Aleppo and Brutia pines

Pinus halepensis/Pinus brutia

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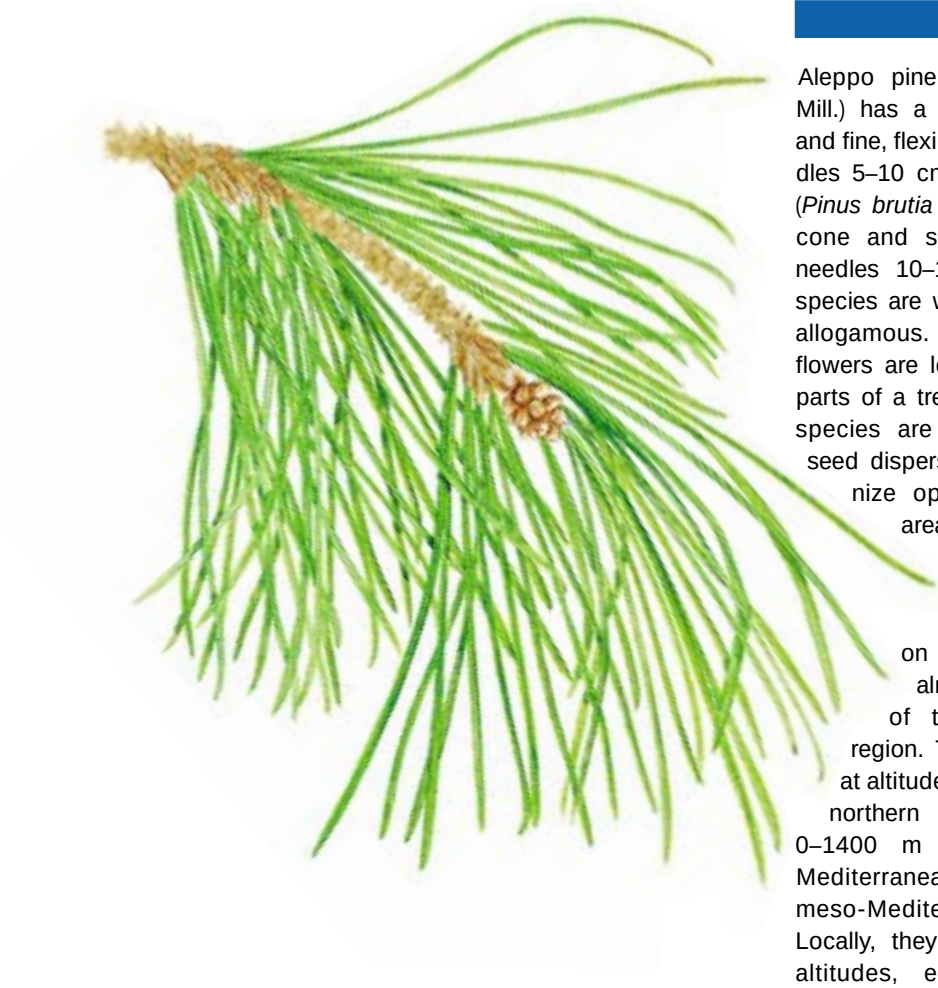
These Technical Guidelines are intended to assist those who cherish the valuable Aleppo pine and Brutia pine genepools and wish to ensure their sustainability, through conserving important seed sources or use in practical forestry. The focus is on conserving the genetic diversity of the species at the 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

Aleppo pine (*Pinus halepensis* Mill.) has a pedunculate cone, and fine, flexible, light green needles 5–10 cm long. Brutia pine (*Pinus brutia* Ten.) has a sessile cone and strong, dark green needles 10–18 cm long. Both species are wind-pollinated and allogamous. Male and female flowers are located on different parts of a tree (monoecy). Both species are extremely prolific seed dispersers and can colonize open and disturbed areas easily.

Aleppo and Brutia pine forests can grow on all substrates and almost all bioclimates of the Mediterranean region. They can be found at altitudes of 0–600 m in the northern Mediterranean and 0–1400 m in the southern Mediterranean (thermo- and meso-Mediterranean levels). Locally, they can reach higher altitudes, e.g. 2600 m for

P. halepensis in the Higher Atlas of Morocco and 1650 m for *P. brutia* in the Taurus Mountains of Turkey. At the upper limit of their distribution, they often constitute a pre-forest colonizing stage or are part of a mixed pine-oak forest.

Optimal development of *P. halepensis* forests occurs at annual rainfalls of 350–700 mm and absolute mean minimum temperatures between –2 and +10°C (semi-arid and sub-humid bioclimates). Optimal development of *P. brutia* forests requires higher rainfalls but accepts a wider range of temperatures (absolute mean minimum temperatures between –5 and +10°C, sub-humid and humid bioclimates).

Distribution

Pinus halepensis and *P. brutia* form a group of related species that can intercross, but occupy different geographical ranges and bioclimates.

Aleppo pine forests cover extensive areas in the western Mediterranean: Spain, France, Italy, Croatia, Albania, Greece, Morocco, Algeria, Tunisia, Libya and Malta. A few natural and artificial populations can be found in the eastern Mediterranean in Turkey, Syria, Israel, Jordan and Lebanon. Total forest cover is estimated to be approximately 3.5 million hectares.

Brutia pine forests cover extensive areas in the Eastern Mediterranean: Greece, Turkey, Cyprus, Syria and Lebanon. A few small populations can be found in Iraq and Iran. Other related taxonomic groups are present in Ukraine (Crimea, *P. stankewiczii* Sukaczew), around the Black Sea (Georgia, Russian Federation, Ukraine, *P. pithyusa* Stevenson) and in the Caucasus (Azerbaijan, Georgia, Iran, Turkey, *P. eldarica* Medw.). Total forest cover is estimated to be over 4 million hectares, of which 3.8 million hectares are in Turkey.

Importance and use

Aleppo and Brutia pines represent the only or main source of wood and forest cover in many Mediterranean countries. Economically, *P. brutia* is the most important conifer species in Turkey; *P. halepensis* is the most important forest species of North Africa, and has high ecological importance in southern France and Italy, especially at the urban-forest interface. Mean productivity is approximately 1–2 m^3 ha^{-1} $year^{-1}$ for Aleppo pine, and 2–3 m^3 ha^{-1} $year^{-1}$ for Brutia pine. Maximum yield can reach 12–15 m^3 for both species. The wood of these Mediterranean pines is used for many purposes: construction, industry, carpentry, firewood and pulp. Seeds are also used for making pastry.

Genetic knowledge

Genetic inventories using biochemical and DNA markers have demonstrated that genetic diversity is geographically structured. Most *P. halepensis* diversity was found in Greek and Spanish populations although other populations had lower diversity than other conifer species. This is consistent with the hypothesis of a recent expansion of the species (in the last 10 000 years) from these two refugial areas, with colonizing populations establishing by migration of a limited number of individuals (founder effect) and/or population dynamics regulated by fire (population bottlenecks). Genetic diversity is higher for *P. brutia* and roughly separates Western and Eastern populations.

Controlled pollination experiments and monitoring of sympatric east Mediterranean populations using molecular markers have demonstrated that unidirectional gene flow is possible from *P. halepensis* to *P. brutia* resulting in the emergence of hybrids. Hybridization is not possible using *P. brutia* as pollen parent.

Provenance and laboratory tests have revealed significant geographic patterns in adaptive trait variability. Although both species demonstrate polycyclic annual growth patterns, initial shoot units are smaller in *P. halepensis*. The easternmost *P. halepensis* provenances tend to have higher juvenile growth. *Pinus halepensis* is better adapted to drought but less adapted to cold than *P. brutia*. However, under severe water-stress conditions, *P. halepensis* has an increased sensitivity to the fungus *Sphaeropsis sapinea*. Both species are sensitive to the pine procecionnary moth *Thaumetopoea pityocampa* which can cause severe defoliation. *Pinus halepensis* is sensitive to the pine bast scale *Matsucoccus josephii*, although *P. brutia* is resistant to it.

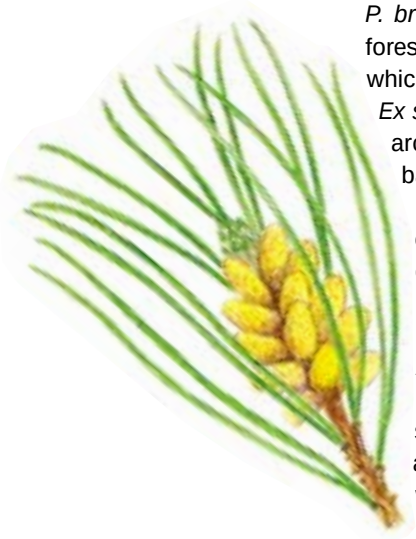
These, along with ecological studies, have been used to define seed-collection zones and seed stands in several countries (e.g. 29 *P. halepensis* seed stands in France).

Threats to genetic diversity

Aleppo and Brutia pines are not considered ecologically threatened as a whole. However *P. pityusa* is considered vulnerable because of population size reduction linked to habitat decline (IUCN red list). *Pinus eldarica* has a patchy distribution and its genetic diversity is lowest among the taxa of this group.

Insects such as *Matsucoccus josephii* represent a major threat in the Eastern Mediterranean. *Thaumatopea pityocampa* can also induce severe defoliation throughout the distribution area of both pines although it does not often lead to mortality. Recently, the canker *Crumenulopsis sororia* has started to cause severe defoliation and dieback on *P. halepensis* in France. The impact of forest fires is ambivalent. Although they actually promote regeneration, they could be responsible for rare allele changes over generations, explain the very low diversity found in *P. halepensis* and promote the spreading of *P. halepensis* genes into *P. brutia* forests. Among-region seed transfers have led to significant frost or water-stress damage after planting when ill-adapted material was used. Reducing local population adaptability through gene flow from plantations is also a risk. Finally,

because these species (and especially *P. halepensis*) are highly resistant to drought, they are often the last forest species to be found at desert or steppe margins. Global warming and its collateral modification of rainfall regimes may dramatically modify their distribution ranges.



Guidelines for genetic conservation and use

Current conservation measures undertaken at national levels most commonly include *in situ* gene conservation networks specifically designed for the target species (e.g. in Turkey, 52 *P. brutia* conservation units) and forest reserves or national parks which include the target species. *Ex situ* measures include clonal archives, cold storage seed banks and DNA banks.

To increase the efficiency of *in situ* genetic resource conservation, a concerted management effort should be carried out range-wide. Although transfer of seed material is often legally possible, it should be avoided across zones and countries with different ecological requirements, notably because of cold, drought and insect damage risks.

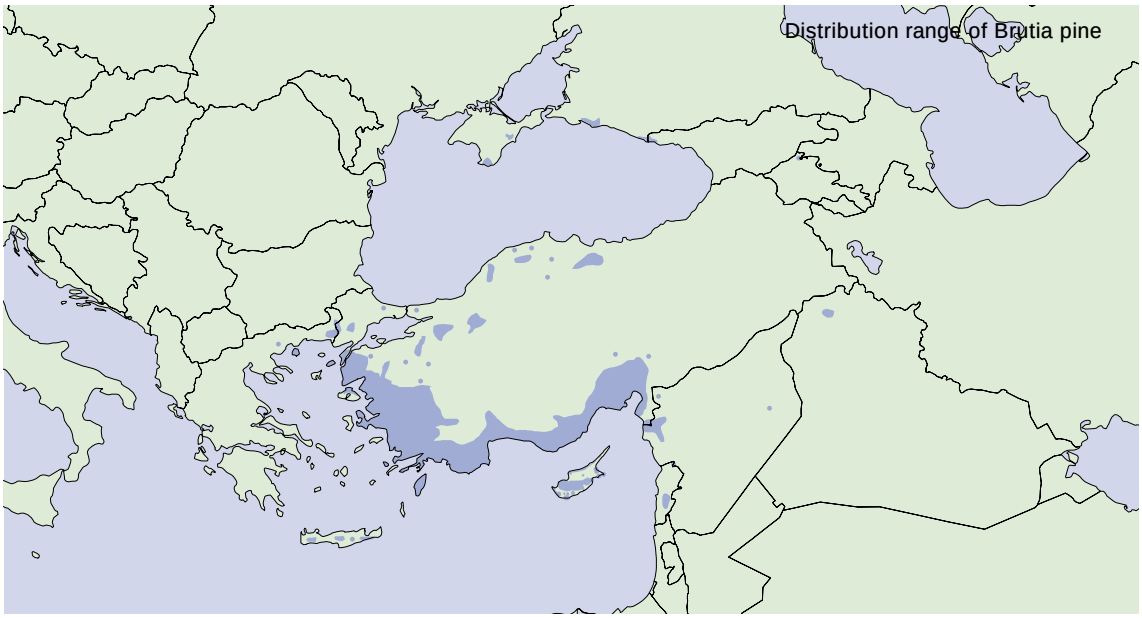
Locally, some populations require specific attention and appropriate forestry practice.

Marginal populations. As populations at high altitudes, in desert margins and mixed forests may contain valuable genes (resistance to drought, cold, pests) for adaptation under global warming, efforts such as gene reserves should be made to conserve them.

Population under recurrent forest fires. Because they are adapted to forest fires, both pines usually regenerate well after fire, using the seed bank released from serotinous cones. If regeneration happens to be poor in the first 2 years after fire, and if only a few isolated seed trees remain in the burnt area, artificial regeneration should be used to counteract the risk of genetic erosion in the juveniles. In this case, seed lots collected from large genepools should be used (e.g. at least 30 trees per population from at least three populations from a single seed zone).

Populations where hybridization may occur. Planting Aleppo pine where Brutia pine is present should be avoided in areas where frost and potential pest damage are limiting factors, or strictly monitored in areas where drought is the limiting factor. Owing to the anisotropy of between-species gene flow, the impact should be reduced when planting Brutia pine in the vicinity of Aleppo pine forests.

Pinus halepensis



EUFORGEN

These Technical Guidelines were produced by members of the EUFORGEN Conifers Network. The objective of the Network is to identify minimum genetic conservation requirements in the long term in Europe, in order to reduce the overall conservation cost and to improve the quality of standards in each country.

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The distribution map was compiled by members of the EUFORGEN Conifers Network based on an earlier map published by W.B.Critchfield & E.L.Little, Jr. in 1966 (Geographic Distibution, of the Pines of the World, USDA Forest Service Misc. Publication, 991 pages).

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