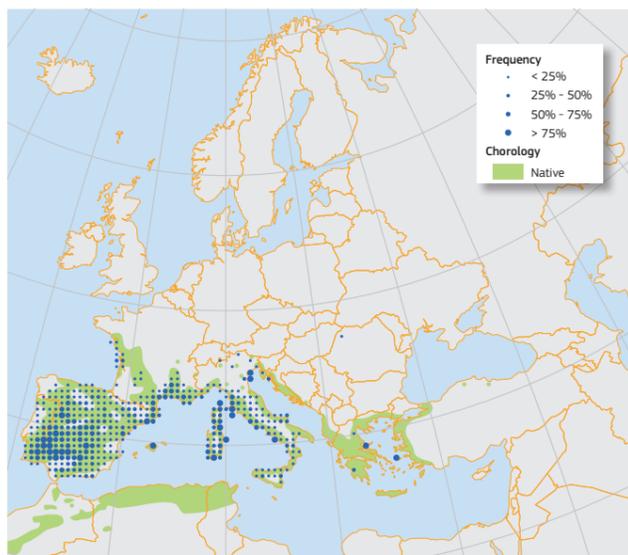


Quercus ilex in Europe: distribution, habitat, usage and threats

D. de Rigo, G. Caudullo

Quercus ilex L., known as holm oak or evergreen oak, is a broadleaved tree or shrub, which can grow up to 25m. It is characterised by **coriaceous** dark green leaves with a woolly lower side, and small acorns. It is native to the central-western Mediterranean basin, where it represents the dominating species in woodlands and **maquis** vegetation. It is a shade-tolerant species regenerating under the canopy cover, but it is also a vigorous root re-sprouting species. In Europe it thrives in meso-Mediterranean bioclimates, where it is not too dry, forming well-structured forests rich in species. Managed principally as coppice forests, its hard wood has been used for the production of charcoal, firewood, railway sleepers and small tools. In the Iberian Peninsula the holm oak woodlands are historically managed as pastures with large isolated trees where livestock feeding on the grass and acorns. Fungal pathogens can create severe damage especially to drought suffering trees. As other oaks it is also damaged by several defoliating lepidopterans. For millennia Mediterranean holm oak forests have suffered for human activities, which have exploited, modified the species mixture and in many cases replaced woodlands with agriculture and urban areas.

The holm oak (*Quercus ilex* L.) is an broadleaved evergreen tree or shrub, which can grow up to 25m and exceptionally 30m with over 2m of trunk diameter^{1,2}. Its lifespan may reach more than 1000 years²⁻⁴. The crown is broad, domed, with ascending branches and often with low stems. The bark is brownish-black and shallowly cracked into small, square, thin plates⁵. The twigs and the buds are grey-tomentose¹. Very variable in the shape, the leaf is generally lanceolate to oval, 3-7cm long, thick but not rigid, **cuneate** or rounded at the base, with 1-2cm woolly **petioles**. The margins are waved or **sinuate**, but they can be **dentate** or in some case spinose on young trees or sprouts^{1,5}. They unfold in spring silvery-white then pale yellow, covered with dense hairs. Soon leaves become rough and shiny blackish-green on the upper side, grey and densely **pubescent** on the lower⁵. Leaf lifespan ranges from less than 1 year to 4 years, with turnover rates changing according to leaf position and environmental factors⁶. This species is **monoecious**, blossoming in May-June with new leaf growth⁶. After dry summers new leaves in autumn can appear². The male flowers are in dense pendulous catkins 4-7 cm long, pale green, then opening in a mass of yellow stamens very visible against the silvery-grey leaves. The female flowers are minute, 2-3 on short and erect peduncles at the axil on one leaf, green-grey and **pubescent**^{2,5}. The fruit is an acorn ripening in the first year, brown in colour, 1.5-2 cm long, one third to half enclosed in a light green cupule with appressed scales, and hanged on short peduncles^{2,5}. Mature acorns fall in November-January with high productions every 4-6 years⁶.

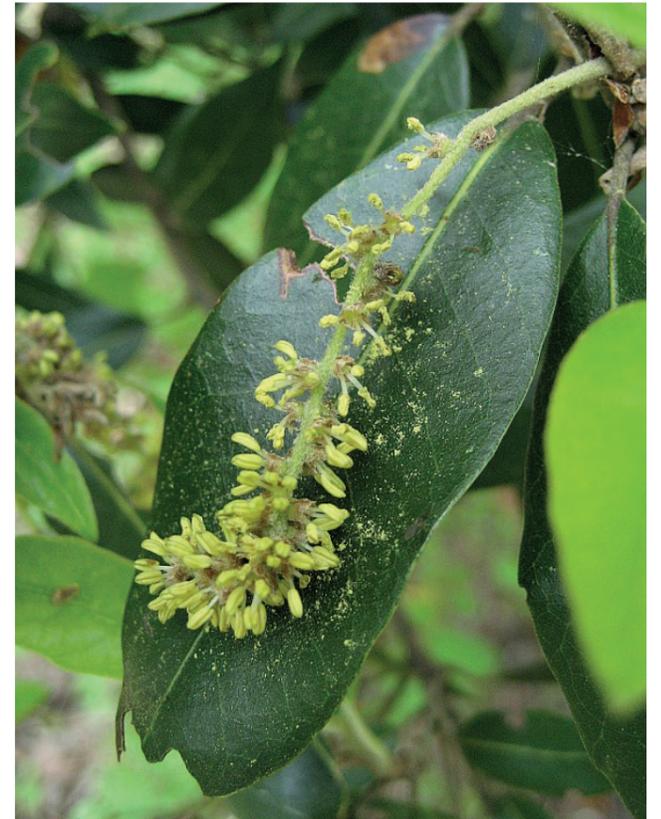


Map 1: Plot distribution and simplified chorology map for *Quercus ilex*. Frequency of *Quercus ilex* occurrences within the field observations as reported by the National Forest Inventories. The chorology of the native spatial range for *Q. ilex* is derived after Meusel and Jager⁷.

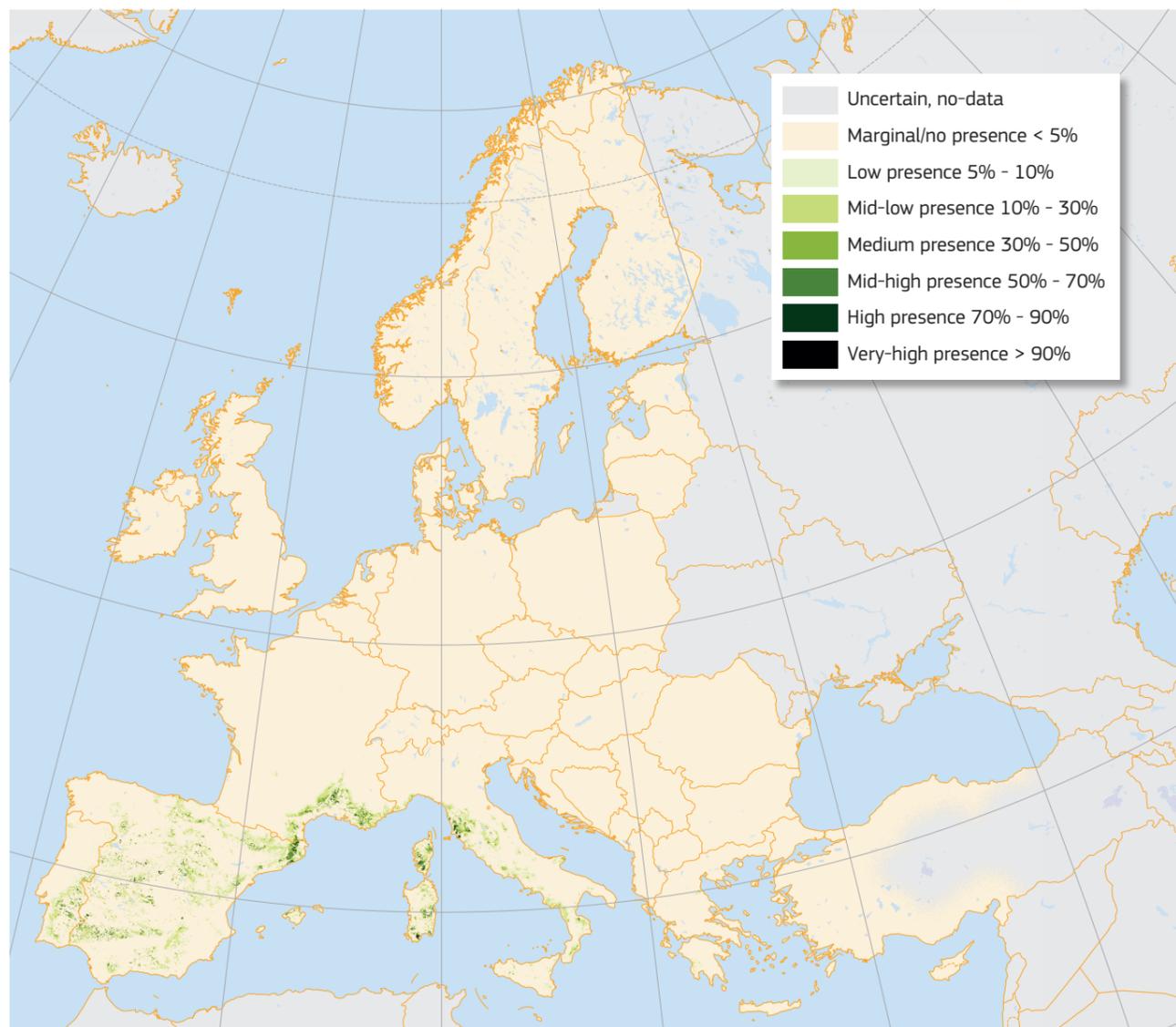
Distribution

The natural distribution of holm oak occurs principally in the central-western part of the Mediterranean basin, covering from Portugal and Morocco, to the Aegean Islands and western Turkey, expanding also northward up to northern Italy and France. It also occurs in a few localities in Anatolia on the coast of the Black

Sea^{7,8}. The altitudinal range is variable, growing from coastal zones up to 1800m in Southern Spain and 2900m in Morocco in the western part of the High Atlas^{7,8}. Along its range two subspecies are recognised principally by differences in leaf shape: *Quercus ilex* subsp. *rotundifolia* (sometimes referred as *Quercus ilex* subsp. *ballota* or as separate species *Quercus rotundifolia*) having more lanceolate leaves with 6-8 veins and occurring in Portugal, South and South-East Spain and Morocco; *Quercus ilex* subsp. *ilex* having more ovate leaves with 8-9 veins and occurring throughout the remaining areas^{1,2}. Under the same climate conditions on the eastern side of the Mediterranean basin, holm oak is substituted by the Palestine oak (*Quercus calliprinos*)⁹.



Male catkins with yellow stamens producing pollen. (Copyright Franco Giordana, www.actaplantarum.org, AP)



Map 2: High resolution distribution map estimating the relative probability of presence.

Habitat and Ecology

The holm oak is a tree able to grow well on a wide variety of soils under different Mediterranean climates, which range from semi-arid to very humid for precipitation and from warm to very cold at high altitudes (only if associated with low precipitations) for temperature⁸. Its leaves are small and **coriaceous** and the lower side is covered by white hairs. These characteristics are typical of **sclerophyllous** species, making it possible to reduce transpiration and to improve their resistance to drought. However, holm oak is less adapted to extreme drought in comparison with other evergreen Mediterranean tree species, carob (*Ceratonia siliqua*), wild olive (*Olea oleaster*) and cork oak (*Quercus suber*)⁶. This oak is also able to suspend the vegetative activities during drought periods and reactivate them when the water is again available¹⁰. On the other hand, unlike other **sclerophyllous**



Acorns half covered by the light green cupule. (Copyright Giancarlo Pasquali, www.actaplantarum.org, AP)



Flowering dehesas pasture in Spain with isolated holm oaks. (Copyright Alfonso San Miguel. CC-BY)

species, this oak resists quite low temperatures, surviving up to -24°C in winter for short periods¹¹. One of the primary limitations to its distribution is the intense competition of other broadleaved trees, principally due to water availability. In fact, in the Atlas Mountains in Morocco, where forests are simpler (counting fewer species), its ecological amplitude is more evident, forming thick forest from 900 to 2500m, while elsewhere from North Africa and the Iberian Peninsula this oak is able to develop only in more limited elevation ranges⁹. Holm oak is a slow-growing shade-tolerant tree and is able to dominate in late successional stages⁶. Its regeneration develops under the canopy, while in case of disturbances most of the regeneration comes vigorously from root re-sprouts^{6, 12}. It can form pure or mixed stands in less optimal sites, often concentrating in the more favourable areas. The vegetation communities where *Quercus ilex* is found are generally three. One is **matorral** vegetation, where holm oak develops in cold and semi-arid climates at high altitudes (North Africa, Spain) and is associated with Spanish juniper (*Juniperus thurifera*), belonging to the alliance *Junipero thuriferae-Quercion*. Another is **matorral** or arboreal pre-forest where holm oak is present and isolated or in clumps and it is often associated with conifers, typically Aleppo pine (*Pinus halepensis*), belonging to the alliance *Rhamno-Quercion cocciferae*. The first two vegetation communities are mostly transitional structures in a dynamic evolution towards more covered and structured formations. Finally, there are **sclerophyllous** woods and **maquis** vegetation where holm oak dominates, belonging to the order *Quercetalia ilicis*⁸. This community represents the most widespread evergreen woodland in the Mediterranean Region, even if few examples of fully developed forests remain, as most of them are managed as coppice often degraded by pasture activities or fires¹³. These forests occur in the thermo-Mediterranean bioclimate, typically found in the Iberian Peninsula, and are principally associated with olive (*Olea europea* ssp. *sylvestris*), carob (*Ceratonia siliqua*), cork oak (*Quercus suber*), and in the undergrowth with strawberry tree (*Arbutus unedo*), mock privet (*Phillyrea angustifolia*), Mediterranean buckthorn (*Rhamnus alaternus*) and terebinth (*Pistacia terebinthus*)^{8, 14, 15}. Holm oak forests are also common in the meso-Mediterranean bioclimates, growing in more humid

areas of the north Mediterranean region ranging from Spain to Greece. These forests are rich in species with a presence of other evergreen trees such as laurel (*Laurus nobilis*), Mediterranean buckthorn (*Rhamnus alaternus*), strawberry tree (*Arbutus unedo*), tree heath (*Erica arborea*) and privet (*Phillyrea* spp.)¹⁴⁻¹⁶. Finally holm oak can also be found on the supra-Mediterranean bioclimates (France, Corsica, Sardinia and South Italy) with the presence (and the competition) of deciduous trees, such as manna ash (*Fraxinus ornus*), hop hornbeam (*Ostrya carpinifolia*), Montpellier maple (*Acer monspessulanum*), bordering other deciduous broadleaved forests dominated by downy oak (*Quercus pubescens*), Turkey oak (*Quercus cerris*) and even beech (*Fagus sylvatica*)^{10, 15}.

Importance and Usage

The wood of holm oak is dense, very hard and difficult to dry and carve. It can be used for making only small tools which undergo heavy usage, for example carpentry tools, handles, gear teeth, etc. and in the past it has been used for the production of charcoal, railway sleepers and stakes, and the bark of young shoots for the extraction of tannins^{2, 6}. The capability of suspending vegetative activities during drought periods creates an irregular wood growth and more than one ring can be produced in a year¹⁷. Actually holm oak woods are managed as coppices principally for the production of firewood⁶, while the more structured high forests have more protective and recreational functions². In the Iberian Peninsula the holm oak woodlands are historically managed as savannah-like ecosystems, with large, isolated trees emerging from a grassland¹⁸. These formations, known as **dehesas** in Spain and **montados** in Portugal, provide trees for shading livestock, firewood from pruning and refuge and breeding sites for a large number of vertebrates, whereas the grassland is used by cows and sheep for milk and meat production, and acorns for feeding pigs. The sustainable and ecological ecosystems are managed by preventing woody plants from invading grasslands through grazing, **disking** and hand weeding, with a high labour effort. Its Mediterranean geographical distribution includes areas with worrying current and potential erosion. This is due to precipitation regimes characterised by intense rainstorm

events between droughts; and due to the vulnerability of typical Mediterranean soils, often very thin¹⁹⁻²². Silvoarable agroforestry with this species²³ may be exploited in Mediterranean areas with high potential soil erosion, also considering the effectiveness of its cover-management on erosion rates^{20, 24}. In the past the sweet acorns were used also for human use, so holm oak in dehesas can be considered as a semi-domesticated fruit tree⁶. Holm oak is also used as an ornamental tree in gardens and parks, where it can reach large sizes².

Threats and Diseases

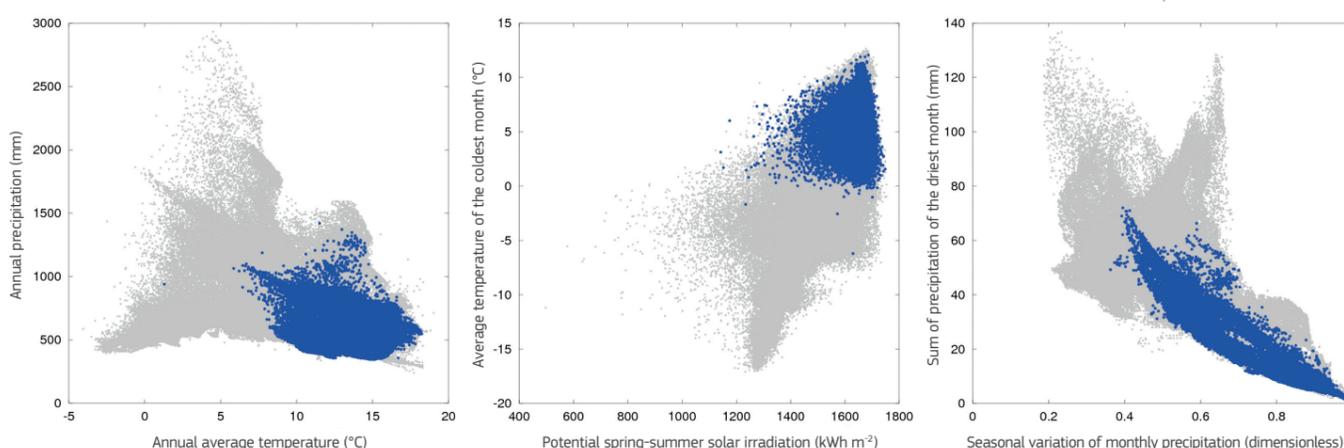
The holm oak under water stress conditions is highly vulnerable to the fungal pathogens *Phytophthora quercina* and other *Phytophthora* species, such as *Phytophthora cinnamomi*, *Phytophthora ramorum*, and cankers caused by *Cryphonectria parasitica*^{2, 25}. *Phytophthora cinnamomi* is a biotic factor associated with holm oak decline²⁶, which may affect holm oak as a synergistic negative combination with abiotic factors²⁷. In particular, severe periods of drought with increasing occurrence of dry years and the co-occurrence of pathogens (either fungi or insects) may induce the decline²⁷. Air pollution and soil contamination²⁷, in particular nitrogen excess²⁶, have been reported as possible negative co-factors in combination with drought stress. Therefore, in drier conditions predicted in the Mediterranean area in the frame of climate change, a reduction of more **mesic** holm oak substituted by more drought-tolerant species is expected^{28, 29}. Among defoliating pests, damage has been reported caused by **polyphagous** lepidopterans such as the nun moth *Lymantria monacha*, gypsy moth *Lymantria dispar*, green oak moth *Tortrix viridana* and lackey moth *Malacosoma neustria*^{2, 25}. Mediterranean forests dominated by the holm oak have been strongly influenced by human activities during the last millennia by means of wood exploitation, species mixture modifications or substitution (e.g. Aleppo pine), livestock grazing and fires. All these disturbances have led to a degradation, and in many cases holm oak forests have been completely replaced by agriculture and urban settlements^{6, 30}.

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Field data in Europe (including absences) ● Observed presences in Europe ●

Autoecology diagrams based on harmonised field observations from forest plots.



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