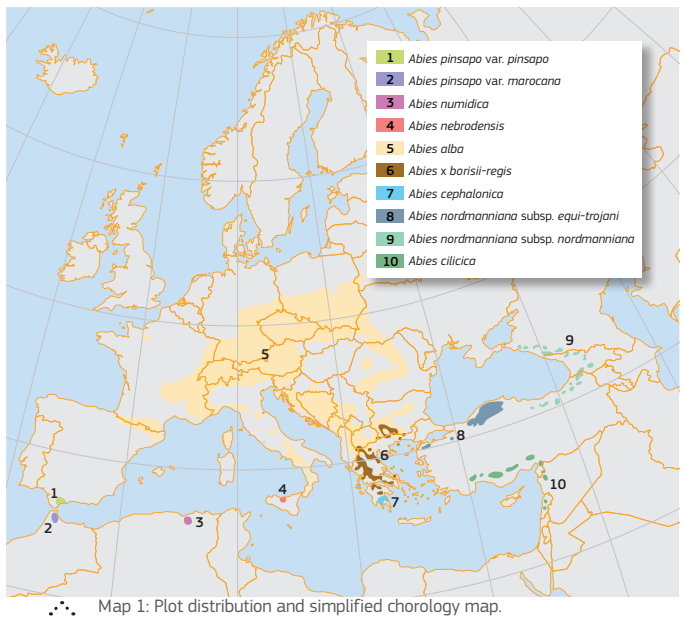
Abies – Circum-Mediterranean firs in Europe: distribution, habitat, usage and threats

G. Caudullo, W. Tinner

Most European firs occur predominantly in small to medium-sized populations in the Mediterranean region, sometimes with fragmented and limited distributions, except for silver fir (*Abies alba*). They all are genetically closely related and can easily hybridise, perhaps as a consequence of late speciation during the late Quaternary. Circum-Mediterranean firs occur principally in mountain areas with medium to high precipitations rates which are mostly concentrated during the winter period. The species are able to tolerate long droughts in summer and tend to form pure stands when in optimal habitats. In the past firs have been extensively logged for construction and fire wood and their stands were replaced by other more disturbance adapted species or converted into rural areas. Nowadays with the exception of silver fir and Caucasian fir (*Abies nordmanniana*), circum-Mediterranean firs do not have a wide commercial interest. In Turkey they are still exploited for timber wood, while other firs have an ornamental use in gardening. Great importance is given to their preservation, especially to those populations which have very limited areas and specimens, with the creation of protected reserves and conservation programmes. Wild fires, livestock grazing and genetic drift represent actually their main threats.

Circum-Mediterranean firs are evergreen conifers from medium (25 m in height for *Abies numidica*) to large size (up to over 60 m in height for *Abies alba* and *Abies nordmanniana*), with columnar trunk and conical crown, which often becomes flattened or rounded in old trees. The stem is straight, composed of short and horizontal branches regularly spaced. The needles are spirally arranged, radially perpendicular and brush-like (*Abies nebrodensis, Abies pinsapo, A. numidica*), twisted to point upward (*Abies cephalonica, Abies cilicica, A. nordmanniana*) or **pectinate** in two lateral sets (*Abies alba*). They are from 1 to 4 cm long, flattened, linear, with two white bands of **stomata** beneath, rounded or more or less notched at the apex. Pollen cones are clustered along the undersides of the current year's twigs, globular or conic, yellow-grey (*A. alba, A. nebrodensis, A. cilicica*) or reddish purplish (*A. cephalonica, A. numidica, A. nordmanniana, A. pinsapo*). Cones are ovoid to cylindrical, resinous, reddish or dark brown at maturity, with rounded scales which present hidden (*A. pinsapo, A. numidica, A. cilicica*) or protruding bracts (*A. alba, A. nordmanniana, A. cephalonica, A. nebrodensis*). Seeds are held in a membranous winged cup, brown-reddish, from 5 to 20 mm long. Wood is soft, white to light tan, with little difference between **sapwood** and **heartwood**[8-10].



Map 1: Plot distribution and simplified chorology map.
Chorology of the native spatial range for the Circum-Mediterranean firs. Derived after Alizoti *et al.* and Jalas and Suominen[17, 31].

Distribution

Today most of these fir species are segregated in small areas as relict and endemic populations, separated by geographical barriers. *A. pinsapo* var. *pinsapo* occurs in South Spain in the provinces of Malaga and Granada. *A. pinsapo* var. *marocana* grows in the western Rif Mountains in northern Morocco. *A. numidica* occupies an area on Mounts Babor and Talahor in the Kabylia region of Algeria. *A. cilicica* occurs in North Syria, Lebanon and South Turkey. *A. nordmanniana* has a wider range and is native to West Caucasus and the mountains of North-East Turkey along the Black Sea. *A. nordmanniana* subsp. *equi-trojani* forms pure stands on mountains in western Anatolia near to the Aegean Sea. Similarly, *A. cephalonica* has a widespread distribution; it occurs in the Regions of Espiros, Macedonia, Peloponnesus, Sterea Ellas and the Ionian Islands. *A.* x *borisii-regis* grows in the mountains of the Balkan Peninsula in Bulgaria, northern Greece, the Republic of Macedonia, Albania and Serbia, overlapping the distribution areas of *A. alba* and *A. cephalonica. A. nebrodensis* forms only a small population located in the Madonie Mountains in the north-central part of Sicily[9, 11-18].

Caucasian fir (*Abies nordmanniana*) is one of the tallest European trees, growing over 60 m tall. (Copyright weisserstier, www.flickr.com: CC-BY)

Habitat and Ecology

Except for *A. nordmanniana*, which can be found also at sea level, generally the circum-Mediterranean firs occur in mountain habitats at altitudes of above 400 m, up to 2 400 m for *A. pinsapo* var. *marocana*[19]. They are located in humid or even very humid climates with an annual precipitation over 700-800 mm, concentrated principally during the winter period[20-22]. When well established, mature trees can tolerate long drought periods, but suffer spring frosts. They develop in different parental materials, but grow best on deeper acid soils with high water reserves. Natural regeneration is normally abundant and easy inside their habitat range, but is best below a level of cover which limits the risk of late frost damage and water transpiration losses. Circum-Mediterranean firs commonly form pure stands in their optimal habitat, while at the borders they can be mixed with other tree species, such as beech (*Fagus* spp.), deciduous and evergreen oaks (*Quercus* spp.), pines (*Pinus* spp.), cedars (*Cedrus* spp.) and junipers (*Juniperus* spp.)[12-16, 18, 19, 23, 24].

Importance and Usage

Fir wood is appreciated because it is easy to work with and aesthetically pleasant, due to its soft and light structure. Even if its quality is mediocre compared with other more valuable woods, like spruce (*Picea abies*), pines and cedars, it has been utilized locally for many purposes. Today *A. nordmanniana, A. cilicica* and *A.* x *borisii-regis*, where abundant, are still exploited and the wood is widely utilized in the building sector, for furniture manufacture, veneer and plywood. *A. nordmanniana* is particularly appreciated for its potential large sized and regular timbers[10, 25-28]. Thanks to their aptitude to inter-species breeding, some firs have been used for selecting hybrids and cultivars with particular foliage colours, habit and dimensions, and are widely planted as ornamental trees in garden and parks. For example, *A. pinsapo* is particularly appreciated for their brush-shape twigs, *A. nordmanniana* is a popular Christmas tree because indoors young plants keep their needles longer and *A. numidica* is sometimes planted in hedges as it takes trimming well[10, 29]. Since most of the circum-Mediterranean firs have no wide commercial interest and due to the threats, **endemism** and geographically scattered distribution, their preservation as genetic resources is a major challenge. Diverse genetic conservation strategies have been elaborated, complementing the protection of natural stands (national or local parks and reserve) with the conservation of genetic resources outside their natural habitats (plantations, orchards and conservation of genetic material in vitro and with cryopreservation[30, 31]). Southern fir populations deserve special attention under global warming conditions, particularly in regard to their genetic characters, which may be relevant for future adaptation processes of firs[30].

Reddish pollen cones of Spanish fir (*Abies pinsapo* var. *pinsapo*). (Copyright MPF, commons.wikimedia.org: CC-BY)

Threats and Diseases

In the past, deforestation due to logging and forest clearance for agricultural purposes was the main threat, especially for those fir species with a limited distribution area[32]. In Lebanon and Syria fragmented and degraded forests of *A. cilicica* still suffer from urban pressure with ongoing cutting in marginal rural areas for fuel wood, while *A. nordmanniana* subsp. *equi-trojani* stands are more threatened by tourism development[10, 13, 15, 33]. Unlike others, *A. pinsapo* has never been extensively felled, probably due to the difficulty of access and the unsuitability for farming of lands occupied by those firs[34].

Actually, in many countries the most endangered fir forests are regulated by conservation laws and protected in natural reserves, which limit human activities. In these protected areas

Taxonomic notes

Circum-Mediterranean firs have been historically classified on the base of macro-morphological and anatomical differences. However, paleo-botanic, genetic and micro-morphometric studies have recently modified their classification[1-4]. In fact these firs are closely related genetically and they can easily hybridise naturally and artificially, so that it is not easy to distinguish between them[5]. The speciation probably occurred from a common Tertiary ancestor. Later, firs expanded and contracted following the glacial cycles. Around the Mediterranean basin firs now occupy fragmented and sometimes limited areas. This is largely the result of the geological and climatic history of the Mediterranean region where firs have evolved, having fostered differentiations and local adaptations, which have led to the emergence of many species, subspecies, and varieties[6, 7]. Actually, the genus *Abies* is classified in 10 sections, of which two include the circum-Mediterranean fir species. The *Abies* section comprises fir species distributed in the Centre-North of the Mediterranean Basin: *Abies alba* Mill. (silver fir), *Abies cephalonica* Loudon (Greek fir), *Abies* x *borisii-regis* Mattf. (Bulgarian fir), which is a hybrid of *Abies cephalonica* and *Abies alba*, *Abies nebrodensis* (Lojac.) Mattei (Sicilian fir), *Abies cilicica* Ant. & Kotschy Carriére (Syrian fir), and *Abies nordmanniana* (Steven) Spach, for which two subspecies are recognised: *Abies nordmanniana* subsp. *nordmanniana* (Caucasian fir) and *Abies nordmanniana* subsp. *equi-trojani* (Turkish fir). Some authors consider this latter as a separate species *Abies equi-trojani* or as a hybrid *Abies* x *equi-trojani* between *Abies cephalonica* and *Abies nordmanniana*. Disjunct fir populations of the subspecies *equi-trojani* in North-West Turkey, which show minor morphological differences, have led some authors to recognise the subspecies *Abies nordmanniana* subsp. *bornmuelleriana*, sometimes considered as separated species *Abies bornmuelleriana*. The *Piceaster* section comprises fir species distributed in the South-West of the Mediterranean basin: *Abies pinsapo* var. *pinsapo* Boiss. (Spanish fir), *Abies pinsapo* var. *marocana* (Trab.) Cebalos & Bolaño (Moroccan fir) and *Abies numidica* de Lannoy ex Carrière (Algerian fir)[8-10].

accidental fires represent the major cause of forest loss. Firs are particularly sensitive to excessive (**anthropogenic**) fire disturbance, which is pervasive in most Mediterranean areas. When severe, wild fires can destroy entire stands and degrade the habitat, making it less suitable for firs, so that post-fire regeneration is not always guaranteed[12, 16, 34-37]. Goat and cattle grazing activity can be particularly destructive when intensive, damaging seedlings and young shoots of juvenile plants and limiting forest regeneration. Now in most fir forests pasturing continues under control, but in some isolated *A. cilicica* stands livestock grazing is still one of the main threats[13, 18, 33]. Forests degraded by fire and grazing activity are more susceptible to pathogens. *A. pinsapo* has seen an increase in attacks of the root rot fungus *Heterobasidion* spp. and the coleopteran *Cryphalus numidicus* in recent decades, especially in drought periods[34, 38, 39].

The total Sicilian fir (*Abies nebrodensis*) population counts 24 mature trees which are protected by fences.
(Copyright Verollanos93, commons.wikimedia.org: PD)

The isolation of populations due to fragmentation could give rise to a low genetic flow and therefore genetic diversity, which may represent another important factor weakening populations and making them more susceptible to diseases. This is the case for *A. nebrodensis*, which is currently one of the rarest conifer species in the world, counting a population of just 24 mature trees[14]. This fir is under an extensive conservation programme locally and abroad for its protection. However, it has not yet been entirely successful, due to the harsh summer conditions and the depleted soil of native areas. New attempts have been planned with the use of compost and summer watering[40].

On the other hand, *A. cephalonica* needs to be genetically protected, since it is potentially threatened by hybridisation with other fir species, such as *A. alba*, used in the past for plantations, and their hybrid *A.* x *borisii-regis*, which naturally co-exists in the northern part of *A. cephalonica* distribution. The latter benefits from wetter conditions, therefore *A.* x *borisii-regis* ingression may occur influenced by a change toward a warming climate [11].

Syrian fir forest (*Abies cilicica*) in Western Taurus Mountains (South Turkey).
(Copyright Vince Smith, www.flickr.com: CC-BY)

Forest of Spanish firs (*Abies pinsapo* var. *pinsapo*) in Sierra Bermeja (South Spain).
(Copyright Alfonso San Miguel: CC-BY)

References

[1] B. Ziegenhagen, B. Fady, V. Kuhlenkamp, S. Liepelt, *Silvae Genetica* **54**, 123 (2005).

[2] S. Liepelt, E. Mayland-Quellhorst, M. Lahme, B. Ziegenhagen, *Plant Systematics and Evolution* 284, 141 (2010).

[3] A. Terrab, *et al., Taxon* **56**, 409 (2007).

[4] K. Sękiewicz, *et al., Plant Biosystems - An International Journal Dealing with all Aspects of Plant Biology* **147**, 125 (2012).

[5] F. U. Klaehn, J. A. Winieski, *Silvae Genetica* **11**, 130 (1962).

[6] J. C. Linares, *Journal of Biogeography* **38**, 619 (2011).

[7] B. Fady, M. Arbez, A. Marpeau, *Trees* **6**, 162 (1992).

[8] J. E. Eckenwalder, *Conifers of the World: The Complete Reference* (Timber Press, 2009).

[9] C. J. Earle, The gymnosperm database (2015). http://www.conifers.org

[10] A. Farjon, *A handbook of the world's conifers* (Brill, 2010).

[11] A. Farjon, D. Filer, *An Atlas of the World's Conifers: An Analysis of their Distribution, Biogeography, Diversity and Conservation Status* (Brill, 2013).

[12] M. Gardner, S. Knees, *The IUCN Red List of Threatened Species* (2011), pp. 38320/0+.

[13] M. Gardner, S. Knees, *The IUCN Red List of Threatened Species* (2013), pp. 42275/0+.

[14] P. Thomas, *The IUCN Red List of Threatened Species* (2013), pp. 30478/0+.

[15] S. Knees, M. Gardner, *The IUCN Red List of Threatened Species* (2011), pp. 42293/0+.

[16] A. Arista, M. L. Alaoui, S. Knees, M. Gardner, *The IUCN Red List of Threatened Species* (2011), pp. 42295/0+.

[17] J. Jalas, J. Suominen, Atlas Florae *Europaeae: distribution of vascular plants in Europe Vol. 2 Gymnospermae (Pinaceae to Ephedraceae)* (Committee for Mapping the Flora of Europe and Societas Biologica Fennica Vanamo, Helsinki, 1973).

[18] N. Yahi, S. Knees, M. Gardner, *The IUCN Red List of Threatened Species* (2011), pp. 30320/0+.

[19] G. Aussenac, *Annals of Forest Science* **59**, 823 (2002).

[20] W. Tinner, et al., *Ecological Monographs* **83**, 419 (2013).

[21] H. J. Schuck, H. Weisgerber, P. Schütt, *Lexikon der Nadelbäume* (Nikol, Hamburg, 2008).

[22] L. Awad, B. Fady, C. Khater, A. Roig, R. Cheddadi, *PLoS ONE* **9**, e90086 (2014).

[23] M. Arista, F. J. Herrera, S. Talavera, *Biologia del pinsapo* (Consejerìa de Medio Ambiente, Junta de Andalucìa, Sevilla, 1997).

[24] Z. Kaya, D. J. Raynal, *Biological Conservation* **97**, 131 (2001).

[25] I. Usta, *Turkish Journal of Agriculture and Forestry* **28**, 1 (2004).

[26] N. Seyidoglu Akdeniz, D. Yayim Yener, *Journal of Forestry Faculty of Kastamonu University* **12**, 256 (2012).

[27] H. Hafizoglu, B. Holmbom, *Holz als Roh- und Werkstoff* 53, 273 (1995).

[28] L. García Esteban, P. de Palacios, *Bois et Forêts des Tropiques* **292**, 39 (2007).

[29] A. Ulus, *Journal of Forestry Faculty of Kastamonu University* **12**, 242 (2012).

[30] J. Krajňáková, D. Gömöry, H. Häggman, *Biotechnology and Biodiversity*, M. R. Ahuja, K. G. Ramawat, eds. (Springer International Publishing, 2014), vol. 4 of *Sustainable Development and Biodiversity*, pp. 287–310.

[31] P. G. Alizoti, B. Fady, M. A. Prada, G. G. Vendramin, EUFORGEN technical guidelines for genetic conservation and use of mediterranean firs (*abies spp.*), *Tech. rep.*, Bioversity International (2011).

[32] M. Barbero, G. Bonin, R. Loisel, P. Quézel, *Vegetatio* **87**, 151 (1990).

[33] S. N. Talhouk, R. Zurayk, S. Khuri, *Oryx* **35**, 206 (2001).

[34] L. G. Esteban, P. de Palacios, R. L. Aguado, *Oryx* **44**, 276 (2010).

[35] M. Arista, J. Herrera, S. Talavera, *Bocconea* **7**, 427 (1997).

[36] P. Ganatsas, E. Daskalakou, D. Paitaridou, *iForest - Biogeosciences and Forestry* **5**, 6 (2012).

[37] M. Arianoutsou, *et al., Post-Fire Management and Restoration of Southern European Forests*, F. Moreira, M. Arianoutsou, P. Corona, J. De las Heras, eds. (Springer Netherlands, 2012), vol. 24 of *Managing Forest Ecosystems*, pp. 257–291.

[38] M. E. Sánchez, et al., *Forest Pathology* **37**, 348 (2007).

[39] J. Linares, J. Camarero, M. Bowker, V. Ochoa, J. Carreira, *Oecologia* **164**, 1107 (2010).

[40] J. a. P. Silva, *et al., LIFE and endangered plants:Conserving Europe's threatened flora* (Environment Directorate-General, European Commission, 2008).

This is an extended summary of the chapter. The full version of this chapter (revised and peer-reviewed) will be published online at **https://w3id.org/mtv/FISE-Comm/v01/e015be7**. The purpose of this summary is to provide an accessible dissemination of the related main topics.

This QR code points to the full online version, where the most updated content may be freely accessed.

Please, cite as:

Caudullo, G., Tinner, W., 2016. ***Abies* - Circum-Mediterranean firs in Europe: distribution, habitat, usage and threats**. In: San-Miguel-Ayanz, J., de Rigo, D., Caudullo, G., Houston Durrant, T., Mauri, A. (Eds.), *European Atlas of Forest Tree Species*. Publ. Off. EU, Luxembourg, pp. e015be7+