

REVIEW PAPER

Sitka Spruce in Estonia

HEINO KASESALU¹, ALAR LÄÄNELAID^{2*} AND URMAS ROHT³

¹Järvelja Study and Experimental Forest District, Kastre parish, 62506 Tartumaa, Estonia, E-mail: heino.kasesalu@mail.ee

²Department of Geography, University of Tartu, Vanemuise St. 46, 51003 Tartu, Estonia, E-mail: alar.laanelaid@ut.ee

³Räpina School of Horticulture, Pargi St. 32, 64505 Räpina, Põlvamaa, Estonia, E-mail: urmasroht@gmail.com
*corresponding author

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Abstract

An overview of the introduction of Sitka spruce (*Picea sitchensis*) in Estonia. First reports of cultivation of Sitka spruce in Estonia come from 1879. In 1895, Peravalla forest area (now Järvelja) obtained a small amount of seed from Thüringen. Saplings from that seed were planted in the forest in 1904, but by 1928, all trees perished. During the 20th century, the seed of Sitka spruce from different provenance of the natural distribution area was repeatedly sown and seedlings were grown in Järvelja and some other places in Estonia, but all the cultivation attempts failed eventually. There are no Sitka spruces remained from the pre-war period in the mainland part of Estonia. In 1984, a group of saplings from the seed of 1978 was planted in Järvelja. These trees are 15 m mean height with 20.6 cm mean diameter now.

In 1975, a small group of large Sitka spruces was found growing in a remote forest park of Suuremõisa Manor, Island of Hiiumaa. These Sitka spruces were revisited by us in spring 2018, to measure the trees and determine their age by tree rings. Nine trees out of 13 bigger spruces were cored. Age of the trees was nearly 120 years. The planting time coincides with work period of Karl Ahrens, the forest officer of Suuremõisa Manor at that time.

In spring 2018, the mean diameter at breast height (DBH) of the tree group was 62 cm and mean height ca 36 m. The biggest tree had DBH 101 cm (with 37 m height) while the maximum height for the tree group was 38 m. The Suuremõisa group of Sitka spruces on 0.02 ha is remarkable by its dense stand. If to extrapolate to one hectare, the growing stock of the stand would exceed $3 \times 10^3 \text{ m}^3 \text{ ha}^{-1}$. The vital group of Sitka spruces at Suuremõisa have proved that this alien tree species can grow rather well on the western islands and the coastal region of Estonia. Sitka spruce can grow faster than native Norway spruce in Estonia. Future decades will show the viability of Sitka spruce cultures in the mainland of Estonia.

Keywords: introduction history, *Picea sitchensis*, Suuremõisa, Estonia

Introduction

Sensational news was launched in summer 1975 in Estonia: a group of large Sitka spruces were found growing on Hiiumaa Island. Up to that a few metres high Sitka spruce at Tihemetsa Dendrium was considered as the biggest tree of that species in Estonia (Hainla and Valk 1961).

The group of Sitka spruces in Suuremõisa forest park in Hiiumaa was discovered in 1973 by nature conservation inspector Maie Jeesser. She searched for White pines (*Pinus strobus*) allegedly growing there according to directions from an old local citizen. White pines were not found at that time, but she was attracted by a small group of spruces growing on the eastern bank of the Suuremõisa river. Sprouts, cones and bark of these

spruces differed remarkably from other known spruce species (Figures 1, 2). She did not get advice either from other colleagues-foresters at that time in Hiiumaa. Nothing to wonder, because in the most authoritative Estonian handbook of that time, Andres Mathiesen's Dendrology (1934), the cone of Sitka spruce was depicted atypically roundish-oval. The same picture has been copied in the Flora of Estonian SSR, vol. 1 (1960). In the first edition of Dendrology by Endel Laas (1967), a picture of the cone of Sitka spruce is missing at all. A photo of cones was added only in the second, revised edition of the monograph (Laas 1987: 142). At that time, forestry students of Estonian Agricultural Academy were not taught Sitka spruce, because examples were not available. Consequently, the newly discovered spruces at Suuremõisa forest park lacked a name for some years.



Figure 1. A twig of Sitka spruce showing the lower side of needles. Photo U. Roht



Figure 2. Cones of Sitka spruce. Photo U. Roht

In summer 1975, a well-known Latvian dendrologist Andris Zvirgzds visited Hiiumaa, to inspect the parks under the guidance of botanist Haide Rebasoo. He was shown these nameless spruces too. A. Zvirgzds confirmed without a doubt that these were Sitka spruces (*Picea sitchensis*). At last, a firm name was attributed to these rare trees.

In 1976, Heiki Tamm and Urve Ratas wrote in *Eesti Loodus* journal, that there were 17 viable Sitka spruces growing on the bank of the Suuremõisa river. A height of the biggest tree was measured 29 metres and diameter at breast height 64 cm. The trees were assumed to be over 60 years old (Tamm and Ratas 1976).

Sitka spruce in its home country

Sitka spruce (*Picea sitchensis* (Bong.) Carr.) has got its name after an island in the Gulf of Alaska on the western coast of North America. The island is now called Baranof Island. Sitka was the headquarters of Russian Alaskan fur trade in 1804-1867. Sitka spruce spreads in nearly 3,000 kilometres long narrow belt along the west-

ern coast of North America from 61 to 39 northern latitude, from Alaska to northern California (Sarvas 1964, Schenck 1939). It extends seldom more than 200 km from the Pacific coast and not more than 1,000 m altitude. Sitka spruce is demanding on air and soil moisture, it grows in temperate rainforests in river valleys and seaward slopes both as pure and mixed stands. First 2-3 years Sitka spruce grows slowly, later faster. This is the tallest-growing spruce species in the world (Johnson 1973), extending up to 96 m tall. Usual height of Sitka spruces in their natural area is 45-60 m with a trunk diameter at breast height (DBH) 120-240 cm. The Queets spruce growing in the State of Washington is known as the largest, with trunk volume of 337 m³, height of 75.6 m and DBH of 455 cm (Wikipedia contributors 2019). Hendrik Relve (2013) has measured thickness of allegedly thickest spruce specimen in the world, the Sitka spruce growing on the southern coast of Lake Quinault in Washington State, US: girth of its trunk at 1.3 m height from the soil surface was 16.6 m (it means DBH 528 cm) and height of the tree was 59 m (63 m in the State register). Age of Sitka spruce can reach 800 years. For the scientific public, Sitka spruce was discovered by a Scottish surgeon and botanist Archibald Menzies in 1792. In 1832, August von Bongard, a German botanist in St. Petersburg, gave the first scientific description of the species.

Sitka spruce in Europe

Sitka spruce was brought to Europe in 1831 by Scottish botanist David Douglas. Since that time, cultivation of Sitka spruce was started in Europe. It appeared that at the coastal areas of Scotland Sitka spruce grew much faster than indigenous Norway spruce on the spot. Before wider cultivation, experiments were carried out to find out what provenance seed was more perspective in Scotland. Seed acquired from the Queen Charlotte Islands appeared to be the best and it was widely used for further cultivation. According to 1988 data, Sitka spruce formed 28% of the forest area in Great Britain. From the forest cultures established in the 1970s, Sitka spruce forms nearly 60%. Annual increment of Sitka spruce in Scotland is 16-22 m³ ha⁻¹.

Somewhat later, cultivation of Sitka spruce was started in Denmark, Norway and Iceland. For today, there are tens of thousands of hectares forested with Sitka spruce in these countries. In smaller extent, Sitka spruce is cultivated in several other countries in western Europe (Schmidt-Vogt 1977).

The wood of Sitka spruce is relatively lightweight and with good technical properties. Besides paper and wood industry, it has been used for sailships and boats, but also in the aircraft industry. Yet in the 2nd World War, British used wood of Sitka spruce to produce the

de Havilland DH.98 Mosquito military aircraft, instead of aluminium. The wood of Sitka spruce is widely used for manufacturing musical instruments like pianos and violins.

Sitka spruce in Estonia

First reports of the cultivation of Sitka spruce in Estonia come from 1879 when botanist Johannes Klinge (1883) wrote that this tree species was cultivated near Tartu. According to ‘Flora of Estonia’ (Vaga and Eichwald 1960), Sitka spruce was grown in parks in Tallinn and Tartu, but no more details about the sites were given. In 1895, Peravalla forest area in Kastre Manor (nowadays the Järvelja Study and Experimental Forest District) obtained a small amount of Sitka spruce seed from Thüringen, Germany. Nursery plants from that seed were used for complementing forest cultures. According to forest scientist Bernhard Haller (1929), all Sitka spruces planted in the forest in 1904 perished during 1928. In 1908 and 1909, the seed of Sitka spruce was bought from Gögginger seed shop in Riga for Peravalla nursery, but the provenance of the seed was unknown. Seedlings from this seed perished soon with cold. Count Friedrich Berg (1924) reported that Sitka spruce had frozen to the last tree in the park of Sangaste Manor.

Sitka spruces were planted in Suuremõisa Forest Park in Hiiumaa Island apparently at the beginning of the 20th century. Unfortunately, no data about seed provenance and planting time were found. In the questionnaire of Baltic Forest Society in 1901, Sitka spruce was not mentioned in Hiiumaa Island. Seed booking and planting of foreign tree species in Hiiumaa was evidently the duty of Karl Ahrens, a forest officer working for Count Ungern-Sternberg. Anyway, the seed of Sitka spruces planted in Suuremõisa forest park reasonably originated from a very proper region. These trees have grown fine with no substantial frost-bites (Kasesalu et al. 2018).

The seed of these trees was probably sowed to the nursery about 1896, basing on the fact that the plants were one-metre height for 1904. The seed of Sitka spruce was in the sale in Thüringen in 1895. Forest officer Karl Ahrens would book the seed from Thüringen. Thus, the Sitka spruces growing in Suuremõisa forest park would be about 120 years old now (Figure 3).

Age of the Sitka spruces in Suuremõisa Forest Park

On May 21, 2018, the authors took borer samples from the Sitka spruces in Suuremõisa forest park, to establish their age. We used a 60 cm Suunto hand borer at 1 m height from the soil surface, mostly from the north side of the tree trunk. The girth of trunks was measured by metal measuring tape at the boring height. The thickness of bark at boring height was assessed at every tree.



Figure 3. Some big Sitka spruces in the Suuremõisa forest park.
Photo U. Roht

Altogether nine trees were bored and increment cores extracted (Table 1). Cores were numbered and packed into plastic tubes.

Table 1. Borer cores from the Sitka spruces in Suuremõisa forest park

Tree No.	Trunk girth, cm	Bark thickness, cm	Sample code	Number of tree rings in sample	Remarks
1	317	1.5	<i>Oes srm1N</i>	97	Core passed pith
2	280	1.5	<i>Oes srm2N</i>	91	Core passed pith
3	231	1.5	<i>Oes srm3N</i>	104	Core passed pith
4	93	1	<i>Oes srm4N</i>	71	To pith
			<i>Oes srm4S</i>	99	
5	150	1	<i>Oes srm5N</i>	110	To pith
6	224	1.5	<i>Oes srm6b</i>	113	Nearly pith
7	223	1.5	<i>Oes srm7N</i>	94	Core passed pith
8	206	1.5	<i>Oes srm8S</i>	99	Core passed pith
9	Not measured	1.5	<i>Oes srm9N</i>	106	To pith

Although the radii of the tree trunks did not exceed our borer bit length of 60 cm, a pith of the trunk was hit only in trees No. 4, 5 and 9. In other cases, borer passed the pith in a few centimetres. This was because the trunks were slightly eccentric, which was in turn caused by an inclined trunk. The trunks of these spruces were tilted to the south. Therefore, the borer samples were extracted from the upper side of the trunk, where tilted conifers have shorter a radius.

Alar Läänelaid measured tree ring widths of the borer samples in TSAP-Win program in the dendrochronology lab in Tartu, using measuring table Lintab and microscope Leica S4E (all Rinntech). Each ring-width series was provided with an identification code containing tree genus, sample site, number of tree and cardinal point of the core. Measurements were taken into Excel, where

cumulative increment curves were calculated (Läänelaid and Tamm 2017, Sander and Läänelaid 2016, Läänelaid et al. 2008). Cumulative curves help to assess the age of trees.

Cumulative increment curves showed that the ring width curves began from the first decade of the 20th century. This indicates a time when the height of trees had exceeded the sampling height, 1 metre.

In spring 2018, there were 13 vital Sitka spruce trees growing in Suuremõisa Forest Park and additionally some thinner and half-dead spruces. The mean diameter at breast height (DBH) of the vital group was 62 cm and mean height ca. 36 m. The largest tree had DBH of 101 cm with 37 m height, while the maximum height for the tree group was 38 m. Even-aged trees differ greatly by their diameter. In addition to the main group, there is a natural renewal of younger Sitka spruces of various age and height. The group of large Sitka spruces grows on the eastern bank of the Suuremõisa river on nearly 0.02 ha area. If to extrapolate the tree measurements to one hectare, there would be 650 trees/ha with a growing stock of more than $3 \times 10^3 \text{ m}^3 \text{ ha}^{-1}$. There are no native tree species in Estonia having so high growth stock. Calculated from the yield tables of Aleksandr Tyurin (Тюрин et al. 1956), the growing stock of 120-year old Norway spruce of Ia quality class is $1.252 \times 10^3 \text{ m}^3 \text{ ha}^{-1}$ (Krigul 1971). An extraordinary high growing stock of these Sitka spruces is caused beforehand by its great DBH and high stand density (Figure 4).



Figure 4. The biggest Sitka spruce had girth 317 cm. Photo U. Roht

Introduction of Sitka spruce in Estonia

In September 1976, Ülo Erik found an aged Sitka spruce growing at Ungru Road 2, Paralepa near Haapsalu. This Sitka spruce is apparently an age-mate with those at Suuremõisa and may be of the same provenance. The height of the tree was 23.5 m and DBH was 72 cm in 1983. In 1988, the treetop of 1.8 m height was broken by a whirl caused by a low-passing military helicopter. In spring

2018, a height of the tree was 27 m and its DBH was 82 cm. Thus, the actual height of this spruce would be around 30 metres.

In the early 1930s, the Järvelja Study and Experimental Forest District obtained the seed of Sitka spruce of Alaskan origin. In the sales price list 1936/1937 of Järvelja nursery, there were also saplings of Sitka spruce of 60-70 cm height. In spring 1937, forestry students established three small-area forest plantations of 4- and 6-year old Sitka spruce saplings at Järvelja. According to Heino Untera (1954), all these forest plantations were actually perished, with exception of some 0.5 to 1 m high shrubby treelets. The likely reasons of perishing were cold and partly damages made by roe-deer. For today, there are no Sitka spruces planted before the 2nd World War which survived at Järvelja (Kasesalu 2012).

Since 1975 Estonian Forest Institute started to grow Sitka spruce wider by the initiative of its director Ülo Erik. A small amount of Sitka spruce seed of origin of the Queen Charlotte Islands was received by way of seed exchange from Canada. In autumn 1976, employees of the Estonian Forest Institute gathered seed from the Sitka spruce group at Suuremõisa, Hiiumaa. In 1977, Ülo Erik succeeded to obtain 30 seed batches of Sitka spruce from the seed bank of International Union of Forest Research Organisations (IUFRO). The seed was sown into a plastic film greenhouse and grown further as film-roll plants. According to Ülo Erik (1978), 60 seedlings of Sitka spruce of the Queen Charlotte Islands origin were planted under the protection of grey alder in Sõe Arboretum on the bank of the Pedja river in 1976. As of 1984, 40 trees of them were survived, with an average height of 0.80 m (Nigul 1985). As of 2005, this forest plantation was entirely perished.

Another forest culture of Sitka spruce was established also on the Pedja river bank in 1981. There were seeds of five origins, including those from Suuremõisa. The seedlings originated from Kitimat, British Columbia, Canada (IUFRO provenance index 3046) were characterised by the best growth. Kitimat is located about 80 km from the ocean coast and at 165 m a.s.l. In autumn 2017, the trees of Kitimat origin were on average 12.5 m in height and with a DBH of 17.6 cm. Trees of seed origins from Nass, British Columbia (IUFRO index 3034), and Hazelton, British Columbia (IUFRO index 3032) showed to some extent weaker growth. Trees of seed originated from Prince Rupert region, British Columbia (IUFRO index 3044) and of seed from Suuremõisa, Hiiumaa, were perished entirely. The latter was surprising, as seedlings from local origin would have been better adapted to the climate.

In September 1980, Sitka spruces of different origin were planted on an experimental plot at former Jäärja Forest District. The planting was initiated by Arno

Joasoo from Kilingi-Nõmme Example Forest District (Ärm and Tomingas 1984). The seedlings were obtained from Ülo Erik at the Estonian Forest Institute. For 2017, most of the seedlings of Hiiumaa origin were perished: of 240 planted trees only 5 were survived, with the biggest height of 11.5 m and with a DBH of 27 cm. Of the seeds of British Columbian origin, the best were trees from the Cranberry River region (IUFRO index 3029), which is located at 200 km from the ocean coast at the altitude of 510 m a.s.l. In 2017, the mean height of these trees was 16.5 m and DBH was 23.0 cm (Figure 5). Spruces with the IUFRO index of origin 3046 also showed relatively good growth, with mean height of 14.0 m and the DBH of 18.5 cm in 2017. The next were Sitka spruces grown from seed from the Nass River region, British Columbia (IUFRO index 3026), which is located about 180 km from the ocean coast and at the altitude of 240 m a.s.l. Mean height of these trees was 13.5 m and the DBH was 17.7 cm in 2017. The weakest growth was demonstrated by trees grown of seeds originated from Kodiak and Afognak Islands in Alaska (IUFRO index 3084). Their mean height was 9.5 m and the DBH was 10.0 cm in 2017.



Figure 5. Sitka spruces at Jäärja in 2014. Photo: U. Roht

First seedlings of Sitka spruce on Ruhnu Island (in the Baltic Sea) were planted in 1978 (Erik 1981). For today, at least one single tree growing near the airport has survived. In 2017, its height was 16 m and DBH was 54 cm. The tree bore rich cones. In the next year (1979), 1860 seedlings of Sitka spruce of 30 different origins were planted in Ruhnu Island (Erik 1980). Forests on Ruhnu Island had heavily suffered from the 1969 wind-storm and Sitka spruces were planted as irregular patches into these storm gaps (Erik 1981). These were mainly of *Vaccinium myrtillus* and *Oxalis-Vaccinium vitis-idaea* forest site types. Unfortunately, marking of sites of different seed batches was insufficient and after

some years, it was impossible to distinguish the origins of the sites. In the preserved forest patches tree heights, last year increments and stem diameters at 0.25 m height were measured in model trees in 1984, trying to find relations with origins of the seed (Nigul 1985). In fact, measurements on so small trees did not yield trustful relations with the origin, because of many other factors affected their growth. Another stock-taking of these patches of Sitka spruce was made in 1987. From the initial 30 seed origins, it was possible to identify 11 seed origins. The IUFRO origin indices 3029, 3046 and 3041 characterised the best-grown trees. The latter of them, seeds indexed 3041, originated from Shames at the Skeena river coast, British Columbia, Canada. The region is located at 90 km from the ocean at the altitude of 30 m a.s.l.

In 2001, Ülo Erik re-measured Sitka spruces survived on Ruhnu Island. The maximum height of the best spruce group was 15 m and the DBH was 20 cm. Due to the absence of a planting scheme, it was not possible to establish the origin of the seeds of these Sitka spruces. In the course of several changes of the jurisdiction of the Ruhnu Island forests, documents of the plantations have got lost. We can add that in autumn 2017, the biggest Sitka spruce of the same tree group in Ruhnu Island was 21 m high with the DBH of 27 cm.

In the office courtyard of the former Sõrve Forest District in Saaremaa Island, a group of 1979-planted Sitka spruces is growing. In summer 2017, the height of the biggest tree of them was 18 m with the DBH of 28 cm. The seed of these trees originates from the Skeena river banks in surroundings of Hazelton, British Columbia, at a distance of 220 km from the ocean and at the altitude of 660 m a.s.l. (IUFRO origin index 3032). In spring 1980, a forest plantation of Sitka spruce covering about 0.5 ha was established in the Sõrve Forest District. Due to roe-deer damage and partly because of unsuitable forest site that plantation has perished for now.

At Sõrve peninsula, in the dendrarium of Prof. Ants Ilus in Saaremaa Island, a 1983-planted Sitka spruce is growing, with the height of 19 m and the DBH of 46 cm.

In Kullamaa, Western Estonia, a small area of Sitka spruce plantation was planted as film-roll-seedlings under ca. 25-year old grey alder forest in spring 1977, according to Lembitu Twerdjanski (pers. comm.). The grey alders were cut in 1985. For 2017, 20 Sitka spruces were survived, with maximum height 21 m and DBH 41 cm. Origin of the seed of these trees is unknown.

In the 1980s, Estonian Forest Institute shared seedlings of Sitka spruce to these forest districts in Estonia where the forest officers were interested in growing the species. Feedback about the growth of Sitka spruces has arrived some decades later from Häädemeeste, Lodja and Vihterpalu Forest Districts, but not from the most forest districts where the seedlings were shared. It is

likely that seedlings in these forest districts simply perished.

In March 1973, IUFRO seed bank provided 10 seed batches of Sitka spruce of different origins to the Järvelja Study and Experimental Forest District. The seed was sown into plastic film greenhouse in April of the same year. Seedlings were grown comparatively uniformly. In autumn, seedlings were dug out and buried in soil, each batch separately. The batches were covered with spruce twigs for winter protection. For spring, eight batches out of ten were perished. The only survived batches originated from Alaska, 30 m a.s.l. (IUFRO index 3024), and from the Skeena river region, British Columbia, at a distance of 120 km from the ocean and at the altitude of 135 m a.s.l. (IUFRO index 3040). The seedlings of these two remained batches were cultivated in the nursery, but the seedlings grew badly, looked stunted and perished later.

In spring 1978, Sitka spruce seeds collected from Suuremõisa Forest Park were sown into a plastic film greenhouse at Järvelja. Next spring the seedlings were schooled to open ground. Unlikely of earlier seed batches, these seedlings did not suffer from cold. In spring 1984, these Sitka spruces were planted into Agali arboretum, Agali-Looga and former Rõkka nurseries. The trees took root well and have reached a remarkable size for now. In Agali arboretum, a mean height of the 39-year old stand is 15 m with the DBH of 20.6 cm; maximum heights of the trees are 19 m and 30 cm, respectively.

Conclusions

In short, the present experience has shown that Sitka spruce can grow rather well in the western islands and the coastal region of Estonia. Introduced Sitka spruces of appropriate seed origin grow faster and yield more timber than native Norway spruce in Estonia. In Järvelja, Eastern Estonia, Sitka spruce trees from the seeds of Hiiumaa origin are growing satisfactorily. Their further growth will be seen in the future. Sitka spruce can grow on poorer sites than Norway spruce. In young age, seedlings of Sitka spruce need protection.

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