Silver fir

Abies alba

Heino Wolf
State Board for Forestry (Saxony), Pirna, Germany

These Technical Guidelines are intended to assist those who cherish the valuable silver fir genepool 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

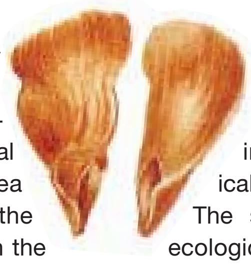
Silver fir is the tallest tree of the genus *Abies* in Europe. Under favourable conditions, the species can reach an age of 500 to 600 years and tree heights up to 60 (65) m. Stem diameter at breast height varies from 150 to 200 (380) cm in adult specimens. The crown is conical on young trees, parabolical to cylindrical with a flattened top on old trees. In uneven-aged forests, the length of the crown comes to one-half to two-thirds of the tree height. The trunk is straight cylindrical with horizontally spreading whorled branches.

Flowering age starts at 25-35 years on isolated trees growing outside the forest, and at 60-70 years for trees within the forest. Flowering is highly irregular among years. Silver fir is monoecious. Male and female flowers occur separately on the same tree, the female flowers typically inserted at the end of the highest branches of the crown, and the male flowers appearing generally lower in the crown than female flowers. Flowering period varies from April to June. The fully developed seeds are mainly dispersed by wind in September and October of the same year. The cones are erect and disintegrate at maturity in contrast to other conifer genera, leaving only the cone axis on the branches. The seed dormancy caused by ethereal oils (containing, for example, terpenes) stored in the seed coat lasts usually one winter. Stored seeds require wet-cold stratification of 6 weeks to germinate. When sown during autumn, sufficient germination results also can be achieved.

Silver fir is tolerant of a wide range of soil conditions, nutrient content and availability as well as pH levels. It depends most on moisture availability and temperature. However, the best growth of silver fir can be expected on deep, nutrient-rich, fine- to medium-textured and well-drained soils. Silver fir forms pure stands or mixed stands with beech and spruce. Although very cold-hardy, the species is very sensitive to frost drought during mild winter periods with still frozen soil, and to late frost during spring.

Silver fir is very shade tolerant and can remain as a “seedling bank” under the canopy of older dominant trees for decades. The species is an obligatory seeder. Vegetative regeneration does not occur under natural conditions. The seed dispersal is very efficient which allows silver fir to colonize, e.g. pioneer pine forests and open shrub lands.

Distribution



The distribution area of silver fir is limited mainly to the mountainous regions of eastern, western, southern and central Europe. The main area ranges from 52°N in the north (Poland) to 40°N in the south (northern border of Greece) and from 5°E in the west (western Alps) to 27°E in the east (Romania, Bulgaria). Isolated occurrences can be found in France (Central Massif and Pyrenees) and in northern Spain (Pyrenees), the latter extending the western limit to 1°W as well as in central and southern Italy (Calabria) extending the southern limit to 38°N.

In the distribution area north-east of the river Danube, silver fir can be found at elevations from 135 m asl in Poland to 1350 m in the eastern Carpathians (Romania). Southwest of the Danube, it grows from 325 m in the Apennines (Italy) to 2100 m in the western Alps, and extending up to 2900 m in the Pirin Mountains (Bulgaria). Within the main distribution area, the species forms a belt 500 to 600 m (800 m) wide which moves to higher elevations from north to south.

Importance and use

Among the different fir species growing naturally in Europe, silver fir is the most important economically and ecologically. The species is of great ecological and silvicultural value for the establishment and management of site-appropriate mixed stands of high stability owing to its deep and intensive taproot system, the easily biodegradable needle litter and its shade tolerance. Since silver fir was and is mainly regenerated naturally, the species is not considered a high-priority species in tree-breeding programmes in most European countries where it occurs.

Silver fir timber is strong, lightweight, light-coloured, fine-grained, even-textured and long-fibered. Sapwood and heartwood cannot be distinguished by colour. Primary resin canals are absent. The timber is mainly used as construction wood, furniture, plywood and pulpwood. Owing to its good cleavability and durability, especially under humid conditions, it is suitable for the production of shingles and for hydraulic engineering. Young trees are very popular as Christmas trees.

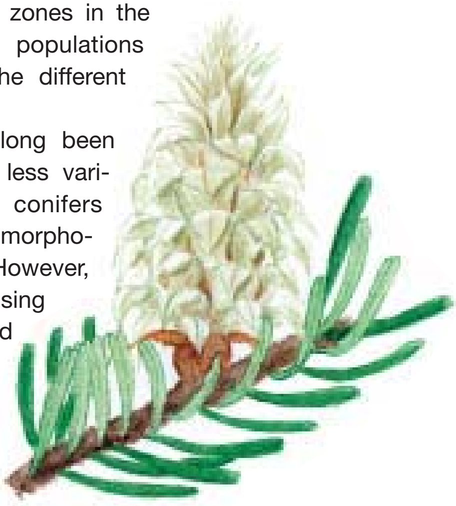
Genetic knowledge

Silver fir is a wind-pollinated, generally outcrossing species. In dense stands with a sufficient number of mature individuals, its outcrossing rate is over 80% of all seeds produced, which is similar to many other conifer species. However, in occurrences with a reduced population size, and during years of low flower production, self-fertilization takes place (up to 95% of all seeds produced on some trees).

Range-wide surveys using biochemical and molecular markers suggest different ice age refugia of silver fir in the following regions: the Pyrenees, central/eastern France, southern and central Italy as well as the southern Balkans. There is evidence that silver fir re-migrated at least into its present-day range from refugia in central Italy and the southern Balkans to form introgression zones in the contact zones of populations originating from the different refugia.

Silver fir has long been considered to be less variable than other conifers because of its low morphological variation. However, genetic analyses using common field and laboratory test methods showed significant differences in mortality, growth, ecophysiological and biochemical traits among populations descended from different parts of the distribution area.

The differentiation observed among populations is comparatively high which may be caused by different factors, e.g. by the separation of occurrences, or the unusually large pollen grains of silver fir. Among populations of the entire distribution range, area-specific gene variants, a correlation between the location of populations and the frequencies of gene variants, as well as a variation of the genetic diversity can be observed with different biochemical and molecular genetic methods. Within populations, the diversity assessed decreases with increasing distance from the respective refugium.



Threats to genetic diversity

Silver fir is not endangered as a species range-wide. However, the area of silver fir forests and its percentage of the forests decreased significantly during the last 200 years in most European countries. Reasons for the decline are human impacts through deforestation, over-exploitation, promotion of faster-growing tree species, clear-cut forestry, improper management, air pollution or damage by game. On the other hand, a complex decline syndrome (the Silver fir decline) reached dramatic proportions in the 19th and 20th centuries, especially in the central and northeastern part of the range. The decline may have been caused by several biotic and abiotic agents possibly in combination with a lack of adaptability due to insufficient genetic variation of silver fir populations in the specific regions. In the northeastern part of the distribution area, silver fir now occurs only in small, very often isolated groups of trees or individuals. However, an improvement in its health can be observed as a result of a decrease in air pollution in the central and northeastern part of the range since the 1990s.

Aware of the value of silver fir for stability and ecology of forest stands, forest managers are now promoting silver fir by supporting natural regeneration and planting as well as by selective thinning, game control, etc.

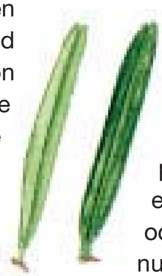
However, there are still some threats to the genetic resources of silver fir. Damage by game influences the success of natural and artificial regeneration. In occurrences with a low number of individuals, selfing, half- or full-sib mating may decrease the genetic variation. Finally, the effects of climate change could lead to a threat to silver fir populations. The increase of temperature together with higher evapotranspiration and lower precipitation could result in a significant change of the habitat of silver fir as well as in higher susceptibility to or in the appearance of pests and diseases.

In several regions, Mediterranean firs are often planted near silver fir stands as its substitute in harsher ecological conditions. Both groups of firs intercross easily and interspecific gene flow could cause a severe genetic threat in areas where native genotypes are to be protected or where local adaptation guarantees long-term survival.

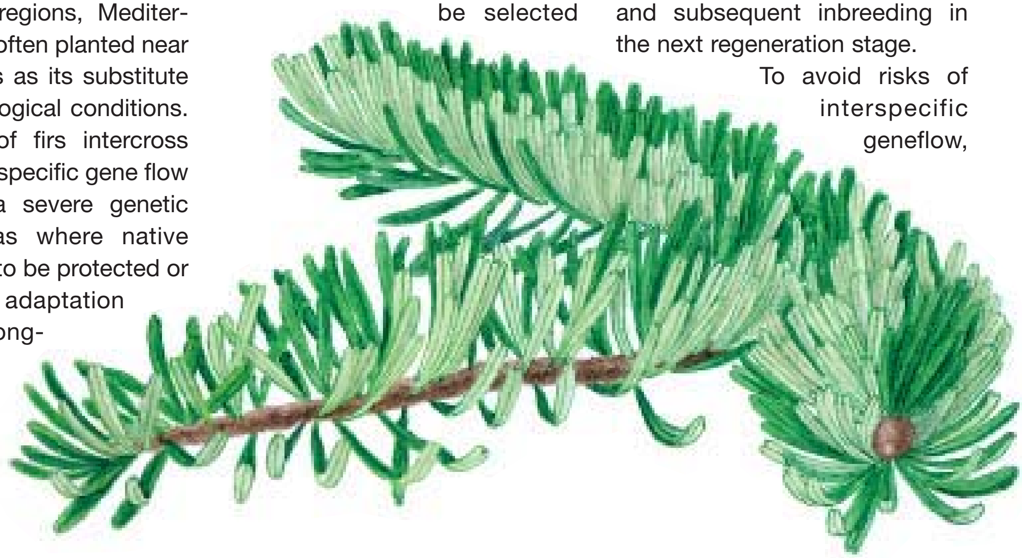
Guidelines for genetic conservation and use

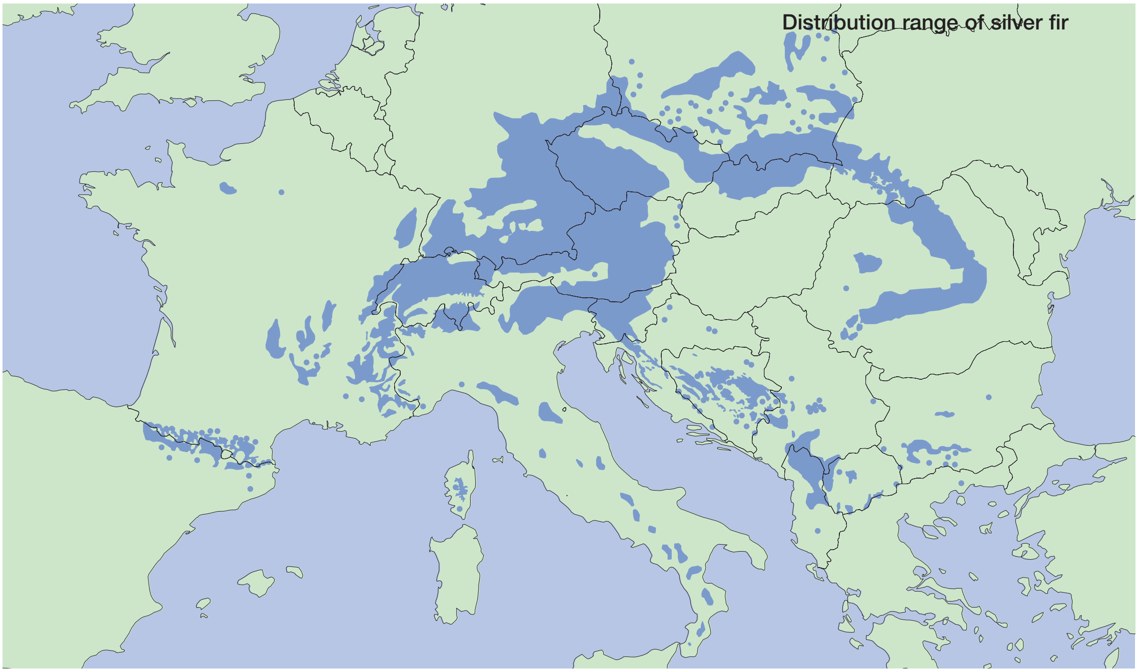
Since silver fir stands have been regenerated mainly naturally for a long period, there is reason to assume that they have preserved their original genetic structure and diversity, although the genetic composition of silver populations may have been modified by adaptation and/or drift processes. It is evident that in several parts of the distribution area genetic variation has been reduced due to the mentioned decline of silver fir. This reduction of population sizes may have reached a stage where the future survival of locally remnant populations is no longer guaranteed.

To preserve the population-specific genetic structures of silver fir, i.e. locally common alleles and the area-specific allele frequency distribution, many different populations from various distribution areas should be selected systematically for gene conservation purposes. The most effective way to conserve larger occurrences of silver fir and their genetic resources is through *in situ* conservation of stands and populations as well as their natural regeneration using long-term and small-scale regeneration methods. Additional activities are the promotion of silver fir individuals by tending and thinning, and the strict control of game. If planting of silver fir is required, culling for height of plants in the nursery should be avoided since genetic effects of this procedure cannot be excluded. In case of occurrences with a low number of individuals, enrichment planting in addition to the natural regeneration is recommended with plants from other, larger occurrences of the same region to avoid a higher frequency of half-sib offsprings and subsequent inbreeding in the next regeneration stage.



To avoid risks of interspecific geneflow,





reforestation using exotic *Abies* species in the vicinity of silver fir stands should be strictly monitored. Only in marginal areas, with highly depleted genepools and where ecological conditions are very degraded could interspecific mating help to create new adapted genotypes. In all other cases, it should be avoided.

For small populations with a decreased number of individuals, and in addition to *in situ* conservation measures, the establishment of *ex situ* gene conservation seed orchards is highly recommended in order to overcome the isolation of individuals and to promote outcrossing. The sampling of single trees does not affect the genetic structure if a sufficient number of individuals is considered. However, sampling should be done exclusively in indigenous populations, randomly in respect to the phenotype but representatively in respect to ecological variation. Wherever possible, the genotype of the individuals sampled should be assessed and considered, e.g. using gene markers to avoid loss of genetic variation and a reduced diversity.

Complementary to *in situ* and *ex situ* conservation measures, seeds of silver fir can be stored in genebanks for about 3 to 5 years provided that outcrossing has taken place among a minimum number of 20 individuals. To overcome the negative effects of isolation in silver fir relicts in the short term, the collection and storage of pollen in combination with artificial pollination of mature trees could be an efficient but expensive approach.

In the European Community, silver fir is under the EU Directive on the marketing of forest reproductive material. For reforestation or re-introduction of silver fir, only forest reproductive materials are to be used according to the regulations and must be suitable for the site conditions in firAbies alba Silver firAbies albaSilver firAbies albaSilver firAbies alba

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EUFORGEN

These Technical Guidelines were produced by members of the EUFORGEN Conifers Network. 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.

question. In nations not under EU law, the procurement of forest reproductive material should follow the principles of approval, identification and control. In every case, however, recommendations should be developed for the proper use of forest reproductive material.

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EUFORGEN Secretariat c/o IPGRI
Via dei Tre Denari, 472/a
00057 Maccarese (Fiumicino)
Rome, Italy
Tel. (+39)066118251
Fax: (+39)0661979661
euf_secretariat@cgiar.org

More information

www.euforgen.org