European beech

Fagus sylvatica

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These Technical Guidelines are intended to assist those who cherish the valuable European beech 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

European beech (*Fagus sylvatica* L.) normally grows to 30–35 m tall but in rare instances it may grow to over 40 m. Unlike many other tree species, it maintains its high growth rate until late maturity. Beech trees can live for 250 years or more but are normally harvested at 80–120 years of age. Beech has separate male and female flowers on the same tree and it is wind pollinated.

The thin, smooth, silver-grey bark is highly characteristic of beech. The leaves are elliptical without any lobes or peaks and have a short stalk. Beech is a good species for soil conservation as it produces a large amount of leaf litter (ca. 900 g/m² per year) and has extensive shallow and intermediate roots.

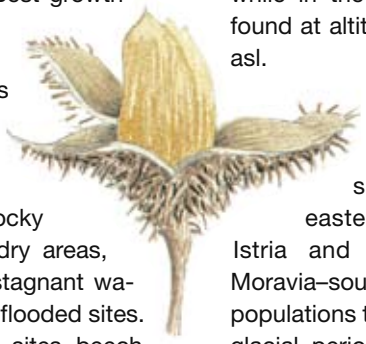
Beech is relatively resistant to most diseases. It does not suffer from massive predations by pests that lead to a total dieback of stands. Late spring frosts often damage young trees or flowers, which emerge simultaneously with leaf flush. Intense sunlight may damage the stem surface. Aphids may attack the bark. The fungus *Nectria ditissima* causes bark necrosis.

The tetrahedral shiny brown beechnuts are positioned in pairs in four-sided cupules. A mast year of beechnuts occurs only every 5–8 years. The seed can be stored for about five years. However, during storage the germination capacity of seeds decreases considerably. Seed dormancy is strong but can be broken by keeping seed at 3° C for at least six weeks.

Beech is highly shade tolerant. It can be regenerated naturally in continuous cover

silvicultural systems. However, where red or roe deer occur, they will browse beech seedlings and regeneration areas should be fenced.

Beech favours damp sites and soils that roots can easily penetrate. Best growth is attained in moist soils on calcareous or volcanic rock beds. Beech does not grow on rocky sites, in very dry areas, on sites with stagnant water or regularly flooded sites. On favourable sites beech is widely distributed because it out-competes other tree species due to its efficient use of light. Once beech has become the dominant species, this creates low light levels in the understory where beech seedlings can survive better than other species.



Distribution

Beech is widely distributed in Central and Western Europe. In the northern part of its range beech grows at low elevations while in the southern part it is found at altitudes above 1000 m asl.

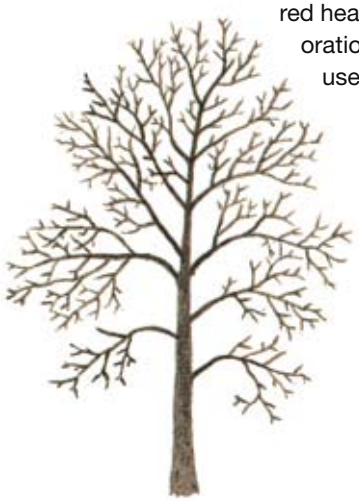
Beech spread to central and northern Europe from southern France, eastern Alps–Slovenia–Istria and possibly southern Moravia–southern Bohemia. The populations that survived the last glacial period in the Mediterranean regions (Italian and Iberian peninsulas) did not spread into central Europe.

Importance and use

Beech wood is homogeneous with fine pores and conspicuous wood rays. The colour varies from nearly white to reddish. The wood has an average density of 700 kg m^{-3} with good stiffness but little elasticity. It is resistant to abrasion but is susceptible to attack by fungi and needs to be protected if used outdoors. With about 250 known uses for its wood, beech is the most diversely used tree species in Europe.

Beech wood is mainly used for furniture. It is also excellent for flooring and staircases. Beech wood is also used extensively in the production of pulp and various boards, veneer and plywood. It is used as fuelwood due to its relatively high energy content.

Beech trees more than 100 years old frequently develop red heartwood, a discoloration that limits the use of the wood.



Genetic knowledge

Genetic variation in beech has been studied in provenance trials and with genetic markers such as isozymes and DNA markers. Studies using nuclear molecular markers show high variation within populations and little differentiation among populations. However, maternally inherited DNA markers of the chloroplasts (transmitted by seeds only) display a very high differentiation among populations. The analysis of the spatial distribution of alleles in a naturally regenerated, isolated pure beech stand using molecular markers shows the tendency of a strong family structure in the distance up to 30 m. Spatial genetic structures are influenced by unpredictable factors (e.g. wind direction at anthesis) and can therefore vary from year to year. Based on these results, it is recommended that seed should be collected over large areas in order to prevent a preponderance of a few families and a reduction of the adaptive potential of the next generation.

Although seed dispersal of beech is limited. Pollen flow ensures long distance gene flow. A study in three relatively isolated beech stands in northern Germany indicated that gene flow from outside beech stands is very efficient. External pollen gene flow is an important factor that should be considered when establishing beech seed production stands and gene conservation units.

There is continuous variation in some characters, e.g. in the time of the flushing of the leaves. This character reflects adaptation to late frost, which occurs more frequently in mild oceanic conditions than under a continental climate. Beech also shows variation in the temperature sum required for initiation of leaf flush, which is higher in oceanic beech populations than in continental populations. Thus, when grown at a single site, provenances from a continental site in the south-east of the distribution range usually flush earlier than those from an oceanically influenced site in the north-west of the distribution range. Provenances from the south-east may thus suffer greater frost damage in spring when grown on sites in the north-west of the distribution range.

Some stem form characters, such as spiral grain, are under relatively strong genetic control. Provenances from higher elevations may show better tree form characters such as trunk straightness, branching and crown shape than those from lower elevations.

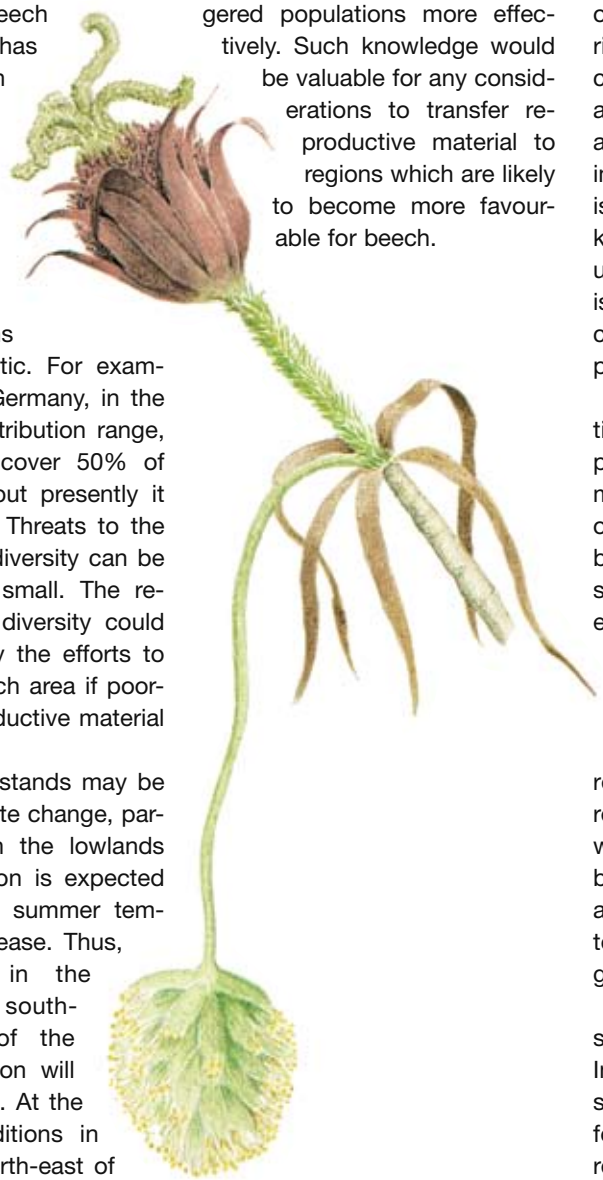
Genetic improvement of beech has relied mainly on seed stand selection. A simple system is usually applied, where characters such as growth increment, health and phenotypic appearance are evaluated on a large number of seed trees (at least 80 trees more than 70 years old). In each seed lot, seed should be harvested from at least 40 trees. The seed stand should have a minimum size of 2.5 ha, preferably larger. Individual selection and subsequent progeny testing have rarely been undertaken and only a few seed orchards are known to exist.

Mass propagation by means of vegetative propagation (cloning) is possible but is not practiced due to the high costs involved. Cuttings are generally difficult to root. Clones differ distinctly in their ability to root. European beech does not produce root-suckers like some other beech species. *In vitro* culture techniques have not been developed to a commercially feasible scale.

Threats to genetic diversity

Beech prefers sites favourable for agriculture and subsequently large areas of beech forest have been cleared for agricultural production. As a result, a large proportion of beech genetic diversity has probably been destroyed. This land clearing has also fragmented the remaining stands. In some regions the reduction in beech populations has been dramatic. For example, in Saxony, Germany, in the centre of the distribution range, beech used to cover 50% of the forest area but presently it covers only 3%. Threats to the present genetic diversity can be assumed to be small. The remaining genetic diversity could be threatened by the efforts to increase the beech area if poorly-adapted reproductive material is introduced.

Some beech stands may be at risk from climate change, particularly those in the lowlands where precipitation is expected to decrease and summer temperatures to increase. Thus, beech stands in the southern and south-eastern parts of the present distribution will be affected most. At the same time conditions in the north and north-east of the present distribution range are likely to become more favourable for beech. These changes will also affect genetic diversity of beech. More knowledge about the genetic diversity, variability and adaptability of beech is required to conserve the endangered populations more effectively. Such knowledge would be valuable for any considerations to transfer reproductive material to regions which are likely to become more favourable for beech.

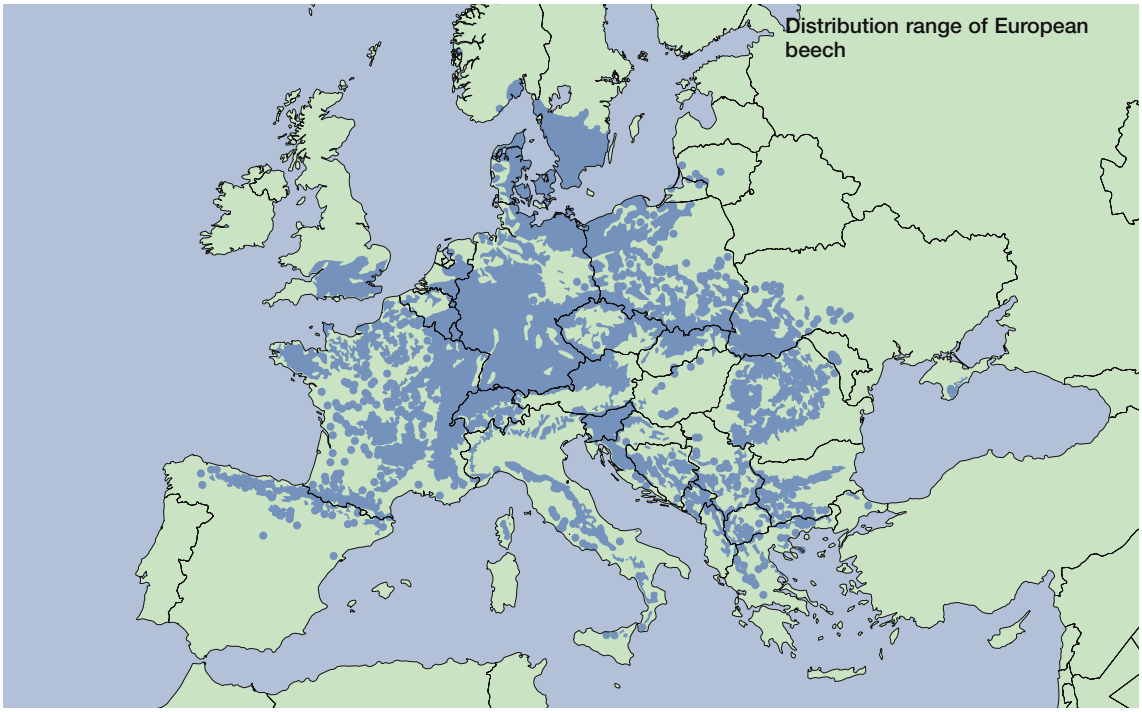


Guidelines for genetic conservation and use

Genetic diversity of beech should be conserved using a mix of *in situ* and *ex situ* approaches. For reforestation, the minimum requirement should be that the origin of the reproductive material is known and its adaptive characters should be appropriate for the ecological conditions at the new site. This is especially important in places where beech is to be re-introduced but little knowledge on site-adapted populations exists, e.g. where beech is used to replace maladapted conifer stands that have been planted on former beech sites.

Besides the present regulations for documenting forest reproductive material in trade, a monitoring system for the use of reproductive materials should be applied. Recommendations should be developed on proper use of different materials in the face of climate change, together with transfer guidelines. The EU directive and OECD scheme provide basic regulations on the transfer of reproductive materials. In years with abundant seed production, beech seed should be harvested and stored in sufficient amounts to capture the widest range of genetic diversity.

Beech can usually be conserved *in situ* in normal stands. In many parts of Europe seed stands alone may not be enough for the conservation of genetic resources of beech. Therefore,



there is a need for gene reserve forests. These are natural stands managed to ensure successful natural regeneration, e.g. through thinning and harvesting older trees. The objective is to maintain continuous evolution of a tree population. Such gene reserve forests should cover at least 100 ha in order to contain sufficient genetic variability. For small, locally adapted populations, however, it may be better to establish a large number of smaller reserves.

The establishment of *ex situ* conservation plantations of beech may be necessary in order to conserve the genetic variation of threatened populations that cannot be maintained at the original site. The objective is to maintain as much as possible of the original genetic variability and to allow continuing adaptation to local conditions. *Ex situ* conservation stands should cover 2–5 ha, and can be established by planting seedlings or by direct sowing.

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EUFORGEN

The series of these Technical Guidelines and the distribution maps were produced by members of the EUFORGEN Networks. The objective 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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The distribution map, showing the natural distribution area of *Fagus sylvatica* was compiled by members of the EUFORGEN Networks based on an earlier map published in: Pott R. (2000) Palaeoclimate and vegetation - long-term vegetation dynamics in central Europe with particular reference to beech. Phytocoenologia 30(3-4): 285-333

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