

Scots pine

Pinus sylvestris

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These Technical Guidelines are intended to assist those who cherish the valuable Scots pine, gene pool and its inheritance, through conserving valuable seed sources or use in practical forestry. The focus is on conserving the genetic diversity of the species at the European scale. The recommendations provided in this module should be regarded as a commonly agreed basis to be complemented and further developed in local, national or regional conditions. The Guidelines are based on the available knowledge of the species and on widely accepted methods for the conservation of forest genetic resources.

Biology and ecology

Scots pine (*Pinus sylvestris* L.) is a pioneer species that readily regenerates after major natural or human disturbances, if weed competition and grazing pressure are low. Natural stands are often pure and fairly even-aged. The species grows predominantly on poorer, sandy soils, rocky outcrops, peat bogs or close to the forest limit. On fertile sites, Scots pine is outcompeted by other—usually spruce or broad-leaved—tree species.

The species is wind-pollinated and has both male and female flowers on the same tree. Flowering is frequent; female flowering starts at the age of 15 years on solitary trees (on grafts, as early as 6–8 years) or 25–30 years in closed stands. Abundant male flowering appears some years later. Most years are relatively frequent but at the boreal forest limit seed maturation is impeded by the short growing season; most years may occur as seldom as once or twice in 100 years.



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Distribution

Scots pine has a wide distribution across the whole Eurasian continent, ranging in latitude from 37°N to 70°20'N. At the boreal forest limit it survives with less than 100 frost-free days/yr and 300 mm annual rainfall. Towards the steppe plains of Central Asia its occurrence is limited by the length of the drought period. In southern Europe and Asia Minor, isolated occurrences are confined to the montane zone (up to 2200 m in altitude in the Balkans and Spain, and 2700 m in the Caucasus).

Importance and use

Scots pine is a commercially important tree species in Europe. Its wood is easily workable, with good mechanical properties, and has many uses, primarily as construction timber and pulpwood.

Its moderate site demands render Scots pine an ideal species for artificial regeneration. Accordingly, its seed has been traded and used across Europe for centuries. Indiscriminate planting from seed of uncontrolled origin sometimes resulted in blatant quality loss, triggering provenance research well before present-day genetic knowledge was available.

Genetic knowledge

Taxonomic status and hybridization

There have been numerous attempts to subdivide the immense distribution area into various subspecies, which are rather unconvincing owing to the lack of any clear discontinuities in the contiguous range. Isolated southern occurrences, regarded as glacial relics, were occasionally described as separate species, such as *P. hamata* (Stev.) Sosn., *P. armena* Koch and *P. sosnowskyi* Nakai for the Caucasus region.

Under natural conditions Scots pine is not readily interfertile with other pine species. Spontaneous hybrids with *P. nigra*, *P. densiflora* and *P. mugo* have been reported. Towards other taxa, the species shows a robust hybrid incompatibility.

Intraspecific variability

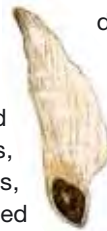
The high migration potential of both pollen and seed results in effective gene flow within the contiguous range, causing a distinct, clinal pattern of variation within the species, at least for adaptive traits. This is typically the case with growth and phenology characters, which are determined primarily by temperature

conditions in the vegetation period. Northern and continental populations need less heat sum to complete phenophases and reach hardiness. Southern and coastal provenances have longer vegetation cycles and are less hardy. Intensive gene flow also maintains high within-population diversity in both adaptive and neutral traits.

Stem form, crown form and branchiness show great variability within the area of distribution. Only the provenances of northern Europe/Siberia and those from higher elevations are straight-stemmed with an ideal conic crown form and fine branches. Certain regional populations (e.g. southeastern Baltic coast populations) show superior growth traits and high phenotypic stability, while in other areas growth and stem form are typically poor, possibly indicating improper silvicultural practices in the past (e.g. in Germany or in the Carpathian Basin).

In accordance with growth and stem form, mechanical properties of Scots pine timber show differences according to origin. This also includes the chemical composition, e.g. the extractive and oleoresin content of wood.

Intraspecific variation in resistance traits has also been recorded. Resistance to fungal pathogens such as *Lophodermium* spp. is higher in the western, coastal parts of the range, while



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southeastern forest steppe populations are especially susceptible. Geographic variation in susceptibility to insect pests has been proven for a number of insects; for instance Central European populations are susceptible to root collar weevil and pine moths, but more resistant to pine shoot borer and pine weevil.

Biochemical and molecular studies have clearly indicated that there is high diversity in Scots pine throughout Europe, with most variation occurring within rather than between populations. Monoterpenes and isozymes have been used to group the remnant areas in Scotland. Both approaches identified one region lying at the extreme northwest of the species' distribution with distinctive characteristics. These approaches have been superseded by DNA-based markers for the chloroplast, mitochondrial and nuclear genomes.

Variation in mitochondrial DNA (maternally inherited in pines) has indicated that the three major mitotypes present in Spanish populations encompass all the variability found in the rest of Europe. However, their individual occurrence throughout Europe separated Italian, west-central European and Fennoscandian populations into three clear groupings. At the extremes of the natural range, only one mitotype occurred in the isolated populations in southern Spain whereas in Scot-

land, although most sources matched the west-central European grouping, the Italian mitotype was present. Overall, molecular studies support the existence of three evolutionary routes within Europe for Scots pine and the higher variability in Spanish populations suggests that this area may have been an original centre of diversity.



Threats to genetic diversity

The main threats to survival lie at the extremes of its distribution, in particular, the north-western and south-western fringes (Scotland and southern Spain). Here the distribution of the species has become discontinuous and fragmentation into isolated populations is common. In extreme circumstances, this has left several remnant populations with fewer than 100 trees. Regeneration at the boreal forest limit is also problematic. In patches of the distribution browsing damage has led to a change of species. Measures such as fencing or reduction of game populations have been used to safeguard Scots pine populations, achieve successful natural regeneration, increase stocking levels and expand the areas concerned. In a number of instances, the need for grafted seed orchards to supply seed representing individual, highly vulnerable sources has been recognized.

In the core area of European distribution, where large-scale artificial regeneration has taken place for a long time, loss of locally adapted, autochthonous populations may have occurred in many areas. In regions where the species has been cultivated outside its natural range (e.g. Germany, France, Hungary)



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Scots pine stands are often of poor quality. Planted stands of unknown origin may exert a genetic pollution threat to natural populations in the surroundings.

Expected climatic changes will prolong droughts in continental SE Europe and in the Mediterranean region; this must be recognized as a potential threat not only to populations at the southern limits of the distribution area but also to high-elevation populations. This is likely to cause a northward shift of the area where the species can be successfully cultivated.

Guidelines for genetic conservation and use

Conservation priorities

Because Scots pine is a species with an extremely wide distribution and occupying a broad range of habitats, genetic conservation seems to be a task of low priority. However, the need to address genetic resources of Scots pine is supported by the widely proven genetic diversity between populations, the effects of century-long cultivation and the expected environmental changes at the margins of the distribution.

As Scots pine is one of Europe's most important tree species under forest management, the anthropogenic influence is obvious. Both survey and recording of native local (autochthonous) stands are important for gene conservation. These records could include various identification data; molecular markers become increasingly useful for this task.

Long-term provenance tests have proved the value and importance of locally adapted populations. This is valid primarily for extreme site conditions (higher altitudes, coastal environments, extreme boreal conditions, rocky or semiarid sites). Preserved populations on these sites exhibit less plasticity when transferred to other conditions, but are usually superior locally. Special care should be taken, therefore, to select representative populations for conservation

on such sites. Native stands selected for gene conservation will also serve as 'population standards' when compared with man-made forests.

As with populations on extreme sites, isolated outliers might have been exposed to specific selection pressures or drift and may carry rare alleles. Such populations should be carefully protected and steps taken to collect forest reproduction material at the sites. Local material should be used for regeneration and material from endangered sites should also be established in *ex situ* conservation stands.

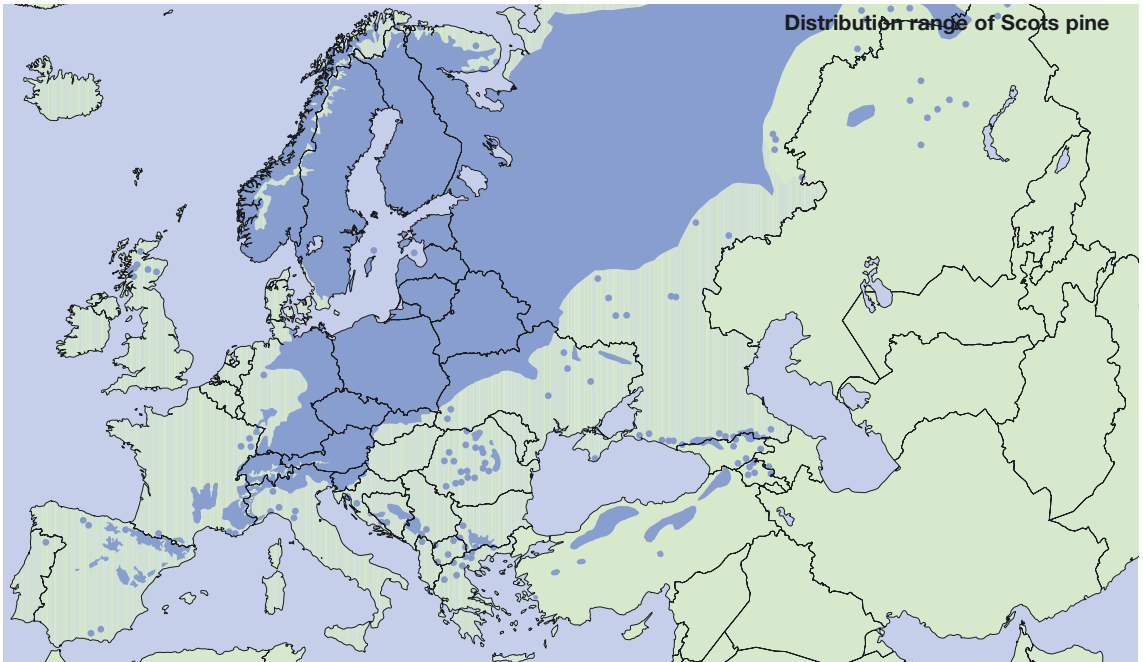
Expected climate change will first affect the populations at the southern fringes of the distributional range. These populations are often remarkably vigorous and tolerant and may be of value for future breeding. Here also *ex situ* measures should be applied to safeguard long-term survival.

The long tradition of artificial regeneration may have developed landraces that could also be targets for gene conservation efforts. These populations usually represent diverse, rather plastic genetic resources, valuable for future breeding and reproduction.

Establishment and management of gene conservation units

When selecting gene conservation units along a continuous cline, ecological information should be preferred to neutral

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markers. In the absence of drift, in a contiguous distribution range adaptively different populations may be expected at distances where annual mean temperature differs by a minimum of 1.0–1.5°C (equal to ca. 200 km in a flat landscape).

The size of gene conservation units of Scots pine should be sufficiently large to compensate for and buffer against outside geneflow: 100 ha should be considered the minimum. Nearby occurrences of genetically degraded or otherwise unsuitable stands should be either avoided or removed. A conservation unit should consist of

numerous adjoining stands of various age, provided their origin is the same. In areas of scattered occurrence, initial size may be 10 ha as a minimum, which can be increased during successive regenerations.

In many instances the pioneer character of Scots pine demands human interaction to prevent ecological succession. As far as possible, natural regeneration should be applied; this is less problematic on drier or poorer sites. Regeneration of admixed species should be tolerated for ecological reasons. The light demand of the species does not allow the development of a very

complex stand structure, but this is not necessary as even-aged stands may hold equal diversity. Regeneration felling should be carried out stepwise, allowing for recruitment from numerous seed years. Scots pine is genetically rather insensitive to the type of regeneration cutting used. However, if the influx of outside pollen were minimized (a goal which can be met with only partial success), shelterwood cutting would be preferred to other regeneration regimes. Fencing of the unit has to be considered where high game density threatens natural regeneration processes.



These Technical Guidelines were produced by members of the EUFORGEN Conifers. The objective of the Network is to identify minimum genetic conservation requirements in the long term in Europe, in order to reduce the overall conservation cost and to improve the quality of standards in each country.

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In certain cases artificial regeneration may be necessary (e.g. for *ex situ* conservation). To sample genetic resources properly, cones from 50 or more well-distributed trees should be collected (preferably in a good seed year). The quantity of seed from each tree must be equal in order to get a balanced participation in the final seed lot. Mixing of repeated seed harvests is beneficial, and no seed sorting or grading must be applied.

Direct sowing should be preferred to planting. If possible, planting should be carried out with higher density than usual to allow for more natural selection.

Intermediate low-intensity fellings and management should maintain a relatively dense stand structure. Selective removal of trees should be confined to malformed individuals; otherwise a broad variation of phenotypes should be allowed.

In summary, priorities for specific gene conservation measures will differ regionally. Preservation of genetic resources of Scots pine should be visualized in the context of locally applied forest management practices (especially control of seed sources for artificial regeneration), the extent of protected or unmanaged areas and the occurrence, density or fragmentation of the species at the landscape level, together with actual threats and risks. The urgency to set up gene conservation units will be much higher in an area with fragmented remnants of local populations surrounded by planted forests of uncontrolled origin than in a region where sustainable forestry relying on natural regeneration and local seed sources is practised.

Selected bibliography

- Giertych, M. and Cs. Matyas, eds. 1991. Genetics of Scots pine. Developments of Plant Genetics and Breeding, Vol. 3. Elsevier, Amsterdam.
- Sarvas, R. 1962. Investigations on the flowering and seed crop of *Pinus sylvestris*. Comm. Inst. For. Fenniae 33.4, Helsinki
- Scots pine breeding and genetics. 1994. Proc. IUFRO Symp. Lithuania, Lithuanian Forest Research Institute, Kaunas/Girionis.
- Silviculture and Biodiversity of Scots pine forests in Europe. 2000. Proc. EU Concerted Action meeting, Valsain, Spain, June 1999. Investigación Agraria, Sistemas y Recursos Forestales, Fuera de Serie No. 1, Madrid.

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