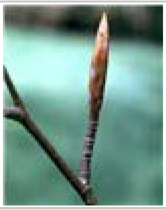
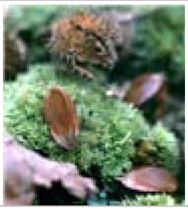
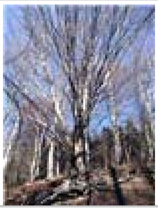
Forestry Compendium

Datasheet report for Fagus sylvatica (common beech)

Pictures

Picture	Title	Caption	Copyright
	Beech forest stand in winter	F. sylvatica subsp. sylvatica, mature shelterwood stand, 120-years-old, tree height 35 m. Location: southern Germany.	Bernhard Felbermeier
	Individual beech tree, summer foliage	F. sylvatica subsp. sylvatica, solitary tree within mixed forest. Age 140 years, height 35 m. Location: southern Germany.	Gudrun Elisabeth Felbermeier
	Autumn foliage, mature tree	An open-grown F. sylvatica subsp. sylvatica, age 140-years, height 35 m. Location: southern Germany.	Gudrun Elisabeth Felbermeier
	Bark	F. sylvatica subsp. sylvatica, mature tree aged 140 years.	Bernhard Felbermeier
	Branch and buds	F. sylvatica subsp. sylvatica branch with long shoots and regular branching pattern.	Gudrun Elisabeth Felbermeier
	Terminal bud	F. sylvatica subsp. sylvatica terminal bud on short shoot.	Gudrun Elisabeth Felbermeier
	Inflorescences	F. sylvatica subsp. sylvatica flowers.	Gudrun Elisabeth Felbermeier
	Leaves	F. sylvatica subsp. sylvatica leaves in spring.	Bernhard Felbermeier

Picture	Title	Caption	Copyright
	Beech nuts	F. sylvatica subsp. sylvatica beech nuts in cupule.	Gudrun Elisabeth Felbermeier
	Beech nut	F. sylvatica subsp. sylvatica beech nut.	Gudrun Elisabeth Felbermeier
	Germinating beech nut	F. sylvatica subsp. sylvatica germinating beech nut.	Gudrun Elisabeth Felbermeier
	Beech with modified branching	F. sylvatica subsp. sylvatica modified branching pattern, probably caused by air pollution. Location: northern Germany.	Bernhard Felbermeier
	Intensive branching	F. sylvatica subsp. sylvatica. This tree, with intensive branching pattern, helps to reduce soil erosion. Location: southern Germany.	Bernhard Felbermeier

Identity

Preferred Scientific Name

Fagus sylvatica L.

Preferred Common Name

common beech

Subspecies

Fagus sylvatica nothosubsp. moesiaca

Other Scientific Names

Castanea fagus Scop.
Fagus hohenackeriana Palib.
Fagus intermedia nov. spec. col.
Fagus macrophylla Koidz.
Fagus moesiaca (K. Maly) Czeczott
Fagus moesiaca K. Maly
Fagus orientalis Lipsky
Fagus silvatica var. asiatica D.C.
Fagus silvestris Gaertn.
Fagus taurica Popl.

Fagus winkleriana Koidz.

International Common Names

English: European beech; oriental beech
Spanish: cascojo; faig; haya; haya
French: fau; fayard; foyard; hetre; hêtre asiatique; hêtre commun; hêtre d'orient
Russian: buk
Arabic: zan
Chinese: ou zhou shan mao ju

Local Common Names

Denmark: bög
Germany: Buche; Gemeine Buche; Orientalische Buche; Rot- Buche; Rotbuche
Greece: oxya
Iran: raasch
Italy: faggio; faggio orientale
Netherlands: beuk; beuken
Poland: buk zwyczajny
Sweden: Bok; boken; rädbok
Turkey: gülgen ag; gürgen ag; kayin ag; kaym

EPPO code

FAUMO (Fagus moesiaca)

Trade name

aceite de haya

Taxonomic Tree

Domain: Eukaryota
Kingdom: Plantae
Phylum: Spermatophyta
Subphylum: Angiospermae
Class: Dicotyledonae
Order: Fagales
Family: Fagaceae
Genus: Fagus
Species: Fagus sylvatica

Notes on Taxonomy and Nomenclature

According to recent findings, F. sylvatica is a completely isolated species of the genus Fagus native to western Eurasia. Two subspecies are distinguished by macroscopic traits: subsp. sylvatica (sensu Denk) in the western part of its range and subsp. orientalis (Lipsky) Greuter et Burdet in the eastern part. Transition forms between these two subspecies are classified as further subspecies or variations. In the southern transition zone the form 'moesiaca' is associated with subsp. sylvatica, in the northern transition area the form 'taurica' is assigned to subsp. orientalis (Encke et al., 1993; Strid, 1997; Denk, 1999a, 1999b). Beside this classification, the traditional segregation of both subspecies into two species, Fagus sylvatica L. and Fagus orientalis Lipsky is widely applied

(Tutin et al., 1964) and F. orientalis replaces F. sylvatica south and east of northern Bulgaria (Mitchell, 1974). Alternative approaches to the taxonomies described above have been published by Duty (1985) and Denk (1999a, 1999b).

Beside the natural taxon, 146 varieties and forms are documented, mainly found in parks (Donig, 1994). The oldest and most important are 'Atropunicea' (found in Switzerland before 1680), 'Laciniata' = 'Heterophylla' (found in Germany, 1795), 'Pendula' (found in England, 1836), and 'Dawyk' = 'Fastigiata' (found in Scotland at the beginning of the 19th century) (Mitchell, 1974; Krussmann, 1960).

Botanical Features

General habit

Deciduous, monoecious, mono- and polycormic trees with a characteristic smooth, silver-grey bark. Isolated open-grown trees develop an extremely wide, spreading crown with branches springing from low down the stem. Trees grown in a forest stand can develop cylindrical clear boles up to 25 m (Radulescu, 1934). Beech assumes a shrub-form when growing at the timber line (Tschermak, 1929; Mayer, 1988; Wilmanns, 1989).

Size

On good sites, mature beech will attain an average height of 35 m and mean d.b.h. of 45 cm (Milescu et al., 1967; Hamilton and Christie, 1971; Schober, 1975). Largest tree dimensions recorded are 50 m height and 290 cm d.b.h. (Schoenichen, 1950; Kramer, 1988; Prentice and Helmisaari, 1991).

Stem form

Stem form of beech depends strongly on environmental conditions and competition. Straight, branchless stems with little taper will form when beech is grown with competing trees in a stand. In other conditions, beech will tend to develop forked, crooked or twisted stems because of its multibranched crown architecture (Burschel and Huss, 1987). With decreasing crown symmetry, stems also tend to develop increasing eccentricity; spiral-grained stems also occur (Knigge and Schulz, 1966).

Shoots

Twigs are green after flushing and become reddish-brown during lignification. Vegetative structures are monopodial, alternate, and acrotonic. Shoot orientation is basically plagiotropic. Terminal shoots develop from secondary growth of basically plagiotropic-oriented shoots, when light conditions are sufficient. Only the terminal shoot of seedlings and secondary shoots (prolepsis) are orthotropic. Two types of shoots may be distinguished: (i) long shoots with alternate buds which branch out regularly; and (ii) short shoots which only develop a terminal bud, do not branch out, and are frequently located at the twig base. Morphological development of beech is further discussed by Troll (1954).

Buds

Brown, fusiform and acute, >20 mm lanceolate, <10 mm spherical, and frequently covered by trichomes (Denk, 1999b).

Roots

During the first three years, young beech seedlings form a sturdy tap root, but then start to develop an intensively twisted heart-shaped root system (Joyce et al., 1998). Root morphology is influenced by site conditions: coarse roots will avoid heavy, anaerobic or skeletal soil horizons. Fine roots will be orientated to eutrophic soil layers (Kostler et al., 1968). The root system has a very high proportion of fine roots and obligatory ectomycorrhizas. Details of the morphology and taxonomy of beech mycorrhizas are described in Brand (1991).

Bark

The bark of young trees is dull coloured, in older individuals it is silvery-grey to grey-white. In contrast to most other trees, primary cork cambium activity is maintained; consequently, the bark remains smooth throughout the whole life of the tree, often with a slightly roughened appearance and perhaps with rippled patches or a fine network of ridges (Holdheide, 1950; Mitchell, 1974). Because cambial activity continues, branch scars remain on the bark and can be used to estimate the depth and angle of former branches: the relation between height and width of the centre scar is correlated to the relative depth of the dead branch. The smaller the angle between both linear scars, the steeper the former branch (Burschel and Huss, 1987). Bud scales also leave annual scars, which can be used to reconstruct annual shoot growth over the past decade (Troll, 1954).

Foliage

Leaves are simple, petiolate, stipulate, and alternate; leaf shape is ovate, elliptic or obovate, symmetric or asymmetric. Leaf margin is more or less sinuate to slightly crenate. Leaf length ranges from 3 to 14 cm, leaf width between 2 and 8 cm. Petiole up to 12 mm long (Tutin et al., 1964; Strid, 1997; Denk, 1999b). Tertiary veins are obliquely orientated. On the abaxial surface major veins are raised, interveinal areas flat, stomata 30 µm long and 22 µm wide. Cuticular ornamentation and obvious wax crystalloids are absent. On the adaxial surface, major veins are level with the leaf surface, interveinal areas are flat. Stomata, cuticular ornamentation and obvious wax crystalloids are absent. Simple hairs exist on both leaf sides (Westerkamp and Demmelmeyer, 1997). Two types of leaves can be distinguished: (i) dark-green sun leaves with multi-layered palisade parenchyma; and (ii) light-green shade leaves with a single-layered palisade parenchyma, half leaf-thickness, fewer veins and fewer stomata (Walter and Breckle, 1986; Eschrich et al., 1989; Rinderle, 1990; Sitte et al., 1998). Cotyledons are kidney-shaped, primary leaves are similar to secondary leaves. Cotyledons and primary leaves are decussate (Troll, 1954).

Inflorescences, flowers and fruits

Male flowers are numerous, in pendant heads on peduncles up to 45 mm long. Calyx 4- to 7-lobed. Stamens 8 to 16. Pollen with spheroidal grains, tricolporate with pronounced pores (Kubitzki et al., 1993). Female flowers usually 2, surrounded by a 4-partite, pedunculate, pubescent and scaly cupule becoming woody in fruit. Perianth 4- to 6-lobed. Ovary inferior, 3-celled, styles 3. Fruit a brown, triquetrous nut up to 20 mm long; 2 nuts are enclosed in the woody cupule. Dispersal is through scattered hoarding and burial by mammals and birds (Kubitzki et al., 1993; Strid, 1997; Denk, 1999a, 1999b).

Phenology

Flowers blossom before and during leaf-bud break in April-May. Bud dormancy is reduced by chilling (Falusi and Calamassi, 1990) and longer day length (Vince-Prue, 1975). Bud burst is then controlled by air temperature (Falusi and Calamassi, 1996). Leaf fall is determined by the onset of shorter day length (Vince-Prue, 1975). Fruits fall in October, pass the winter in leaf litter, and germinate, depending on temperature and moisture, between January and May (Bourne, 1945; Burschel et al., 1964). The ratio between the number of long and short shoots increases with increasing precipitation of the preceding year. Light conditions are correlated with the formation of sun- or shade-leaves in the following year (Eschrich et al., 1989). Flowering is favoured by high temperatures (1.5°C higher than normal) and low rainfall in June and July of the preceding year (Wachter, 1964; Havranek, 1972).

Subspecies characteristics

The macroscopic differences between F. sylvatica subsp. sylvatica and subsp. orientalis are, respectively: cupule length 20-25 mm versus 15-20 mm; cupule peduncle 5-25 mm versus 20-45 mm; secondary veins 6-10 versus 6-11; and cupule with acute bristles versus cupule with foliar appendages (Tutin et al., 1964; Strid, 1997; Denk, 1999b). The wood of subsp. orientalis is darker in colour and more homogeneous (Greguss, 1959) and false heartwood is less frequently found (Begemann, 1987) compared to subsp. sylvatica.

Characteristics of beech forms

F. sylvatica varieties exhibit some very different features; for example, 'Atropunicea' has black-purple leaves of variable size and form. Seedlings germinate with purple colour and become green during summer. The variety 'Laciniata' = 'Heterophylla' develops various leaf shapes ranging from triangular with deeply incised edges to long thin leaves similar to those of willow (Salix spp.), and branching is very dense. The variety 'Dawyk'= 'Fastigiata' has upright branches and a narrow pyramidal crown form. The branches of 'Pendula' spread horizontally from the stem and then abruptly hang down; it has a wide and irregular crown. Further forms and descriptions may be found in Mitchell (1974) and Krussmann (1960).

Importance

F. sylvatica, European beech, is a deciduous broadleaved tree found in temperate and warm temperate climates of western Eurasia, where it dominates the natural development of forest vegetation (Ellenberg, 1986). The oldest known individuals may attain an age of 900 years (Larcher, 1994); however, in natural forests beech usually reaches an age of 300 years (Korpel, 1995; Joyce et al., 1998). Economic rotations are between 80 and 140 years, as wood quality declines after this age (Pfeil, 1829; Burschel and Huss, 1987). Beech is able to grow well in a wide range of site conditions provided it has a satisfactory supply of nutrients; it does not tolerate waterlogging. Although cold tolerant, it may be damaged by spring frost events. It is the most shade tolerant broadleaved tree in its range.

Beech produces a highly versatile, high quality hardwood timber with excellent woodworking properties, which has a wide range of applications in both craft and wood industries. Economically, it is one of the most important timber tree species in Europe (Peters, 1992). The technical properties of beech wood are such that, in Europe, it is likely to be an important substitute for declining supplies of tropical timbers (Joyce et al., 1998).

Disadvantages

F. sylvatica is sensitive to repeated flooding and fire. Avalanche protection forests with a high proportion of beech are problematic, because of reduced interception and snow accumulation on the ground, which can easily slip downhill on the slippery leaf litter (Fiebiger, 1977; Konetschny, 1990). The consumption of large amounts of unpeeled beech nuts can be toxic (Hotovy, 1948; Burger and Wachter, 1993).

Review of Natural Distribution

The southern limit of the natural distribution of F. sylvatica in Europe is from the Pindos Mountains (Greece), the islands of Sicily and Corsica, the Pyrenees, and the Cantabrian Mountains in northern Spain. The western distribution limit is the coast of continental Europe, although beech is indigenous to southern England and southern Scandinavia. The eastern limit is roughly a line from the Baltic Sea to the Black Sea.
There is a transition zone in the eastern Balkans and the northwest Black Sea coast, from which F. sylvatica subsp. orientalis spreads via northern Asia Minor, the Crimea to the Caucasus Mountains, the Caspian Sea and the Elburz Mountains. In this transition zone, subsp. sylvatica colonizes mountainous areas, whereas subsp. orientalis is found at lower altitudes (Tutin et al., 1964; Gomory et al., 1993). The altitudinal limits of F. sylvatica vary from close to sea level in Scandinavia, 1800 m in the Alps and Mediterranean montane areas (Ellenberg, 1986), 2000 m in the Pontic Mountains and Caucasus (Jaroschenko, 1936; Mayer and Aksoy, 1986), 2250 m in Sicily on the slopes of Etna (Ellenberg, 1986), to 2700 m in the Elburz Mountains (Denk, 1999a). In the oceanic west, the southern Alps, Mediterranean montane zones and the northwest Caucasus, beech forests occur at the tree line (Rohrig, 1991; Ellenberg, 1986; Denk, 1999a).

There are gaps in this distribution, in winter cold-dry regions of the Alps and the Caucasus mountains, and in lowland basin regions which have warm dry summers. The limits of beech distribution can be explained by the lack of frost-resistance of buds, shoots and bark (Tranquillini and Plank, 1989), late spring frost damage to young foliage and flowers, as well as drought damage to mesomorphic beech foliage (Ellenberg, 1986; Matuszkiewicz and Pott, 1989). Huntley and Birks (1983) cite prehistoric humans as the limiting factor to further beech migration in the British Isles.

Vegetation types
F. sylvatica forms pure or mixed forests in temperate or warm-temperate climates. Within closed forest canopies, beech can establish almost pure regeneration due to its high shade tolerance; this regeneration will subsequently develop into beech-dominated stands. Consequently the optima for beech coincide with optima for beech tree growth (Schutt et al., 1992; Korpel, 1995; Ellenberg, 1986). Beech-dominated forests occupy a very large area under widely varying site conditions and ground vegetation associations; forest types are, because of this, distinguished by site characteristics (e.g. calcicolous, mesotrophic and acidophilous beech forests) and ground vegetation (Ellenberg, 1986). At the limits of its distribution range beech forms mixed stands (Walter, 1974; Ellenberg, 1986) with a large number of different tree genera: Pinus, Picea, Abies, Taxus, Betula, Carpinus, Quercus, Castanea, Tilia, Ulmus, Prunus, Sorbus, Aesculus and Acer (Peters, 1997). These forest associations are classified by woody species composition. Examples of syntaxonomial classifications are found for:
(i) F. sylvatica subsp. sylvatica in Mayer (1984) and Ellenberg (1986);
(ii) F. sylvatica subsp. orientalis in Mayer and Aksoy (1986) and Walter (1974);
(iii) the transition zone between the two subspecies in Horvat et al. (1974) and Walter (1974).

Beech is a characteristic species of mixed mountain forests (Mosandl, 1990; Mayer, 1984). In montane areas in southern Europe, it utilizes moisture from mist and cloud to survive summer dry periods (Ellenberg, 1986).

Forests within the distribution area of beech have been heavily affected by human activities since the Neolithic period (Huntley and Birks, 1983; Jahn, 1991; Ellenberg, 1986). Consequently, today most areas of beech forest are assumed to be secondary forest.

Latitude

between 60º N and 36º S

Vegetation types

cloud forests
deciduous forests
mixed forests
mountain forests
secondary forests

Location of Introductions

Beech was successfully introduced as a forestry species into Ireland from the 17th century (Joyce et al., 1998) and to Scotland during the 19th century (Savill et al., 1997).

Distribution Table

The distribution in this summary table is based on all the information available. When several references are cited, they may give conflicting information on the status. Further details may be available for individual references in the Distribution Table Details section which can be selected by going to Generate Report.

Country	Distribution	Last Reported	Origin	First Reported	Invasive		References	Notes
ASIA								
Armenia	Present					natural		
Azerbaijan	Present					natural		
Georgia (Republic of)	Present					natural		
Iran	Present					natural		
Philippines	Unconfirmed record						CAB Abstracts	
Turkey	Present					natural		
EUROPE								
Albania	Present					natural		
Andorra	Present					natural		
Austria	Present					natural		
Belgium	Present					natural		
Bosnia-Hercegovina	Present					natural		
Bulgaria	Present					natural		
Central Europe	Present							
Croatia	Present					natural		
Czech Republic	Present					natural		

Country	Distribution	Last Reported	Origin	First Reported	Invasive		References	Notes
Czechoslovakia (former)	Present					natural		
Denmark	Present					natural		
Europe	Present							
Former USSR	Unconfirmed record						CAB Abstracts	
France	Present					natural		
-Corsica	Present					natural		
Germany	Present					natural		
Greece	Present					natural		
Hungary	Present					natural		
Ireland	Present					planted		
Italy	Present					natural		
Liechtenstein	Present					natural		
Luxembourg	Present					natural		
Macedonia	Present					natural		
Moldova	Present					natural		
Netherlands	Present					natural		
Norway	Present					natural		
Poland	Present					natural		
Romania	Present					natural		
Russian Federation	Present					natural		
-Southern Russia	Present					natural		
San Marino	Present					natural		
Serbia	Present					natural		
Slovakia	Present					natural		
Slovenia	Present					natural		
Spain	Present					natural		
Sweden	Present					natural		
Switzerland	Present					natural		
UK	Present					natural and planted		
-Channel Islands	Present					natural		
Ukraine	Present					natural		
Yugoslavia (former)	Present					natural		

Altitude

0 - 2700m

Climate

F. sylvatica occurs in temperate and warm temperate climatic zones. It prefers a moist or maritime climate with some rainfall occurring throughout the summer period, and annual rainfall exceeding 750

mm (Joyce et al., 1998). Beech can endure dry periods of up to 3 months, depending on topography and soil conditions (Aranda et al., 1996). It can tolerate high temperatures when not combined with long dry periods (Joyce et al., 1998). In Central Europe, beech growth increases with higher temperatures as long as precipitation is not limiting (>450 mm annual precipitation) (Felbermeier, 1993). High growth rates appear with climatic parameters of 7 to 8°C mean annual temperature and 600 to 700 mm annual precipitation (Rohe, 1985; Felbermeier, 1993; Kahn, 1994).

Flowering achieves its maximum at temperatures of -1 to -4°C in January and 18°C in July (Huntley et al., 1989). Extreme low winter temperatures (Tranquillini and Plank, 1989), late frost and distinct dry periods during the vegetation period limit the growth and occurrence of beech (Ellenberg, 1986).

Air Temperature

Parameter	Lower limit	Upper limit
Absolute minimum temperature (ºC)	-45	
Mean annual temperature (ºC)	4	15
Mean maximum temperature of hottest month (ºC)	19	31
Mean minimum temperature of coldest month (ºC)	-9	6

Rainfall

Parameter	Lower limit	Upper limit	Description
Dry season duration	0	3	number of consecutive months with <40 mm rainfall
Mean annual rainfall	450	2000	mm; lower/upper limits

Rain Regime

Bimodal
Summer
Uniform
Winter

Soil and Physiography

F. sylvatica will grow on all slopes and aspects, plains and lowlands within its natural distribution area. It can thrive on a wide range of soil conditions, from acid to alkaline, provided there is no waterlogging (Joyce et al., 1998). Thus, it can be found on almost all geological substrates, soil depths and soil types, including duplex soil textures (Ellenberg, 1986). Soil pH can range from very acid (pH <3) nutrient-poor soils (Leuschner et al., 1993) to alkaline soils (pH >7) (Tschermak, 1950). Foliage can decompose rapidly, but can accumulate on nutrient-poor sites (Mayer, 1992). Beech can tolerate humus types from mull to peat swamps. It can tolerate a wide range of soil hydrological conditions, from gley and pseudogley soils to dry soils (Scamoni, 1989; Ellenberg, 1986).

Beech grows best on base-rich soils with no hydromorphic traits (Joyce et al., 1998). It will not be present on sites which flood frequently or have groundwater levels near the surface (Gehu et al., 1989). At climatically induced distribution limits, the interaction between solar radiation and topography will

determine the sites where beech will grow. At the southern European limit of its range, beech grows on north-facing slopes, which do not have large temperature differences or summer drought through high air saturation deficits: in such locations, beech can tolerate drought periods of up to 3 months if the soils have a high water storage capacity (Aranda et al., 1996). At the northern limit of its distribution, and in montane areas, beech will not flourish in frost hollows or in valleys liable to the accumulation of cold air.

Soil Tolerances

Soil drainage

free

Soil reaction

acid
alkaline
neutral
very acid

Soil texture

heavy
light
medium

Special soil tolerances

shallow

Soil Types

acid soils
alkaline soils
alluvial soils
calcareous soils
cambisols
colluvial soils
gleysols
granite soils
gravelly soils
hydromorphic soils
karst soils
limestone soils
loess soils
luvisols
mountain soils
palaeosols
peat soils
podzols
podzoluvisols
pseudogleys

rankers
regosols
rendzinas
sandstone soils
sandy soils

Genetic Resources and Breeding

Genetic analyses of selected gene loci indicate that populations have a different allele frequencies (Borghetti et al., 1993; Starke et al., 1995; Wolf and Braun, 1996). The degree of heterozygosis is unexpected low, probably caused by self-fertilization and preferential fertilization from immediately neighbouring trees. Genetic variability within populations is essentially larger than between populations (Comps et al., 1991; Leonardi and Menozzi, 1995; Wolf and Braun, 1996). Both subspecies show great similarity (Bussov, 1995). Solar radiation does not influence the allele frequency, genetic diversity or degree of heterozygosis (Thiebaut et al., 1992). The different silvicultural methods for natural stand regeneration do not influence the genetic characteristics of the following beech generation (Starke, 1996).

Provenance

Provenance trials from different sites in Europe indicate the following: provenances from locations with mild winters and oceanic climatic conditions exhibit a lower increment and yield when grown in subcontinental sites. Beech from high altitude and the northern distribution range grow more slowly, but have better frost-resistance, than beech from the southern part of the natural distribution range (Rohmeder and Schonbach, 1959; Rzeznik and Nebe, 1987; Mayer, 1992). Provenances from low altitudes have earlier bud break and autumn coloration develops later, than other provenances (Mayer, 1992). Phototropic sensitivity decreases from south to north (Lyr et al., 1992). Stem form is detemined by environmental conditions and competition (Rohmeder and Schonbach, 1959).

Seed material for use in forestry is collected from autochthonous stands; thus, beech genetic resources are mainly conserved in stands managed using 'close to nature' silviculture. There are some beech seed orchards, but at present there are no tree breeding programmes applied to beech for forestry use. Breeding of beech is presently not applied in forestry. Nevertheless, in some countries there are seed orchards producing beech seed for wood quality and yield, e.g. Turkey (Rohmeder and Schonbach, 1959; Turkey, 1989).

Typical tree breeding methods are applied to ornamental forms of F. sylvatica.

Reproductive behaviour

Beech is a monoecious, wind-pollinated tree. Solitary trees flower at age 30-50 years, stand-grown trees sometime later, age 50-80 years. Regular mast years occur, at frequencies of between 5 and 15 years (Milescu et al., 1967; Burschel and Huss, 1987; Joyce et al., 1998). A shortening of this cycle has been observed during recent decades. Dispersal takes place through scattered hoarding and burial of beech nuts by mammals and birds (Jensen, 1985; Nilsson, 1985; Kubitzki et al., 1993).

Silviculture Characteristics

F. sylvatica is very shade tolerant, and initially has a low height growth rate. However, it can adapt to light conditions with much greater increment rates when older. Beech can create pure stands of high quality trees. In mixed stands on good sites it will outgrow and dominate most species because of its high shade tolerance, if silvicultural measures are not undertaken. Beech can be used as an understorey species, in order to encourage good stem development of the dominant overstorey trees (Joyce et al., 1998). It can also be used for underplanting, to obtain forests with two distinct age classes (Savill et al., 1997).

Beech grows well on a wide range of sites with a preference for base-rich soils. Windthrow appears mainly on gley and pseudogley soils. The tree is susceptible to damage by late spring frosts and to competition from ground vegetation - it is, therefore, difficult to establish beech on open exposed sites without overhead shelter. In such open situations, other species must be planted as nurse trees (Savill et al., 1997). It has a moderate capacity for natural pruning, and is prone to stem forking or twisting and epicormic growth - to avoid these developments, beech should be established at a minimum density of about 5000-6000 plants per hectare (Teissier, 1981; Burschel and Huss, 1987; Joyce et al., 1998).

Silviculture Characteristics

Ability to: coppice; pollard; self-prune; sucker
Tolerates: frost; shade; weeds; wind

Silviculture Practice

Natural regeneration

Natural regeneration of beech is widely applied. It is mainly based on seedlings, whereby mammals and birds play an important role in the distribution and consumption of fruits and seeds (Jensen, 1985; Nilsson, 1985). On rare occasions, natural vegetative propagation may occur, as stump shoots from adventitious buds following felling. Root suckers from adventitious buds may originate in very old beech trees, or as the result of a trauma such as windthrow. When in contact with the ground, branches take root (Hartig, 1877; Roloff, 1985).

Seed collection and storage

Artificial regeneration is mainly carried out by sowing and planting. Seeds are collected by hand, or from nylon nets or pierced plastic sheets after fruit-fall in November. The first nuts to fall should be avoided, as they are usually empty or damaged by parasites (Joyce et al., 1998). Harvesting with nets prevents fungal infections from soil contact, and improves germinating capacity (Dubbel, 1989). Seed weight is 150-300g/1000 nuts. Fruits can be stored for 6 months without special treatment, for two years at reduced moisture content (25-30%) and temperature of 4-5°C, and in the long term at moisture content 3-10% and temperatures of between -3 and -10°C (Schonborn, 1964).

Vegetative propagation

Artificial propagation can be successfully undertaken using shoot cuttings from seedlings. Rooting can be improved by the application of growth hormones (Bartels, 1996) and etiolation (Krussmann et al., 1981). Two- to 3-year-old seedlings are used as stock plants, which are grafted with 2-year-old twigs mainly by splice grafts (Bartels, 1982). Tissue culture of beech has not been successful (Eschrich, 1989).

Nursery practice

After harvesting, beech nuts are spread out in 10-cm deep layers in a dry well-aired location, and the nuts are turned every second day. During this process, seeds fully ripen and inhibition to germination is reduced. The moisture content of the fruits should decrease to 30%. If the water content falls below 25%, fruits must be moistened under frost-free conditions. In January, beech nuts are spread out in enclosed chilled rooms, to a depth of 30 cm, and covered with jute tarpaulins or straw. Storage in sand (30 cm depth covered with 20 cm of leaf litter) is an alternate method of stratification. In approximately the second half of March, fruits are stratified in moist sand, and are sown as soon as the first germinating tops are visible in April and May (Bartels, 1982).

Beech nuts in long-term storage need to be re-moistened to a 30-34% moisture content (the upper moisture level is critical and should not be exceeded) at temperature 3°C for a period prior to sowing (Joyce et al., 1998).

Sowing

Beech seeds are sown in strips at least 30 cm wide in prepared seed-beds. Approximately 200-300 kg beech nuts per hectare are required. Seedlings are covered to prevent late spring frost damage (Krussmann, 1981). In the autumn seedlings are transplanted to 10 x 25 cm spacing in nursery beds. Transplants are undercut in October of the first year (or in the following spring). Overall, 1000 seedlings and 900 transplanted beech plants will be obtained for each kg of fruits. Seedlings can reach 50 cm in height (Krussmann, 1981). Planting stock is mainly 2 to 3 years old (2+0; 1+1; 1+2) and will be between 30 to 100 cm in height (Burschel and Huss, 1987; Joyce et al., 1998).

Stand establishment and tending

Today high forest is the silvicultural system most widely applied to beech. Coppice with standards forests ('middle forest') are present over small areas, frequently as the result of traditional forest utilization. Beech was, in the past, managed as simple coppice forest ('low forest'), but this was never an important system, as beech does not produce sufficient numbers of stump shoots. Within the high forest system, even-aged beech forest is the predominant type. Selection forest is mostly restricted to mixed forests. Beech high forest is regenerated by shelterwood and selective felling. The uniform shelterwood system, which has been widely applied in Europe since the 18th century (Hartig, 1791), entails the following:

- mature, fully-stocked closed stands at the regeneration stage;
- preparatory felling: cautious opening of the canopy through removal of about 15% of standing volume, to encourage litter decomposition;
- seeding felling: in mast years, 30-40% of standing volume is removed after seed fall;
- removal fellings: beginning in a central area between two racks, the shelter of the old stand is gradually removed, perhaps over a period of 8 to 20 years; mixtures can be introduced by enrichment planting at this stage;

- final felling: the remainder of the old crop is removed, concentrating on the margins: trees along the extraction paths, which do not present a danger to young trees, may be retained for longer;
- the mostly even-aged and uniform young growth replaces the old crop: with high densities of naturally regenerated plants (Joyce et al., 1998).

Direct sowing

Artificial regeneration by seed is generally undertaken with fruits collected in autumn and then stored in clamps, sheds or cellars until spring (Burschel and Huss, 1987). Seed density amounts 200-300 kg per hectare. Fruits are sown in strips or grooves after soil working. In Central Europe, 30 to 40 kg beech nuts per hectare are sufficient to establish a 30% proportion of beech in conifer stands. Planting is done with a minimum density of 5000-6000 bare-rooted plants per hectare (Teissier, 1981; Burschel and Huss, 1987; Joyce et al. 1998). Most planting stock will originate from nurseries, but wildings (seedlings from the forest) can also be utilized. The storage of plants, e.g. in cool-houses, between delivery from the nursery and planting is crucial for the success of a plantation, since beech is one of the most sensitive broadleaves in its ability to withstand rough handling prior to planting (Joyce et al., 1998). The use of containerized stock is restricted to planting in difficult site conditions, such as the restoration or rehabilitation of protection forests.

Site preparation

Site preparation may involve removal of the humus layer or fertilizer application. Mechanical removal of the humus layer and loosening of the mineral soil will encourage the primary roots of seedlings to develop directly into mineral soil, thus protecting the root system from adverse microclimatic conditions such as frost and drought (Burschel et al., 1964). Fertilizers may be added to improve seed bed conditions by increasing or encouraging litter decomposition, or to improve nutrient supply to the establishing root systems of newly planted beech seedlings (Burschel and Huss, 1987).

Mycorrhizas

Beech is associated with obligatory ectomycorrhizas. The spectrum of mycorrhizas associated with naturally regenerated beech seedlings is similar to that of mature trees, while plants from nurseries exhibit a very different and impoverished spectrum of mycorrhizas (Brand, 1991).

The success of beech regeneration is highly dependent on microclimatic conditions. As with many climax species, beech has relatively slow initial growth. Therefore, weeds can be serious competitors, when radiation is high and beech loses its advantage of high shade tolerance. In this case weed control can be necessary (Joyce et al., 1998).

Tending

Even-aged beech stands with an optimum density are carefully tended to remove predominant, multi-branched individuals and to encourage the development of an understorey layer. When the self-pruning process has achieved a defined branchless stem-length, (precommercial) selection thinning is applied, to promote 150 to 200 evenly-spaced trees per hectare, which are of high vigour and quality. As soon as these trees dominate the future stand development, the long-term growth potential of beech is utilized and stand increment is directed to crop trees by (commercial) increment thinnings (Burschel and Huss, 1987, Joyce et al., 1998).

Further information and alternative silvicultural treatments of even-aged beech stands can be found in Gayer (1882), Seebach (1845), Assmann (1961), Kato and Mulder (1978), and Burschel and Huss (1987). Unevenaged beech stands are covered by Landbeck (1952) and Kostler (1956), mixed mountain forests by Mosandl (1991), and mixed forests by ONF (1996).

Silviculture Practice

Seed storage: orthodox
Stand establishment using: direct sowing; natural regeneration; planting stock; wildings
Vegetative propagation by: air layering; cuttings; grafting; sets

Management

Merchantable beech wood amounts to between 60 and 85% of total volume (Kucera and Pohler, 1998). On good sites, merchantable volume achieves a maximum annual increment of 10 to 14 cubic metres/ha between age 40 and 80 years, while mean annual increment gradually increases with age, to reach 8 to 9 cubic metres/ha at 120 years old. Corresponding merchantable gross volume is 900 to 1100 cubic metres/ha and standing volume 500 to 600 cubic metres/ha depending on thinning (Milescu et al., 1967; Schober, 1975).

The production goal of beech forest management should be to produce high-quality wood of a size suitable for veneer and furniture manufacture. This involves the production of straight, cylindrical, branch-free boles, 8 m or more in length and diameter from 50 to 60 cm at mid-point (Joyce et al., 1998). Consequently crop trees should have a diameter of >60 cm at breast-height. On good sites this objective can be achieved over a rotation age of 80 to 120 years depending on silvicultural treatment. The extension of the rotation age is limited by increasing risk of the occurrence of red heart (Burschel and Huss, 1987).

There exists a large market for beech wood. Two factors determine the production goal: (i) the price of beech wood is determined by stem dimension and wood quality. Highest prices are achieved for wood that can be used for sliced veneers; and (ii) beech wood can achieve good dimensions, as beech forests tend to be stable, and beech can be managed on long rotations to produce high quality timber, which brings a good economic return. There is a wider safety margin in beech forestry for the production of large-dimension timber than there is for other species (Mosandl and Felbermeier, 2000).

Notes on Pests

The following section describes pests and disease organisms according to the plant part affected. Beech is less affected by serious diseases than other tree species in western Eurasia. Pathogens can destroy regeneration and individual older beech trees, but no mass destruction on a regional scale has been described (Hartig, 1877; Klimetzek, 1992).

Beech nuts and seeds

The insects Laspeyresia fagiglandona and Rhynchaenus fagi can kill 40% of beech mast (Veldmann, 1978). Germinative capacity can be reduced by infection of beech nuts with the pathogen Thanatephorus

cucumeris (= Rhizoctonia solani) (Dubbel, 1992). Rodents, especially mice, can damage and destroy beech nuts. Twenty-six bird species and 17 mammals are known to consume high amounts of beech nuts in the winter (Schwerdtfeger, 1981). Drought and frost conditions also reduce seed germination capacity (Bourne, 1945; Burschel et al., 1964). Temperatures below -6°C cause high mortality of free and recumbent fruits (Savill, 1991).

Fungal infections and staining of fruits can be prevented by use of nets to harvest beech nuts (Dubbel, 1989; Burschel and Huss, 1987). Damage through frost and animal predation can be reduced by leaf litter or soil cover (Hartig, 1877; Bourne, 1945).

Seed germination and seedlings

Elateridae larva, snails (Agriolima agrestis, Arion spp.), Noctuidae larva (Agrotis segetum) and fungal pathogens of seedlings (Phytophthora cactorum, P. cinnamomi, Pythium debaryanum, P. ultimum) cause high mortality (Schwerdtfeger, 1981). The radicle is very sensitive to solar radiation in spring (Burschel et al., 1964) and to drying up during summer (Bourne, 1945). Cotyledons can be killed by large temperature and microclimatic changes (e.g., night frost and intensive solar radiation during the day) (Rohmeder, 1951).

Minimising possible biotic damage to seedlings can be undertaken by correct soil preparation and fertilisation. Damage in forest nurseries can be mitigated by pesticides. Microclimatic conditions are improved through shelterwood and selective fellings, which reduce stress from solar radiation and frosts. Site preparation reduces humus layers, which prevents the seed bed from drying out during summer.

Stem and branches

Generally the most serious and mortal diseases of beech affect the stem.
Beech bark disease is the only serious disease of beech in Europe. It tends to occur on trees previously subjected to stress due to prolonged drought (or other causes): a minute sap-sucking insect, the felted beech coccus (Cryptococcus fagisuga), attacks the tree, followed by infection of the pathogenic fungus Nectria coccinea. The combined attack of insect and fungus can result in tree death due to moisture stress. In some cases, the succession of secondary pathogens may include wood-boring insects (Xyloterus domesticus and Hylecoetus dermestoides) and, finally, white rot (Fomes fomentarius, Fomitopsis pinicola, Polyporus spp.) (Lunderstadt, 1992; Joyce et al., 1988; Schwerdtfeger, 1981). The first symptoms of beech bark disease are brown-black, moist, and hand-span sized stains on the bark of the stem. Beneath the stain, the phloem is a reddish colour and the cambium perishes. Subsequently, a mucous flux is produced, which contains numerous bacteria and fungi. The putrefaction of the bark encroaches on the wood, which is destroyed by white rot. Within a few years, beech stems of trees so infected are frequently snapped by storms (Schwerdtfeger, 1981). This complex disease can be widely observed and appears to be chronic on a local to regional scale.

Other routes for stem infections of beech are split or torn bark due to intense solar radiation of trees located on the southern edges of forest stands (Hartmann et al., 1988), frost cracking (Knigge and Schulz, 1966), damage caused during logging, or from grey squirrel damage by gnawing at the base of stems (Joyce et al. 1998), or from deer (Schwerdtfeger, 1981). Young shoots are damaged by late frosts (Hartmann et al., 1988), and can only be partly replaced by secondary shoots in summer, as beech does not usually have a second flush (Joyce et al., 1998).

Protection against biotic damage can be achieved by the immediate removal, through felling, of infected trees. Abiotic damage from solar radiation can be avoided through carefully planned forest edges. Late frost damage to young trees can be reduced by overhead shelter.

Roots

Heavy metals (Pb, Cd) from atmospheric emissions, or available aluminium (Al3+) from soil acidification, disturb beech nutrient uptake and fine root growth (Sander, 1996). Protection can be achieved by liming if appropriate to the soil type.

Buds

The sucking insects Contarinia fagi and Dasyneura fagicola can destroy buds at bud burst (Schwerdtfeger, 1981). Late frost can damage buds at whatever developmental stage (Joyce et al., 1998). If the terminal bud is injured the tree tends to become forked. Buds are also a preferred browse for deer in winter. Appropriate silvicultural treatments (overhead shelter, game animal management) can help to reduce such abiotic damage.

Foliage

Several insect species (e.g., Operophtera fagata, Ennomos quercinaria, Rhynchaenus fagi, Dasychira pudibunda) can completely defoliate beech stands, but as attacks do not occur until well after foliage has developed, the main effect of them is a reduction in annual increment and fruit production, rather than long-term damage (Schwerdtfeger, 1981). Young foliage may be damaged by late frost (Hartmann et al., 1988).

Nutrient deficiencies may result in the following symptoms: lack of magnesium - necrosis beginning from intervenial areas of older leaves; lack of calcium - yellowing of leaves from the edges, then foliar browning and finally scrolling of leaves from the top and edges (Hartmann et al., 1988).

Air pollution directly effects foliar vigour. High ozone concentrations cause brown speckles on leaves (Hartmann et al., 1988), reduces photosynthetic capacity (Lippert et al., 1996), and leads to an increases rate of leaf senescence (Mikkelsen, 1996). Exposure to fluorine causes leaves to turn yellow, then brown and finally black, the colour changes progressing from the leaf edge, and necrotic areas having a sharp limit with the remaining green foliage. High sulphur dioxide (SO2) concentration causes necrosis in the middle of foliar intervenial areas, and a discoloration of the whole leaf. Common salt (NaCl) causes chlorotic foliage in spring, which then brown and fall (Hartmann et al., 1988); beech is generally sensitive to common salt (Larcher, 1994).

Roloff (1989) records a range of crown damage features (short shoots, leaf loss, multiple breaking of short shoots in beech, and discusses the identification of tree vitality. Throughout Europe, about 60% of beech trees have suffered some foliar loss (37% slight loss, 20% medium loss, 1% heavy loss).

Protection from biotic damage can be undertaken using chemical pesticides, but these are only used in nurseries. Stand nutrient deficiencies can be rectified by fertiliser application, although generally this is too costly.

Blossom

Flowers may be destroyed through frost, which can frequently appear because of early flowering (Joyce et al., 1998). Summer drought causes premature fruit falling or sterile seeds (Wachter, 1964). There is no protection possible.

Pests Recorded

Acer pseudoplatanus (sycamore)
Aceria stenaspis
Adoxophyes orana (summer fruit tortrix)
Agrilus sulcicollis
Agriopis aurantiaria
Agriopis marginaria
Amphipyra pyramidea (copper underwing)
Antheraea pernyi
Apiognomonia errabunda (anthracnose)
Armillaria mellea (armillaria root rot)
Armillaria mellea (armillaria root rot)
Armillaria ostoyae (armillaria root rot)
Bean yellow mosaic virus (bean yellow mosaic)
Calliteara pudibunda (hop, dog)
Cephalcia arvensis
Cherry leaf roll virus (walnut ringspot)
Cryptococcus fagisuga (beech coccus)
Cryptodiaporthe salicina
Cydia fagiglandana (beech seed moth)
Cydia splendana (chestnut tortrix moth)
Diaporthe eres (apple leaf, branch and fruit fungus)
Diurnea fagella
Erannis defoliaria (mottled umber moth)
Euproctis chrysorrhoea (brown-tail moth)
Eutypa lata (Eutypa dieback)
Fomes fomentarius (hoof fungus)
Fomitopsis pinicola (brown crumbly rot)
Fusarium arthrosporioides (root rot: pea)
Ganoderma pfeifferi
Gibberella avenacea (Fusarium blight)
Hartigiola annulipes
Heterobasidion abietinum
Heterobasidion annosum
Hylesinus varius (bark beetle, ash)
Hylobius abietis (large pine weevil)
Isotoma notabilis
Isotomiella minor
Kretzschmaria deusta (canker of beech)
Lymantria dispar (gypsy moth)
Lymantria monacha (nun moth)

Malacosoma neustria (common lackey)
Melolontha melolontha (white grub cockchafer)
Mikiola fagi
Neonectria coccinea (bark disease: beech)
Neonectria ditissima (Nectria canker (apple, pear))
Operophtera brumata (winter moth)
Operophtera fagata
Orgyia antiqua (European tussock moth)
Orthosia cerasi (common quaker)
Otiorhynchus armadillo (armadillo weevil)
Phalera bucephala (buff tip moth)
Phyllactinia guttata (powdery mildew of hardwood trees)
Phyllaphis fagi (beech, aphid)
Phyllonorycter maestingella
Phytomyza ranunculi
Phytophthora cactorum (apple collar rot)
Phytophthora cambivora (root rot of forest trees)
Phytophthora citricola (black hop root rot)
Phytophthora hedraiandra
Phytophthora pseudosyringae
Phytophthora ramorum (sudden oak death (SOD))
Pleurotus ostreatus (oyster mushroom)
Pratylenchus penetrans (nematode, northern root lesion)
Pythium ultimum (black-leg of seedlings)
Rhododendron ponticum (rhododendron)
Rhynchaenus fagi (weevil, beech flea)
Schizophyllum commune (wood rot)
Scolytus intricatus (European oak bark beetle)
Sinodendron cylindricum
Thyridopteryx ephemeraeformis (evergreen bagworm)
Trametes versicolor (wood decay)
Tremex fuscicornis (Tremex wasp)
Trypodendron domesticum
Uraba lugens (eucalypt leaf skeletonizer)
Xiphinema diversicaudatum (dagger nematode)
Xyleborinus saxesenii (fruit-tree pinhole borer)
Xyleborus dispar (pear blight beetle)
Xylosandrus germanus (black timber bark beetle)

Uses: Wood Uses

F. sylvatica has a reddish-white heartwood with diffuse fine pores and sharp limits between tree rings. Beech wood consists of one third each of vessels, tracheids, and parenchyma. Vessels have a scalariform perforation plate (Fengel and Wegener, 1984). With increasing age vessels are affected by tylosis and red 'false' heartwood is formed. Beech wood is heavy, hard, dense (585-650 kg/m^3), very tough, and not elastic (Grosser, 1984). Wood density decreases from root collar to the crown (Lewark, 1987); water content decreases continuously from bark to the centre of the bole (Bosshard, 1984a). Beech wood is slightly acid (pH 5.1 to 5.4), has a high cellulose content, and has no characteristic odour

(Grosser, 1984).

Wood of beech is widely used. It is easy to saw and split, and - with the exception of red heartwood - takes wood preservatives and waterproofing well (Kucera and Pohler, 1998). It is in great demand for veneers. It can be turned and polished, and it absorbs stains, lacquers and paints well. Nail- and screw-holding, and gluing properties are good (pre-boring of wood is only necessary in exceptional circumstances).

Beech wood must be carefully and slowly dried, because it tends to split and warp. After drying, beech wood still reacts to changing climatic conditions - especially humidity and temperature. Beech can be steamed, whereby these disadvantageous attributes are strongly reduced. Steamed beech wood becomes red, later red-brown. Steamed beech wood is easy to bend (Begemann, 1987). Beech has little natural resistance to decay (Joyce et al., 1998); therefore beech should be felled in winter and processed as soon as possible.

Industrial wood has a wide range of applications: pallets, crates, particleboard, laminated wood, barrels, piano parts, toys and woodware. It is also used to make charcoal, wood gas, and fuelwood: beech wood has a high calorific value and burns well, and the charcoal is also of high quality (Hartig, 1877; Sandhof, 1809) either for domestic use or, as in the past, for steel production (Radulescu, 1934).

Hardwood pulp from beech may be processed for paper or synthetic fibres (Knigge and Schulz, 1966). Sulfite pulp has to be bleached because of its high lignin content (Bosshard, 1984b). Chemicals (i.e., calcium acetate, acetic acid, methanol, acetone and tar) can be extracted from beech wood by distillation (Radulescu, 1934). Beech wood tar contains aromatic hydrocarbons, especially phenols, phenol derivatives, and resins. Beech wood chemicals are utilized in organic chemistry, pharmacy, conservation, pesticide manufacture and flavourings (Zink, 1990; Burger and Wachter, 1993). Beech-ash was once used in the glass and soap manufacturing industries.

Beech roundwood is used for building timbers and in furniture and general carpentry, especially for stairs, chairs and internal framework of upholstered furniture. Parquet flooring, floorboards, tools and tool handles, factory benches, looms, toys, domestic vessels and utensils are some of the wide range of products from beech (Grammel, 1989; Radulescu, 1934). Because of a high resistance to decay below water, it is used as keel wood in shipbuilding (Hotovy, 1948). Bentwood furniture is produced from steamed wood (Hotovy, 1948). Roundwood of lower quality is processed to railway sleepers, which have a life-span of 40 years after preservative treatment (Grosser, 1984).

Peeled veneers are used to produce plywood and blockboard, sliced veneers are produced for the furniture industry, and chips and offcuts can be used for a range of composite woods (Grammel, 1989).

Wood Products

Blockboard
Boats
Boxes
Brushes
Carpentry/joinery (exterior/interior)
Cases
Charcoal

Composite boards
Containers
Crates
Cutlery
Fibreboard
Flakeboard
Flooring
For light construction
Furniture
Gypsum board
Hardboard
Improved wood
Industrial and domestic woodware
Laminated strand lumber
Laminated veneer lumber
Laminated wood
Lignin products
Medium density fibreboard
Musical instruments
Oriented strand lumber
Oriented strandboard
Other cellulose derivatives
Pallets
Parallel strand lumber
Particleboard
Plastics from wood
Plywood
Pulp
Railway sleepers
Sawn or hewn building timbers
Short-fibre pulp
Sports equipment
Textiles
Tool handles
Toys
Turnery
Vehicle bodies
Veneers
Waferboard
Wall panelling
Wood cement
Wood extractives (including oil)
Wood flour
Wood gas (and other hydrocarbons
Wood hydrolysates
Wood residues
Wood wool
Wood-based materials

Woodware

Uses: Non-Wood Uses

Byproducts of beech forests are beech nuts, tannin, leaf crops, and mulches (Hotovy, 1948).

Beech nuts contain 40 to 50% oil and 23% protein (Schutt et al., 1992; Burger and Wachter, 1993), and can be pressed to produce an oil after peeling. Pure beech oil is bright yellow, odourless, non-toxic and durable under regular storage conditions. One litre of oil can be produced from 4 kg beech nuts. Beech oil may be used for nutritional and pharmaceutical purposes.

A white flour can be produced from the residue of oil pressing, and has been used in food production. Intoxication can occur if large amounts of unpeeled nuts are eaten, due to the chemical fagin, which is a saponin (Hotovy, 1948).

Since antiquity, beech nuts have been used for animal fodder (Sandhof, 1809; Savill et al., 1997). Tannins have been extracted from beech bark (Hotovy, 1948). Beech leaves were also suitable for livestock bedding.

The production and usage of many of these non-wood products of beech are today only found in rural regions of Europe, where more traditional agricultural practices are still used.

Uses: Land Uses

F. sylvatica was used in traditional silvopastoral systems, as it produces beech nuts and a leaf fodder which are both very nutritious; however, young trees were susceptible to damage, and the destruction of beech stands as well as changing agricultural practices led to the widespread abandonment of this practice in Europe (Jahn, 1991; Ellenberg, 1986). The environmental functions of beech are many: soil conservation is achieved by the active and complete nutrient cycle of beech forests; and the inclusion of beech in conifer forests can improve soils through the acceleration of leaf litter decay in humus layers, as beech leaf litter is high in base nutrient content (Gayer, 1882; Rothe, 1997). The extensive root system prevents soil from erosion by wind and water (Mayer, 1992). The addition of beech to conifer forests reduces interception and increases ground water rates and water quality (Rothe, 1997). Durable products manufactured from beech wood store atmospheric carbon dioxide. The usage of these products, and biomass and fuelwood, can substitute for a certain amount of fossil fuel consumption (Burschel et al., 1993).

It is estimated that about 1800 animal species are adapted to beech forest ecosystems (Walter and Breckle, 1986), which therefore play a key role in the conservation of biodiversity in Central Europe.

Many ornamental varieties and forms of F. sylvatica are planted in parks and gardens. Mature solitary individual trees and large pure beech stands with no understorey - the so-called 'cathedral' stands - retain an aesthetic and sociocultural importance in Europe. Carving names and messages into beech bark - although deprecated by foresters - is a traditional practice. Coppice with standards beech forests serve as demonstration areas of natural and forest history.

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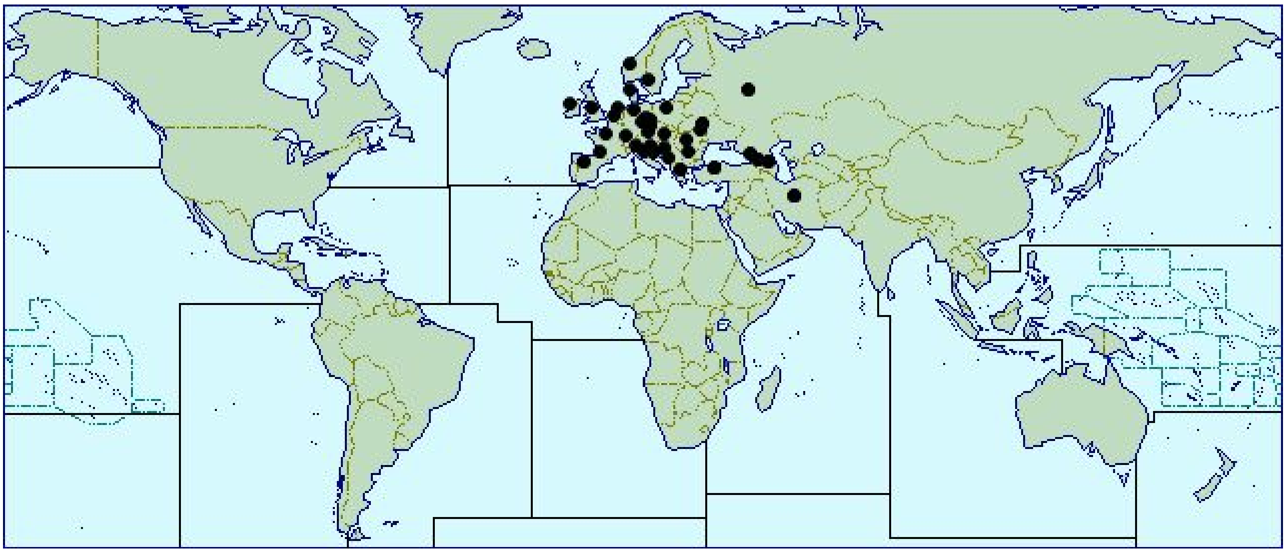
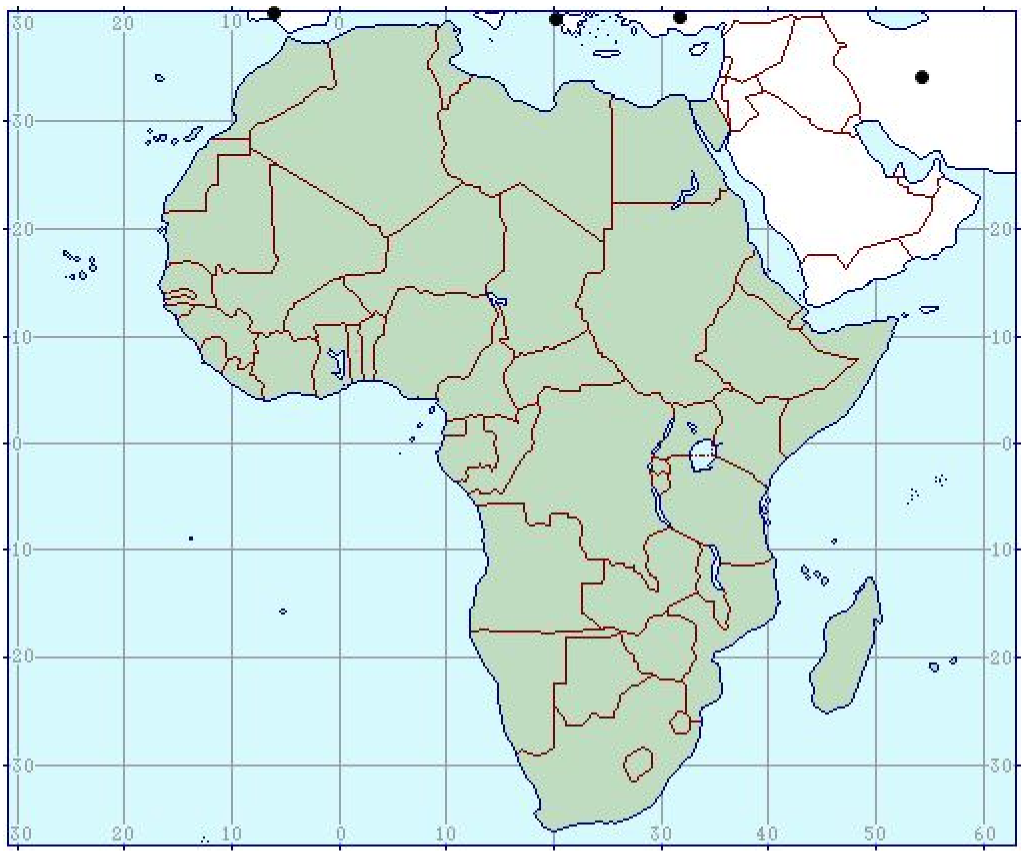
World Map

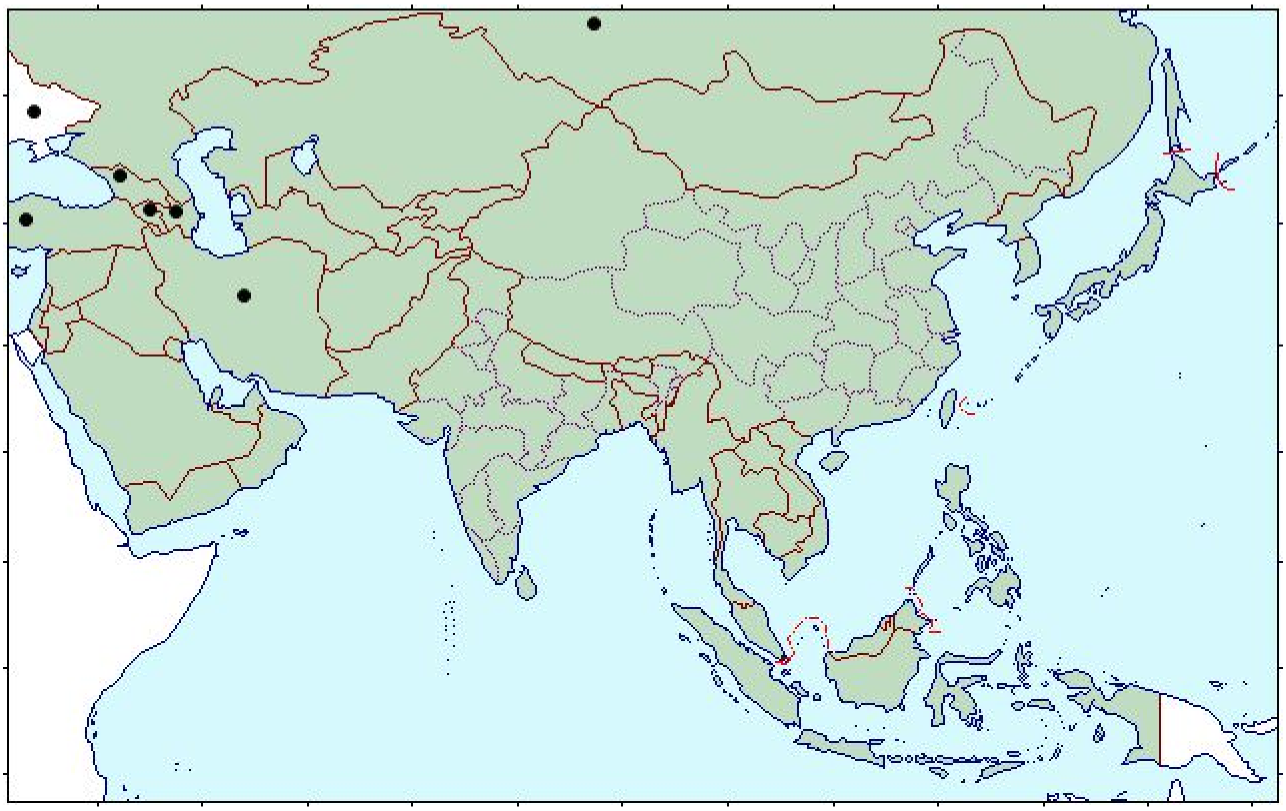


	Present, no further details		Evidence of pathogen
	Widespread		Last reported
	Localised		Presence unconfirmed
	Confined and subject to quarantine		See regional map for distribution within the country
	Occasional or few reports		

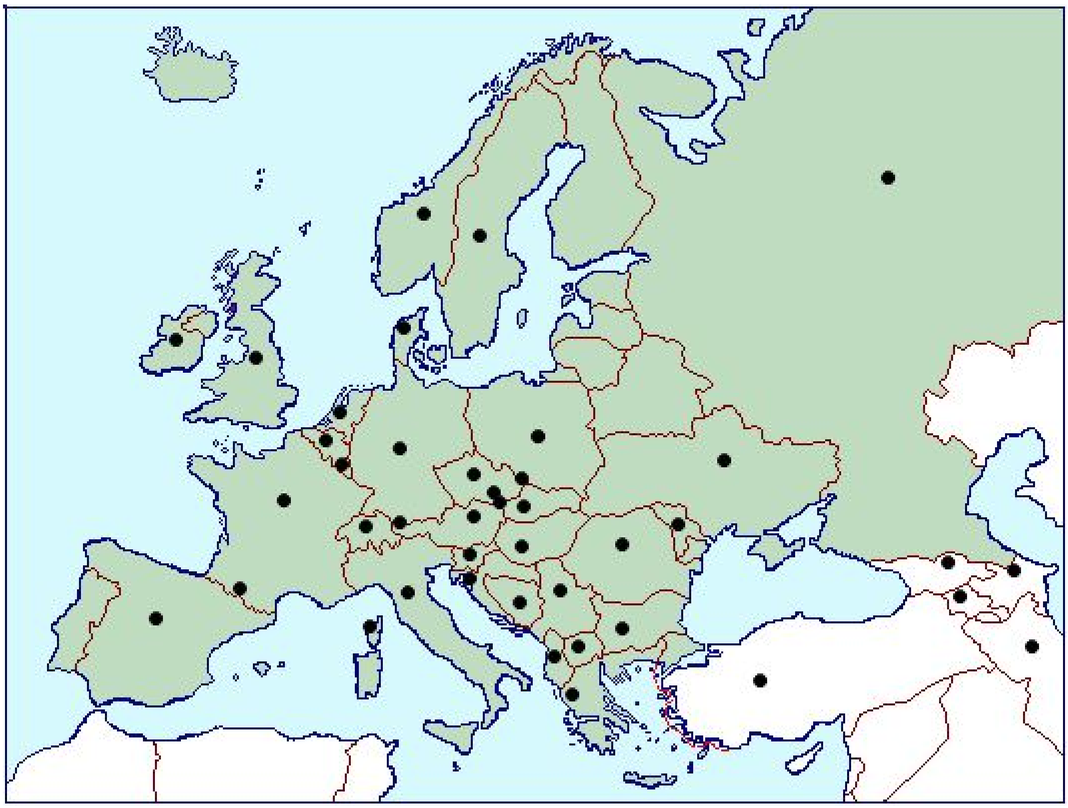
Africa



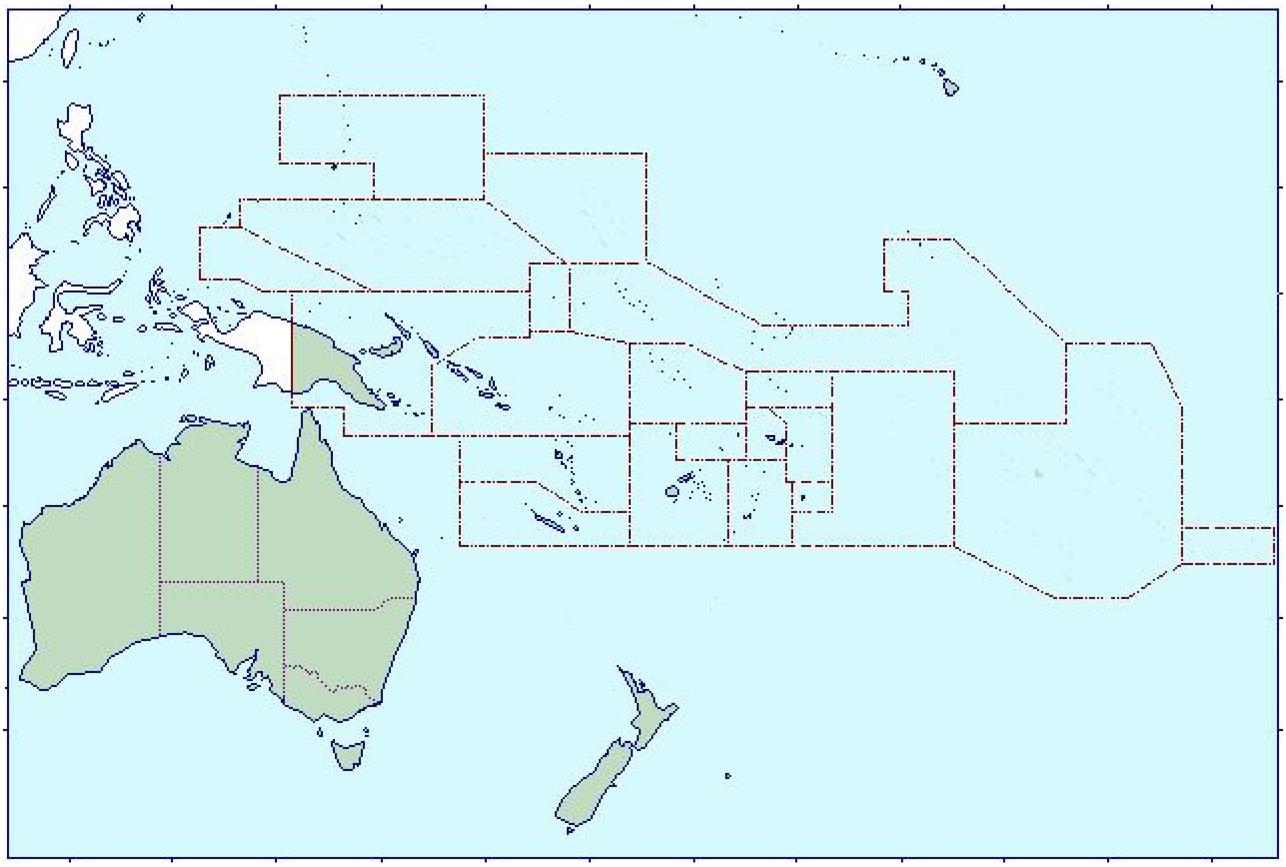
Asia



Europe

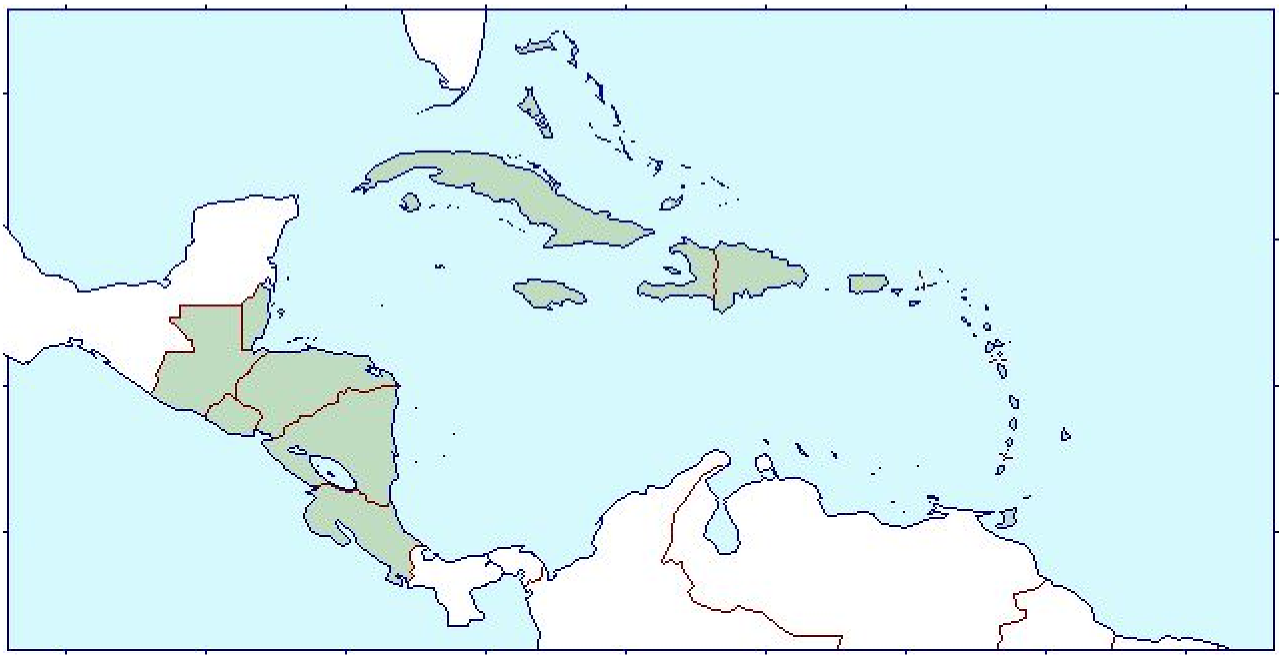


Pacific



North America

Central America



South America

Date of report: 29 September, 2015