Swiss stone pine

Pinus cembra

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These Technical Guidelines are intended to assist those who cherish the valuable Swiss stone pine 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

Pinus cembra L. is a five-needled pine tree (subgenus *Strobus*, section *Cembra*, subsection *Cembrae*). The species rarely exceeds heights of 25 m, its growth is very slow but long-lasting and trees between 500 and 1000 years of age are reported. Under natural conditions, it may take 30 years to reach 1.30 m. Owing to its slow growth, *P. cembra* is a weak competitor compared with other trees. However, it is better adapted to the harsh upper subalpine climate conditions than any other European tree species. Consequently, it can compete in mixed stands where the performance of the other subalpine trees (mainly *Picea abies* and *Larix decidua*) is reduced and establish pure stands above their growth limit. *Pinus cembra* is often associated with *Pinus mugo*, *L. decidua* and/or *P. abies*.

Stone pine tends to be a climax species tolerating some shade in the juvenile stage and germinating well on organic soils with an accumulated layer of litter and moss. However, it can germinate and establish itself on mineral soils or even rocky surfaces as well.

The slow juvenile growth of *P. cembra* makes the species vulnerable to browsing for a long time and susceptible to lethal fungus infestations occurring under prolonged snow cover. For the latter reason, *P. cembra* is not found in microhabitats or regions with long-lasting snow cover (e.g. border zones of the Alps).

Stone pine is a wind-pollinated species with male and female flowers on the same tree (monoecious). Within natural stands, reproductive maturity is not reached before plants are 40–60 years of age. Flowering and seed production occur every 2–3 years, but only a single year

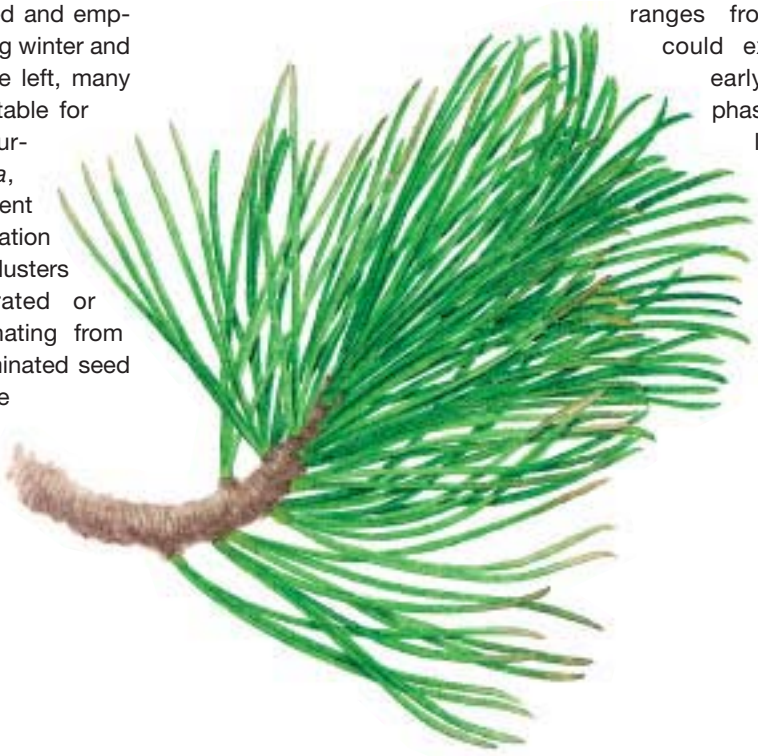
out of 4–10 is an abundant mast year. Self-fertilization is possible. The seeds ripen in the year after pollination, but the cones remain closed and do not release the heavy, wingless seeds. The seeds are mostly dispersed by the European nutcracker (*Nucifraga caryocatactes*), a bird species with a strong mutualistic relationship with *P. cembra*. The nutcracker picks most of the cones from the trees and caches those seeds it does not immediately eat in shallow underground deposits as a food source for the winter. A single nutcracker may store more than 25 000 seeds every year. Dispersal distances can be as far as 15 km horizontally and 700 m altitudinally. Most of the deposits are retrieved and emptied by the bird during winter and spring, but some are left, many of them in sites suitable for germination and survival of *P. cembra*, resulting in a sufficient and regular regeneration of the tree. Tree clusters (with either separated or fused trunks) originating from more than one germinated seed from one deposit are frequent and improve the stability of the subalpine forest.

Distribution

The distribution range of the Swiss stone pine is small compared with other pine species. It is restricted to the subalpine belt in the continental (i.e. central) parts of the Alps (France, Italy, Switzerland, Austria, Germany) and to some higher regions of the Carpathian Mountains (isolated patches from Tatra Mountains in Slovakia and Poland to the Southern Carpathians in Ukraine and Romania). The total species' coverage was estimated as about 30 000 hectares (density-weighted area) in the 1970s.

The altitudinal range of *P. cembra* forests is from 1500 to 2400 m asl (single individuals 1200–2850 m) in the Alps and from 1300 to 1700 m asl (900–1985 m) in the Carpathians. The lower boundary is determined by the competition of other tree species (mainly *P. abies*), whereas the upper limit seems to be a physiological (climatic) boundary.

The likely origin of *P. cembra* seems to be in the Siberian region, where its closest relative, *P. sibirica* (treated as *P. cembra* var. *sibirica* or *P. cembra* subsp. *sibirica* by some authors), covers vast areas. It is supposed to have survived the last glaciation period in the vicinity of the Alpine and Carpathian mountain ranges from where it could expand in an early postglacial phase to occupy large areas. At lower altitudes it was subsequently replaced.



Importance and use

Wherever it occurs naturally, *P. cembra* contributes to the uppermost forest belt in the mountains, forming mixed or pure stands. Consequently, the species has a crucial protective function for the surrounding area. The presence of (evergreen) trees in the stone pine's altitudinal zone helps to minimize the risk of avalanches and soil erosion. *Pinus cembra* is, therefore, valued as a stabilizing factor and often used for afforestation at high elevations.

Stone pine forests (pure and mixed) have a high aesthetic and ornamental value for many regions famous for summer and winter tourism.

Besides the protective and aesthetic functions of the species, the timber of *P. cembra* is highly valued, especially for paneling, carvings and traditional furniture because of its special wood characteristics (soft, light, resistant, warm reddish colour, perfume of resin). However, the traded quantities are comparatively small and mainly serve the local markets.

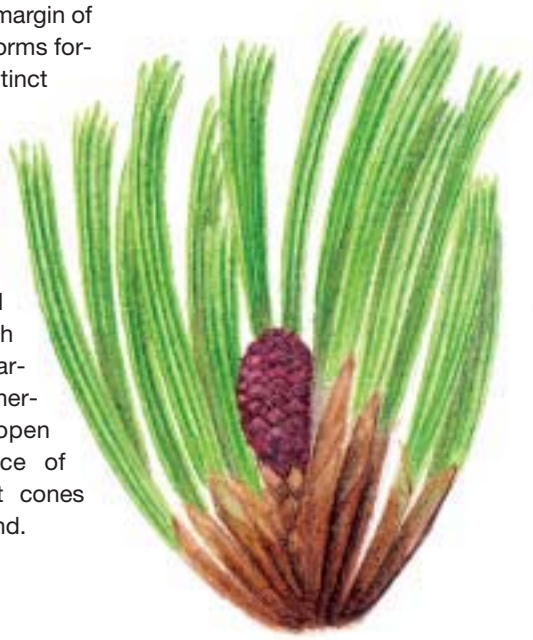
Genetic knowledge

In concordance with the putative survival areas during the last glaciation, isozyme variation indicates a low degree of genetic differentiation between a stone pine population from the Carpathian mountains and the populations from the Alps. Most of the genetic diversity found in Carpathian stands resides within populations. This also holds for the Alpine range, where the two main distribution areas in the eastern and the western Alps cannot be separated based on chloroplast diversity owing to extended historical pollen flow. However, there is a reduced genetic variation in isolated populations at the northern margin of the Swiss Alps. Crown forms formerly recognized as distinct races are considered to be the result of environmental effects rather than deserving of taxonomic status. However, elevational variation was observed with respect to growth response in common garden experiments. Furthermore, it remains open whether the occurrence of green instead of violet cones has a genetic background.

Threats to genetic diversity

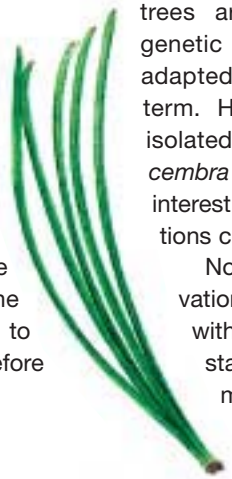
Owing to its ecological characteristics (weak competitiveness) and to negative anthropogenic impact (overuse, deforestation, intentional burning for gaining grassland), the occurrence of *P. cembra* today is highly fragmented in parts of its distribution range, and small population sizes are common.

The fragmentation may inhibit gene flow among the populations. Small populations are generally prone to elevated inbreeding and genetic erosion, but they are specifically threatened in an unstable area such as subalpine regions by avalanches, forest fires, landslides or unusual climatic events which can lead to further dramatic losses of genetic information.



A specific problem of many *P. cembra* stands is the highly skewed age distribution owing to a lack of recruitment and young trees (often as a result of browsing or other damages by ungulates or grazing livestock). If those stands cannot be regenerated, these populations risk losing some of their genetic information in the short term and extinction in the long term. Furthermore, high ozone loads seem to cause a decline of *P. cembra*, whereas the species has shown a higher degree of resistance to other air pollutants than do sympatric pine species.

An altitudinal cline of growth characteristics has been observed in provenance tests showing that *P. cembra* performs best in the altitudinal zone from which it originates. Once the growth belt of stone pine is reduced to a narrow altitudinal strip and the genepool is depleted, the capability of the species to spread out again is therefore limited.



Guidelines for genetic conservation and use

The main strategy of genetic conservation of Swiss stone pine should be a dynamic *in situ* conservation. However, complementary dynamic or static *ex situ* conservation may be appropriate in some cases.

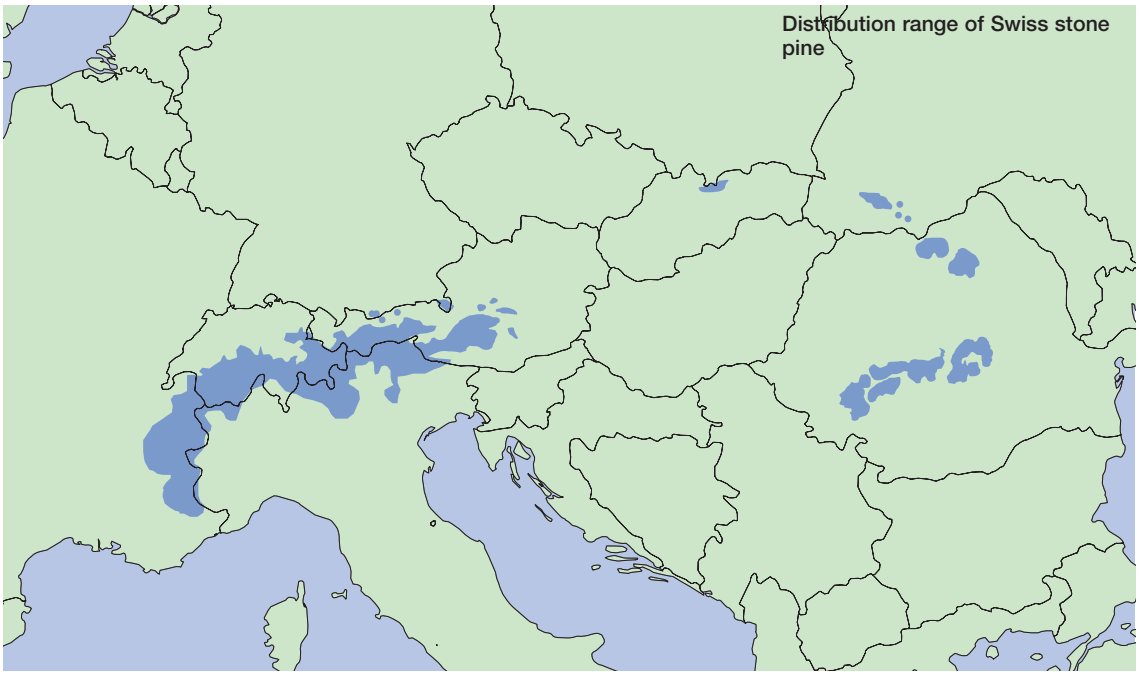
In situ conservation can be done within natural forest reserves, in gene conservation units specifically managed for the purpose, as well as in forests managed mainly for other purposes. Generally, abundant and large stands of interfertile autochthonous stone pine trees are best to assure genetic adaptability and adaptedness in the long term. However, small and isolated populations of *P. cembra* can be of special interest if particular adaptations can be assumed.

Normally, gene conservation can be matched with other goals of the stand management. As many of the *P. cembra* forests are expected to fulfil protection and/or aesthetic functions, a continuous tree cover is needed. A sufficiently dense, multilayered, uneven-aged forest with a clustered structure meets these demands best. Small-scale silvicultural practices such as the group selection method or the cluster selection method are recommended for both wood production and protection purposes. Where stone pine is naturally mixed with other tree species it is advisable to retain the mixture.

The crucial point in any case for a dynamic *in situ* gene conservation is the regeneration of the stand. Natural regeneration is considered to be the best way for gene conservation.

If there are suitable germination sites and seed trees within the nutcracker's dispersal range, regeneration of *P. cembra* occurs naturally. Sometimes a very dense cover of grasses or Alpine roses can be an obstacle for seedling growth, and the removal of patches of this vegetation can be useful. If necessary, animals affecting the young plants have to be excluded or individual protection measures must be taken. Forest gaps smaller in diameter than the height of the surrounding stand tend to accumulate snow during the winter and become snow-free only late in spring. Therefore, the dimensions of regeneration gaps should be 1–4 times the stand height depending on the site conditions.

For artificial regeneration in existing stands or for high-elevation afforestations with *P. cembra*, reproductive material must be chosen carefully owing to extreme site conditions. Only well-adapted and sufficiently variable material originating from similar sites ensures a long-term success for both production and



protection purposes. For plantations near the tree limit, the provenance of the material should lie within a 100-metre altitude range relative to the planting site. It is suggested to breed the plants in montane altitudes and to transplant them into a nursery located above 1500 m asl to ensure hardy acclimatization. Direct seeding has proven to be a satisfactory alternative to planting. As a consequence of the erratic seed production and the slow growth process, the planning of a plantation should start well in advance. Seed orchards at lower altitudes containing high-elevation provenances can facilitate a more regular supply of seeds.

Seed orchards can serve as a means of dynamic *ex situ* conservation of *P. cembra* if the number of progenies is sufficiently high (at least 50 trees proposed per origin population), especially in the case of endangered small or relic populations. However, it is preferable to conduct dynamic *ex situ* conservation in the vicinity of the original site and to use the local material. This is what the nutcracker tends to do when it "salvages" the species from accessible spots to rocky outcrops where the seedlings may survive.

Static *ex situ* conservation of reproductive material of *P. cembra* for gene conservation purposes is advisable only in case of emergency and the material should be recultivated as soon as possible.

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.

*Citation: Ulber, M., F. Gugerli and G. Bozic. 2004. EUFORGEN Technical Guidelines for genetic conservation and use for Swiss stone pine (*Pinus cembra*). International Plant Genetic Resources Institute, Rome, Italy. 6 pages.*

ISBN 92-9043-619-0

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