

# Mediterranean firs

*Abies* spp

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

## Biology and ecology

Mediterranean firs are inter-fertile species that belong to two sections: i) Section *Abies* (*Abies bornmuelleriana* Mattf., *A. borisii-regis* Mattf., *A. cephalonica* Loud., *A. equi-trojani* Asch., *A. nebrodensis* Lojac and *A. nordmanniana* Spach.), and ii) Section *Piceaster* (*Abies cilicica* de Lannoy, *A. marocana* Trabut, *A. numidica* Carrière and *A. pinsapo* Boissier).



They are evergreen conifers growing up to 50 m in height, with straight trunk and pyramidal crown that later turns to flat-topped. The 3-5 vegetative buds, at the apex of the shoots, are conical to ovoid and resinous (except in *A. cilicica*,

*A. nordmanniana* and *A. numidica*). Leaves are linear, flattened with acute (*A. cephalonica*, *A. borisii-regis*, *A. equi-trojani* and *A. pinsapo*) or round (*A. cilicica*, *A. nebrodensis*, *A. nordmanniana* and *A. numidica*) apex.

The firs are obligate seeders, monoecious and wind-pollinated and their seeds are wind-dispersed. The cones ripen in one season, while abundant seed production occurs only every 3-5 years.

They form pure or mixed forests that span a considerable altitudinal range (600-2000 m) and grow in humid bioclimates, except for *A. cephalonica*, *A. cilicica* and *A. nebrodensis* that may also grow in sub-humid regions. *A. borisii-regis*, *A. bornmuelleriana*, *A. cephalonica* and *A. cilicica* can tolerate wider ranges of mean annual temperature (7.5 to 16 °C) than the rest of the species. Bud bursting occurs from early April (*A. cephalonica* and *A. cilicica*), mid April (*A. marocana*, *A. numidica* and *A. pinsapo*) to early May (*A. bornmuelleriana* and *A. nordmanniana*).

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## Distribution

Mediterranean firs have disconnected and limited distributions that are relict ranges of mostly endemic species. The distribution area of most fir species is concentrated in the eastern Mediterranean and the Black Sea region.

## Importance and use

Fir wood is generally considered of lesser technical value than pine wood, but is used for carpentry purposes due to its softness and workability. It is also used for general construction, paper, glued and composite wood products, veneer, plywood, panels and poles, as well as fuel wood. The bark, buds and cones may contain a large amount of fine, highly resinous turpentine. A fine oil of turpentine can be distilled from the crude material, while the residue forms a coarse resin named colophony or rosin. Fresh oleoresin is mainly used for pharmaceutical purposes.

Because of their fragrance, colour, good form and exceptionally long leaf retention after being cut, most of the firs are used as ornamental trees and are grown in plantations for Christmas trees (e.g. *A. borisii regis*, *A. cephalonica* and *A. nordmanniana*).

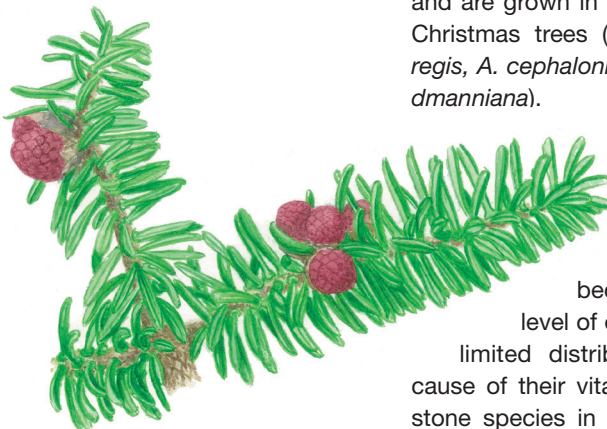
Mediterranean firs are often found in protected areas either because of their level of endemism and limited distribution or because of their vital role as keystone species in Mediterranean mountain ecosystems.

## Genetic knowledge

Disjunct geographic distributions and different population sizes explain the generally high level of genetic diversity found among and within Mediterranean fir populations. No variation exists at chromosome level ( $2n=24$ ) but broad genetic variation has been recorded at morphological (e.g. needle traits), anatomical (e.g. position of resin canals), biochemical (e.g. terpenes, isozymes) and molecular (e.g. microsatellites) levels.

Paleo-ecological records and genetic studies based on markers with low evolutionary rates (mitochondrial DNA and isozymes) suggest that Mediterranean firs might have stemmed from a common Tertiary ancestor and were later separated into different genepools: eastern (*A. cephalonica*, *A. bornmuelleriana*, *A. equi-trojani* and *A. nordmanniana*, except *A. cilicica* that differed from the other species), southern (*A. numidica*) and western (*A. pinsapo* and *A. marocana*). More rapidly evolving markers (chloroplast microsatellites) indicate that *A. cilicica* is related to the eastern Mediterranean group and that *A. marocana* and *A. pinsapo* constitute different species. Similarly, *A. nebrodensis* appears as an original genetic group.

Within-population genetic variability increases from west to



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east as a result of harsher past climate in the western than the eastern Mediterranean. *A. nebrodensis* constitutes an exception with high genetic diversity, although the single remaining natural population is extremely small (29 individuals).

Because of their coancestry, Mediterranean firs can hybridize naturally and artificially. *A. borisii-regis* is considered a natural hybrid between *A. cephalonica* and *A. alba*. Successful artificial crossing also suggests weak reproductive barriers among Mediterranean firs, as opposed to the relatively strict barriers that exist between North American and Mediterranean firs. This supports the argument that geographic isolation has been the main driver of speciation in the Mediterranean basin.

Species and provenance tests have revealed strong variation in adaptive traits such as survival, growth, bud-break, drought resistance, morphological and anatomical traits. Forest reproductive material originating from the Peloponnese in Greece (*A. cephalonica*) performs well under many types of Mediterranean climate.

## Threats to genetic diversity

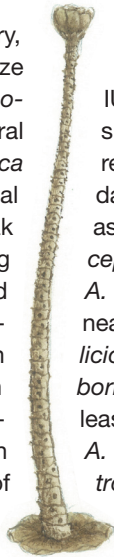
Overharvesting, grazing, prolonged drought and wild fires are major threats to Mediterranean firs. The conservation status of the firs ranges from critically endangered to least concerned according to the IUCN Red List of Threatened species. *A. nebrodensis* is recognized as critically endangered and *A. numidica* is as threatened-vulnerable. *A. cephalonica*, *A. marocana* and *A. pinsapo* are considered as near threatened species. *A. cilicica*, *A. nordmanniana* and *A. borisii-regis* are recognized as least concerned species, while *A. bornmuelleriana* and *A. equi-trojani* are not mentioned in the IUCN Red List.

Even though no serious insect-related threats seem to exist, Mediterranean firs are usually damaged by *Cacoecia muriana*, *Choristoneura murinana*, *Cryphalus piceae*, *Dioryctria aluloi*, *Ips vorontzowi*, *Mindarus abietinus*, *Phaenops cyanea*, *Pissodes picea*, *Pityokteines curvidens*, *Pityokteines spinidens* and *Xyloterus lineatus* (especially after dry periods). Seed insects of the genus *Megastigmus* are known to significantly reduce seed crops. The most dangerous fungi for the firs include *Armillaria mellea*, *Fomes annosus*,

*Polyporus fulvus* and *Trametes radiciperda*. Other damaging fungi include *Aecidium elatinum*, *Armillaria gallica*, *Dioryctria abietata*, *Fusarium* sp., *Heterobasidion annosum*, *Phytophthora cactorum* (for young seedlings) and *Trichosphaeria parasitica*.

Climate change is predicted to intensify summer droughts in the Mediterranean. It represents a serious threat for fir forests and is also likely to increase the frequency and extent of wild fires, with devastating effects on survival, reproduction and regeneration of the firs. Furthermore, climate change may decrease winter hardening and cause earlier bud burst, thus increasing the risk of frost damage. This can jeopardize the development of seedlings and young trees especially in open areas, and cause fir forests to disappear from their low altitude sites. Temperature

rise during summer combined with water stress can result in extensive crown defoliation and tree mortality. The fir forests growing at low elevation, superficial soils or on southern slopes are those currently facing the greatest threats.



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## Guidelines for genetic conservation and use

Due to the threats, endemism and geographically scattered distribution, the conservation of Mediterranean firs and their genetic resources is a major challenge.

The genetic resources of the firs are currently conserved in various protected areas that have rarely been established for this purpose. Due to their evolutionary history and specific adaptation, the fir forests harbour unique genetic resources that are important beyond the Mediterranean. Thus, the establishment of conservation units for the firs that meet pan-European minimum requirements for dynamic gene conservation is of crucial importance.

At present, several of the species and their genetic resources are protected either *in situ* (national parks, nature reserves and gene conservation units) or *ex situ* (conservation seed orchards and stands). The critically endangered *A.*

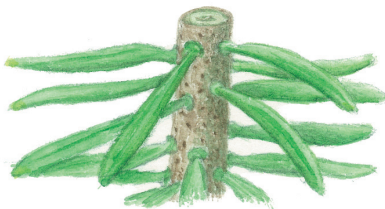
*nebrodensis* is conserved *in situ* in the Madonie Regional Park in Sicily, but the reinforcement of the species has been problematic mainly due to soil degradation in its natural habitat. *A. nebrodensis* is also conserved *ex situ* in a seed orchard (with grafts of the

29 remaining individuals of the species) in Arezzo, in botanical gardens (40 000 plants in the Botanical Garden of Palermo), arboreta and in private properties in the Madonie Mountains close to the natural habitat. *A. borisii-regis* and *A. cephalonica* are protected *in situ* in various protected areas in Greece. Genetic material, representing almost the whole natural distribution of the fir species, is included in provenance trials established in Greece and France. *A. cilicica* is protected in national parks, nature reserves and seed stands in ten areas in Turkey and in Lebanon while in Syria it is considered as an endangered species. *A. equi-trojani* is conserved *in situ* in the Kazdagi Goknari nature reserve in Turkey. *A. nordmanniana* is also covered by protected areas in Turkey and several provenances are growing *ex situ* in test sites, plantations and arboreta in Denmark and France. The *A. pinsapo* forests are included in three protected areas in

Spain. *A. numidica* is protected in the Djebel Barbor nature reserve located in the Petite Kabylia Mountain range of Algeria and the same provenance is reportedly also conserved in *ex situ* stands. At present *A. marocana*

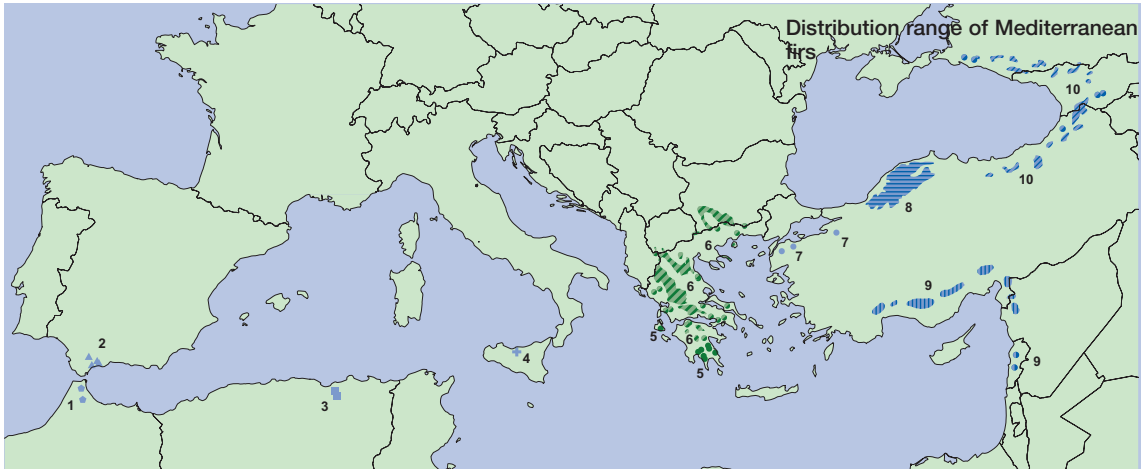
is conserved in a nature reserve in Morocco and seven *ex situ* stands have also been established for the species.

Climate change will have an impact on the current *in situ* conservation efforts but it is difficult to predict its effect on seed production, natural regeneration and recruitment of the firs as well as on the risks from insects and pathogens. The dynamic gene conservation units should be monitored in order to ensure that the populations are not seriously affected and that they retain their evolutionary potential and regenerate naturally. Management of the units should aim mainly at assisting natural regeneration and when this is not possible, the area should be artificially regenerated with local genetic material. Management of natural forests should also safeguard genetic resources by allowing natural selection to occur on regeneration in a variety of situations. *Ex situ* conservation efforts should focus on small populations that have an endangered status, insufficient seed production or unsuccessful pollination in their natural environment. This approach is useful especially in case of rare species or species with limited or scattered distribution as *ex situ* stands with a sufficient number of genotypes form new interbreeding populations that will produce seeds with a potentially high genetic diversity.



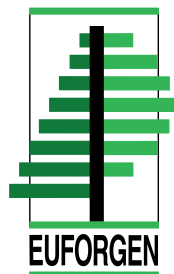
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- 1 *Abies marocana*
- ▲ 2 *Abies pinsapo*
- 3 *Abies numidica*
- ✦ 4 *Abies nebrodensis*
- 5 *Abies cephalonica*
- ▨ 6 *Abies borisii-regis*
- 7 *Abies equi-trojani*
- ▨ 8 *Abies bornmuelleriana*
- ▨ 9 *Abies cilicica*
- ▨ 10 *Abies nordmanniana*

Mediterranean firs offers an opportunity to tackle the predicted forest decline in southern Europe as a result of climate change. *A. nordmanniana* has already been used for reforestation in Europe. Other Mediterranean firs (particularly *A. cephalonica*, *A. bornmuelleriana* and *A. cilicica*) are far less water demanding and could represent an alternative for silver fir (*A. alba*) in Europe. Fir provenance tests in the Mediterranean include material that has demonstrated good growth, adaptation to drought and late bud burst in spring. Such provenances of Mediterranean firs could be of interest for the European forestry.



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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.

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## More information

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