7.6 m estimated to be 2,000 years old. Graced with a sacred straw rope, the trunk is beautifully straight.

Torreya nucifera, location and specimen details

JAPAN

NAME	PREFECTURE	HEIGHT (metres)	TRUNK WIDTH (metres)	ESTABLISHED AGE	LOCATION	LANDMARK STATUS (S - RECOGNIZED NATIONAL MONUMENT)
Aki Kaya	Hyogo	20	5.55	600	Sakai City	? S60?
Kaya of the former Ishihara residence	Hyogo	12	5	-	Sakai City	-
Kateokuji Kaya	Hyogo	30	4.0	600	Ono City	-
Kaya of Sayama family	Hyogo	14	4.20	-	Tamba City	-
Kamitakeda Kaya	Hyogo	13	4.30	-	Tamba City	S54 (March 19)
Kayahara's Kaya	Hyogo	15	6.30	-	Tamba City	H5 (January 17)
Kaya of Kayanon Temple	Hyogo	17	5.00 (5.25)	-	Nishiwaki City	-
Kaya of Nishiura Komachi	Kyoto	15	8.9	900	Kyoto City	-
Kaya of Ono-Kashiri-Cho	Kyoto	13	4.80	-	Kyoto City	-
The Golden Age of the Kongoin	Kyoto	22	5.3	over 1000	Maizuru City	S52 (February 17)
Kaya of Shohoji	Kyoto	21	4.3	500	Kyoto City	H17 (February 17)
Kaya of Tohtori	Kyoto	25	4.9	400	Kyoto City	-
Kaya of Shimizu House	Kyoto	20	3.5	-	Ojitahara	-
Kaya Oku Yamada	Kyoto	~25	~5	-	Okuyamada	-
Kaya of Ishishimizu Hachimangu Shrine	Kyoto	20	-	over 200	Hachiman City	-
Kaya of Nanyo Temple	Kyoto	17	3.9	-	Nantan City	-
Kayanoki of Nishinenji Temple	Mie	16	-	500	-	H23 (February 23)
Shibanashigaya of Hakuji Temple	Mie	21	3.50 (50 cm above ground)	-	Konoji Temple	-
Kaya of Fudoji Temple	Mie	18	5.10	-	-	-
Sleeping Kaya of Minami-Natsu Tsuhara	Mie	-	1	-	Inabe City	-
Big Kaya in Minami-Natsu Tsuhara	Mie	10	5.5	1000	Inabe City	S15 (March 3)
Kaya of Anikiji	Mie	20 (eye)	4.88	-	Nabari City	-
Kaya of Nagaizumi Temple	Mie	16	4.00 (4.46)	-	Nagaizumi Temple	H11 (Feburary 8)
Kayanoki of the Valley of the Sun	Mie	14	3.50 (3.85)	-	Kumano City	-
Anda's House Kaya	Nagano	60	3.60	-	Takamori	-
Kaya of Nishigishi Temple	Nagano	18	5.24	500	Nishigishi Temple	-
The left-handed spider of Naruyama	Nara	15	6.60	-	Nara City	S28 (March 23)
Kaya (?)	Nara	15	5.2	-	Gojo City	-
Kaya	Nara	15	5.2	-	Gojo City	-

Torreya nucifera, location and specimen details

JAPAN

NAME	PREFECTURE	HEIGHT (metres)	TRUNK WIDTH (metres)	ESTABLISHED AGE	LOCATION	LANDMARK STATUS (S - RECOGNIZED NATIONAL MONUMENT)
Kaya of Matsumoto Family	Nara	25	4	600	Uda City	-
Kaya in Daifukuji	Nara	12	6.07	700	Uda City	-
Kaya of Kitsuki Shrine	Nara	20	4	-	Hiragun Town	-
-	Nara	25	5.5	-	Hiragun Town	-
Kaya at Gorakuji Temple	Okayama	28	4.5	380	Tsuyama City	H8 (November 26)
Kanoyaki of Nagano Shrine	Osaka	17	4	-	Nagano City	S47 (March 31)
Kaya of Iwawakiji	Osaka	20	5.97	400	Kawachinagano City	-
Kaya of Inaba-cho Yakushido Ruins	Osaka	10.85	3.85	-	Kishiwada City	S41 (March 22)
Yono no Kaya	Saitama	21	7.60	1000	Myoujyo-ji Temple	S7 (July 25)
Kaya of Senfukuji Temple	Shiga	19	4.33	-	Senfukuji Temple	-
Kaya of Jyogen Temple	Shiga	23	3.12	-	Jokenji Temple	-
Big Kaya of Kitahama	Shizuoka	23	5.4	600	Hamamatsu City	S29 (March 20)
Nine Gods Buddha Kaya	Tokyo	26.5 (stem height 4-5)	-	700	Joshinji Temple	S27 (November 3)
Kojo of Zojoji Temple	Tokyo	25	4.00	600	Zojoji Temple	S55 (November 15)
Big Kaya of Zenyouji Temple	Tokyo	20	6.00	-	Zenyouji Temple	S39 (November 21)
Zenpukuji Kaya	Wakayama	23	7.03	800	Kimino Town	-
Kayagami Yakushiji Temple	Wakayama	15	6.0	over 500	Kinokawa City	-
Kayauchi Niyo Shrine Kaya	Wakayama	15	2.8	-	Kinokawa City	City-designated Natural Monument
Shiga Amano's Four Gaya	Wakayama	20	3.88	-	Katsuragi Town	-

Tabulated data for Japan reproduced by kind permission of the following websites:
www.plant.kjmt.jp/bigtree/kigi/listkaya.htm and http://show-en-kei.com/kyoboku/kb_kanto/kb_tochigi/kb_tochigi_ashikaga_03.html

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The Great Kaya of Mansho-ji, Kuwaori Town, Fukushima Prefecture. Although the tree itself is not the tallest in Japan, being only 15 m, it has an astonishing trunk circumference of 8.70 m.

Nagoya Castle. At the castle's Nishinomaru-enokida Gate grows a *Torreya nucifera* over 600 years old and designated the only Natural Monument in the city. Despite being damaged in the air raids of 1945 during World War II, the tree survived remarkably and is currently approximately 16 m tall and 8 m wide. Tokugawa Yoshinao, the first lord of Nagoya Castle, is said to have eaten the nuts and prayed for victory before heading to battle.

Cultivars

***Torreya nucifera* 'Gold Strike'.** Although this variegated selection had existed in Japanese collections, horticulturist and plantsman Barry Yinger and Carl Hahn, the former chief of horticulture at Brookside Gardens in Maryland, had imported it as *Fuiri Kaya* (variegated *Torreya*) from the Kiraku En Nursery, Ibaraki, Japan (Hahn & Yinger, 1983). Phil Normandy (pers. comm.) said that the original plant imported is no longer alive, but propagules have been established and are growing at McGrillis House and Gardens, Bethesda, Maryland. However, there is a good-sized plant in the Gotelli Conifer Collecton at the US National Arboretum, Washington, DC. Variegation is irregular, with some shoots having both green and yellow needles and others entirely yellow.

It is not stable, despite half of the shoots being variegated. 'Gold Strike' will remain a novelty plant in collections.

***Torreya nucifera* 'Prostrata'** (den Ouden & Boom, 1982). This cultivar was first mentioned in Murray Hornibrook's *Dwarf and slow-growing conifers* (1923) under *Torreya nucifera* var. *prostrata*. It was one of the two seedlings that has maintained its spreading mat habit and when last witnessed in 1963 had doubled the original dimensions of 1 m high by 5 m wide.

***Torreya nucifera* cv. (variegated).** Unlike 'Gold Strike', this unnamed cultivar has consistent variegated foliage resembling a snow-dusted miniature Christmas tree. Nelis Kools is currently growing and evaluating it at his nursery in Deurne, Netherlands.

Varieties

Botanical name	Japanese name
Torreya nucifera var. *nucifera*	*Kaya*
f. *igaensis*	*Kotsubugaya*
f. *macrosperma*	*Hidarimakigaya*
f. *nuda*	*Hadakagaya*
f. *sphaerica*	*Marumigaya*
Torreya nucifera var. *radicans*	*Chabogaya*

Ohwi (1965) listed three varieties: var. *macrosperma* (Miyoshi) Koidz.; var. *radicans* Nakai; var. *igaensis* (Doi & Morikawa) Ohwi. Iwatsuki et al. (1995) reduced var. *macrosperma* and var. *igaensis* to forms and maintained the varietal status for *radicans*. Kitamura & Murata (1971) reduced all the varieties to forms and placed them under var. *nucifera* while retaining separate variety for *radicans*.

Regardless of these botanical designations, the Japanese often refer to these selections under their Japanese names, which include the following: 'Chabogaya' (var. *radicans*), 'Hadakagaya' (f. *nuda*), 'Hidarimaki-kaya' (var. *macrosperma*), 'Kotubugaya' (var. *igaensis*), 'Marumi-gaya', 'Shibunashi-kaya'.

'Chabogaya' (var. *radicans*). The dense, horizontal branching and smaller habit of this variety may be the phenotypic consequence of ecological adaptation to the snow-belt habitat (Japan Herb Federation, 2019). The US National Arboretum, Washington, DC, has several mature plants that superficially resemble *Cephalotaxus* or *Taxus* from a distance, several shoots making a feeble attempt at apical dominance or upright habit, but they eventually revert to lateral growth.

'Hadakagaya' (f. *nuda*). The seeds lack the outer coating, but however seedlings do not exhibit the same 'naked' trait in their nuts once they produce

photograph © Harry Baldwin

One of several specimens of *Torreya nucifera* at Royal Botanic Gardens, Kew (photograph taken in mid April 2020).

them. This variety needs to be propagated vegetatively.

'Hidarimaki-kaya' (var. *macrosperma*). Has oblong seed 3.5–4 cm. long marked with twisting lines and whitish in colour, and found only in the Mie and Shiga Proviences (Ohwi, 1965).

'Kotubugaya' (var. *igaensis*). Smaller and shorter leaves 1–1.8 cm long and seeds approximately 2 cm long. The leaf apices are not as sharp as those of the typical species.

'Marumi-gaya'. Round seeds rather than oblong seeds.

'Shibunashi-kaya'. A variety having kernels that separate easily from the inner skins within the nuts, and is often known as the naked *Torreya*.

Cultivation and propagation

Torreya nucifera has proven remarkably resilient in the challenging conditions of north-east US—the fall and winter of 1910–1911, which experienced excessive rainfall during October and November, and unusually cold temperatures in January and February, was damaging to conifers and broad-leafed evergreens in New York Botanical Garden, but the *Torreya* was unscathed (Nash, 1912).

The large specimens cultivated in the mid-Atlantic US region indicate that a full-sun location with moist, well drained soil is ideal for healthy trees. However, partial shade can be tolerated, although the plants will form longer and looser branching to maximise light. Consistent summer heat is needed for growth and ripening of the shoots before the winter, trees fail to thrive in northern latitudes where summer heat is lacking despite having enough light and moisture.

Torreya nucifera can be propagated either from seed, cuttings, or grafting. Seed is the most common method of propagating, although it requires some patience. With the embryos slow to develop and taking up to 18 months to mature, the drupe-like fruit of *Torreya nucifera* usually ripens between September and November in the second year. Several gymnosperms (cycads, *Cephalotaxus*, *Ephedra*, *Gnetum*, and *Welwitschia*) produce seeds with fleshy seed coats known as sacrotesta. *Torreya*, along with other taxads, is no exception. However, the sacrotesta are often removed and excised from the seeds to enhance the germination rates. Because the seeds do dry out easily without the sacrotesta, it is important to sow them as soon as possible. Once sown, the seed can take up to two years to germinate, despite going through a period of cold stratification during the first year. It is important to protect the pots or seedling beds from rodents, especially squirrels who find the seeds delectable, by placing wire mesh over the pots. Seedlings should be pricked out and planted in individual pots. The Torreya Guardians, a group of conservation-minded citizens concerned about the extinction of the US native *Torreya taxifolia*, has a comprehensive detailed webpage on propagation that can be applied to *Torreya nucifera* (2019).

Cuttings can be taken and rooted successfully from side shoots during

summer. However, rooting is not always strong, therefore pruning the surplus or excessive top growth can channel the energy towards better rooting upon planting (Wonsoon Park pers. comm.).

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