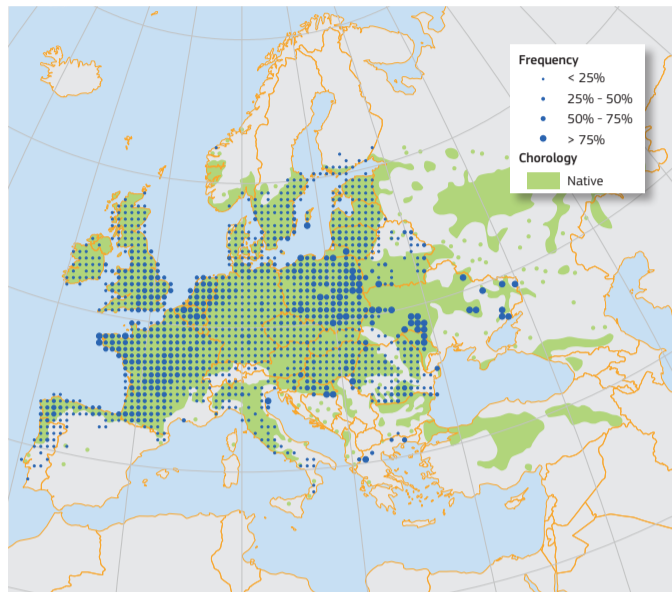


Quercus robur and Quercus petraea in Europe: distribution, habitat, usage and threats

E. Eaton, G. Caudullo, S. Oliveira, D. de Rigo

Quercus robur L., (pedunculate oak) and *Quercus petraea* (Matt.) Liebl., (sessile oak) are common broadleaved tree species in Europe, found from Scandinavia to the Iberian Peninsula. The two species are quite similar in appearance and have a broadly overlapping range. Oak trees have cultural significance for people throughout Europe and the trees or leaves are frequently used in national or regional symbols. Oak trees can live for more than 1000 years and grow to be 30 to 40m in height. The wood from oaks is hard and durable and has been valued for centuries. It is favoured for construction and for wine and spirit barrels; historically it was a major source of ship timbers. Recently, concerns have arisen about the fate of oaks in the face of Acute Oak Decline, a little understood syndrome.

Quercus robur L., known as pedunculate or English oak, and *Quercus petraea* (Matt.) Liebl., known as sessile oak, are large, rugged, deciduous broadleaved trees, native to most of Europe. Individuals can be very long-lived (over 1000 years in some cases) and become large (over 40m tall), attaining diameters of three to four metres¹⁻³. More usually, these oaks achieve a height of 30m and diameters of up to 1m⁴. These two tree species, as well as other oaks, are very variable morphologically, and can naturally hybridise, generating individuals showing intermediate traits or the prevalence of one, so that it can be difficult to characterise them unequivocally by observations alone^{5, 6}. The main trunk of *Q. robur* tends to disappear in the crown, developing irregular boughs with twisting branches, while *Q. petraea* usually develops a main stem with boughs gradually decreasing in size⁷. The barks are grey, fissured, forming rectangular elongate blocks, which are thicker in *Q. robur*, while those of *Q. petraea* often tend to exfoliate⁷. The leaves are simple, obovate-oblong and deeply and irregularly lobed, with a short stalk (2-7 mm) in *Q. robur* and a long stalk (13-25 mm) in *Q. petraea*. These oaks are **monoecious** and wind-pollinated, with drooping male flowers in yellow catkins about 5 cm long and inconspicuous globular female flowers of 1 mm at terminal shots, which appear just after the first leaves have flushed⁸. The fruits are the acorns, which are often in pairs and sit in scaly cups on the ends of long stalks in *Q. robur* and on short or absent stalks in *Q. petraea*, giving rise to its common name “**sessile**”, meaning “stalkless”. The acorns are very variable in size and shape, but those of *Q. robur* are usually smaller and rounded with olive-green longitudinal stripes visible when fresh⁷. Mammals and birds are important for the seed dispersal, especially the Eurasian jay (*Garrulus glandarius*) which can be considered the primary propagator^{9, 10}.



Map 1-A: Plot distribution map (*Q. robur*). Frequency of *Quercus robur* occurrences within the field observations as reported by the National Forest Inventories. The chorology of the native spatial range for *Q. robur* is derived after EUFORGEN⁴⁹.

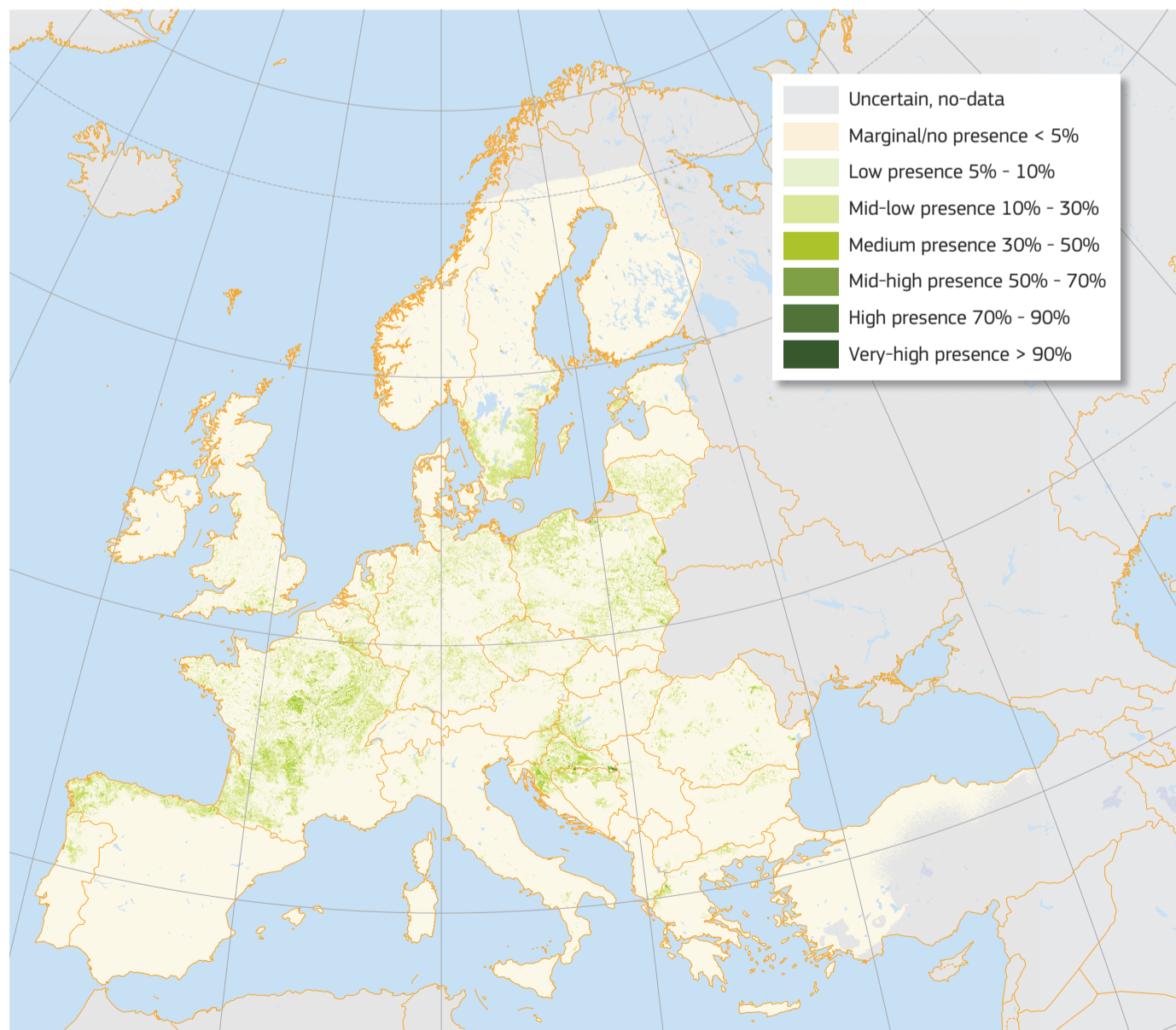
Distribution

Both oaks occur widely across most of Europe, reaching northwards to southern Norway and Sweden, and southwards to the northern part of the Iberian Peninsula, South Italy, the Balkan Peninsula and Turkey. They are **sympatric** in many parts of their range. *Q. robur* has a more extended distribution, reaching more northerly ranges on the Norwegian coast and in northern Scotland; in Mediterranean areas it is also present in Portugal, Greece and South Turkey, and eastwards into continental central Russia, up to the Urals^{7, 11}. The southerly range limits are difficult to define, as

these oaks can mix, compete and naturally hybridise with other Mediterranean oaks, such as *Quercus pubescens* and *Quercus frainetto*, even if at relatively low rates¹². Both oaks occur at higher elevations in southern regions: *Q. robur* is recorded to grow up to 1300m in the Alps¹³, while *Q. petraea* is more montane and in southern Turkey can reach over 2000m^{4, 14, 15}. Due to the substantial human interest and usage of the species over many centuries, there is widespread disturbance in their distribution, and the structure of their original forests is highly uncertain¹⁶. *Q. robur* has been introduced into the United States for timber production and in some areas it has naturalised; more recently they have been exported into other continents as ornamental trees^{17, 18}.

Habitat and Ecology

Q. robur and *Q. petraea* co-occur at many sites as a main component of temperate deciduous mixed forests, and they share several common characteristics. These oaks are vigorous trees with a large ecological amplitude, although they prefer fertile and moist soils, and are able to dominate forests in number and size at low-mid elevations¹⁹. Both are able to behave as pioneer trees, the acorns possessing large reserves and able to survive amongst grasses whilst developing sufficiently deep roots to allow rapid shoot growth^{2, 10}. As these trees do not come into leaf until relatively late in the year (late April to early May), late frost damage is rarely a problem, unless the temperatures reach -3°C killing new foliage^{2, 10}. Sustained temperatures below -6°C in winter can kill acorns, despite the epicotyl requiring some chilling to break its dormancy¹⁰. Both oaks have a good re-sprouting aptitude, so they coppice and pollard easily^{2, 7}. Their deep and penetrating taproots (more developed in *Q. petraea*) give them structural stability against windthrow and allow them to withstand moderate droughts by accessing deeper water^{2, 10}. However, in conditions far from their optimum, they show ecological differences. The tendency is for *Q. robur* to grow on heavier soils in more continental climates, in wet lowlands and damp areas by streams and rivers, tolerating periodic flooding. The more drought tolerant *Q. petraea* prefers to grow in more Atlantic climates on light and well-drained, often rocky, soils (hence the specific Latin name *petraea* = of rocky places), generally occurring on slopes and hill tops, and preferring a more acid soil pH^{2, 7, 10, 15, 20}. They are both light-demanding trees (*Q. robur* more so than *Q. petraea*)^{2, 10}, and their canopies permit a good deal of light to pass through to the undergrowth, promoting the regeneration of many tree species and enriching



Map 2-A: High resolution distribution map estimating the relative probability of presence for *Quercus robur*.



Stalkless acorns of sessile oak (*Quercus petraea*). (Copyright AnRo002, commons.wikimedia.org: CCO)



Acorn of pedunculate oak (*Quercus robur*) with long stalk. (Copyright Graham Calow, www.naturespot.ork.uk: AP)

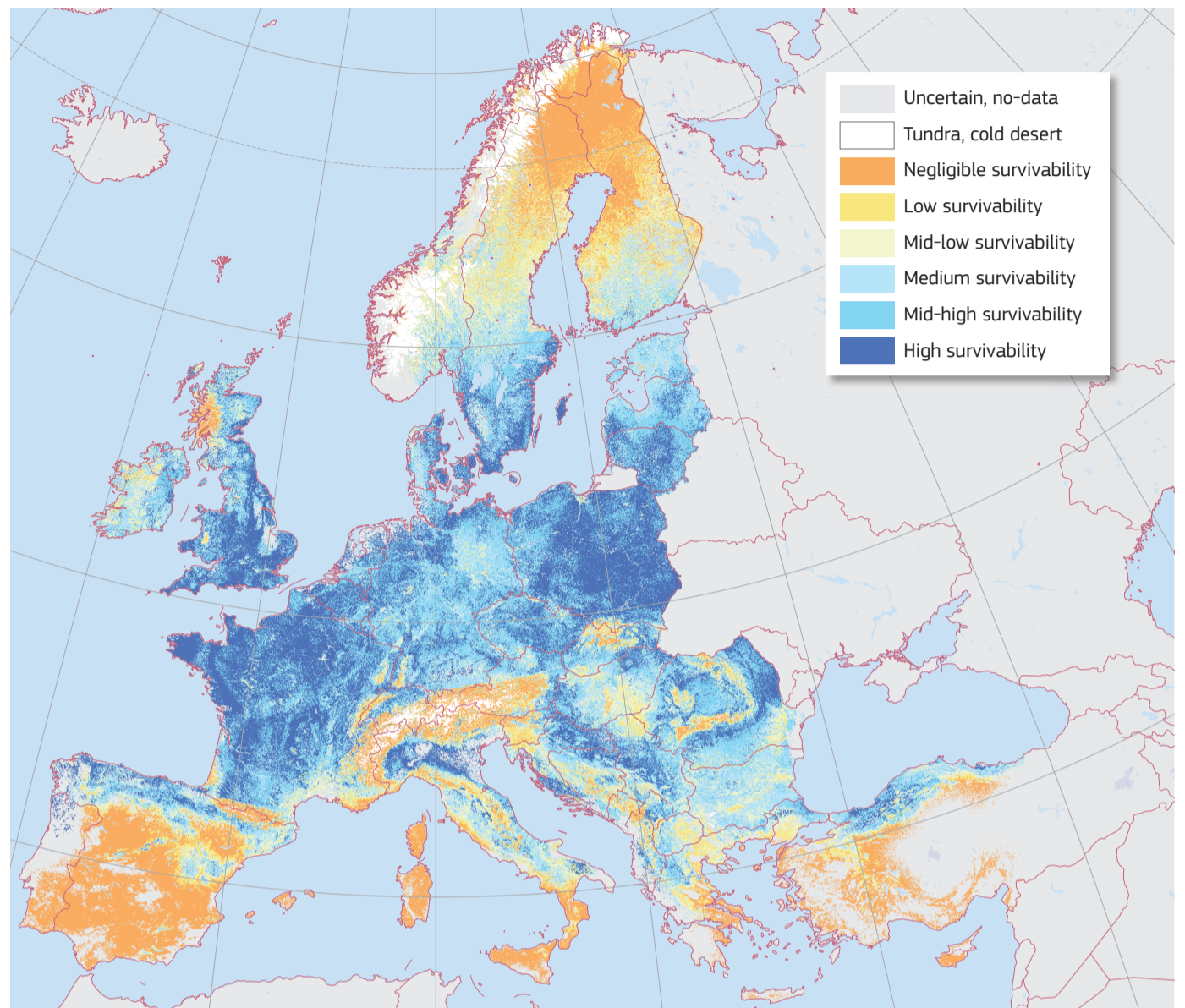
forest diversity¹⁹. These oaks rarely form pure forests under natural conditions. Their substantial competitor is represented by beech (*Fagus sylvatica*) and in a minor way other shade or half-shade trees, in the presence of which the oaks are unable to predominate as they are at a disadvantage. Typically, oaks dominate in damp to wet and nutrient-rich soils, where they occur principally with hornbeam (*Carpinus betulus*) and other deciduous tree species such as ash (*Fraxinus excelsior*, *Fraxinus angustifolia*), maple (*Acer campestre*, *Acer platanoides*) and small-leaved lime (*Tilia cordata*). In these oak-hornbeam forest communities, assigned to the *Carpinion betuli* alliance, beech is out of its range, or replaced as the soils are relatively dry and warm or too wet. On warmer dry sites in sub-Mediterranean regions, *Q. petraea* tends to mix with *Q. pubescens* and with other drought-tolerant tree species, forming communities belonging to the order of *Quercetalia pubescenti-petraeae*. In poor and acid soils, where beech is unable to regenerate, oaks form mixed forests belonging to *Quercetalia robori-petraeae* communities, which are relatively small and scattered inside the beech range. Oaks are also present in many other forest types as secondary species, principally in beech forests at low elevations, where soils and climate conditions are still favourable to oaks^{19, 21, 22}.

Importance and Usage

Since the earliest times, these oaks have held an important role in human culture in Europe, providing wood for fuel, acorns for livestock, bark for tanning, and timber for construction. From the Greeks to the Germans, Slavs and Celts, the oak was a sacred tree¹⁵ and this is why oak is frequently a national or regional symbol, e.g. it has appeared on German, Croatian and British coins, and in the coat of arms of Bulgaria. The increasing demand for oak wood products and the reduction of natural forests have influenced the development of modern silviculture²³. Due to their capacity to produce large volumes of valuable timber, oak stands



Large pedunculate oak (*Quercus robur*) in Dunkeld Hilton park (Scotland). (Forestry Commission, www.forestry.gov.uk; © Crown Copyright)



Map 3: High resolution map estimating the maximum habitat suitability for *Quercus robur*.

are frequently managed either as high forest or as coppice with standards²³⁻²⁷. Pedunculate and sessile oaks are amongst the most economically important deciduous forest trees in Europe, providing high quality hardwood for construction and furniture manufacture². *Q. petraea* wood is largely indistinguishable from that of *Q. robur* and is particularly appreciated for its straight grain, its durability thanks to its hardness, and its high tannin content, which makes it resistant to insect and fungal attacks^{28, 29}. Oaks have traditionally been used in timber-framed buildings, as well as for fencing, gates and mining timber, and in the past it was the most important wood used in the manufacture of wooden sailing vessels⁷. Furniture, floor-boards, panelling, joinery and veneer are also important uses of the wood¹⁰. As the wood is resistant to liquids, it has been used for barrels for wines and spirits, where the flavour imparted by the wood is often much desired^{13, 30}. The most valuable oak wood has narrow rings and is produced in high mixed forests on fertile sites with long economic rotations (about 160 years of age for *Q. petraea*, about 130 years for *Q. robur*)². Successful oak silviculture requires particular attention, selecting the proper deciduous tree species mixture, proportion and density, which strongly influence the wood quality with regard to tree diameters, ring widths and the presence of wood knots formed by lateral epicormic shoots. Choice of site and management is also important to minimise the number of trees with 'shake' (the development of circular or radial cracks through the timber, which substantially reduces its value and which is influenced by a number of factors including soil type and

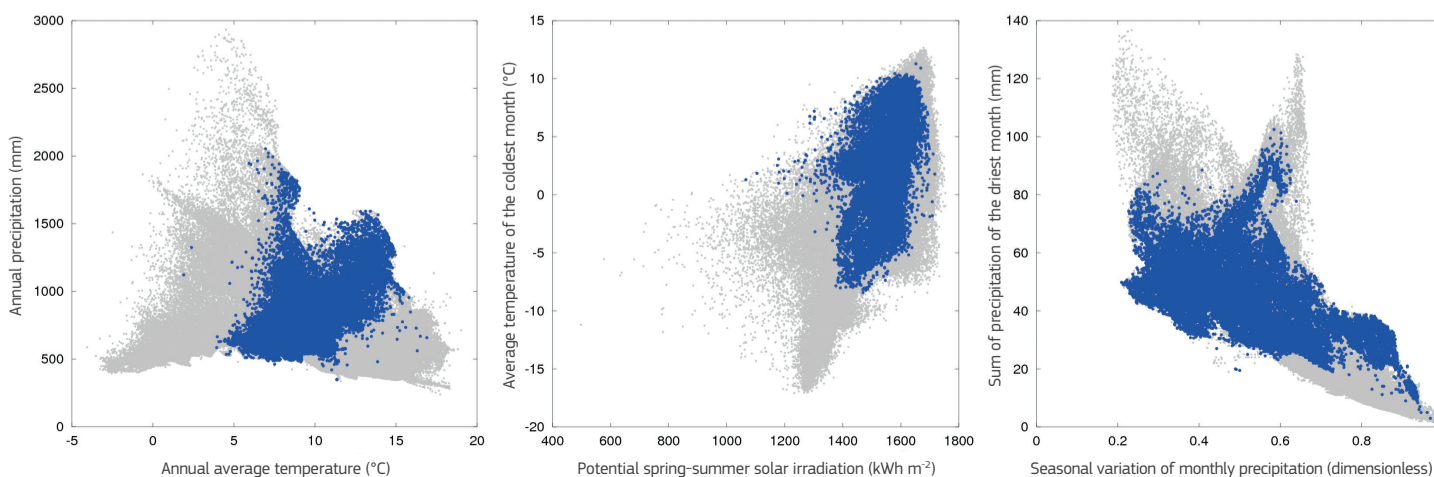
mechanical stresses)^{10, 31, 32}. Furthermore promoting an abundant and uniform natural regeneration is also crucial^{10, 15, 20, 33, 34}. In coppices, oaks provide a valuable source of firewood and charcoal, and in the past the bark has been much used in the tanning of leather¹⁰. Several cultivars have been selected for ornamental purposes, especially from *Q. robur*, and exported all over the world. Oaks are particularly appreciated as park or roadside trees for their size and shade. *Quercus robur* 'Fastigiata' is one of the most common cultivars, large in size and with a columnar cypress-like habit; *Quercus petraea* 'Laciniata' has long narrow and deeply incised leaves⁴. These tree species also have an important ecological role, as they support many species of insects such as moths, wood-boring beetles and gall-forming hymenoptera, and the acorns provide a valuable food source for many birds and mammals, such as jays, mice, squirrels and pigs¹⁰.



Bud of sessile oak (*Quercus petraea*) in late winter. (Copyright Sten Poise, commons.wikimedia.org; CC-BY)

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

Autoecology diagrams based on harmonised field observations from forest plots for *Quercus robur*.



Threats and Diseases

Defoliation of the first flush of leaves is common by several caterpillars, e.g. *Tortrix viridana*, *Lymantria dispar*, *Operophtera brumata*². A second leaf crop (known as 'St John's' or 'Lammas' growth, depending on its timing) is usual. As a result of particularly heavy infestations, especially when combined with oak mildew (*Erysiphe alphitoides* syn. *Microsphaera alphitoides*), an oak's productivity can be seriously limited, as the mildew covers the remaining leaf surfaces, preventing light

Quercus robur and Quercus petraea



300 year old sessile oak (*Quercus petraea*) in Rigney (eastern France).
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oaks, and this has become a more widely recognised problem in recent years. It is characterised by a decrease in the density of the crown, the appearance of dark oozing wounds ('bleeds') on the trunk, and in most cases the presence of the jewel beetle *Agrilus biguttatus*. This syndrome can kill trees over the course of a number of years³⁹. Whilst not yet fully understood, it may be the consequence of an assemblage of contributing human, environmental and biotic factors, such as lowering ground water table or absence of flooding, air and water pollution, non-adapted silvicultural practices, and climate change (e.g. ⁴⁰⁻⁴⁴).



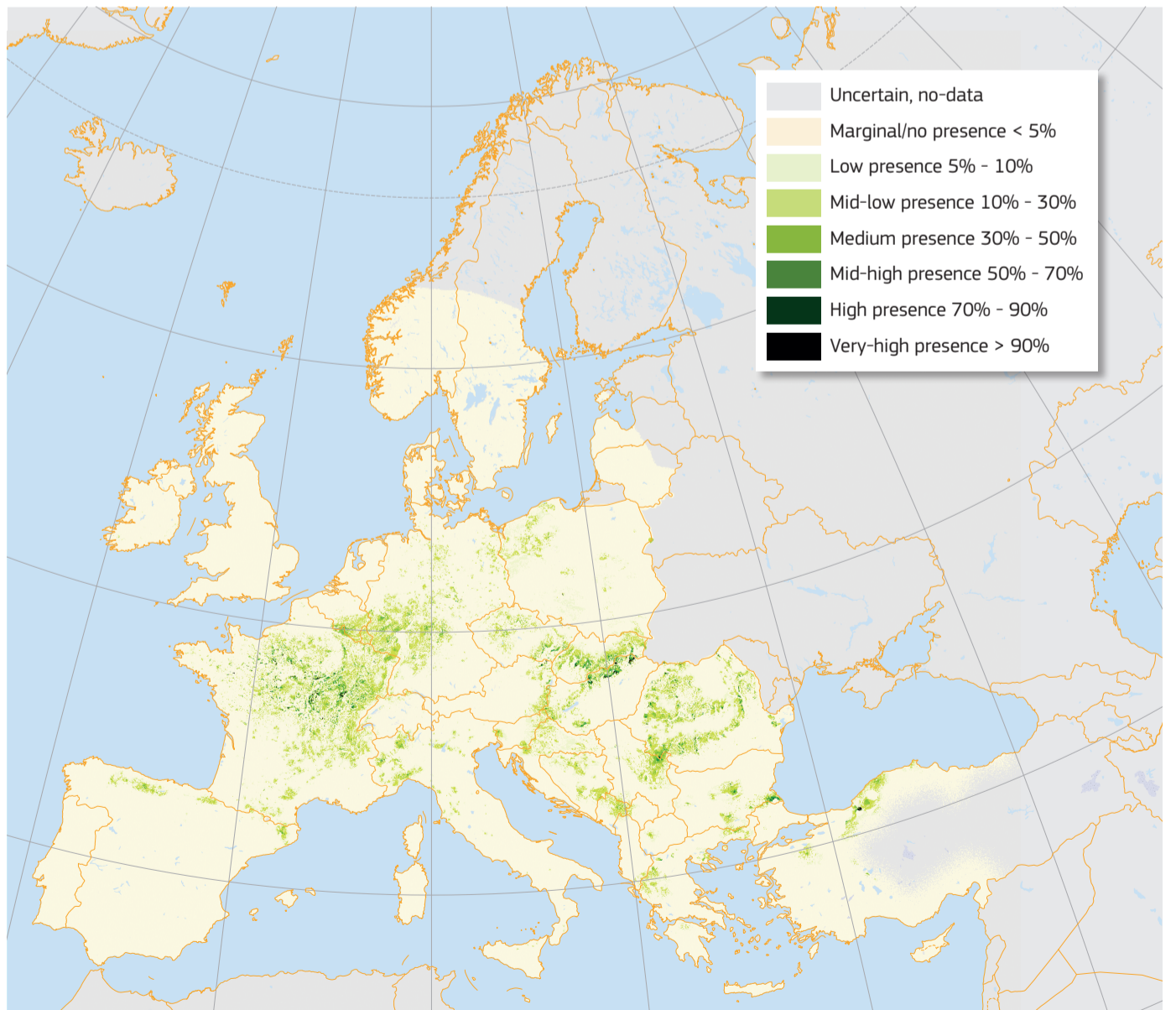
Bark of a sessile oak (*Quercus petraea*).
(Copyright Stefano Zerauscek, www.flickr.com: AP)

reaching them^{7, 10}. In recent years, oak processionary moth (*Thaumetopoea processionea*) has spread from its native habitat in southern Europe further north³⁵. This caterpillar defoliates oaks and sheds micro hairs that are a serious irritant to the human respiratory system, eyes and skin. Knopper gall wasps (*Andricus quercuscalicis*) cause some damage to acorn crops³⁶. Young oak trees often have their bark stripped by grey

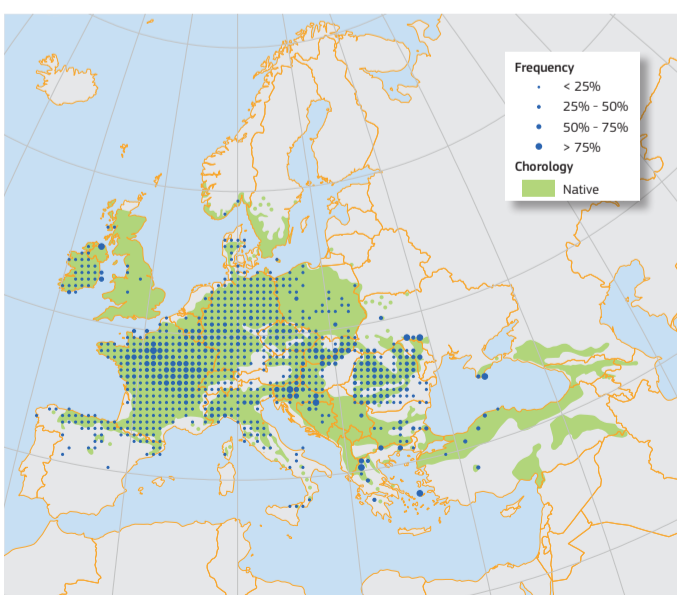
squirrels¹⁰. Pedunculate and sessile oaks are vulnerable to *Lymantria dispar* and moderately susceptible to *Cryphonectria parasitica*³⁷. They both suffer because of root pathogens of the oomycete genus *Phytophthora* (*P. cinnamomi*, *P. ramorum*, *P. quercina*)³⁷. *Phytophthora ramorum* has been known to cause extensive damage and mortality in North America, known as Sudden Oak Death. Although this pathogen has been detected in Europe, it has not yet had a substantial effect on native European oaks and it is under observation³⁸. Acute Oak Decline is a new syndrome affecting principally pedunculate and sessile



Maturing catkins of pedunculate oak (*Quercus robur*) in spring.
(Copyright AnRo0002, commons.wikimedia.org: CCO)



Map 2-B: High resolution distribution map estimating the relative probability of presence for *Quercus petraea*.



Map 1-B: Plot distribution map (*Quercus petraea*).
Frequency of *Quercus petraea* occurrences within the field observations as reported by the National Forest Inventories. The chorology of the native spatial range for *Q. petraea* is derived after EUFORGEN⁴⁶.



••• Pedunculate oak (*Quercus robur*) in winter near Havré village (Mons, Belgium).
(Copyright Jean-Pol Grandmont, commons.wikimedia.org: CC-BY)



••• Forest dominated by sessile oak (*Quercus petraea*) in Sierra Ancares (North Western Spain).
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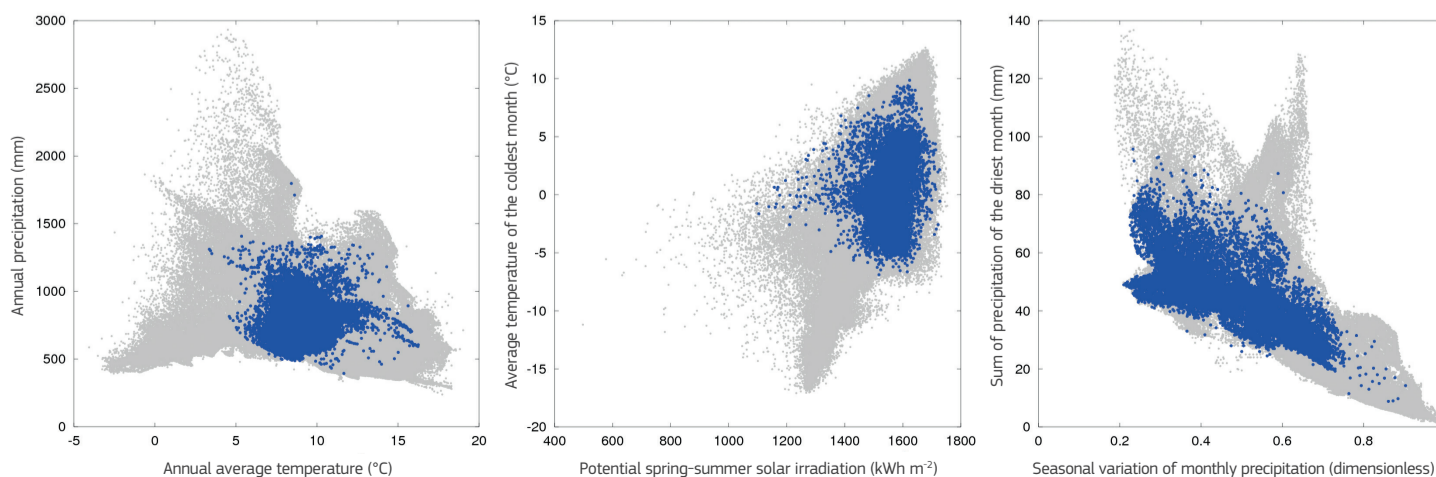
••• Leaves of pedunculate oak (*Quercus robur*) in autumn.
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Field data in Europe (including absences) ● Observed presences in Europe ●

••• Autoecology diagrams based on harmonised field observations from forest plots for *Quercus petraea*.



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/e01c6df>. The purpose of this summary is to provide an accessible dissemination of the related main topics.

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