Alternative Spruces to Sitka and Norway

Part 1- Serbian spruce (*Picea omorika*)

In the first of two articles looking at alternative spruces, **Peter Savill**, **Scott Wilson**, **Bill Mason**, **Richard Jinks**, **Victoria Stokes** and **Tom Christian** focus on Serbian spruce.

The genus *Picea*, or the spruces, is large, with species distributed over the temperate zone of the Northern Hemisphere. It includes the most important forest tree

Figure 1. A Serbian spruce tree in Bosnia and Herzegovina. Note the characteristically very slender crown and short branches. (Photo: Tom Christian/RBGE).

in Britain, *Picea sitchensis* (Sitka spruce), together with *P. abies* (Norway spruce). Sitka spruce was introduced from its native Pacific coastal area of North America in 1831. It had become established as one of the chief non-native species in Britain by the early 1920s and, by the mid-1950s, it became the most widely planted tree in Britain (Streets, 1962). Norway spruce originates from northern, central and eastern Europe and was a much earlier introduction, probably before 1500 according to Mitchell (1974). Together in 2011 Sitka and Norway spruce occupied 28% of all forest area in Great Britain, or 744,000ha (Forestry Commission, 2016). To put their significance into context, other common species include the pines at 15%, oaks and birches at 9% each, larches and ash at 5% each. These two spruce species are also the most important species for the timber processing industry in Britain, accounting for over 55% of softwood timber in 2012, a figure which is projected to increase to nearly 70% by 2030 (Forestry Commission, 2014).

According to Macdonald et al. (1957), a wide range of other spruce species have been grown in Britain at one time or another. Two of these spruces, Serbian spruce (*P. omorika*) and oriental spruce (*P. orientalis*) are among the alternative species that were considered by Read et al. (2009) and Bladon and Evans (2015) to be worth trying in Britain as the impacts of climate change become more serious, particularly in areas where Sitka spruce and Norway spruces might be subject to damage due to drought (Green et al., 2008). The potential of these two alternative spruces, along with some other spruce species, is considered in this two part article, beginning in this issue with Serbian spruce. (See April 2017 *QJF* for the concluding part of this article.)

Characteristics of Serbian spruce – *Picea omorika* (Pančić) Purk.

Identification is made easy by its distinctive habit (see Figures 1-3) and its needle characteristics. In cultivation substantial variation in form of the trees occurs from seed. Most trees have a slender stem and short (less than 2m long) ascending or drooping branches forming a narrow, very graceful, spire-like habit. This snow-shedding form is comparable to that of Engelmann spruce (*Picea engelmannii*) in western North America.

Serbian spruce is one of the few spruces with flattened needles like those of western hemlock, not the four-sided needles typical of most spruces. The short, 1.5 to 2.5cm long needles are lustrous dark green above and the underside has two broad, white stomatal bands. These bands collectively stand out, creating a unique silvery contrast that is very effective when the upswept branches move in the wind. Female cones are an elongated egg-shape, 4-7cm long and pendulous with stiff scales, blue-black when young, cinnamon when mature. Male cones mature in May and female cones in September-October. Most remain closed until the following May-June and they may persist on the tree for up to five years. Typically, a good coning year is followed by a poor one.

Occurrence and introduction

The native range of Serbian spruce is in south eastern Europe. It is restricted to western Serbia and eastern Bosnia and Herzegovina in a small area around the River Drina. The species was widespread in Europe millions of years ago, but after the Pleistocene glaciations it survived only in this refugium. It is found chiefly on calcareous soils at 700-1500m elevation, usually on steep north-facing slopes. It occurs both in pure stands and in mixture with other species (Farjon, 2016a). The total natural extent of Serbian spruce is only about 60ha, dispersed across 4,076km^2. It was originally discovered near the village of Zaovine on Tara Mountain in 1875, and named by the Serbian botanist Josif Pančić in 1877. 'Omorika' is its Serbian name.

Within this restricted range there are four main localities where it is found (see Figure 4): 1) the Tara National Park in Serbia and the almost adjacent areas in Bosnia and Herzegovina between Višegrade and Srebrenica; 2) Viogor (Čajniče Municipality) in Bosnia and Herzegovina; 3) Radomišlje (Foča Municipality) in Bosnia and Herzegovina; 4) Ravnište-Kanjon Mileševke (Municipalty of Prijepolje) in Serbia. Details of the localities where the species can be found in the wild are given in the IUCN Red List (2016). In total there are 25 individual sites found in the four main

Figure 2. Serbian spruce at Bargrennan, Glentrool Forest, Galloway, regarded as one of the better stands in Scotland [age 50 years; P62; GYC 8] (Photo: Dr Scott Wilson).

Figure 3. The characteristic form of Serbian spruce among survivors from a P56 plot at Alice Holt, with Norway spruce in the background. The seed identity is unknown but is presumed to be German. (Photo: Dr Richard Jinks).

localities mentioned above. Some of these sites contain as few as 100 trees.

Until the middle of the 19th century the natural range of *P. omorika* was more continuous and less fragmented than it is today. *Picea omorika* was harvested for timber until the early 20th century, but the few remaining small stands are now protected (Jovanoviæ, 1986). Its current distribution is mainly the result of anthropogenic factors such as general forest clearance and selective cutting, pastoralism and wildfires. Fire has perhaps been the biggest threat, and logging has been a subsidiary one.

Recent fieldwork indicates that there is a continuing slow decline in the natural extent of occurrence, area of occupancy, quality of habitat and number of mature individuals in some locations. This is primarily due to poor natural regeneration and an inability to compete with associated tree species including *P. abies* and *Fagus sylvatica* (Farjon, 2016b).

Serbian spruce was introduced to cultivation in Britain in the late 1880s and specifically to Kew Gardens in 1889. Trees from the original introduction survive at Murthly Castle, Perthshire (Mitchell, 1982).

Climate and site

Serbian spruce occurs naturally mainly on steep, sometimes precipitous, north to northwest-facing limestone slopes that overlie igneous material. Soils are typically shallow rendzinas and calcareous brown earths. In the wild state, the species is strictly confined to limestone soils and never grows on the slate that is found in parts of the Drina valley. However, when

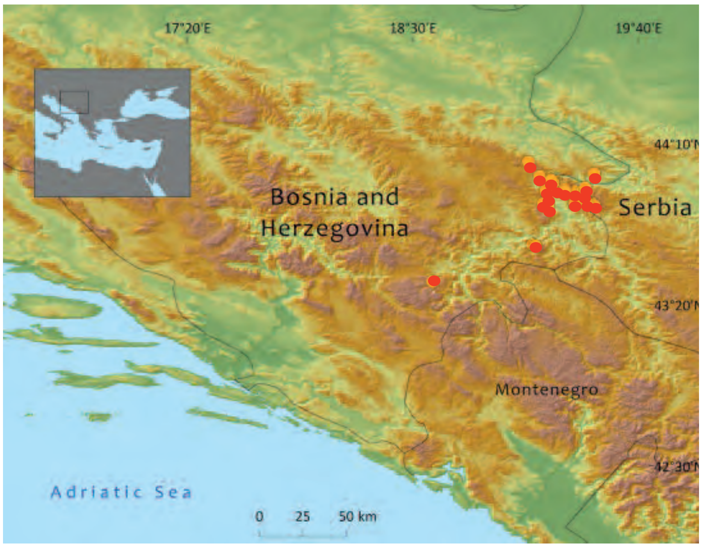

Figure 4. Natural distribution of Picea omorika (Map: Vanezza Morales/RBGE)

cultivated, it does very well, at least in its early years, on soils that are not calcareous (Elwes and Henry, 1906; Stirling-Maxwell, 1929).

The climate in its natural range is characterized by very high humidity, high precipitation, regularly distributed over the year, deep snow cover which lasts 4-5 months, and low winter temperatures. It was considered by Wardell (1956), who concluded that there should be no climatic limitations to its growth in Britain (though it can occasionally be damaged by frost). It is said to be more drought tolerant than Norway spruce, and is in fact unexacting as regards both moisture and nutrients, and in its resistance to exposure and frost. It is reported to be hardy to Zone 5 (cold hardiness limit between -28.8°C and -23.3°C) (Bannister and Neuner, 2001).

Most sources indicate it will tolerate a wide soil pH range, drought-prone soils and polluted urban conditions. Serbian spruce was regarded as being relatively pollution resistant by Kommert (1982) and Dallimore and Jackson (1948). According to Macdonald et al. (1957), growth in Britain differs very little over a wide range of sites, though it has perhaps distinguished itself best on moist moorland soils and on peats where the majority of stands have been established in the past. Macdonald et al. (1957) also concluded very tentatively that it could be planted on calcareous sites in Britain based on its natural occurrence, but few examples are known. Stirling-Maxwell (1929) described the species as "very accommodating as regards soil, thriving better than any other on dry gravel at Kew and seeming equally at home here (at Corrour, Inverness-shire) on good black peat". On good sites it is unlikely that Serbian spruce will appear impressive in rate of growth when compared with other, more demanding spruces. Although the potential yield is less than that of Norway spruce, *P. omorika* is characterized by greater drought resistance and freedom from snow- and insect-damage, and is recommended for sites of low to medium quality in the calcareous beech zone in Switzerland (Leibundgut, 1978).

Habitat and ecology

In the native range, associated tree species typically include *Abies alba*, *Picea abies*, *Pinus nigra*, *Fagus sylvatica*, *Acer pseudoplatanus*, *Populus tremula*, *Sorbus aucuparia*, *S. aria*, *Quercus* spp and *Ostrya carpinifolia*. Sometimes it forms almost pure stands. On rocky outcrops it is co-dominant with *Pinus nigra* and on steep slopes at high altitudes it grows with *Picea abies* and *Pinus nigra* while on steep slopes at lower elevations it is co-dominant with *Fagus sylvatica*.

Post fire regeneration is usually very good although limited to steep slopes and cliffs.

After visiting sites where the tree grows in the wild, Wardell (1956) concluded that the spruce, which is a relic in the flora of the Balkan Peninsula, succumbs to competition with other species and is poorly adapted to its present environment but holds its own when competition is absent as on north-facing cliffs or screes or where it has regenerated itself after fire or exploitation – the sort of areas inhabited by chamois, according to Elwes and Henry (1906). In one site that was disturbed by ordnance during the Bosnian-Serbian conflict in the 1990s, regeneration was prolific (Pers. comm., T. Christian, 2010).

Silviculture

Macdonald et al. (1957) state that Serbian spruce had never been planted extensively in Britain. The earliest larger-scale plantings were at Corrour and Fersit (Inverness-shire) in 1908. It was estimated that by 1957, less than 200ha had been planted. More recent data suggest that in 2015 there was around 160ha of Serbian spruce in public forests in Britain, most dating from the period between 1950 and 1970, but with a small increase in planting of this species in the last few years. There has also been limited adoption on private estates, as at Brahan Estate in Ross-shire, northern Scotland.

There is therefore little experience of the silvicultural requirements of this species in Britain. The narrow form of the tree suggests that it could be established at greater densities than the conventional 2500 per hectare (potentially around 4000 per hectare). Thinning could also be carried out later than normal. Rotation length seems likely to be similar to that for Norway spruce (about 70 years), though as Stirling-Maxwell (1929) stated: “the habit is slender, and it makes less wood than the Norway spruce in proportion to height”. Keenleyside, writing in 1985, observed that the Corrour trees, then over 70 years old, had very narrow crowns, not more than 2m in diameter; “Growth has been very steady but very slow, equivalent to General Yield Class 6”. Serbian spruce grows well in full sun to partial shade on sites protected from winter wind. If grown in too much shade the tree becomes thin and leggy and will not thrive. It is considered to be one of the most adaptable spruces and was said by Dallimore and Jackson (1948) to have succeeded better than any other spruce at Kew Gardens “in spite of the enervating conditions of a hot dry soil and an impure atmosphere”. It flushes late, thereby escaping injury from late spring frosts. There are some quite impressive plantations in Britain, especially in Galloway, Wales and around the inner Moray Firth (see Figures 2 and 5).

Dallimore (1945) described experiments at the National Pinetum at Bedgebury and suggested that this species will do well on an acid soil at low elevation. Young trees (35-45cm high) planted in 1926 were about 9m high in 1945, and 22cm dbh at 1.5m above ground, and had a branch spread near the ground of almost 5m. They had not been injured by winter or spring frosts, nor attacked by insect pests. Trees planted in 1931 were 6.0-6.7m high at age 14, and in 1942 they bore a heavy crop of cones with a fair percentage of fertile seeds. The great value of this species appears to be for planting in places where other spruces are liable to injury by drought or spring frosts.

Figure 5. Serbian spruce at Wentwood, Monmouthshire, one of the best stands in Wales [age 65 years; P47, GYC 12]. (Photo: Dr Scott Wilson)

Natural regeneration

As already stated, *P. omorika* is a poor competitor with associated species and consequently natural regeneration in its native range is unusual except on the steepest rocky slopes and on cliffs where broadleaved trees are unable to compete effectively. Regeneration also occurs in the bottoms of wet, shaded ravines (Elwes and Henry, 1906). It is dependent on disturbance events for good recruitment and healthy subsequent growth to take place. Once established it often becomes suppressed by *Abies alba*, *Fagus sylvatica* and *Picea abies* (Burschel, 1965).

Record and potential in Britain

According to Forest Research records, about 135 experiments and trial plots that included this spruce were established between 1920 and the present day. Twenty-seven of these trials are still active. Nearly 50% of them were planted in the 1950s with relatively little experimental planting between 1970 and 2010. More recently, there has been increasing interest in the potential of the species for diversifying upland conifer forests or as a means of adapting forests to the threats from pests and diseases, so that the species has been included in a new series of operational species trials established in various parts of Britain in 2015.

Possibly because of the restricted native range of Serbian spruce, it appears that many of the earlier experimental plantings will have used plants grown from seed collected in British stands of uncertain origin. Examination of seed records suggests that relatively little seed was imported from the native range before the 1960s; further investigation would be necessary to check which, if any, of the surviving experimental plots were of specific native origins and might therefore have value for ex situ genetic conservation.

Growth

The tree has a moderate height growth rate of up to 30cm a year and will usually attain an eventual height of 15 to 18m and a spread of 6 to 7m. In continental Europe it is regarded as being slightly slower-growing than Norway spruce (e.g. Leibundgut, 1978; Altherr, 1981). In Britain it has achieved yield classes of between 14 and 16$m^3ha^{-1}yr^{-1}$ in the south of England, and 8 to 12 in the north of England and Scotland (see Tables 1 and 2).

Growth at higher elevations has tended to be poor (e.g. 6$m^3ha^{-1}yr^{-1}$) at Corrour, Inverness-shire. Basal areas per hectare are often quite high, probably reflecting the narrow crown form of the species resulting in high stocking densities compared to other spruce species.

Pests and diseases

Few diseases appear to affect Serbian spruce. Some sources list aphids, mites, scale insects and budworm as potential pests, however so far there are no reports of these affecting the tree significantly in Britain, though aphids were observed by T. Christian, and were numerous enough to cause damage to the trees. This is contradicted by Klqft et al. (1964) who reported

Table 1. Growth of selected sample plots of Serbian, Oriental and other spruces in different parts of Britain.

Species	Location	Age	Top height (m)	Cumulative basal area production (m^2ha^{-1})	Yield class (Local yield class) ($m^3ha^{-1}yr^{-1}$)
Serbian spruce	Bedgebury, Kent (plot 1170)	49	22.6	81.6	16
	Bedgebury, Kent (plot 1175)	49	23.1	92.1	16
	Thetford, East Anglia	49	18.5	75.7	14
	Brechfa, Carmarthenshire	45	22.0	70.8	16 (14)
	Forest of Deer, Aberdeenshire	48	14.3	103.0	8 (10)
	Newcastleton, Borders	57	18.0	87.8	10 (11)
	Glen Urquhart, Inverness	64	18.8	103.9	8 (12)
	Bennan, Galloway	73	27.0	118.3	12 (15)
Oriental spruce	Bedgebury, Kent	35	17.2	67.2	16 (19)
	Dawyck, Borders	53	19.7	93.8	10 (12)
Black spruce	Bedgebury, Kent	31	10.3	-	12
	Brechfa, Carmarthenshire	33	13.5	37.5	10 (9)
Red spruce	Bedgebury, Kent	39	16.7	48.6	16(17)
Englemann spruce	Bedgebury, Kent	32	16.7	37.2	18 (14)
Hondo spruce	Bedgebury, Kent	49	12.6	28.2	4

Table 2. Comparative performance of five different spruce species after 50-65 years at Kilmun Forest Garden Argyll.

Species	Age (years)	Top height (m)	Basal area (% of Norway spruce)	Yield class ($m^3ha^{-1}yr^{-1}$)
Norway spruce	62	28.1	100	18
Serbian spruce	62	29.0	112	18
Oriental spruce	62	28.1	143	18
Red spruce (*Picea rubens*)	61	25.8	103	16
Sakhalin spruce (*Picea glehnii*)	52	14.5	80	10

that the green spruce aphid (*Elatobium abietinum*) hardly attacked *P. omorika* at all. Even the great spruce bark beetle (*Dendroctonus micans*), which affects *P. abies* and *P. orientalis* very severely, has not been recorded as a pest on *P. omorika*.

Gibbs et al. (2002) recorded that in Thetford forest, in the east of England, it was one of the species least affected by Fomes (*Heterobasidion annosum*).

Genetics and provenance

There have been no attempts to compare different provenances of Serbian spruce in Britain, but Ravensbeck and Madsen (1998) described the results of a provenance trial in Northern Jutland comprising 29 seed lots collected from plantations within Denmark and one Yugoslavian provenance. The differences in height were moderate: the ten tallest provenances were predicted to attain heights 11% taller than a provenance of average growth. Frequency of forking varied considerably, but seemed primarily determined by site variation within the trials.

Nasri et al. (2008) suggest that: "current *P. omorika* populations are shaped by an extreme demographic bottleneck and random genetic drift linked to quaternary glacial cycles. *P. omorika* thus belongs to the small group of genetically depauperate tree species".

Outcrossing rates were estimated in a natural wild population and in a cultivated Finnish population of Serbian spruce. The outcrossing rates (which vary from 1 = all out-crossing, to 0 = all selfing) were 0.98+/-0.03 and 1.02+/-0.04 in two different years in the cultivated stand, and 0.84+/-0.05 in the natural stand. The relative self-fertility was also estimated in seven trees in the cultivated population. The results indicated high self-fertility, which agrees with earlier information. Thus, despite its very narrow natural range and morphological uniformity, Serbian spruce is naturally an out-crossing species but is tolerant of high levels of self-crossing when required – presumably this evolved as an evolutionary adaptation in years when few trees are flowering (Kuittinen and Savolainen, 1992).

Picea omorika has been planted in Denmark for various purposes (e.g. as a park tree and for Christmas trees) as well as for wood production, especially on poor soils and frost-exposed sites. The species is known to hybridize with Sitka spruce and other spruces. In cultivation, it has produced hybrids with the closely related black spruce and also with Sitka spruce. For this reason seed should not be collected from stands adjacent to mature Sitka spruce in British plantations.

Picea omorika is widely grown in gardens throughout northern Europe but few of these collections are either comprehensive or well documented. More recently the International Conifer Conservation Programme, based at the Royal Botanic Garden Edinburgh, has made comprehensive introductions of Serbian spruce from throughout its natural range, for its ex situ conservation collections, sampling from the majority of the twenty-five sites across all four localities. These young trees have since been widely distributed across 61 host locations in Great Britain and Ireland (Pers. comm. T. Christian, 2016).

The advice given on the Forest Research (2016) website is: "There is little evidence of significant provenance variation; seed from good British stands or from the natural range should be preferred", however, the Danish work by Ravensbeck and Madsen (1998) suggests that this may need further refinement. There are provenance differences, but as there are no provenance trials in Britain yet, recommendations cannot be given.

Nursery

There is likely to be difficulty in procuring seed from the native range for some years to come and every opportunity should be taken of collecting seed from trees of good form in larger home-grown stands. Kuhns and Rupp (2000) state that propagation is straightforward as seeds require no pretreatment. However, a slight improvement in germination percentage occurs when seeds are stratified for up to 3 months at 4°C. Meyer (1960), working in Germany, thought that Serbian spruce required a year or two longer in the nursery than most other conifers because it is slower growing, but others dispute this finding.

Serbian spruce transplants well in spring or autumn from containers or as B&B (balled and burlapped) plants and establishes quickly under a variety of landscape conditions.

Uses

At present, outside its native range, Serbian spruce is of major importance only as an ornamental tree, mainly in northern Europe and North America, for use in large gardens. It is regarded as one of the most attractive spruces because of its elegant form and its dark green needles and ability to grow on a wide range of soils, including alkaline, clay, acid and sandy soils, although it does best on moist, drained loams.

The tree deserves a more prominent place in commercial and residential landscapes. It can be used in groups, as single specimens, or even as an evergreen street or avenue tree. It has utility as a natural screen and selections with a narrow habit are suitable even for small urban landscapes. Serbian spruce represents a welcome alternative to the all-too-common Norway spruce.

It is also grown to a small extent for Christmas trees, timber and paper production, particularly in northern Europe, although its slow growth makes it less important than Sitka spruce or Norway spruce in Britain.

Chylarecki (1966) in a trial of 16 alternative species of *Picea* in Poland, regarded *P. omorika* and *P. pungens* as being best for the country as a whole because they are undemanding as to site, highly ornamental, healthy, almost completely resistant to cold, vigorous in growth, and producing seeds of high germinative capacity.

Its wood is said to be very similar to that of Norway spruce: close-grained, compact, yellowish and easily worked. Density, at about 441kg/m^3 (Sachsse, 1981) is lower, especially in younger trees (Kommert, 1990). Ramsay and Macdonald (2013) give several timber properties for small clear samples from five trees. They quote the specific gravity as 0.36. Norway spruce is given at 0.35.

Role in British forestry

Elwes (in Elwes and Henry, 1906) stated that: "though the tree is very ornamental, I do not expect it can have any value as a forest tree". This was, of course, before climate change was anticipated. In the light of the evidence above, it seems that Serbian spruce may have some value as an alternative spruce on sites in eastern Britain where Sitka spruce is expected to suffer from moisture stress. However, other alternatives such as Norway, oriental and hybrid spruces (see part 2 of this article in the next issue) may be more productive candidates for the majority of sites. Serbian spruce has some potential for use in spaced-tree silvopastoral systems due to its narrow crown architecture, allowing retention of forage throughout the rotation.

Acknowledgements

We are grateful to Ian Craig of Forest Research, Alice Holt for providing data from the various sample plots that had been established with spruce species in Britain and to Vanezza Morales of RGBE, for producing the distribution map (Figure 4). Stephen Bathgate kindly provided recent information on the area of Serbian spruce found in public forests and Steve Lee clarified an obscure point of genetics for us.

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