Norway spruce (\textit{Picea abies} (L.) Karst.) is a large coniferous tree, which can grow up to 50-60 m and with a trunk of up to 150 cm in diameter, normally reaching an age of 200-300 years. In the Swedish Scandes, fossil remains of dead Norway spruce underneedle living individuals have been dated with radiocarbon to the early Holocene, about 9500 years ago, suggesting vegetative survival (by re-sprouting from the roots) over millennia. The crown is irregular cone, columnar, with whorled, short and stout branches, the upper level ascending and the lower drooping. Buds are reddish brown, 5 mm long with an acute apex. Needles are 1-2.5 cm long, 4-angled in cross section, rigid, light to dark green with fine white speckled lines. The species is monoecious, with unisexual flowers usually appearing at an age of 20-30 years, but up to 40 years in dense stands. Male flowers are located principally at the base of the preceding year’s shoot, 1.2-5 cm long globular, crimson then yellow when mature. Female flowers are located at the tip of the shoot, dark red, 5 cm long, erect before pollination, becoming pendent afterwards. Cones are cylindrical, 12-15 cm long, green before maturity, turning brown in autumn. When dry the cones open to disperse 4 mm winged seeds. The bark is orange brown and the wood is creamy white and easy to work.  

**Distribution**

Norway spruce is the main species in the Boreal and subalpine conifer forests, from Central (in mountains) to Northern and Eastern Europe up to the Ural Mountains, where the species ranges with Siberian spruce (\textit{Picea obovata}), which is sometimes considered as a sub-species of \textit{Picea abies} \textsuperscript{1, 3, 4, 5}. Its elevation range goes from sea level in Northern Europe up to above 2400 m in the Alps, where it grows in a stunted form\textsuperscript{6, 7, 8}. Due to its large distribution there are a great number of varieties and forms, which can be considered as normal patterns of variation within a widespread species. Historically cultivated since the 18th century, Norway spruce plantations, even outside natural ranges (e.g., in the temperate lowland areas), have changed natural forests into artificial ones\textsuperscript{9, 10}. Now it is locally naturalised in many areas of Europe outside its native range, including Britain and the Pyrenees Mountains. It was also introduced in other countries outside Europe; in central Europe spruce forests cover wide areas of the montane (mostly planted) and sub-alpine zones, in lowlands it is more mixed with other species\textsuperscript{11}.  

**Habitat and Ecology**

Spruce forests dominates in the Boreal zone of N and NE Europe; in central Europe spruce forests cover wide areas of the montane (mostly planted) and the sub-alpine zones, in lowlands it is more mixed with other species. The natural distribution shows continental tendencies but thanks to its climatic tolerance it grows even in extreme oceanic climates\textsuperscript{12}. Norway spruce is a secondary coloniser, but can be both a pioneer and a climax species. It shows good yield and quality performance under different site conditions, and has been favoured over long periods by silviculture, especially in the lowlands, but also in mountain areas\textsuperscript{13}. Shade-tolerant, it can survive for decades under a closed canopy, fast growing after 5-10 years. It does not grow close to coasts when exposed to salt winds, nor does it like summer drought or waterlogged conditions\textsuperscript{14}. Although it can occur on most substrates, it is most common and widespread on acidic soils, preferring nutritious deep soils with enough fresh moisture. \textsuperscript{15} Spruce shows a noticeable soil-acidifying ability\textsuperscript{16}, \textsuperscript{17} in the Boreal forests it grows with birch, Betula spp and European aspen (\textit{Populus tremula}), with willow, Salix spp alongside streams and lakes. In the Alps, when it is not in pure stands, it occurs with European larch, \textit{Larix decidua} and Swiss stone pine (\textit{Pinus cembra}) on higher elevations (ca. 1800-2100 m), with European beech (\textit{Fagus sylvatica}) and European silver fir (\textit{Abies alba}) under fresh conditions at intermediate altitudes (800-1800 m), and with Scots pine (\textit{Pinus sylvestris}) in drier conditions\textsuperscript{18}. Stages and reproductive processes are regulated by climatic conditions, in particular by temperature, which become more important in higher altitudes.  

**Map 1. Plot distribution and simplified chorology map for \textit{Picea abies}**

Caption: Frequency of \textit{Picea abies} occurrences within the field observations as reported by the National Forest Inventories. The chorology of the native spatial range for \textit{P. abies} is derived after EUFORGEN\textsuperscript{39}.  

**Map 2. High resolution distribution map estimating the relative probability of presence.**  

Droplets of resin are common over the bark of the trunk and branches.

(Copyright Stefano Zerauschek, www.flickr.com: AP)

Majestic isolated spruce in a mountain field in Leskova Dolina

(Copyright Agnieszka Kwiecień, commons.wikimedia.org: CC-BY)
latitude regions. Seeds are dispersed mainly by wind, but also by birds and other animals. The symbiotic relationship between roots and mycorrhizal fungi (hundreds of species described) is important for spruce forest ecosystems, especially in non-optimal growing conditions such as in dry and marginal habitats.8,9

Importance and Usage
Norway spruce is one of the most important coniferous species in Europe both from an economic and ecological point of view. It has a long history of cultivation, having expanded its range considerably.8,14 Especially in northern European countries the main products of economic interest are the solid wood for timber constructions and pulpwood for paper.9,14 The wood is also used for a wide range of commodities, such as joinery timber, furniture, veneer and as tone-wood (sound boards of pianos and the bodies of guitars and violins).8,9,14 However, spruce wood is not durable, so not suitable when decay-resistance and toughness are required.8,9 Stradivari and other eminent Italian violinmakers of the 17th and early 18th centuries used Norway spruce wood from the forests of the southern parts of the Italian Alps for the tops of their violins, in particular from the “Forest of the Violins” in the Parco Naturale di Paneveggio (Trentino, N-E Italy). Known among violinmakers for its trees of resonance8,9,14. This species is also the most popular Christmas tree, a tradition that actually started in Germany, with the extensive afforestation beginning in the 18th century.8,9 Spruce stands are also planted for protection forests and erosion control, and can provide considerable recreational value.9,14 Since the 1940s the importance of this species has led some European countries to develop long-term breeding programmes to create base material for seed procurement with the objective of improving wood quality.14 The Norway spruce genome was sequenced in 2013, the first available for any gymnosperm. Its genome contains approximately 20 billion base pairs (about six times the size of the human genome, despite a similar number of genes). The large genome size seems to result from the slow and steady accumulation of a diverse set of long-terminal repeat transposable elements, possibly owing to the lack of an efficient elimination mechanism.8,9

Threats and Diseases
The most important natural disturbance factors affecting Norway spruce are fires, drought, storms and pathogens such as bark beetles. The fire tolerance is very poor. Spruce has a shallow root system, so that storms easily blow them down, especially in pure and dense stands, and access to deep soil water is impossible during dry periods.8,9 The root system makes spruce less resistant to windthrow and rockfall.24,25 Its rockfall mortality rate is higher than that of thicker-barked species such as larch.24 The bark beetles Ips typographus is one of the most destructive forest pests causing damage to spruce forest ecosystems in Europe.26,27 This bark beetle is often associated to damaging assemblages of fungal pathogens.27-30 It is a secondary agent, affecting trees

Mature Norway spruce plantation in Dalbeattie Forest (Dumfries and Galloway, South Scotland). (Forestry Commission, www.forestry.gov.uk: © Crown Copyright)

Open and opening cylindrical brown cones in autumn. (Forestry Commission, www.forestry.gov.uk: © Crown Copyright)

Top side of a violin made with spruce wood. (Copyright Takeshi Kuboki, www.flickr.com: CC-BY)

Dead spruces killed by the bark beetle Ips typographus near Boží Dar inside the protected area Krušnohorské plató (Ostrov, North-West Czech Republic). (Copyright Jiří Berkovec, commons.wikimedia.org: PD)

Tree species European Atlas of Forest Tree Species 115
that are already weakened (by storms, drought or other causes). It is currently expanding its range with mass outbreaks mainly on spruce stands outside their natural range [38]. The large pine weevil (Hylobius abietis L.) is among the most serious pests affecting young coniferous forests in Europe[39]. In northern and central Europe, Norway spruce coexists with the natural niche of the large pine weevil[40]. The fungus Heterobasidion annosum causes root and butt rot throughout the northern hemisphere, which leads to important economic losses both in growth and wood quality. Another important root rot disease is caused by the fungus of the genus Armillaria. Armillaria affects a wide range of tree and shrub species: larch, spruce and pine trees mainly, resulting in serious economic losses, reducing timber volumes and wood quality. As primary pathogens, both of these fungi can weaken plants, cause mortality and growth reduction in natural and planted forests over Europe, principally in the Boreal forest of Fennoscandia. Severe damage can be caused by deer and wild boar with bark peeling, which affects seedlings and young trees, allowing them to be more easily infected by fungi[38,41]. Starting from the 1980s, spruce forests have shown symptoms of decline in mountainous areas of central Europe including yellowing, loss of needles, die-back of branches and reduced growth. Air pollution has often been used to explain this[38]. Health problems in central European forests have reduced its popularity for reforestation, particularly outside its natural range[42]. Due to its preferences for cool and most climatic conditions this economically very valuable species may become severely affected under global warming conditions[39]. European alternatives to Norway spruce are mostly fir species such as Abies alba (e.g. Mediterranean or dry inner Alpine provenances) which can tolerate significantly warmer and drier conditions[38,43].

References

Field data in Europe (including absences) & Observed presences in Europe

Autoecology diagrams based on harmonised field observations from forest plots.

This is an extended summary of the chapter "Picea abies" of the Full Version of this publication. The full version of this chapter will be published in "European Atlas of Forest Tree Species - Volume 11: European Baxter" by Strelkov et al. (2013) (National Council for Forest Research and Development (COFORD), Mexico, 2013), vol. 2. The purpose of this summary is to provide an accessible dissemination of the original main topics. This OBD code points to the full online version, where the most adapted graphics can be freely accessed. Please cite as: