Holm oak

Quercus ilex

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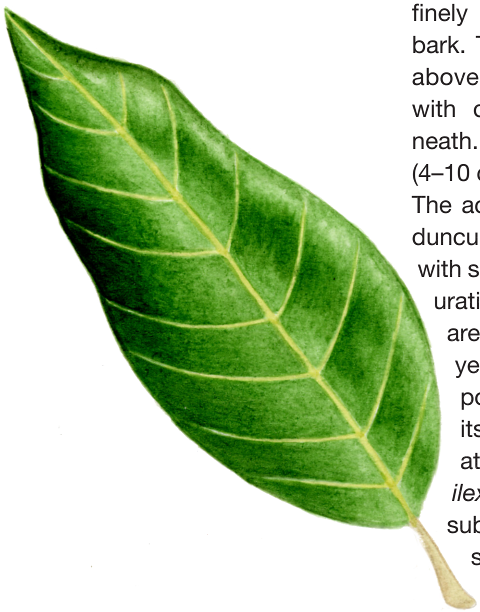
These Technical Guidelines are intended to assist those who cherish the valuable holm oak genepool and its inheritance, through conserving valuable seed sources or use in practical forestry. The focus is on conserving the genetic diversity of the species at the European scale. The recommendations provided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

Biology and ecology



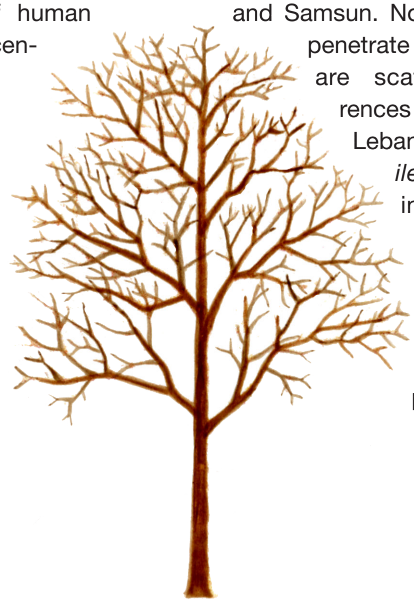
Holm oak (*Quercus ilex* L.) is a monoecious, evergreen, wind-pollinated oak tree. It is a medium-sized tree (20–27 m tall), with finely square-fissured, blackish bark. The leaves are dark green above, and pale whitish-grey with dense short hairs underneath. The leaf shape is variable (4–10 cm long and 1–3 cm wide). The acorns are dark brown, pedunculated, and held by cupulae with short, tight scales. The maturation is annual, but in some areas more flowerings in a year are possible. *Q. ilex* is polymorphous, but it exhibits its two main formae ranked at the subspecies level: *Q. ilex* subsp. *ilex*, and *Q. ilex* subsp. *rotundifolia*. There are several known natural hybrids: *Q. x morisii* Borzì (with *Q. suber*), *Q. x turneri* Willd. (with *Q. robur*), *Q. audleyensis* Henry (with *Q. petraea*), *Q. albescens* Rouy (with *Q. pubescens*), *Q. auzendi* Green and Godr. (with *Q. coccifera*).

Q. ilex is a very drought tolerant species among the evergreen Mediterranean oaks.

Its ecological plasticity allows it to thrive in almost all bioclimates, except extremely arid ones, where annual precipitation is under 450 mm. It is highly termophilous, but it can resist winter cold (as low as -20°C). Holm oak is indifferent to soils, but the best stations are found on calcareous brown or well-drained soils.

It can be found from sea level to 100–140 m above sea level in the Black Sea area, up to 400-600 m in the Mediterranean, while on the Moroccan Reef, it grows up to altitudes of 2000–2600 m.

When climatic conditions are favourable, *Q. ilex* is strongly competitive and forms long-lasting, pure stands. These forests are now becoming rare, mostly as a result of human activities over centuries.



Distribution

Holm oak shows a circum-Mediterranean range, absent only in Egypt. It is more abundant in the western regions, where it forms large pure stands (Morocco, the Iberian peninsula, the Atlantic and Mediterranean coasts of France, the Italian peninsula, the main Mediterranean islands), than in the east, where it can more usually be found in mixed stands (Balkan coasts, Greece, Crete, northern Anatolia, Black Sea and northern Lebanon). In Africa there are scattered putative indigenous occurrences along the Libyan coast up to Cyrenaica. The northernmost limit of the range is at the Gironde estuary; in the east it reaches the Turkish shores of the Aegean Sea and the Black Sea provinces of Zonguldak, Sinop and Samsun. Nowhere does it penetrate inland. There are scattered occurrences in Cyprus and Lebanon. In Italy, *Q. ilex* is absent in the Padan Plain, except for some isolated stands around the big pre-Alpine lakes.

Importance and use

Holm oak forests play a very important socio-economic role, owing to the diversification of products: wood, environmental protection, tourism and forage resources.

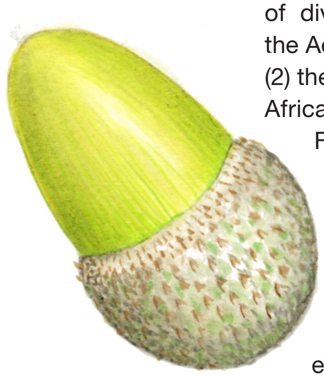
The ability to survive in regions of extreme climates with cold winters and very hot and dry summers, together with a remarkable resistance to fire, makes holm oak a key ecological species virtually without alternative in the harsh inland regions of Portugal. Substitutions tend to fail both on physiological and on economic aspects. Where pines are used to replace holm oak, fire risk increases in these areas.

Holm oak forests cover about 4,000,000 ha in Spain, and are mainly exploited in a silvo-pastoral regime for pig grazing. From the free-range black pigs that feed on acorns, the exquisite delicacy *jamon de bellota* is produced, playing a major role in the rural economy in various regions. The silvo-pastoral regime for animal grazing benefiting from the nutritious holm oak acorns is practised also in other countries, though on a smaller scale than in Spain.

The wood is hard and tough and has been used since ancient times for general construction purposes, such as pillars, tools, wagons, vessels and wine casks. It is also used as firewood, or for charcoal production.

Holm oak is one of the top three tree species used in the establishment of truffle orchards, or trufferies. Truffles grow in an ectomycorrhizal association with the tree's roots.

The acorns, like those of the cork oak, are edible (toasted, as a flour or boiled in water). When boiled they can also be used as a medicinal treatment for disinfection of wounds. The tree can be clipped to form a tall hedge, and it is suitable for coastal windbreaks, in any well drained soil. It forms a picturesque rounded head, with pendulous low-hanging branches. Its size and solid evergreen character give it an imposing architectural presence that makes it valuable in many urban and garden settings.



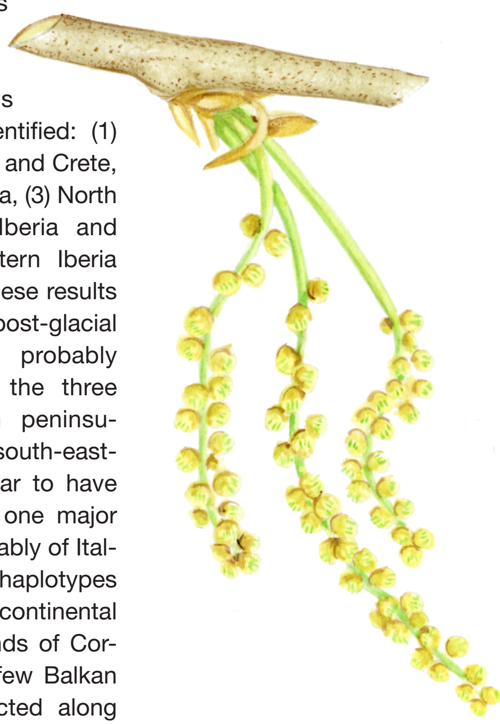
Genetic knowledge

The karyotype of *Q. ilex* consists of 18 metacentric, 4 submetacentric and 2 subtelocentric chromosomes. Pair 1 shows a secondary constriction on the long arm; pair 2 bears a satellite on the short arm. Holm oak shows a different karyomorphology from other oak species, but is similar to *Q. coccifera*, thus confirming its belonging to the same subgenus Sclerophyllodrys (D'Emerico et al. 2000).

Lumaret et al. (2002) analyzed the variation of chloroplast DNA in *Q. ilex* over its whole distribution range.

Five macro-regions of diversity were identified: (1) the Aegean peninsula and Crete, (2) the Italian peninsula, (3) North Africa, (4) eastern Iberia and France, (5) western Iberia and France. These results indicate that post-glacial recolonization probably started from the three Mediterranean peninsulas. Italy and south-eastern France appear to have been colonized by one major haplotype, most probably of Italian origin. Additional haplotypes are rarely detected in continental Italy and on the islands of Corsica and Sicily, and few Balkan haplotypes are detected along the Italian Adriatic coast. Fineschi et al. (2005) concluded that Sicily represents the Italian reservoir for holm oak haplotypic diversity. The analysis of nuclear markers (isozymes) over the whole species distribution revealed that some Sicilian populations are characterized by the occurrence of private alleles.

The reproductive profile is rather regular and balanced and the juvenile stage is much shorter than in other oaks. This means that already at young age trees in a stand contribute to a high effective population size of these stands. This means good perspectives for gene conservation whenever natural regeneration is encouraged (Varela, et al. 2008).



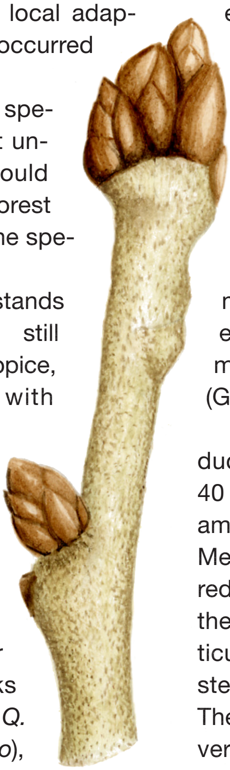
Threats to genetic diversity

Holm oak is affected by several anthropogenic pressures that could lead to a loss of genetic diversity. Loss and/or fragmentation of habitats by intense human impacts on forest and agricultural landscapes has been recorded for centuries in areas like Sicily. Replacement with fast-growing species or clear cuttings for tourist facilities such as golf courses is also threatening the holm oak forests in some parts of Portugal and Spain. Indiscriminate cuttings and recurrent fires have mainly affected all the Mediterranean coastal stands, while overgrazing (especially during the regeneration period) is particularly present in the Iberian peninsula. In addition, natural enemies, such as fungi and insects, have affected holm oak stands, in particular in urban areas (central and southern Italy). Nowadays, in the central-eastern Mediterranean Basin (e.g. Italy and Dalmatia), holm oak, like other oaks, is naturally prone to vegetative sprouting from stumps or roots of dead or fallen trees. Forest owners, especially when attempting to propagate interesting phenotypes, frequently use this methodology, which results in the cloning of these trees. This leads to a decreased genetic diversity.

Adding to the potential reduction of genetic variability and inbreeding from empirical cloning practices, in some zones natural regeneration is poor, thus creating a highly skewed age distribution towards old trees. The combined effect of old trees and cloned trees may be driving threats to the genetic resources of the species, especially in particular ecological conditions where local adaptation may have occurred during evolution.

Guidelines for specific management under coppice should be part of the forest management of the species.

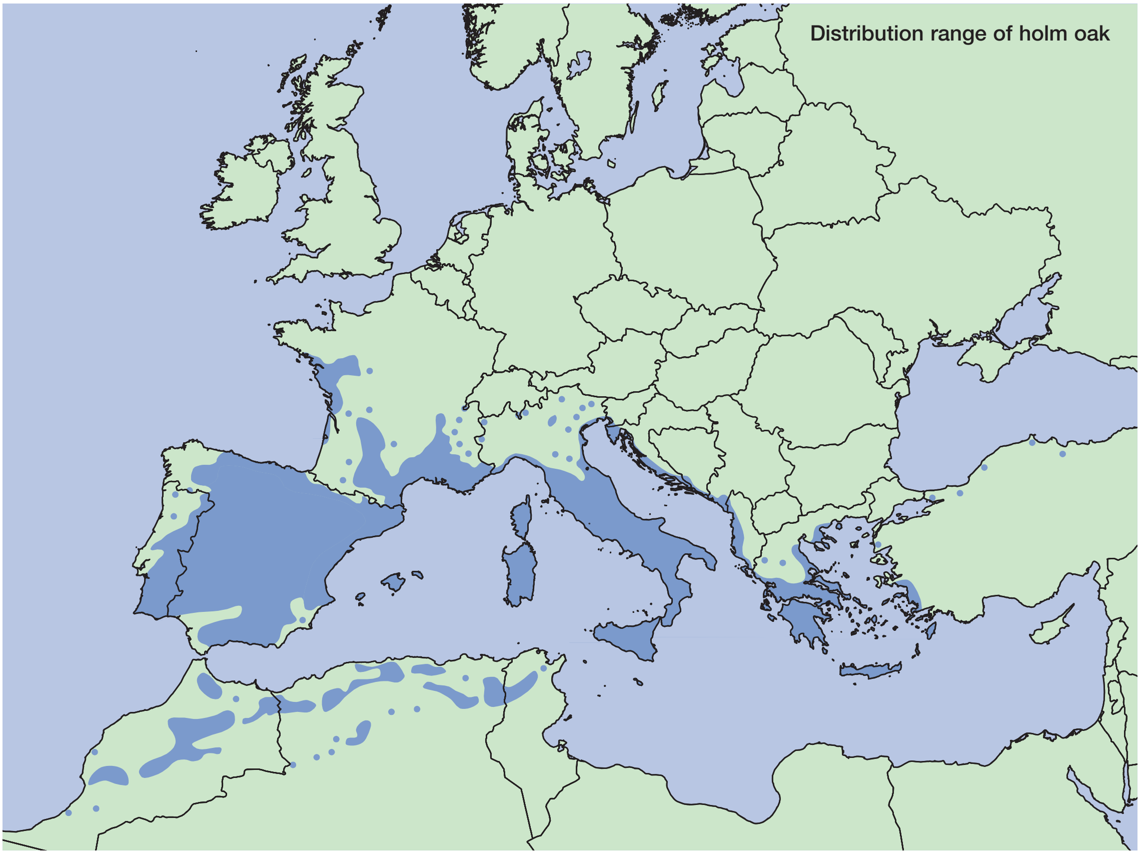
Holm oak stands are today often still managed as coppice, sometimes with short cycles of less than 20 years. This is because the holm oak wood technological properties are not as good as other deciduous oaks (e.g. *Q. robur*, *Q. petraea*, *Q. frainetto*), which produce high quality logs. Therefore, a considerable loss of intraspecific genetic diversity is observed in holm oak, because adequate high-forest management models in which much longer cutting cycles take place, have not been developed yet. These models could theoretically permit better conservation of the species diversity.



Guidelines for genetic conservation and use

Seed propagation for high forests is the most suitable management method to maintain and increase genetic diversity and, therefore, the conservation of the genetic resources of the species. It is the most adequate regime for landscape protection, ornamental and recreational functionalities. High forest merits are also on the use of water, which is a special feature for Mediterranean regions where increasing human demands for water are expected together with climate change induced drought (Gracia, 2009).

Coppices for firewood production (coppicing every 30–40 years) usually host a large amount of the biodiversity of Mediterranean ecosystems, but reduce the genetic diversity of the coppiced species, in particular where up growing single stems per stump are not left. Therefore, the chance to convert coppices into high forests, through a gradual increase of the number of single stems per stump, should be considered. For instance, a coppice stand with a single stem per stump system, with long cycles (not less than 40 to 50 years) and a large number of seed-bearing trees (even >200), contributes to the regeneration of the population and the maintenance of the understory and favours the



natural evolution of *Q. ilex* towards its climax situation (which is pure high forest).

Holm oak hybridizes with other oak species and hybridization may result in a loss or an increase of genetic diversity according to the concrete situation of the population or species evolution (Soltis & Soltis, 2009). Where populations for conservation of genetic resources are established in mixed oak- stands, hybridization monitoring is recommended, whenever possible through genomics, transcriptomics and progeny testing.

Since limited genetic information about *Q. ilex* is available, it is recommended that genetic conservation programmes start with the following objectives: conservation of endangered, marginal populations and habitats of *Q. ilex*; sampling the genetic diversity; establishment of Dynamic Conservation Units based on long term autochthony, high biodiversity value and location in ecologically diverse regions of large populations (> 1000 individuals).

EUFORGEN

The series of these Technical Guidelines and the distribution maps were produced by members of the EUFORGEN Networks. The objective is to identify minimum requirements for long-term genetic conservation 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 is based on: Caudullo, G., Welk, E., San-Miguel-Ayanz, J., 2017. Chorological maps for the main European woody species. Data in Brief 12, 662-666. https://doi.org/10.1016/j.dib.2017.05.007

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