Tree of the Year : *Taiwania cryptomerioides*

JOHN GRIMSHAW writes about *Taiwania cryptomerioides* Hayata, a very large coniferous tree in the family Cupressaceae, native to Taiwan, Myanmar, western China and Vietnam. It has distinct juvenile and mature growth forms and foliage, becoming fertile only with maturity. It can achieve 70m in the wild, and produces good, decay-resistant, high-value timber. Exploitation has left populations greatly reduced in the wild and its IUCN Red Data list status is Vulnerable, with the Vietnamese population considered Critically Endangered. Introduced from Taiwan in 1918 by E. H. Wilson, and now widely grown, it is most successful in areas with warm or hot summers, forming a shapely conical tree with pendulous branches in youth. It is hardy to -15°C (at least), USDA Hardiness Zone 7 in Europe and North America.

Foreword

As a young gardener and botany student I was more or less familiar with the 'standard range' of British native and ornamental woody plants, but had never given trees much attention: they were just there. Then, in the early summer of 1989, I joined a group visiting Batsford Arboretum where the late Lord Dulverton gave us an introductory talk. In it, he said how proud he was of the *Taiwania* he had got established. I had read about the species in Kingdon-Ward's posthumous *Pilgrimage for Plants* (1960) and piped-up something about it being a 'coffin-tree'. Lord Dulverton seemed not to be aware of this, but was keen that I should see the tree in question. To do this, we got into his sleek Jaguar and drove up the grassy slope to as close as possible to what was then still a young tree. It seemed such a fantastically eccentric thing to do that it made a great impression, and I can fairly state that this was the first time I really took notice of an unusual and 'different' tree: I am very grateful to Lord Dulverton for this.

Introduction

It is easiest to start an account of the discovery of *Taiwania* with the fact that its description was first published, by Bunzo Hayata (1874-1934), in 1906. Hayata was then a young botanist working at the Imperial University of Tokyo, but employed by the Japanese colonial government of Taiwan to investigate the island's flora: it became a major part of his career and he is known as the founding father of Taiwanese botany (Ohashi 2009). Under Japanese rule (1895-1945) the island was known as Formosa, its old Portuguese name: Taiwan appears to be derived from a Dutch construct of the name of a local tribe (Wikipedia 2011).

The unrecognised tree from which the type specimen and description were derived was found by the Government botanist Nariaki Konishi in 1904, at

Henry John Elwes observes the processing of a *Taiwania* log in the forest, Taiwan, 1912. (from a photograph probably taken by W. R. Price and published in Elwes, 1935).

2000m on the lower slopes of what was then called Mount Morrison, after an English missionary, Robert Morrison. It is now usually called Yushan or Yu-Shan, but the old name persists in numerous plant names, with well-known dendrological examples being *Cotoneaster morrisonensis* Hayata, *Picea morrisonicola* Hayata, *Pinus morrisonicola* Hayata, while *Acer morrisonense* S.L.Li non Hayata is an oft-seen synonym for *A. rubescens*. (Although chosen at random, the deep involvement of Hayata in the naming of Taiwan's flora is very evident from these names.) Konishi was soon to be commemorated in *Cunninghamia konishii* Hayata, which he had discovered in 1906.

The original specimens of *Taiwania*, which include both fertile mature and juvenile shoots, are mounted for comparison with a couple of *Cryptomeria* shoots: the material in its entirety had long been accepted as the holotype (single specimen on which a species' description is based), but Ohashi & Ohashi (2008) have designated the fertile specimen as the lectotype (a specimen later designated as 'first among equals', where the original author had not made that distinction). Its description was published in the *Botanical Journal of the Linnean Society*, reflecting the importance of the discovery. The name's derivation is simple and obvious: *Taiwania* commemorates the island to which it was then thought to be endemic, while *cryptomerioides* acknowledges the similarity of at least the juvenile growth form to that of *Cryptomeria japonica* (L.f.) D.Don.

Hayata was to regard the publication of *Taiwania* as the greatest contribution he had made to the elucidation of the island's flora, and went on to publish two further articles on the subject (1907, 1932) (Ohashi 2009). In the 1932 paper he proposed a new family, Taiwaniaceae, containing only *Taiwania*, but this was never widely accepted. The biological journal published by the College of Life Science, National Taiwan University, is also named *Taiwania*.

Unbeknownst to Hayata, however, Konishi's material was not the first collection of the species, and *Taiwania* is not endemic to the eponymous island. In May 1886 a specimen of *Taiwania* was gathered by D. J. Anderson, from a cultivated tree growing in Tengchong, western Yunnan, in mainland China (Page 1979). Juvenile material, it was assumed to be *Cryptomeria*, and was kept for nearly a century with material of that species in the Kew herbarium. A specimen from an apparently planted tree in 'Upper Burma' (a much more evocative description than 'northern Myanmar') was collected by the Burmese collector M. Kyaw for J.H. Lace in 1912, but it too remained unrecognized at Edinburgh until the 1930s (Grove 1938). More material was gathered in Myanmar in 1915 by J. S. Gamble, and in the following year the species was discovered in the mountains of Yunnan by Heinrich Handel-Mazzetti; it was also collected there in 1918 by George Forrest (Farjon 2005).

Handel-Mazzetti (in the excellent translation by David Winstanley, 1996) has left us perhaps the most striking description of mature *Taiwania* trees to date: 'Their pale grey trunks, well over 6m in girth, had smooth bark, though on older trees there was some longitudinal fissuring. They soared arrow-straight into the sky, certainly reaching heights of 70m, and were comparable in size to the largest pines of the region, though their lower branches spread out horizontally and were so large that any one of them could have stood comparison with a fair-sized tree. In some instances the trunk forked high above the ground and the separate branches towered up like a candelabrum into the mist which hung about these woods nearly all day, saturating the deep humus and bulky moss cushions on the forest floor."

The first Western dendrologist to see and study *Taiwania* in the wild was, however, Henry John Elwes (1846-1922) who, despite advancing years and girth, made an extensive tour of Taiwan in the early months of 1912 (preceding this by a visit to Malaysia and Java, and following on with a trip to Japan: all while *The Trees of Great Britain and Ireland* was still to be completed!). In Taiwan he was accompanied by the young William Price (1886-1975), who also featured in Tree of the Year 2009, *Trochodendron aralioides* (Andrews 2010). Elwes (1935) reported seeing and measuring *Taiwania* trees near Alishan. He compared the mature specimens to *Araucaria araucana,* finding them scattered among forests of *Chamaecyparis formosensis* and *C. obtusa*, on which he also made interesting observations. The largest tree was measured at 58 × 8.5m (girth) and he counted 'not less than 400' rings on a felled stump '8 or 9 feet across' (approximately an 8m girth), thus giving one of the few indications of the

photograph © John Grimshaw

Taiwania cryptomerioides at Batsford Arboretum, Gloucestershire, April 2011.

growth rate of the wild trees. A few weeks later he observed a felled specimen being cut into planks *in situ*; a photograph of the old patriarch sitting on a log and observing the process appears in his autobiography (see p. 25).

Ernest Wilson visited Taiwan in 1918 and as well as plants, which were

to form the first introduction to Western gardens, made several herbarium collections of *Taiwania*. In addition he took a series of photographs of notable trees, both mature and juvenile. These are available on the Harvard University website (referenced below as Harvard University (2011): search for *Taiwania*). His account of the island's forests, which he regarded as the finest in eastern Asia, includes a description of *Taiwania* as the tallest tree (*Chamaecyparis formosensis* being the bulkiest), and 'strikingly distinct… singularly like an old *Cryptomeria* and both trees suggest gigantic Lycopods.' (Wilson 1922). He noted that if the top was broken the lateral branches could become vertical, an effect also seen in young cultivated specimens.

Phylogeny and systematics

The relationships between *Taiwania* and other genera have been investigated on numerous occasions over the past century, and have been extensively reviewed by Farjon (2005). Despite the superficial similarity to *Cryptomeria*, its relationship to *Cunninghamia* was recognized by Hayata (1906) and shortly afterwards (Hayata 1907) a link was made with the Australian genus *Athrotaxis*. All three, plus the genera *Sequoia*, *Sequoiadendron*, *Metasequoia*, *Taxodium*, *Cryptomeria* and *Glyptostrobus* were long included in the family Taxodiaceae, which to many dendrologists will be a more familiar placement than the currently accepted Cupressaceae. The numerous morphological and molecular reasons for the inclusion of these taxodiaceous genera within Cupressaceae are given in detail by Farjon.

Taiwania and its sister genus *Cunninghamia* remain paired together in analyses based on DNA analysis (e.g. Gadek *et al*. 2000), with *Athrotaxis* forming a separate but adjacent clade (effectively a branch on the family tree in which all members are derived from a shared ancestor). They are part of a basal group of rather primitive members of the Cupressaceae, which Aljos Farjon (2005) calls "a rather loose assembly of descendants of earlier ancestors, survivors of a greater diversity." The three genera are all placed in monogeneric subfamilies within Cupressaceae by Farjon (2005): Cunninghamioideae, Taiwanioideae and Athrotaxoideae.

The fossil record of plants is always rather sparse, and well-preserved specimens are mostly fragmentary, making interpretation and use in constructing ancestries difficult, but it seems as if the Jurassic fossil genus *Elatides*, and the Cretaceous *Cunninghamiostrobus* are ancestral to the *Cunninghamia*/*Taiwania* clade (Farjon & Ortiz Garcia 2003). In Taiwanioideae the earliest attributable fossil are those known as *Parataiwania nihongii* and *Mikasastrobus hokkaidoensis*, both found in Upper Cretaceous deposits in Japan; both have features shared with Cunninghamioideae (Stockey *et al*. 2005). Plant fossils collected in northern Alaska during the 1950s and 60s have been found to include perfectly preserved, and indisputably recognizable examples of *Taiwania*. Despite dating back to about 106 million

years ago (MYA) in the Lower Cretaceous and extending to about 56 MYA in the Paleocene, these fossils are apparently identical with living *Taiwania cryptomerioides* (LePage 2009). Similar finds have also been made in deposits in Svalbard and continentral Europe dating to between 65-34 MYA, while *Taiwania japonica* Tanai & Onoe is a name given to fragmentary fossils from China and Japan (Stockey *et al*. 2005). These fossils demonstrate that *Taiwania*, exactly as we know it, was once very widely distributed across the northern hemisphere, at least up until the comparatively recent period of the Pliocene (5.3-1.8 MYA), and that it was capable of growing in a wide range of climatic conditions, including those of polar latitudes (LePage 2009).

Family Cupressaceae
Subfamily Taiwanioideae
Taiwania
One species: description below.

***Taiwania cryptomerioides* Hayata**
Cupressaceae
Syn. *Taiwania flousiana* Gaussen, *Taiwania cryptomerioides* var. *flousiana* (Gaussen) Silba, *Taiwania yunnanensis* Koidz.
Common names: Taiwania, (Chinese) coffin-tree, Formosan redwood, Taiwan cedar, tai wan shan, Taiwanya sugi

Large tree, to 60 or 70m (to 80m) in maturity, with distinctly dimorphic growth phases. Juvenile phase persists until tree is *c*. 15m (or perhaps more in cultivation), characterized by dense branching from the straight trunk; bark reddish-brown; the branches spreading to pendulous, with more or less pendulous branchlets, forming a densely clad conical or pyramidal tree; juvenile foliage 'cryptomerioid' with the leaves alternate to helically arranged, falcate-subulate (curved and needle-like, though the degree of curvature varies somewhat), with a broader base, 10-24 × 1.5-3.5mm, bilaterally flattened, with a ridge on both sides, sharply pointed, glaucous-green in colour with glaucous wax on the surface, gradually transitioning in morphology to mature foliage. In maturity the tree is massive, with a long bare trunk and a broad, but sometimes ragged crown. Trunk straight and columnar above a slightly buttressed base, to 3-4m in diameter, free of branches for up to two-thirds its length; bark thin, reddish-brown or brown, weathering to grey, peeling in thin strips or as flakes, eventually becoming fissured; branches becoming very large with age, more or less horizontal, creating a domed or flat crown; branchlets not pendulous, covered in appressed scale leaves; these 'sequoiadendroid' leaves scale-like, short and stout, appressed to or standing 'free' from the shoot, pointed with a broad base, curving to the tip, 3-6 × 1.2-3mm, shiny dark green with whitish stomata and pale midrib; pollen

Type specimens of *Taiwania cryptomerioides*, collected by N. Konishi in 1904, mounted with comparison shoots of *Cryptomeria japonica*. The specimen on the left has been designated the lectotype.

cones in clusters of 2-7 at the ends of leafy shoots, rounded, 2-3mm long, yellowish green, with numerous microsporophylls; seed cones solitary at the tips of branchlets, the scale leaves transitioning into cone scales, light green and 4-5 mm long when young, developing and maturing in one season to more or less cylindrical light brown cones, which mature in early winter (Vietnam: Luu & Thomas 2004), 12-20 × 6-11mm, usually with 12-25 scales; seeds light brown, 14-30 per cone, flat, ovate-oblong, 4 × 2-3mm, surrounded by a narrow (1-2mm) wing; cotyledons 2 (-3). 2n = 22. (Description modified from Farjon (2005), which should be consulted for full anatomical details. A shorter but essentially similar technical account is also given by Farjon 2010.)

Distribution and genetic diversity

The present-day distribution of *Taiwania* is interesting, with three centres of indubitable natural occurrence in Taiwan, Vietnam and the China/Myanmar border areas, all regions of high diversity and apparent refugia during glacial periods.

In Taiwan it is distributed through the mountains in the central part of

the island, usually sparsely in coniferous or mixed forests at between 1800 to 2600m (Li 1963), with many areas being logged-out of the species. A large, old-growth population of about 10,000 trees was discovered in a remote and inaccessible part of southern Taiwan in 2002 (Marinelli 2004, Farjon & Thomas 2007). In Vietnam a tiny relict population under severe threat is found only at 1800 to 2100m in the Hoang Lien Son range near Lao Cai, Van Ban district, in the north of the country (Luu & Thomas 2004). Callaghan (2008), however, believes he has seen *Taiwania* in the vicinity of Sapa at the foot of Fansipan, in northern Vietnam, a locality for the species that requires confirmation.

An undisputedly native metapopulation of *Taiwania* straddles the China/Myanmar border, between the Salween and Nmai rivers, occurring in several localities in north-eastern Myanmar, north-western Yunnan and possibly south-eastern Tibet, usually between 2100 to 2500m. In China it is most abundant in the Gaoligongshan and Gongshan areas. Some extensive stands still exist in some of these sites (Farjon 2005). Within this area, as mentioned above, it has also been planted as an ornamental or for timber. In addition, *Taiwania* occurs in a scatter of other localities in western and central China, for example in south-eastern Guizhou, south-western Hubei, south-eastern Sichuan and northern Fujian, but in these it is considered by some to have been introduced for the purpose of producing timber locally (e.g. Bartholomew *et al*. 1983, Farjon 2005, Farjon & Thomas 2007), largely on the grounds that the habitat and climate are not comparable with those in which it occurs naturally elsewhere, and that other conifer species are known to have been extensively planted around China, far from their presumed natural sites. McNamara (2007) has described visiting a specimen in Sichuan growing surrounded by other cultivated species. This assumption is disputed by others, for example by Li *et al*. (2008), who regard them as natural relict populations analogous to those of several other species of Chinese conifers, rather than ancient introductions. The issue is not likely to be easily resolved, although DNA may offer some insights (see below), but in view of the broad range of climatic conditions envisaged by LePage (2009) as natural for *Taiwania* in its evolutionary past, a narrow circumscription of climatic tolerances should not perhaps be given too much weight (P. Thomas, pers. comm. 2011).

The name *Taiwania flousiana* Gaussen was given in 1939 to material from Yunnan collected by Handel-Mazzetti in 1916 (which was also used as the basis for *T. yunnanensis* Koidz.). It commemorates the French conifer specialist Fernande Flous de Durand (1908-). It was based on small distinctions, particularly the size of the seed cones and their number of scales; Koidzumi also saw differences in the morphology of the seed wings (Farjon 2005). Farjon has made a careful comparative study of the herbarium material available from all populations and has concluded that there are no consistent morphological characters to distinguish one population from another and that the name *T. cryptomerioides* is therefore valid across the board. This view is concurred

in by the authors of the conifer section of *Flora of China* (Fu *et al*. 1999) and by most commentators.

The name *T. flousiana* is persistent, however, and is used by both Western horticulturists and Chinese foresters for material of Chinese origin, who perceive differences in living plants. Mitchell (1972) made a distinction that, on a specimen so-labelled at the Hillier Gardens, the foliage of '*T. flousiana'* was less spiny and a brighter grassy-green as a consequence of having fewer glaucous stomata; this view was reiterated by Hillier & Coombes (2002), who also claim that it has proved to be a hardier tree than specimens of Taiwanese origin growing in Hampshire. Stocks are also distinguished in the southeastern United States. Tom Cox of Canton, Georgia writes (pers. comm. 2011): "Plants [labelled *T. flousiana*] I've observed at Atlanta Botanical Garden and at John Ruter's test plots have somewhat small leaves, are a darker green, less upsweep of branches and are a bit more coarse. The mainland species is also slower growing. John reports that he planted both in 1997. The Taiwan specimen is now 10.5m and the mainland specimen is approx 6.0m. If you were to see the plants side-by-side, you could easily discern each species." In China foresters have established test plots comparing Taiwanese and mainland-origin material and find that stock of '*T. flousiana*' performs better (Wang *et al*. 2009).

Test-plot performance, and small differences between specimens do not a species make, however, and cannot be regarded as evidence for specific status. What is becoming clear from genetic analysis, however, is that there are (as might be expected) genetic differences between populations. Li *et al*. (2008) found significant differences between populations in mainland China, but low levels of genetic diversity within them, suggesting that the populations have been isolated from each other for a long time (since the Pleistocene in the opinion of the authors). Infrapopulation genetic diversity has also been found to be low in the Taiwanese population (Lin *et al*. 2003, Chang 2005). Studies of genetic diversity across the whole species have been undertaken by a team of collaborators from Taiwan, China and the Royal Botanic Garden Edinburgh, elucidating the relationships between populations across the species' range. Although as yet unpublished, an online abstract of this forthcoming paper indicates that the Taiwanese population shows genetic differences from mainland populations that suggest that they have been isolated for a very long time during which there has been very limited (if any) gene flow between the two areas (Chou *et al*. 2008).

Ecology

In all its genuinely indigenous localities in eastern Asia *Taiwania cryptomerioides* is most likely to be found as a mature, sometimes ancient tree, growing as scattered emergents towering above the surrounding forest. This may be largely coniferous forest, as in Taiwan, where it is often found with

Huge emergent *Taiwania cryptomerioides*, in a forest of mixed oak and *Chamaecyparis formosensis*, from a photograph taken by E. H. Wilson, Taiwan 1918.

Chamaecyparis formosensis and *C. obtusa* var. *formosana*, but may also be broad-leaved, composed especially of Fagaceae and Lauraceae in varied genera. Maurice Foster (pers. comm. 2011), vividly recounted seeing huge taiwanias rising above the broad-leaved forest in the Dulong valley of western Yunnan, but on the Yunnan-Myanmar border it is also found in coniferous

photograph © John Grimshaw

photograph © John Grimshaw

photograph © Douglas Justice

Above ***left***, pendulous branchlets, showing the sharp juvenile foliage. This is a nicely glaucous specimen at Batsford in April 2011.

right, frost damage to unripened young shoots, Colesbourne, Gloucestershire.

Left *Taiwania* is much hardier than generally assumed.

Below The different foliage types of *Taiwania*: juvenile at lower left, adult at middle left, transitional with male cones, upper right.

photograph © Tony Rodd

photograph © Tony Rodd

Top Male cones on a tree of *Taiwania cryptomerioides* in Mount Tomah, NSW, grown from Taiwanese seed in the 1970s.

Middle *Taiwania* seed cone from the fruiting tree under glass in Düsseldorf (see p. 49).

Bottom The lower trunk and bark of a *Taiwania* at the University of British Columbia Botanical Garden, Vancouver.

photograph © Patrick Knopf

photograph © Douglas Justice

forest (Farjon 2005). The Vietnam population is found in an area noted for its diversity of coniferous genera, although in the forest remnants where it grows the only other large conifer is *Fokienia hodginsii*, with the forest being otherwise comprised of Fagaceae, Lauraceae and *Magnolia* (Farjon 2005).

The indisputably indigenous mainland populations all grow on acidic soils (ph3.5-5) derived from granite or metamorphic rock, and both the Myanmar-Yunnan and Vietnam sites, despite being some 500km apart, are part of the Hengduan Mountain System extending from the southeastern Himalaya into Vietnam (Farjon & Thomas 2007). The mountains of Taiwan are of more recent origin. In all these areas the climate is monsoonal, with very wet summers. An annual rainfall of about 2000mm is recorded for its locality in northern Vietnam (Luu & Thomas 2004), and up to 4000mm in western China (Farjon 2005)–hence the mossy conditions described so vividly by Handel-Mazzetti (above). It is not found below 1600m

in these indigenous areas, with most populations occurring between 2100 and 2500m, though there are records of it occurring to 2800m in Yunnan (Farjon & Thomas 2007). *Taiwania* usually grows on the northeast facing slopes, where conditions are wettest. In such sites the annual mean temperature is about 11 to 15°C (LePage 2009), but Fu & Jin (1992) state that specimens growing at high altitudes in Yunnan can experience -15 °C. One of the objections to the indigenicity of *Taiwania* in central China is that here it occurs at much lower altitudes and in conditions of lower rainfall, where coniferous forest is not present, but even here trees are of large size and considered to be several hundred years old (Li *et al*. 2008).

The absence or extreme scarcity of seedlings and young trees has been frequently commented on (e.g. Elwes 1935, Kanehira 1936, Wilson 1926) and it seems that *Taiwania* is dependent on disturbance for regeneration, whether by fire or through landslides opening up extensive areas of bare ground (Farjon 2005). Many conifers, including such well-known species as *Sequoiadendron giganteum*, are dependent on this occasional disturbance for germination and seedling establishment (e.g. Farjon 2008). A comparable case that I am particularly acquainted with is that of *Juniperus procera* in East Africa, which establishes only on open ground and in such places, can rapidly develop an almost plantation-like stand of young trees. Self-thinning gradually reduces their numbers until only a few mature trees remain, which in turn become surrounded by broad-leaved species that form the climax forest: the post-disturbance pioneers stand as emergents, waiting for a new disturbance event for regeneration. Seedlings are effectively absent. This also seems to be the situation with *Taiwania*, with further proof of the validity of this model in the occasional reports of pure *Taiwania* forests, such as that recorded by Kingdon-Ward (1960) in the vicinity of the Wulaw Pass on the Myanmar-Yunnan border, and mentioned by Fu *et al*. (1999) in *Flora of China*. Farjon & Thomas (2007) suggest that the trees in the Hoang Lien Son area regenerated following a forest fire about 100 to 150 years ago.

Although they have been compared to sequoias (e.g. by Handel-Mazzetti, see Winstanley 1996), an important difference, especially in view of the above scenario for regeneration after disturbance, is that *Taiwania* has thin bark that is not fire-resistant (an adaptation of little value in a tree usually growing in exceedingly wet forest).

Taiwania is considered to be the tallest tree in China, but its height is surpassed by the 95m tall specimens of *Cupressus himalaica* Silba (*C. cashmiriana* Royle ex Carrière in Farjon's view) recently discovered in Bhutan by Sabine Miehe, which can be accounted the tallest temperate trees in Asia (Farjon 2008). Regardless, *Taiwania* is a massive tree, with heights of 80 to 85m sometimes cited, though it is not clear if this stature has been authenticated. In maturity large trees are perhaps more striking than attractive (E. Hsu, pers. comm 2011). The large trees in the very wet forests of Yunnan/Myanmar

and in Taiwan are estimated at 1600 to 2000(+) years old, but in the drier conditions of Vietnam the living trees are smaller, 30-35 x 1m (Farjon 2005), and much younger, though old, larger stumps are still visible (P. Thomas, pers. comm 2011). Great age is generally attributed to the big solitary specimens surrounded by other species: Hu (1950) reports on a felled 50m specimen (3-4m dbh) that had 1600 annual rings, and ages are often extrapolated to over 2000 years (Fu *et al*. 1999, Farjon 2005).

Forestry and utilisation

The most famous use of *Taiwania* timber is in the manufacture of coffins, being greatly valued by the Chinese for this purpose (Kermode 1939, Kingdon-Ward 1960), hence its English name of coffin-tree, although it is not clear if this use is still prevalent (Farjon 2010). The wood is strong, heavy and extremely durable: Elwes (1935), with his love of timber, noted that there was only a narrow band of sapwood, and that the heartwood contained many dark red streaks, while Farjon (2010) says that "it is beautifully marked with red and pale yellow annual rings (late and early wood)." It is these qualities that make it so desirable for enduring coffins, furniture and other purposes.

Kingdon-Ward (1960) painted a very vivid picture of the importance of a good coffin to wealthy Chinese people, and during his extensive travels over many decades was able to observe all stages of their production, especially in Myanmar. Six boards were required for each, with the lid being particularly massive (270cm long, 90cm tapering to 60cm in width, and 7.5cm deep). He calculated the weight of a good coffin to be between 180 and 227kg. One large *Taiwania* tree provided timber for a dozen coffins, being felled and cut into planks *in situ*. These were packed out on mules, or floated downstream to a convenient landing place; the lighter ones were carried over the pass to Yunnan on mules, but the heaviest were carried by local porters. He records that trees were in private or village ownership, and then worth (in the 1930s) one hundred rupees: a finished coffin, however, would be sold for 600 to 700 rupees, so it was a profitable business.

The sense of ownership of trees in Myanmar recorded by Kingdon-Ward (1960) led to the planting of saplings around villages, and such trees were the source of several of the early collections made by Westerners in mainland Asia. It is now cultivated in China (especially in Guizhou and Hunan), and, to a lesser extent, in Taiwan, as a forestry plantation tree, but as Farjon (2005) notes, it will probably be many decades before they reach harvestable size. These plantations have been studied extensively by Chinese foresters and superior genetic material has been selected for (e.g. Wang *et al*. 2009, but an internet search will reveal the abstracts of many further papers, mostly in Chinese).

In Vietnam its wood is used for roofing material by the local community near the only known population (Farjon 2005). Extracts from the tree have potential anti-cancer and insecticidal properties (He *et al*. 1997), while essential

photograph © Paul Licht

A transition from pendulous young growth to more erect, 'sequoiadendroid' growth occurs as the tree matures. This is 1959.1152 at the University of California Botanical Garden, Berkeley, almost certainly one of the original trees grown from seed collected in Hubei in 1948 as *Taiwania flousiana*.

oils extracted from heartwood have miticidal properties against house dust mites (Chang *et al*. 2001).

Conservation

Although both Kermode (1939) and Kingdon-Ward (1960) wrote that in the early twentieth century *Taiwania* was common in the forests of Myanmar and Yunnan, they both observed its increasing scarcity and disappearance from accessible areas due to 'ruthless exploitation' on account of the profitable trade in its timber as coffin planks, and suggested that it was likely to disappear from many areas. This seems to have indeed been the case, but because *Taiwania* is still found in comparatively large populations in Taiwan and western China/Myanmar, its IUCN Red List status is Vulnerable (IUCN 2010). This is because populations are often isolated and many are very much still at risk from logging, while poor regeneration is also a concern. Hu *et al*. (1995) estimated that there were about 6000 to 7000 known individuals of *Taiwania* in mainland China, although there may be unaccounted-for populations in remote parts of Yunnan (Li *et al*. 2008). Some regional populations are very small, for example those in Lichuan, Hubei, and Gutian and Pingnang, Fujian, number only about a dozen individuals each (Li *et al*. 2008). In these areas there is the accompanying risk of a loss of genetic diversity. The species is supposedly protected in China and some stands occur in reserves, but others are still vulnerable to logging and more protection is required (Farjon 2005).

In Vietnam the situation is much worse, with a population of only about 90

to 100 trees known. They are classed as Critically Endangered at the national level, being at risk from both felling and uncontrolled burning, and regeneration is poor (Farjon & Thomas 2007). Despite this there is some evidence that the local people value the trees and according to Magin (2006), the Hoang Lien Son *Taiwania* trees are 'so valued by local people that in winter they dress the trees in clothes to keep them warm!' This population has been the subject of much conservation concern since its discovery in 2002, and considerable effort has been put into working with the local community to encourage them to preserve the trees and their surrounding forest (Farjon & Thomas 2007).

Conservation in cultivation

Taiwania cryptomerioides is not now a rare tree in horticulture, being represented in many public and private gardens wherever conditions permit its cultivation. It is important, however, to ensure that accession and provenance data for each specimen is correctly recorded, although for many it is sadly too late to do so.

Introductions to cultivation

As so often seems to be the case, the story of the introduction of *Taiwania cryptomerioides* is bedevilled by the lack of records and the passage of time. Authors have an unfortunate obsession with recording the first introduction, and omitting any mention of others, while private and purely commercial importations often do not get recorded at all. In consequence, it is not now possible; it seems, to tie up all the loose ends, leaving the origin of many specimens unclear.

In 1912 Elwes (1935) had failed to find seedlings 'small enough to move', so the credit for the first introduction of *Taiwania* to the west must go to Ernest Wilson, who collected seed and four young plants on his visit to Taiwan in 1918 (Wilson 1926, Hu 1950, Jacobson 1996). Cuttings were propagated from the young plants, and distributed, at least within the United States, with one being passed to Pierre S. du Pont of Longwood and from him to Fairmount Park, Philadelphia (though long since disappeared) (Nicholson 2004). It is not known what became of any other of Wilson's plants in the United States. The seed Wilson collected in Taiwan was not viable (Wilson 1926), but in 1924 R. Kanehira sent him seed that germinated. Briggs (1993) says that several hundred plants were grown at the Arnold Arboretum from seed and distributed world-wide. If true, this must refer to these Kanehira seedlings.

According to Bean (1920), in an account written within weeks of Wilson's arrival, he brought 'some half-a-dozen plants' with him on a visit to the UK in 1920–carefree days before phyosanitary restrictions! These plants–presumably rooted cuttings–were distributed, probably through Kew, to apparently suitable gardens. One of them at Exbury was 3.5m tall in 1933 (Grove 1938), but has 'long since disappeared' (J. Anderson, pers. comm.

2011). One planted at Kew was killed by frost over several years (Osborn 1933). There seem to be no records of where the others went, but it seems probable that the tree planted in 1928 at Killerton, Devon, where there was a long, strong connection with the Veitch family (Wilson's former employers), is one of them (13.4m in 1970 (Mitchell 1972)) and 17m in 2001, making it the tallest *Taiwania* in the United Kingdom (Johnson 2003, TROBI 2011). No current measurements are available, but the tree is still growing straight and well (M. Hickson, pers. comm. 2011).

Another may have been given to the 4th Marquess of Headfort, a well-known conifer enthusiast, since a specimen was planted in his garden at Headfort Hall, Co. Meath, Ireland, in 1928 (Mitchell 1972), which would be a suitable period for an initially pot-grown rarity to seem large enough to plant out. It had reached 8m in height by 1966 (Mitchell 1972), and was 11m (35cm dbh) in 2004 (TROBI 2011). This specimen was the source of a cutting-raised plant donated to the Royal Botanic Garden Edinburgh in 1933 and grown there in the Palm House. It became the only specimen known to have reached reproductive maturity in the United Kingdom to date, producing pollen cones before it was removed in 2004 (M. Gardner, P. Thomas, pers. comms. 2011). A cutting from it has however been established at Mount Stuart, Isle of Bute, but has lost apical dominance, so is now something of a broad heap, 120cm tall by 200cm wide (G. Alcorn, pers. comm. 2011).

A young plant, probably a Wilson original or early cutting, was growing at Mount Usher, Wicklow, in the late 1920s, when recorded by H. M. Fitzpatrick (1933), but was not recorded again. The current older specimen there, which is not thrifty, was planted in 1956 (J. Anderson, pers. comm. 2011).

It seems probable that most, if not all, specimens of *Taiwania* planted in the British Isles before and for a while after the Second World War, were derived from cuttings taken from Wilson's importations of 1920, though it is tempting to speculate that there was a second introduction, of seedlings derived from Kanehira's seed, in the later 1920s. For this there is no proof, however. It was soon in commerce, as a tree was supplied to Bedgebury National Pinetum by Hilliers in 1935 (D. Luscombe, pers. comm. 2011). In addition to those mentioned above, Mitchell (1972) recorded the presence of older taiwanias at Bodnant (9m, 19cm dbh, 2005), Sidbury Manor, Embley Park (9m, 29cm dbh, 2006), Garinish Island (21.5m, 59cm dbh, 2002: British & Irish Champion), Holkham, Wakehurst Place and Tregrehan (current measurements, from TROBI 2011). In comparison with more recent introductions few of these trees did particularly well, most remaining rather stunted and with multiple leaders (P. Thomas, pers. comm. 2011). This is exemplified by the Bedgebury specimen, which had reached 3m in 1962, 3.1m in 1971 (D. Luscombe, pers. comm. 2011), although in recent years it 'has perked up and [is] growing fast' and was 11m (25cm dbh) in 2010 (TROBI 2011). This failure may have been to the climatic conditions prevailing at the time, or perhaps to a low altitude provenance.

The wider distribution of Wilson's plants and later the Kanehira seedlings is an interesting question. There appear to be no old trees in North America dating to that era, but one at Mount Dandenong Arboretum, outside Melbourne, Australia, appears to have been planted in the 1920s. In 1920 Wilson proceeded from England to Australia: did he take a supply of young plants with him, or were they sent direct from Boston, then or later? As we all know, it is nice for a visitor to bring a choice tree for his hosts… This handsome tree is now 17m tall with a 2m girth (64cm dbh), and a spread of 11m (Victorian Heritage Database 2011), and is showing a transition to mature foliage, although it has not produced any cones as yet (M. Krause, pers. comm. 2011).

No further introductions can be traced until 1948, when seed was collected from trees in Hubei by C. T. Hwa, working for Prof. W. C. Cheng of the National Central University, Nanjing, alongside the much more famous collection of *Metasequoia* that he made at the same time. As is well known, a large quantity of *Metasequoia* seed was gathered and distributed around the world from the Arnold Arboretum, but only a small quantity of *Taiwania* seed was gathered (as *T. flousiana*) and this was divided between the Arnold Arboretum and the New York Botanical Garden (where it germinated in 1949) (Hu 1950).

A tree at the University of California Botanical Garden at Berkeley can be traced to this collection with almost 100% certainty (see photo p. 38), and it seems probable most trees grown under this name, especially in the United States, are derived from the Hubei collection of 1948. It was certainly circulating between collections in the 1950s: for example, the United States National Arboretum received a specimen so-labelled from Brian Mulligan of the Washington Park Arboretum, Seattle, in 1958 (R. Olsen pers. comm. 2011). As already mentioned, a tree labelled *T. flousiana* was at some point obtained by Sir Harold Hillier for his collection, presumably originating from this same introduction. This tree was 11.7m (28cm dbh) in 2009 (TROBI 2011).

After 1949 mainland China was closed to western botanists until 1980, and Taiwan remained unvisited by Western horticulturists since Wilson's expedition of 1918. Spotting this opportunity, Dr John L. Creech proposed and then undertook a collecting trip to Taiwan in 1967-68 on behalf of the USDA and Longwood Gardens. In early December 1967 he visited the National Forestry Bureau's Experimental Forest at Chito, near Taichung, and obtained both seed and seedlings of *Taiwania* there (Anísko 2006, which contains an image of Creech in the act of collecting seedlings). These were received by USDA under the Bureau of Plant Introduction numbers *PI 325070* & *325071*, and material was distributed from the Glenn Dale Plant Introduction Station, Maryland (where no specimens remain) (R. Olsen, pers. comm. 2011). Two good specimens in the University of Washington Botanic Gardens (Washington Park Arboretum) are Creech originals (*PI 325071*) and are currently 13 to 14m (30, 35cm dbh) (R. Hitchin, pers. comm. 2011).

Since then, official bodies in Taiwan, especially the Taipei Botanic Garden

E. H. Wilson's photograph (1918) of the specimen planted by Hayata at the Experimental Forest of the Taiwan National University at Chitou, Taiwan in 1907.

and the Taiwan Forestry Research Institute have been steady suppliers of seed for gardens around the world, certainly including Belgium, Germany, Switzerland, Canada and the United States, and presumably many more, so most of the younger specimens currently seen in cultivation have come from such sources. In the UK these include several at Kew and Wakehurst Place, dating back to 1979, with 11 dating from 1993 (RBG Kew records). This

Hayata's tree at Chitou, as it is today.

importation followed closely behind the expedition to Taiwan in the autumn of 1992 by Tony Kirkham and Mark Flanagan (recorded in Flanagan & Kirkham 2005, where a mature specimen is illustrated - see also page 54), when the duo saw *Taiwania* in the forest on Chilan Shan, but did not collect seed there. With mature wild *Taiwania* trees being so vast it is not surprising that official help has been sought.

The Royal Botanic Garden Edinburgh and its International Conifer Conservation Programme led by Martin Gardner have taken a particular interest in *Taiwania* and maintain records on over 130 specimens planted under their auspices, either in the network of Scottish botanical gardens under the aegis of RBG Edinburgh, or out-housed to other collections in Britain and Ireland. A few of these are of cultivated origin, such as the Headfort stock noted above, but the majority are of known provenance. The earliest of these were grown from collections made by Christopher Page in Taiwan in 1979 (under the numbers *C. N. Page 10224*, *10298*), but the majority are from the Edinburgh Taiwan Expedition (ETE) of 1993, collected at Ilan under the numbers *ETE 279* and *282*. It is interesting to note that trees collected on the Edinburgh Taiwan Expedition, and only planted in 1996-1997, have already reached up to 9m in height and 20cm dbh in sites as disparate as Tregothnan Estate in Cornwall, and Kilmun Arboretum in Argyll (T. Christian, pers. comm. 2011).

Material from mainland China seems to be very scarce, and trees with authenticated provenance are even more so. A collection was made on the Royal Botanic Garden Edinburgh's Gaoligongshan Expedition of 1996 under the number *7614C*, one specimen of which is maintained under glass at RBG Edinburgh. It is probably safe to assume that specimens labelled *T. flousiana* are of mainland origin, even if their precise provenance is unknown. Some may be derived from the 1948 collection discussed above. Living trees at the United States National Arboretum under the accession number NA 69463 were originally received in 1998 as *T. flousiana*. The records are unclear but it seems that the seeds were received from Kunming Botanical Garden *via* an intermediary (S. Koesch of Wisconsin, USA) (R. Olsen, pers. comm. 2011). Seed labelled *T. cryptomerioides* var. *flousiana* was supplied to the Adelaide Botanic Gardens, South Australia, in 1980 by John Silba, an American conifer enthusiast (S. Kingdon, pers. comm. 2011). It is conceivable that he has distributed seed elsewhere too.

No collections from Vietnam are known to be in cultivation (P. Thomas, pers. comm. 2011).

Taiwania is not always easy to obtain by gardeners. Plants have been offered in recent years by nurseries in North America, and it is currently offered by Arboretum Waasland, Nieuwkerken-Waas, Belgium. Seed is occasionally available from specialist tree seed suppliers; the China National Tree Seed Corporation (CNTSC) (2011) currently offers '*T. flousiana*' seed for US$100-110/kg, dependent on quantity.

When I worked for the seed company K. Sahin, Zaden B.V. in The Netherlands, the company's founder, the remarkable Kees Sahin, obtained a sample of *Taiwania cryptomerioides* [*sic*] seed from CNTSC, though its provenance is not known. Sown in a warm greenhouse this gave excellent germination and a batch of seedlings was grown-on without trouble in the same conditions. I brought a number of these (then about 30cm tall, in 9cm

pots) with me when I moved to Colesbourne in 2003. Several were distributed to friends, but after growing-on for a couple of years in pots, three were planted in the grounds of Colesbourne Park, where they have repeatedly lost their leaders to early, late or midwinter frost.

Propagation

Seed is by far the best option for propagating *Taiwania*, giving vigorous, straight-growing trees with robust roots. Luu & Thomas (2004) give some useful details. The seed is very light in weight, with a count of 450-700,000/kg. It can be dried and stored at 4°C for several years without losing viability, which in Vietnamese samples has been about 40%, though Wang *et al*. (2009) have found that the germination rate of *Taiwania* seed in forest nurseries in China is about 10% of seeds sown. Sown in warmth in spring germination occurs in three to four weeks, and growth is rapid. Young seedlings should be protected from hot sun, and if grown in cold climates given protection from frost for the first few years.

Cuttings can be rooted, and were the principle method of propagation between 1920 and 1969. They root poorly, and slowly, however, giving a 24-46% success rate over a period of 150 to 300 days for Fordham & Spraker (1977), with or without the application of rooting hormone. In the late 1980s/early 1990s J. C. Raulston gave American nurserymen large batches of *T. cryptomerioides* cuttings from the North Carolina State University Arboretum (later the JC Raulston Arboretum), probably derived from one of Creech's imports. He records that the success in rooting cuttings varied from year to year, and that the young plants will sprawl for a few years before developing good leaders (Raulston 1990). Such plagiotrophic (i.e. non-vertical) growth is a well-known problem when grafting or raising conifers from cuttings, and is the best reason for avoiding doing so, but Dan Luscombe (pers. comm. 2011) recalls a conversation with conifer growers in the United States in which he was told that if cutting-grown taiwanias are placed in shade they form upright shoots and grow normally. Interestingly, Cedar Lodge Nursery (2011) in New Zealand, state in their online catalogue that cutting-raised specimens of "*T. flousiana*" rapidly make a good leader, unlike plants of Taiwanese material. It may be worth attempting to strike cuttings from the multiple leaders that develop after apical damage has occurred.

Growing *Taiwania*

In 1920 Wilson imported, along with the seedlings, the view that *Taiwania* would not be hardy in Britain 'except in the south-western counties and similar mild localities' (Bean 1920). This view has persisted in the literature and opinion, despite the fact that the species' remarkable hardiness was soon observed: Grove (1938) reported that there had been no deaths from the 'intense cold' of the 1928-29 winter. The myth of the tenderness of *Taiwania*

is only just beginning to dissipate, and a comparison made by John Anderson at the Royal Horticultural Society's garden at Rosemoor, Devon, in April 2011 is illustrative: he noted that a 4m specimen there was unblemished, while neighbouring evergreens such as *Neolitsea sericea*, *Eriobotrya deflexa*, *E. japonica* and *Magnolia delavayi* were hit hard by the winter of 2010-11. It is probably safe to say that it is hardy to USDA Hardiness Zone 7 (-17.7 to -12.3°C, 0-10°F), with several reports suggesting little or no damage to -15°C, but Michel Decalut (pers. comm. 2011) reports that a specimen at Hof ter Saksen in Beveren, Belgium, was not damaged by -23°C in 1985, when only four years old.

The existence of numerous good, attractive specimens across Britain and Ireland, Belgium and France has demonstrated just how false this myth was. There are the variables of provenance to consider (perhaps Wilson's collections were from particularly low altitudes) and climate may have played a part: the long run of comparatively mild winters in northern Europe from 1983-84 to 2008-09 may have been of great advantage in allowing young plants to get established. In Tony Kirkham's view this is critical: 'a couple of kind years' is his expression. Shelter from the wind, but not shade is desirable, too: all are agreed that (at least in northern Europe) trees planted in shade become leggy and unattractive, and that bright sunshine is needed for good growth. Martin Gardner (pers. comm. 2011) believes *Taiwania* to be more successful in British conditions than either *Chamaecyparis formosensis* or *C. obtusa* var. *formosana*, and comments that 'it is perhaps more hardy than it ought to be'. In the light of LePage's assertion (2009) of its tolerance of cold periods in its evolutionary past this is perhaps not so surprising.

Despite the much improved success with *Taiwania* in recent years in northern and western Europe, there is no doubt that it performs very much better in regions with hot (or at least warmer) summers, but with good rainfall in winter at least. This is amply demonstrated by the superb trees seen in the south-eastern United States, and on the Pacific Coast, as well as in Australia and New Zealand. For example, Tom Cox (pers. comm. 2011) reports a staggering growth rate of 1m per annum in Georgia, where it tolerates clay soil and regular heavy rainfall in summer. Once established they are also capable of surviving hot dry years in the SE USA (Dirr 2009). In Seattle, Randall Hitchin notes (pers. comm. 2011) that its pendulous branches shed snow easily and are not damaged by it, unlike *Cunninghamia lanceolata*. He also notes that it has no obvious pests or diseases.

Tolerance to a range of climatic conditions is also evident in the British Isles, with specimens from the same collection thriving equally well – assuming successful establishment – in the mild moistness of Benmore Botanical Garden, Argyll and the nearby Kilmun Arboretum, and the relatively dry and cold situations of Edinburgh and Bedgebury in Kent. Similarly, the trees are very tolerant of different soil conditions (including limestone), but do need good drainage (T. Christian, M. Gardner, pers. comms. 2011). John Anderson (pers.

photograph © Dirk De Meyere / National Botanic Garden Belgium

A group of young *Taiwania* (planted in 2006) at the National Botanic Garden of Belgium.

comm. 2011), however, believes that ample moisture during the growing season is important.

A recurrent problem is the loss of the leader. Bizarre though it may seem, given the sharpness of the needles, slugs and snails are very fond of the new growth and have frequently been observed to browse off the tip of the leading shoot. This effect was first noticed at Ardkinglas Woodland Garden in Argyll (P. Thomas, M. Gardner, pers. comms. 2011, though this is an oft-heard story). Frost can also kill the leader, especially early in the winter when the autumnal growth flush has yet to harden. Philip Thomas (pers. comm. 2011) has observed that there are two distinct growth phases in the UK – one in May/June and another in October/November and it is at these times that it is most susceptible to both frost and slug damage. Between December and March even young shoots can tolerate -15°C if the growth is sufficiently hardened off (P. Thomas, pers. comm. 2011). Trees with damaged tips usually reform a leader and recover, but it can take some years before apical dominance is restored.

At present, the juvenile 'cryptomerioid' phase is that best known to most dendrologists, as the mature 'sequoiadendroid' phase has as yet seldom been attained in cultivation, though it is to be hoped that one day the current youngsters will achieve their magnificent adult potential. A healthy, vigorous

young *Taiwania* is a most attractive sight, with the pendulous growth forming swags of shoots falling from the pendulous branches to form a beautiful, if vicious, jade curtain. It is not a tree for caressing. When doing well it forms a shapely narrow spire, but some of the older specimens in the British Isles that were damaged by frost in their youth are gaunt and misshapen with little to commend them as ornamentals. Unless the lower branches are deliberately removed they are retained for many years, forming a skirt to the ground (T. Christian, pers. comm. 2011), though with age the stems become clean of branches to a great height. The leaves do reduce in size with age, however, changing from the long, green needles of the seedling and first few years of growth to stouter more curved structures that aren't quite so sharp and more glaucous.

The colour of the leaves varies somewhat, both genetically and from the tree's situation: Tony Kirkham (pers. comm. 2011) notes that specimens in sun are more glaucous than those in shade, which appear plainer green, and older, persistent leaves lose the stomatal wax and therefore look dull green. Even so, some individuals are bluer than others: a tree planted by the late Edward Needham in Cornwall is exceptional in this, while others are more distinctly green.

Taiwania around the world

In the past 100 years *Taiwania cryptomerioides* is now cultivated widely around the world, starting perhaps with one planted by Hayata himself at the headquarters of the Experimental Forest of the Taiwan National University at Chitou, Taiwan, between 1905 and 1910, where it was photographed by Ernest Wilson in 1918 (see pp. 42-43). It is now described by Ohashi (2009) as a 'huge tree' and his illustration shows a shapely narrow specimen, apparently in adult foliage.

Europe

As recounted above, early plantings in Britain and Ireland seldom resulted in good specimens, although some have eventually 'got going' and are now making good growth, perhaps in response to recent climatic change. This includes the tree at Batsford Arboretum, mentioned at the beginning of this article, now standing about 12m tall with a trunk of 32cm dbh. The evidence is now clear that 'the books' need rewriting, as *Taiwania* is proving much hardier than previously believed. Krüssmann (1985) states it to be hardy only to the USDA Hardiness Zone 9 (i.e. with winter minima -6.6 to -1.2°C), but as reported by Bernard de la Rochefoucauld (pers. comm. 2010), in whose Arboretum des Grandes Bruyères in the Orléans forest, about 70 miles south of Paris, it grows very well despite annual winter minima of -10-17°C (between USDA Hardiness Zones 6 and 7) and hot summers. A specimen grown from Taiwanese seed and planted in 1998 is now an elegant 5m tree there.

Specimens of *Taiwania* planted in Belgium and reported-on by its observant

(and communicative!) dendrologists seem to confirm the view that good establishment is essential for success. Charles Snyers planted two specimens at Arboretum Lenoir, Rendeux, in 1952, but both were killed in the winter of 1956. Christa Maes at Hof ter Saksen has a 29 year old specimen, currently 4.37m tall, but it lost its top in 2000 and is not a happy plant. Much more successful so far are trees at the University of Ghent Botanical Garden, where a specimen has grown well since 2005 (P. Goetghebeur, pers. comm. 2011), grown from seed from Tayuling, Taiwan, supplied by the Taiwan Forestry Research Institute, and a group of trees at the National Botanical Garden, Meisen, sown in 1998 and planted out between 2004 and 2007. Of these the tallest is 5m (40cm girth), but Dirk De Meyere (pers. comm. 2011) indicates that trees planted out with damaged leaders have remained comparatively low, while those with good leaders have grown vigorously. There are also several specimens at Arboretum Bokrijk grown from wild-origin seed supplied by the Taiwan Forestry Research Institute but collected at the upper end of the species' altitudinal range in Taiwan, at about 2400m at Taanchi and 2200m at Tahsuehshan. Such high altitude provenances are important for hardiness, in the view of Jef Van Meulder, who also comments that *Taiwania* thrives in drier conditions than tolerated by *Cryptomeria* in Belgium: the Bokrijk plants grow in a sandy-peaty soil with pH4. One from Taanchi sown in 1980 is now 6.5m tall (67cm circumference), while a group of 20, grown from seed from Tahsuehshan sown in 1991, averages 4m and 40cm girth (J. Van Meulder, pers. comm. 2011). A particularly fine 9m (37cm circumference) specimen planted in 1992 from a commercial source grows at Arboretum Wespelaar, sheltered by *Pinus nigra* (K. Camelbeke, pers. comm. 2011). Several Belgian specimens suffered damage to their growing points in the winter of 2009-10, but recovered in the following season.

The warmer parts of Europe can be expected to grow *Taiwania* better, so long as there is sufficient moisture. The Lakes region of southern Switzerland and northern Italy would seem to be ideal, and this seems to be the case. Michael Frankis (pers. comm. 2011) reports that a tree in the gardens of Eisenhut Nursery, between San Nazzaro and Piazzogna, Locarno, Switzerland, at 320m asl, was 18 to 20m tall and had produced female cones in 2008 and 2009, when he saw it; a similarly-sized tree, but not yet fertile, grows in the Isola di Brissago gardens, in the Swiss part of Lago Maggiore, at 200m asl.

In the assumption of tenderness, specimens have frequently been grown under glass in Europe, but this tends to encourage sparseness of growth and they are seldom attractive plants. Where climatic conditions preclude outdoor cultivation, however, protection is essential. Space and good light are required, but the reward at the Botanical Garden of the Heinrich-Heine-University of Düsseldorf in 2006 was the production of the first female cones on any *Taiwania* grown in Europe (Jagel & Knopf 2007). The tree is 15m tall and 35 years old and is grown in a large dome-shaped glasshouse; its upper

A specimen of *ETE 279*, flourishing at Tregothnan, Cornwall.

growth has completed the transition to mature, scale-like foliage, again a rarity anywhere in cultivation. Elsewhere in Germany, young plants at the Arboretum Freiburg-Günterstal have done well, surviving the winters but some have experienced damage from wet snow. The tallest specimen there is 8m and doing very well, under a light canopy of tall old trees (Hubertus Nimsch 2008).

Young plants were killed by spring frosts in their first year outside in the nursery at the Norwegian Arboretum at Milde, Norway (P. Salvesen, pers. comm. via A. Rieber 2010).

photograph © Danny Frazer

A semi-mature tree of *Taiwania* (CR0222, planted 1952, now 25m) at Eastwoodhill Arboretum.

North America

In North America *Taiwania* thrives in two areas,the Pacific coast from British Columbia to California, and in the south-eastern United States. On the east coast, despite many attempts to grow it in e.g. Philadelphia, *Taiwania* is not successful north of Washington DC (A. Aiello, pers. comm. 2011): the two cities are only 140 miles apart, but between them is the transition between USDA Hardiness Zones 6 and 7, a sort of horticultural Mason-Dixon Line. Just south of it, at the United States National Arboretum in Washington DC, several plants of *Taiwania* are currently thriving, although earlier plantings did not

succeed. The oldest, received from Taiwan in 1975, is now 10m (25cm dbh), but the best grows in the Asian Valley and has a nice skirt of growth to the ground that is about 5m wide. This tree is about 14m (50cm dbh) and was a seedling received from the Taiwan Forestry Research Institute in 1980 (R. Olsen, pers. comm. 2011).

There are specimens of *Taiwania* in many arboreta and gardens of the southeastern United States, including the JC Raulston Arboretum, Raleigh, North Carolina, where the largest tree is currently about 13m (31cm dbh) (M. Weathington, pers. comm. 2011). As already noted, J. C. Raulston was instrumental in distributing *Taiwania* to growers throughout the United States, and a tree known at Atlanta Botanical Garden, Georgia, as *T. flousiana*, came from him in 1995. Planted in shade it is drawn up and somewhat spindly, but currently about 10m tall; propagations from it grown elsewhere in Georgia have made nice shapely trees (J. Blackburn, pers. comm. 2011). There are good trees of *T. cryptomerioides* at Atlanta, however, the nicest being about 6m tall despite having been planted only in 2006. The phenomenal growth-rate of 1m per year at the Cox Arboretum in Georgia has been noted above. Here a 'particularly graceful' specimen of Taiwanese provenance came from the Morris Arboretum in 2000 and is currently 15m tall (T. Cox, pers. comm. 2011). Tom Cox notes that its only demerit is the habit of turning a slightly yellowish green in winter, but revives its colour in spring.

The finest specimens noted in the eastern United States by correspondents grow at the Dodd & Dodd Native Nursery, Semmes, Alabama. Richard Olsen (pers. comm. 2011) recalls that the trees here are 'pushing 20m', but it has not been possible to obtain detailed information for this article.

There are good specimens of *Taiwania* in arboreta on the west coast too, including those mentioned above in Seattle. The most attractive specimen I've ever seen (and Tom Cox agrees) grows in the garden at Bishop's Close, Portland, Oregon, and has a perfect shape, with layers of overlapping branches to the ground, their upturned tips giving it great elegance. It was planted in about 1980 (S. Hogan, pers.comm. 2011). There are specimens at Quarryhill and the San Francisco Botanical Garden (Strybing Arboretum), and a large tree from Hubei accessioned in 1959 grows at the University of California Botanical Garden in Berkeley (P. Licht, pers comm. 2011).

There are ten specimens of wild Taiwanese origin at the University of British Columbia Botanical Garden in Vancouver, planted in 1982 (from Hsuiluan) and 1990 (from Tachien, at 2200m). The first group receive some irrigation, the others nothing, but in general they have done well, some forming very attractive, elegant specimens. The tallest of the 1982 group is 11.6m (42cm dbh). However, Wharton et al. (2005) note that trees in exposed, sunny positions have grown more bushily and more slowly than those in light shade, and some are 'chronically sunburned in the open'; these have since been removed (D. Justice, pers. comm. 2011). None have shown frost damage

in more than 20 years (Justice 2007). There was a possible sighting of male cones in 2006 (Justice 2007). So far as is known, no specimens in North America have achieved maturity as yet. In a note appended to Douglas Justice's online article, Daniel Mosquin of the UBCBG mentions that the sap of *Taiwania* is allergenic, and that care should be taken when pruning. Trees in the Pacific Northwest receive most of their moisture in winter, and unless summer irrigation is provided, have to cope with long periods of low moisture, but this does not seem to bother them unduly (Wharton *et al*. 2005).

Australasia

The possible introduction of *Taiwania* to Australia by Ernest Wilson himself has been discussed above. The fine tree at Mount Dandenong Arboretum demonstrates its potential, and this is replicated by other good specimens elsewhere, especially at higher, cooler altitudes in Tasmania, Victoria and New South Wales (E. Hsu, pers. comm. 2011). A tree at the Royal Botanic Gardens Melbourne, of unknown provenance and planting date, is 12m (70cm dbh), and has been producing both male and female cones for some years, and although not a large specimen is considered to be stately and impressive in the landscape (J. Shugg, pers. comm. 2011). Four smaller, similarly-sized specimens of both Taiwanese (accessioned 1983) and mainland provenance (from John Silba in 1980, as mentioned above) grow at Mount Lofty Botanic Garden, Adelaide, South Australia, but none is more than 5.5m tall (N. Fidler, S. Kingdon, J. Sandham, pers. comms. 2011). At the Blue Mountains Botanic Garden, Mount Tomah, NSW, there are three fine trees of approximately 20m in height, grown from seed received from Hengchun Tropical Botanic Garden, Taiwan, in 1974 and planted in their current locations in 1985 (M. Murray, pers. comm. 2011). In Mount Tomah itself a tree of the same provenance and of similar size grows in the garden of the Australian horticulturist Tony Rodd and has borne male cones, with images indicating that the foliage is transitional from juvenile to mature phase (Flickr: Tony Rodd's photostream 2009). This tree is now 20-21m (45-50cm dbh), despite having been transplanted in 1984 when a vigorously growing youngster of about 3m (T. Rodd, pers. comm. 2011).

The growth rate of *Taiwania* in Australasia is often remarkable. A tree planted in 1996 at the Australian Bicentennial Arboretum at Jamberoo, New South Wales, is now 11.1m (17.5cm dbh) (C. Callaghan, pers. comm. 2011).

Although it generally does well there, *Taiwania* is sparsely cultivated in New Zealand**,** only being represented by specimens in a few collections (D. Frazer, pers. comm. 2011), but it is at least occasionally commercially available there (Cedar Lodge Nursery 2011). It was imported to Eastwoodhill Arboretum, the National Arboretum of New Zealand, by its founder, William Douglas Cook from Hillier & Sons in 1947 and 1955 (C. Callaghan, D. Frazer, pers. comms. 2011). Trees from this era have performed variably: one from 1947 has been suppressed by other trees and is only 5m tall, but one planted

photograph © Tony Kirkham

A mature tree of *Taiwania cryptomerioides*, c. 2000m, Chilan Shan, Taiwan.

in 1952 has made a very handsome specimen, now 25m (89cm dbh) (see p. 51). It appears to be in the process of converting to adult growth, with the branches becoming upright and with tightly foliaged shoots at their tips, but it has not yet become fertile. More recent plantings have also been made at Eastwoodhill and although one shows signs of frost damage two others are doing well (D. Frazer, pers. comm. 2011). Graham Dyer (pers. comm. 2010) has reported on trees grown from seed received in 1975 from the Forestry Department in Taiwan to be planted at McLarens Falls Park, Tauranga, New Zealand. Although their height was not stated, the two trees at McLarens Falls Park have girths of 2.9m (92cm dbh) and 2.6m respectively, while one on the Dyers' own property is 22.5m and 2.84m in girth. The site is 129m a.s.l with good rainfall.

Acknowledgements
Many people have generously contributed information and assistance for this article, for which I am greatly indebted and I thank them all. They are: Anthony Aiello, Morris Arboretum, Philadelphia, USA; Graham Alcorn, Mount Stuart, Bute, Scotland; John Anderson, Exbury,

England, Hampshire; Susyn Andrews, Kew, England; James Blackburn, Atlanta Botanical Garden, Georgia; Chris Callaghan, Australian Bicentennial Arboretum; Koen Camelbeke, Arboretum Wespelaar, Belgium; Tom Christian, Royal Botanic Garden Edinburgh, Scotland; Tom Cox, Cox Arboretum, Georgia, USA; Jan De Langhe, Eeklo, Belgium; Dirk De Meyere, National Botanical Garden, Belgium; Michel Decalut, Arboretum Waasland, Belgium; Bernard de la Rochefoucauld, Arboretum des Grandes Bruyères, France; Graham Dyer, Tauranga, New Zealand; Nicky Fidler, Stephen Kingdon, John Sandham, Botanic Gardens of Adelaide, Australia; Mary Forrest, University College Dublin, Ireland; Maurice Foster, Kent, England; Danny Frazer, Eastwoodhill Arboretum, New Zealand; Martin Gardner, Royal Botanic Garden Edinburgh, Scotland; Paul Goetghebeur, University of Ghent Botanical Garden, Belgium; Michael Hickson, Devon, England; Randall Hitchin, University of Washington Botanic Gardens, Seattle, USA; Sean Hogan, Portland, Oregon, USA; Eric Hsu, Maryland, USA; Douglas Justice, University of British Columbia Botanical Garden, Canada; Tony Kirkham, Royal Botanic Gardens, Kew; Patrick Knopf, Botanical Garden, Heinrich-Heine-University, Düsseldorf, Germany; Mark Krause, Dandenong Ranges Gardens, Australia; Holly Forbes & Paul Licht, University of California Botanical Garden, Berkeley, USA; Dan Luscombe, Bedgebury Pinetum, England; Christa Maes, Hof ter Saksen, Belgium; Mat Murray, Blue Mountains Botanical Garden, NSW, Australia; Hiroyoshi Ohashi, Botanical Garden, Tohoku University, Japan; Richard Olsen, United States National Arboretum, Washington DC; Anne Rieber, Bergen, Norway; Tony Rodd, Sydney, Australia; Jim Shugg, Royal Botanic Gardens Melbourne, Australia; Charles Snyers d'Attenhoven, Bruxelles, Belgium; Philip Thomas, Royal Botanic Garden Edinburgh, Scotland; Jef Van Meulder, Arboretum Bokrijk, Belgium; Mark Weathington, JC Raulston Arboretum, North Carolina, USA and the librarians of the RHS Lindley Library.

References

Andrews, S. (2010). Tree of the Year: *Trochodendron aralioides*. *IDS Yearbook 2009*: 28-48.

Aniśko, T. (2006). *Plant Exploration for Longwood Gardens*. Portland, Oregon: Timber Press.

Bartholomew, B., Bouford, D.E., Spongberg, S. (1983). *Metasequoia glyptostroboides*: its present status in Central China. *Journal of the Arnold Arboretum* 64: 105-128.

Bean, W. J. (1920). New and noteworthy plants: The Formosan Redwood, *Taiwania cryptomerioides* Hayata. *Gardeners' Chronicle* ser. 3, 68: 213.

Briggs, R. W. (1993). *'Chinese' Wilson*. London: HMSO.

Callaghan, C. (2008). Mount Fansipan, northern Vietnam. *IDS Yearbook 2007*: 162-169

Cedar Lodge Nursery (2011). Online conifer catalogue. At <http://www.conifers.co.nz/conifer_lists.htm> (accessed 23 April 2011).

Chang, S-T., Chen P-F., Wang, S-Y., Wu, H-H. (2001). Antimite activity of essential oils and their constituents from *Taiwania cryptomerioides*. *Journal of Medical Entomology* 38: 455-457.

Chang, J. L. (2005). The genetic diversity of *Taiwania cryptomerioides* Hayata. Master degree thesis. Taiwan: National Sun Yat-sen University.

China National Tree Seed Corporation (2011). Price list. At <http://www.chinaseeds.com/searchin.asp?letter=t> (accessed 10 April 2010).

Chou, Y-W., Thomas, P. & Wang, C-N. (2008). The phylogeography of *Taiwania cryptomerioides*, a living fossil remains in Taiwan, China and Vietnam. Abstract at: <http://2008.botanyconference.org:80/engine/search/index.php?func=detail&aid=322>(accessed 26 April 2011).

Dirr, M. A. (2009). *Manual of Woody Landscape Plants*. Champaign, Illinois: Stipes Publishing LLC.

Elwes, H. J. (1935). *Memoirs of travel, sport and natural history*. (Posthumously edited by E. G. Hawke.) London: Ernest Benn Ltd.

Farjon, A. (2005). *A monograph of Cupressaceae and Sciadopitys*. Kew: Royal Botanic Gardens.

Farjon, A. (2008). *A natural history of conifers*. Portland: Timber Press.

Farjon, A. (2010). A *handbook of the world's conifers*. Vol. II. Leiden/Boston: Brill.

Farjon, A. & Ortiz Garcia, S. (2003). Cone and ovule development in *Cunninghamia* and *Taiwania* (Cupressaceae sensu lato) and its significance for conifer evolution. *American*

Journal of Botany 90: 8-16.
Farjon, A. & Thomas, P. (2007) *Taiwania cryptomerioides* - an overview: Biogeography and conservation. In: The International Symposium on *Taiwania cryptomerioides*, 8-10 December 2007, Nantou County, Taiwan. Taiwan: Experimental Forest, College of Bioresources and Agriculture, National Taiwan University, pp. 9-17.
Fitzpatrick, H. M. (1933). The trees of Ireland - native and introduced. *Scientific Proceedings, Royal Dublin Society* 20: 597-656.
Flanagan, M. & Kirkham, T. (2005). *Plants from the Edge of the World*. Portland, Oregon: Timber Press.
Flickr: Tony Rodd's photostream (2009). Images and notes on *Taiwania cryptomerioides*. At <http://www.flickr.com/photos/tony_rodd/with/3845348958/> (accessed 12 April 2011).
Fordham, A. J. & Spraker, L. J. (1977). Propagation manual of selected gymnosperms. *Arnoldia* 37: 1-88.
Fu, L.-K., Yu, Y., Adams, R. P. & Farjon, A. (1999e). Cupressaceae. In: Z.-Y. Wu & P. H. Raven (eds), *Flora of China: Cycadaceae through Fagaceae*, vol. 4, pp. 62-77. Beijing/St Louis: Science Press/Missouri Botanical Gardens Press.
Fu, L-K. & Jin, J. M. (eds) (1992). *China Plant Red Data Book. Rare and endangered plants.* Vol 1. Beijing, New York: Science Press.
Gadek, P. A., Alpers, D. L., Heslewood, M. M. & Quinn, C. L. (2000). Relationships within Cupressaceae sensu lato: A combined morphological and molecular approach. *American Journal of Botany* 87: 1044-1057.
Grove, A. (1938). *Taiwania*. *New Flora and Silva* 10 (3): 191-193.
Harvard University (2011). Harvard University Library. Visual Information Access. At <http://via.lib.harvard.edu/via/deliver/advancedsearch?_collection=via Accessed 30 March 2011>. [search for *Taiwania*] (accessed 26 April 2011).
Hayata, B. (1906). On *Taiwania*, a new genus of Coniferae from the island of Formosa. *Journal of the Linnean Society (Botany)* 37: 330-331.
Hayata, B. (1907). On *Taiwania* and its affinity to other genera. *Botanical Magazine (Tokyo)* 21: 21-28.
Hayata, B. (1932). The Taxodiaceae should be divided into several distinct families, i.e., Limnopityaceae, Cryptomeriaceae, Taiwaniaceae and Cunninghamiaceae; and further *Tetraclinis* should represent a distinct family, the Tetracliniaceae. Botanical *Magazine (Tokyo)* 46: 24-27.
He, K., Zeng, L., Shi, G., Zhao, G. X., Kozlowski, J. F., McLaughlin, J. L. (1997). Bioactive compounds from *Taiwania cryptomerioides*. *Journal of Natural Products* 60: 38-40.
Hillier, J. & Coombes, A. J. (2002). *The Hillier Manual of Trees and Shrubs*. Newton Abbot, Devon: David & Charles.
Hu, H-H. (1950). *Taiwania*, the monarch of Chinese conifers. *Journal of the New York Botanical Garden* 51: 63-67.
Hu, Y. S., Lin, J. X., Wang, X. P. & Wei, L. B. (1995): The biology and conservation of *Taiwania cryptomerioides*. *Chinese Biodiversity* 3: 206–212.
Hubertus Nimsch (2008). Beiträge zu Koniferen weltweit. At <www.hubertus-nimsch.de/pages/beitraege_taiwania.htm> (accessed 10 April 2011).
IUCN (2010). IUCN Red List of Threatened Species. Version 2010.4. At <www.iucnredlist.org> (accessed 9 April 2011).
Jacobson, A. L. (1996). *North American Landscape Trees*. Berkeley, California: Ten Speed Press.
Johnson, O. (2003). *Champion Trees of Britain and Ireland*. Stowmarket, Suffolk: The Tree Register of the British Isles & Whittet Books.
Justice, D. (2007). Botany Photo of the Day: *Taiwania cryptomerioides*. At <http://www.ubcbotanicalgarden.org:80/potd/2007/12/taiwania_cryptomerioides.php> (accessed 11 April 2011).
Kanehira, R. 1936. *Formosan Trees indigenous to the island. Revised.* Department of Forestry, Government Research Institute, Taihoku, Formosa.
Kermode, C. W. D. (1939). A note on the occurrence of Taiwania cryptomerioides in Burma

and its utilisation for coffin boards in China. *Indian Forester* 65: 204-205.
Kingdon-Ward, F. (1960). *Pilgrimage for Plants*. London: George G. Harrap & Co. Ltd.
Krüssmann, G. (1985b). *Manual of cultivated conifers*. Portland, Oregon: Timber Press.
LePage, B. A. (2009). Earliest occurrence of *Taiwania* (Cupressaceae) from the early Cretaceous of Alaska:Evolution, biogeography, and paleoecology. *Proceedings of the Academy of Natural Sciences of Philadelphia* 158: 129-158
Li, H-L. (1963). *Woody Flora of Taiwan*. Narberth, Pennsylvania: Livingston Publishing Company.
Li, Z-C., Wang, X-L. & Ge, X-J. (2008). Genetic diversity of the relict plant *Taiwania cryptomerioides* Hayata (Cupressaceae) in mainland China. *Silvae Genetica* 57: 242-249.
Luu, N. D. T. & Thomas, P. I. (2004). *Cay La Kim Vietnam / Conifers of Vietnam*. Hanoi: Nha Xuat Ban The Gioi/Darwin Initiative.
Magin, G. (2006). Putting threatened trees centre stage. *IDS Yearbook 2005*: 35-38.
Marinelli, J. (2004). *Plant*. London: Dorling Kindersley.
McNamara, W. (2007). Three conifers south of the Yangtze. At <http://www.quarryhillbg.org/page16.html> (accessed 12 April 2011).
Mitchell, A. F. (1972). *Conifers in the British Isles*. London: HMSO.
Nicholson, R. (2004). A good day: plant-collecting in Taiwan. *Arnoldia* 63: 21-27.
Ohashi, H. (2009). Bunzo Hayata and his contributions to the Flora of Taiwan. *Taiwania* 54: 1-27.
Ohashi, H. & Ohashi, K. (2008). Lectotypification of *Taiwania cryptomerioides* Hayata (Cupressaaceae). *Journal of Japanese Botany* 83:177-184.
Osborn, A. (1933). *Trees and shrubs for the garden*. London: Ward, Lock & Co.
Page, C. N. (1979). The earliest known find of living *Taiwania* (Taxodiaceae). *Kew Bulletin* 34: 527-528.
TROBI (2011). Tree Register of the British Isles, records for *Taiwania*. Available for members at < http://www.treeregister.org/>. (accessed 26 April 2011).
Raulston, J. C. (1991). Plants distributed to NCAN nurserymen. First published in *Friends of the NCSU Arboretum Newsletter* 22, August 1991. Reprinted in *The Chronicles of the NCSU Arboretum* (1993), pp 359-367. Privately published by J. C. Raulston.
Stockey, R. A., Kvaček, J., Hill, R. S., Rothwell, G. W. & Kvaček, Z. (2005). The fossil record of Cupressaceae *s. lat*. pp 54-68 in Farjon, A. *A monograph of Cupressaceae and Sciadopitys*. Kew: Royal Botanic Gardens.
Victorian Heritage Database (2011). *Taiwania cryptomerioides*. At <http://vhd.heritage.vic.gov.au:80/search/nattrust_result_detail/71298> (accessed 10 April 2011).
Wang, M-H, Chen, J-X., Xie, J-L., Liang, S-Y, Huang, Y-M. & Liang S-W. (2009). Open pollination progeny test for superior tree of *Taiwania flousiana*. *Journal of South China Agricultural University* 30: 60-63 68.
Wharton, P., Hine, B. & Justice, D. (2005). *The Jade Garden*. Portland, Oregon: Timber Press.
Wikipedia (2011). Taiwan. At <http://en.wikipedia.org/wiki/Taiwan> (accessed 25 March 2011).
Wilson E. H. (1922). A phytogeographical sketch of the ligneous flora of Formosa. *Journal of the Arnold Arboretum* 2: 25-41.
Wilson E. H. (1926). The taxads and conifers of Yunnan. *Journal of the Arnold Arboretum* 7: 37-68.
Winstanley (1996). *A Botanical Pioneer in South West China*. Translation of H. Handel-Mazzetti, *Naturbilder aus Südwest China* (1927). Privately published.

Tree of the Year 2011

Next year's Tree of the Year will be 'Asian species of *Catalpa*'. Please send your comments, photographs and any other information to John Grimshaw, Sycamore Cottage, Colesbourne, Cheltenham, Gloucestershire, GL53 9NP, but preferably by email to: j.grimshaw@virgin.net.