Cryptomeria japonica (Thunb. ex L.f.) D.Don Japanese red cedar, or Sugi

Silviculture and properties

The second in a series of articles by **Peter Savill** examining individual tree species in detail.

Japanese red cedar (or Japanese incense cedar, according to Ramsay and Macdonald (2013) or peacock pine (Edlin, 1981)) is one of several species being considered as an alternative plantation tree to various more commonly used species if climate change proceeds as predicted, or introduced diseases become more common. Other species are listed in the 'SilviFuture' database (http://www.silvifuture.org.uk/database). *Cryptomeria* is already being used to some extent by the Forestry Commission in England and Scotland and Natural Resources Wales, as well as some by private estates. Earlier accounts of the species were given by Wilson (2010) and Savill (2013).

This tree, in the *Cupressaceae*, is an endemic giant Japanese conifer related to the two sequoias of North America as well as to *Taxodium distichum* (swamp cypress) (Farjon, 2010). According to Farjon (2012), there is one species with two varieties (*Cryptomeria japonica* var. japonica, and *Cryptomeria japonica* var. sinensis Miquel in Siebold & Zuccarini). The Chinese variety is sometimes referred to as *C. fortunei*. They are distinguished by range and by the morphological differences detailed in the box below. Var. japonica is native only to Japan, where it occurs naturally in pure and mixed stands.

Dallimore and Jackson (1948) describe *Cryptomeria* as a very variable tree with a clean tapering, trunk rising above well-defined buttresses. Farjon (2012) says that the trees are monoecious, evergreen, up to 50 to 65m tall and up to 300cm in diameter, with a conical crown and a characteristically straight, slender trunk (Figures 1 and 3-6). The bark is reddish brown to dark gray, fibrous, peeling off in long shreds (Figure 1). Branches are whorled, horizontally spreading or slightly pendulous; branchlets are usually pendulous, those of the first year green and glabrous. Winter buds are small. Cones are brownish, globular, and solitary 1.5 to 2cm in diameter (Figure 2). A peculiarity of the species is that the growing shoot is sometimes prolonged from the apex of the cone due to abnormal development of dormant buds. The 0.5 to 1.5cm long leaves are spirally arranged.

Key to the varieties (Fu et al., 1999, from Farjon, 2012)

1a.	Leaves ± straight at least in proximal 1/2, often recurved apically on leader branchlets, arising at 35-45° to axis on leader branchlets, 45-55° on fertile branchlets, rigid and hard; most pollen cones longer than their subtending leaf; cone scales 20-30, each bearing 2-5 seeds; distal projections of bracts and cone scales 2-3.5mm.	1a. var. japonica
1b.	Leaves usually strongly incurved throughout, arising at 15-30° to axis on leader branchlets, 30-40° on fertile branchlets, rigid but relatively soft; most pollen cones shorter than their subtending leaf; cone scales ca. 20, each bearing 2 seeds; distal projections of bracts and cone scales 1-2mm.	1b var sinensis

Species Profile

Origin and introduction

Japanese red cedar (var. japonica), or sugi as it is known in Japan, is indigenous only to the central and southern islands of Japan, from Kyushu to northern Honshu, at elevations up to 400m. It occurs naturally in pure and mixed stands (Vidakovic, 1991). It has also been very widely planted in Japan since World War II. The variety has also been introduced for forestry to Taiwan and many provinces of mainland China. Var. sinensis is native to China: Fujian, Jiangxi, Sichuan, Yunnan, and N.W. Zhejiang, and has also been introduced for forestry in other provinces of China. In natural conditions it grows in forests on deep, well-drained soils subject to warm, moist conditions at elevations from below 1100m to 2500m. Typical associated trees in Japan are *Fagus crenata*, *Thujopsis dolabrata*, *Fagus japonica*, *Abies firma* and *Zelkova serrata* (Röhrig and Ulrich, 1991). It also grows with a variety of shrubs, including *Acuba*, *Skimmia*, and *Hydrange*, and also tall herbs, including *Spirea* (Elwes and Henry, 1906-13)

Wilson (2010) notes that it was a regular inclusion in early 20th century forest gardens in Britain. It has apparently performed conspicuously well at locations across the country, including the Crarae and Kilmun forest gardens in Argyll, where it is among the most impressive species although typically unthinned. Rather larger-scale trial plantings took place from 1930 to 1965 in Argyll, Wales, Cornwall and southern England. Most of the limited experience with the species in Britain has been with the Japanese provenance. The species was originally introduced in 1842 from China and the Japanese provenance was introduced in 1861. Troup (1921) noted that *Cryptomeria* was an important species in British India, especially in plantations around some warmer hill stations such as Darjeeling, Sikkim and Ootakamund in the Nilgiri Hills in the south, at elevations of 1200-1800m. It grows much faster than the indigenous *Pinus kesiya*. Timber was used, among other things, for cutting into thin section boards for tea chests (Gamble, 1902).

Climatic requirements

Var. japonica comes from a warm maritime climate and, according to Forest Research (2011), the best growth in Britain is to be found in areas with more than 1200mm of annual rainfall but which are sheltered and where the summers are warm. It is described by Ray et al. (2010) as "moderately drought tolerant". There seems, in fact, to be no clear drought limit since it grows reasonably well on the Isle of Wight, and in Alice Holt Forest with 600-800mm rainfall. The tree does not stand exposure well, especially in spring and exposed sites should be avoided. The need for warmth means that the best stands are in Wales and south-west England, but it also does well in Wester Ross and Argyll, where it can be a very high-volume producer. Var. sinensis is scarcer than the Japanese variety, but it is thought by some to be better adapted to cool regions.

Site requirements

These are not exacting according to Macdonald et al. (1957). Japanese red cedar grows best on deep, well-drained loams in elevated but reasonably sheltered situations. In windy locations it is prone to foliage scorch and crown fraying, which slow growth. It is not suited to very infertile or dry soils, to peats or to calcareous soils. Heathery sites should be avoided.

Figure 1. Tree at Alice Holt, Hants showing straight trunk, reddish brown bark, which is fibrous and peels off in long shreds. (Photo: Dr Scott Wilson)

Figure 2. Leaves and cones of Cryptomeria. (Photo: © Crown Copyright Forestry Commission)

Other silvicultural characteristics

On good sites in Britain the tree will grow to over 30m tall. In Japan, where it is the national tree, it is renowned for growing to great ages (well over 1000 years) and for the very high-quality timber it produces. In Japan the tree is currently grown on a 40 to 60 years rotation in plantations, though if large diameter timber is required, it is extended to 80 to 100 years.

Japanese red cedar is sufficiently shade-tolerant to be of probable use in continuous cover systems (Hemery and Simblet, 2014). Though there are very few mixed species stands in Britain it may do well with western red cedar, western hemlock and Douglas fir on sites where selective thinning is feasible. As with many such species, pruning is an important component of a management regime to reduce knots, maintain evenly spaced annual rings and to reduce stem taper. In Japan, according to FAO Japan (1997), pruning should start when the dbh is 6-7cm. By contrast, Macdonald et al. (1957) note that the tree self-prunes well, in a similar way to the larches. Unusually for a conifer, it coppices well and also produces root suckers. In Japan the species is planted at densities that are similar to those used in Britain: 2,500 to 4,000 per ha, and on most sites it is weeded once or twice a year for the first 5-6 years after planting. According to Elwes and Henry (1906-13) fast growing plantations are pruned from their 8th to 23rd year, and the earliest thinning begins is at age 12.

Natural regeneration

Macdonald et al. (1957) mention that sporadic natural regeneration has been recorded, and since then it has become prolific in some Scottish stands. However, Elwes records that during his visit to Japan, a careful search did not reveal a single self-sown seedling. All young trees originated from suckers or coppice shoots (Elwes and Henry, 1906-13).

Diseases and Pests

Japanese red cedar is susceptible to *Phytophthora* root disease, including *Phytophthora cinnamomi*. It is also considered to be susceptible to *Armillaria* root rot (honey fungus). Elsewhere, it has been reported to be affected by Juniper blight (*Phomopsis juniperovora*), which is present in Britain and already widespread on juniper (SilviFuture, 2014). Ohba (1993) states that 'strecklings' (rooted cuttings) are apparently free from needle blight (*Cercospora sequoia*) that afflicts trees grown from seed.

Flowering, seed production and nursery conditions

Seeds ripen in September and October during the year of flowering. They should be sown early in spring after stratification (chilling) for 2-3 weeks at 4°C. However, both British-collected and imported seed is reputed to have a very poor germination rate, averaging 12%. There are said to be about 60,000 seeds that will germinate per kg. Collections from small British stands may suffer from inbreeding depression due to a narrow genetic base. According to Macdonald et al. (1957) *Cryptomeria* can be raised in the nursery by standard techniques for cedars, though it is slightly prone to damage by autumn frosts.

Japanese red cedar is easy to propagate from unrooted cuttings but is most commonly propagated from 'strecklings'. According to Ohba (1993) there is an average

57% strike rate with strecklings. In S.W. Japan more than 200 clonal cultivars have been selected, each suitable for a variety of local conditions. In fact, this species possibly has the longest history of clonal propagation of any tree. There are records of planting rooted cuttings around Kyoto from about 1400 (Ohba, 1993). The attractions of clonal forestry are that both yield and wood quality are predictable. Kimura et al. (2013) believe that vegetative propagation by, for example natural layering, may be an important evolutionary strategy for establishment in harsh environments, such as frequent disturbances by heavy snow. This tends to happen above 1750m. (Taira et al.,1997).

Cryptomeria pollen causes allergic conjunctivitis to humans and to dogs in both spring and autumn (Fujishima et al., 1995).

Provenance

Virtually no provenance testing has been carried out in Britain. Forest Research (2011) recommends that seed should be sourced from the northern part of the natural range within Japan. It is imperative to avoid garden cultivars which produce natural topiary-like forms.

Figure 3. Stand at Brechfa, Wales. (Photo: Dr Scott Wilson)

Figure 4. Crarae, Argyll showing typically rather clean stems. (Photo: Dr Scott Wilson)

Timber and uses

In Japan sugi and hinoki (*Chamaecyparis obtusa*) are the most economically important timber species and, of the two, *Cryptomeria* is the most generally useful and popular tree. It has been planted there from time immemorial. According to Japan FAO (1997) it is the most common plantation conifer, constituting 44%, or 4.54 million ha, of the total area of Japanese man-made forests. In terms of current planting, hinoki is more important.

Cryptomeria is described by Edlin et al. (1981) as "one of the great timber trees". The wood is strongly rot resistant, has a natural lustrous gloss and is easily worked. It has long been valued for the beauty of both the tree and wood and is widely planted around temples. It was used for making barrels and casks and was said to have revolutionized the brewing and market of saké (rice wine). The wood imparted a peculiarly pleasant aroma to the saké. Outside China and Japan it is very extensively cultivated as an ornamental in warm and cool temperate climates.

The timber is strong and very durable and has been used in Japan and China for construction purposes for centuries. There is very little experience of processing British home-grown material and attempts are being made to get thinnings from the various older stands tested in the laboratory to assess its timber properties. Most material is probably processed along with that of western red cedar and Lawson's cypress without noticing. Peter Quelch has sawn Argyll (Knapdale) material for garden uses and has commented upon its impressive natural durability. It is rather soft and coarse-grained but is easily worked and is used for buildings, bridges, ships, lamp posts, furniture, utensils and paper manufacture (Farjon, 2012; Fu et al., 1999). The

Figure 5. Lael, Wester Ross. (Photo: Dr Scott Wilson)

density of the wood varies widely from about 300 to 500 kg m^{-3} at 15% moisture content. The heartwood is a warm reddish-brown colour with some dark streaking though it can be very variable. In Japan the darkest wood is said to come from the south of the island of Kyushu and is known as Satsuma sugi. The heartwood is typically formed at a cambial age of 20-22 (Yang et al., 1994). It is fragrant and insect resistant. The sapwood is almost white. There is a suspicion that in Britain most has been mistaken by sawmillers for western red cedar with which it is often grown and sold in mixed parcels. Wilson (2010) states that the timber is lighter in colour but has much the same properties, durability and likely applications. It is described as "easy to saw and season, it is favoured for light construction, boxes, veneers and plywood"..

Brown and Nisbet (1894), by contrast, described the wood as soft, white and brittle and unlikely ever to become a timber tree in Britain. It seems possible however that they were dealing with young sapwood.

A frequent defect found in Japan arises because of the high water content in the tracheids that causes a blackish colour to the heartwood (Kuroda et al 2009).

In Britain up to the present the tree has mostly been planted for ornament in parks and big gardens. In Japan, where it is a favourite avenue tree, many forms have also been selected for their ornamental values; almost all of them dwarf varieties.

Place of Japanese red cedar in British forestry

Sufficient evidence exists that *Cryptomeria* will perform acceptably well in British forestry, thriving under a wide range of conditions including moderately exposed mountain slopes. It may prove to be a high volume producer. Streets (1962) has described the history of many introductions to Commonwealth countries. They frequently follow a pattern of initial introductions to gardens and arboreta and then, if successful, perhaps half a rotation later, by small scale planting on estates and by Government departments. *Cryptomeria* has shown itself to be very successful in the first stage; the introduction into gardens and arboreta. It now needs to be extended into the second stage, involving wider planting. Climate warming should extend the range of sites where it will grow well, such as in western Scotland. It is one of several species that seems worthy of serious trials which should begin with small scale plantations on the right sites. A few large scale provenance trials also need to be established with plots big enough for testing silviculture and wood properties, and should include some Chinese provenances. Wilson (2010) says that it would be necessary to clarify on

Figure 6. Parkhurst, Isle of Wight. (Photo: Dr Scott Wilson)

which site types it might be preferable to western red cedar (*Thuja plicata*). He thinks that there are indications that it might do better at higher elevation exposed sites whereas western red cedar is not usually reliable above 200m in England and Wales, and lower in Scotland (Savill, 2013).

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Since retiring from Oxford University in 2006, **Dr Peter Savill** has been involved as a Trustee of three charities: Woodland Heritage, the Future Trees Trust and the Sylva Foundation. He has also written *The Silviculture of Trees used in British Forestry* (CABI, 2013) and edited *Wytham Woods – Oxford's ecological laboratory* (OUP, 2010).