Tree lungwort

Tree Lungwort *Lobaria pulmonaria* (L.) Hoffm.

Climate Change Sensitivity:	HIGH	Ability to Manage:	MEDIUM
Non climatic threats:	HIGH	Vulnerability:	HIGH

Summary

This charismatic, leafy lichen is special to Britain in that much of its European population occurs here. In England, tree lungwort is closely associated with parklands and ancient wood pasture, including 'temperate rainforest' to the north and west along the Atlantic seaboard. As an epiphyte, it grows on a wide range of broadleaf trees, but in England chiefly occurs on oak and ash. Historically, it has suffered marked declines due to sulphur dioxide pollution and 'acid rain', loss of ancient/veteran trees, and changes in woodland management. Today, it is an uncommon species in England and shows little sign of re-colonising areas from which it was lost. Tree Lungwort is possibly the most researched lichen species globally, and there is strong evidence of its high sensitivity to air quality and climate. Many colonies in England are small, isolated from one another, and, those in less oceanic areas, are already in climatically sub-optimal conditions. Together these factors increase the risk of local extinction and range contraction, especially under a changing climate.

Description

Tree lungwort is a large foliose (leafy) lichen that can form spectacular cascades down tree trunks and along branches. Its appearance changes depending on whether it is wet or dry, being khaki to green-grey when dry and bright green when wet (Dobson 2011). Individuals can exceed 30cm in width, and when fertile its spore-producing fruitbodies are easily visible as orange to red-brown discs up to 4mm diameter (Smith *et al* 2009). The upper surface of the lichen has a distinctive network of ridges and depressions that are lung-like in appearance. The ridges and lobe margins are often lined with minute vegetative propagules. In contrast, the lower surface is finely tomentose, brown, and covered in pale blister-like swellings. The morphology is variable, according to substrate and climatic conditions as well as to size and age of the thallus (Wolseley & James 2000).

As a symbiotic organism, this lichen is chiefly composed of a fungus with a thin layer of photosynthetic green algae (*Dictyochloropsis reticulata* in this case) beneath its surface, but it can also develop tiny wart-like structures containing cyanobacteria (*Nostoc*) that are not only photosynthetic but can fix nitrogen from the air. Tree lungwort individuals (ramets) grow seasonally during the wetter months (Muir *et al* 1997) and have an expected lifespan of about 40 years, although tree colonies can persist until the tree dies (Scheidegger, Frey & Walser 1998; Öckinger & Nilsson 2010). Under optimal conditions, for example in the highly oceanic climate of west Scotland, the species is capable of comparatively rapid growth and colonisation (Eaton & Ellis 2014).

Tree lungwort is host to many lichenicolous fungi (fungi that grow on lichens). Of these, some appear to be specific to L. *pulmonaria* (Etayo & Diederich 1996; Coppins & Coppins 2005).

Ecology and distribution

This species is scarce and has declined in England. It was once reported from all English counties except Huntingdonshire, Middlesex, Norfolk and Northamptonshire (Hawksworth, Rose & Coppins 1973), but today is present in less than 30% of English counties (including the above) (Greenaway & Wolseley, in press).

Although its current GB threat status is Least Concern (Woods & Coppins 2012), this is due to large healthy populations in the west of Scotland. In Wales, the species is red-listed as Vulnerable (Woods 2010). In central and northern Europe there have been substantial declines during the twentieth century and this species is considered threatened in many European lowland countries (Rose 1988). Consequently, in Britain it is listed as an International Responsibility species (Woods & Coppins 2012) despite the species being quite widespread globally (Widmer *et al* 2012). This species is also prohibited from sale under Schedule 8 of the Wildlife & Countryside Act (1981, as amended).

Tree lungwort prefers cool, wet climates and is considered a strong climate indicator (Will-Wolf *et al* 2015). In sub-oceanic areas of Central Europe it typically occupies the montane zone but is otherwise limited to more oceanic areas with high rainfall (Rose 1988; Wirth 2010). A fundamental requirement for this species is clean air. It is highly sensitive to air pollution, both acidic (i.e. sulphur dioxide), and fertilising (i.e. nitrogenous) compounds (e.g. Will-Wolf *et al* 2015).

In England, its primary habitats are ancient pasture woodlands and old parkland, including, under a much more oceanic climate, grazed upland oakwoods in Cumbria. Because of the strong association with old-growth woodland, tree lungwort is considered as an 'old forest indicator' species in Britain, Europe and Canada (Rose 1976; Andersson & Appelqvist 1987; Coppins & Coppins 2002; Campbell & Fredeen 2004).

In common with other lichens, this species will only grow on particular substrates, showing a preference for slightly acidic bark (Looney & James 1990; Wirth 2010). In England, its most common hosts in decreasing order of frequency are: oak, ash, sycamore, beech and willow (Greenaway & Wolseley, in press). Less frequently, it grows on other trees and shrubs, heather and even mossy rocks. Trees with a naturally high bark pH have a buffering effect to acidifying pollution, providing refugia for *Lobaria* species (Wolseley & James 2000). Favoured substrates include moss mats on lower trunks or directly on the bark in more exposed parts of the tree. The presence of bryophytes (at low to intermediate cover values) may facilitate tree lungwort colonisation (Jüriado, Leelia & Liira 2012; Eaton & Ellis 2014). Tree girth is also an important factor in less oceanic areas, with tree lungwort showing a preference for large diameter trunks, and restricted to trees over 100 years of age (Gauslaa 1985; Öckinger, Niklasson & Nilsson 2005; Edman, Eriksson & Villard 2008).

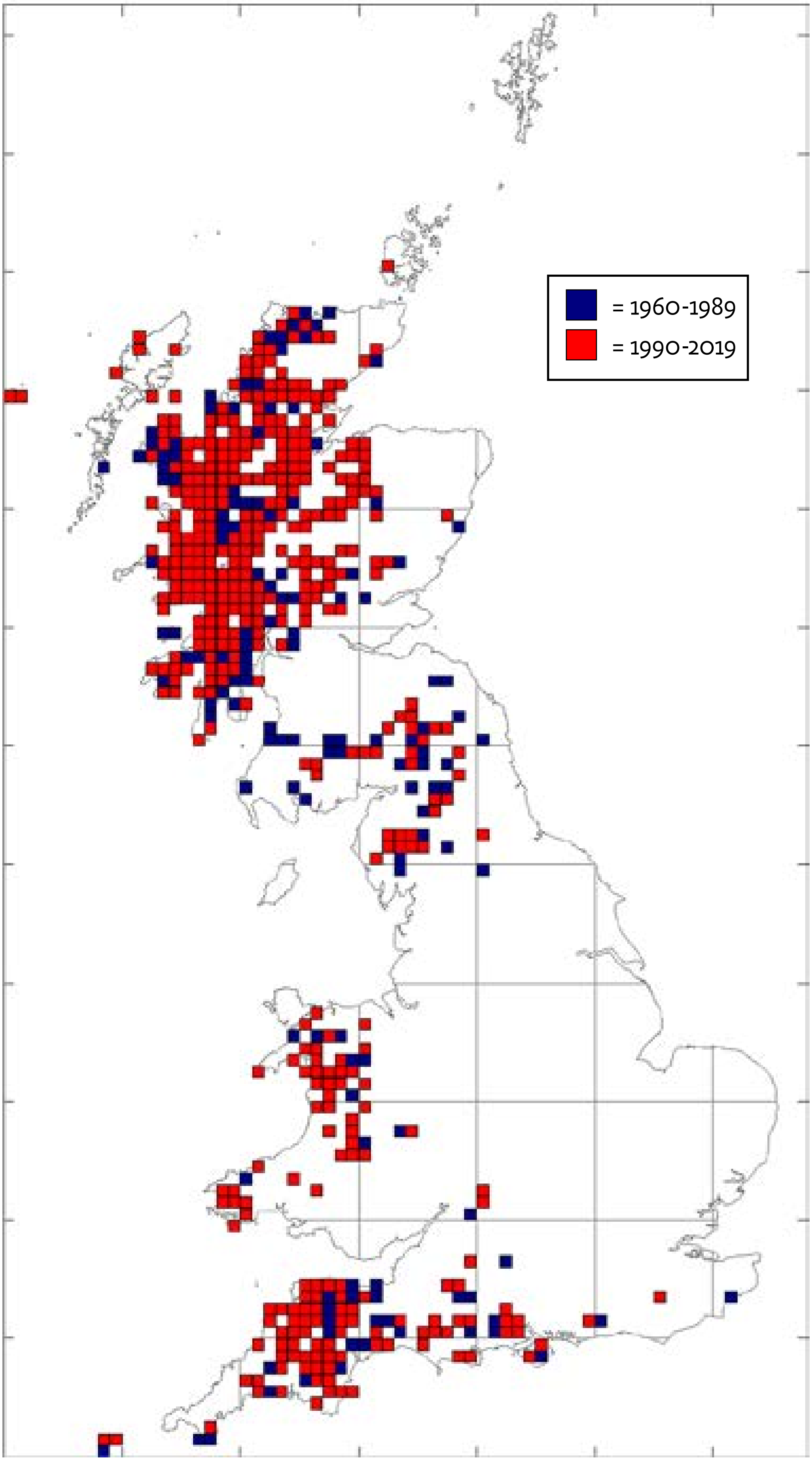
Tree lungwort needs moderate-high light levels to thrive but can be killed by exposure to direct sunlight (Gauslaa & Solhaug 1999, 2000). In semi-natural woodland these conditions are typically achieved through the collapse of post-mature trees and/or woodland grazing which suppresses tree regeneration and understorey vegetation. In managed woodland, glades and rides provide similar conditions and are good alternatives where they can be maintained (Sanderson 2012; Lamacraft *et al* 2016).

Aside from habitat loss and agricultural intensification (slurry and inorganic fertilisers), which are still relevant today, the main causes of past decline have been sulphur dioxide pollution (near population centres) and, more generally, 'acid rain' and Dutch Elm Disease (Hawksworth, Rose & Coppins 1973; Watson, Hawksworth & Rose 1988; Looney & James 1990). Historically, the species was collected from the wild for medicinal applications (Crawford 2015).

Today, the key non-climatic pressures are woodland neglect (understorey development and invasive non-native shrubs), habitat discontinuity (cohort gaps in tree populations), and air pollution caused by an increase in nitrogenous compounds from both agricultural sources and vehicle emissions (Wolseley & Lambley 2004; Mitchell *et al* 2005; Yemets, Solhaug & Gauslaa 2014; Greenaway & Wolseley, in press).

The British Lichen Society occurrence records for tree lungwort are shown on the map below (10km grid scale).

Known occurrence of tree lungwort, 10km². Map kindly supplied by the British Lichen Society.



Confidence in climate change impacts[38]

Distribution change: **HIGH CONFIDENCE** Mechanism: **MEDIUM CONFIDENCE**

Epiphytic lichen distributions are strongly influenced by macroclimate (van Herk, Aptroot & van Dobben 2002; Werth,Tømmervik & Elvebakk 2005; Aptroot & van Herk 2007). Lichens have no means of regulating their water content, which naturally finds equilibrium with the environment (Honegger 1998). As a result, they are rapidly affected by changes in humidity and rainfall, and more susceptible to desiccation than many other organisms, although they have complex adaptations to cope with this (Schofield *et al* 2003; Gauslaa *et al* 2006; Kranner *et al* 2008).

Tree lungwort is most at home in the wettest parts of Britain, the Atlantic woodland of the west coast. Any sustained changes to the precipitation patterns here would very likely impact on the range and abundance of the species. Oceanic species tend to have higher niche specificity in a drier climate (Werth, Tømmervik & Elvebakk 2005; Scheidegger & Werth 2009), hence populations to the east and south in Britain may already be drought stressed and less tolerant to rising temperatures. The 1989 drought has been attributed as one of the causal factors of *Lobaria* decline in SW England (Wolseley & James 2000). Higher temperatures, in combination with increased risk of sun-scorch, have been shown to be detrimental to tree lungwort (Gauslaa & Solhaug 2000, 2001). Nevertheless, the species may fare better than other *Lobaria* species in future, although current bioclimatic models appear insufficiently nuanced to make accurate predications (Nascimbene *et al* 2016; Ellis *et al* 2017; Eaton *et al* 2018).

In England, tree lungwort faces a number of constraints that could reduce its adaptive potential to climate change. For example, individuals are seldom fertile (lacking sexual spore-producing structures) and colonisation of new sites appears exceedingly slow (Rose 1993; Wolseley & James 2000; Greenaway & Wolseley, in press). In addition, this species has two self-incompatible mating types, reducing the chances of sex in fragmented populations (Singh *et al* 2012, 2015). Clonal reproduction is thus relatively more important, although it is estimated to take 35 years growth before thalli produce vegetative propagules (diaspores) (Scheidegger & Goward 2002). Moreover diaspore dispersal is short range, possibly limited to 15-30m from the parent (Walser 2004; Jüriado *et al* 2011). At a landscape scale, genetic analyses have shown that tree lungwort is (or was) capable of wider dispersal (Werth *et al* 2006, 2007; Otálora *et al* 2015). Nevertheless, small populations may be unsustainable, representing an extinction debt (Scheidegger, Frey & Walser 1998; Öckinger & Nilsson 2010).

Indirect impacts include threats to substrate trees. Increasing storminess, more frequent/severe droughts and flooding are likely to cause a rise in windthrow and canopy damage (Broadmeadow 2002). New and emerging tree pests and diseases are also likely to diminish native tree populations, e.g. ash dieback is expected to impact on tree lungwort (Edwards 2012).

Fertilisation from rising CO_2 levels is expected to have varying effects on vegetation but may increase canopy shading (a denser canopy and more prolonged due to earlier bud-break) in upland oak woods, which could threaten this species (Broadmeadow 2002; Körner 2003; Masters *et al* 2005). Similarly, the enhanced growth of understory vegetation, e.g. saplings, may further reduce light levels. Climbing plants such as ivy, which tend to shade out epiphytic lichens, are increasing, showing a competitive advantage from rising CO_2 levels (Zotz, Cueni & Körner 2006).

Please read this case study alongside the relevant habitat sheets.

38 An assessment of the strength of evidence that distributions are changing and the mechanisms causing change are understood. Refer to Part B, section 5 of the species section introduction for more information.

Adaptation options

The narrow ecological niche of this species in England, combined with its small, fragmented, infertile populations, makes this species especially vulnerable to environmental change. While uncertainties exist over how this lichen will respond to further climate change, a range of no/low regret measures can make populations more resilient. Adaptation at existing sites should focus on reducing known pressures and optimising habitat condition, but further measures are advisable to build populations to sustainable levels and help to regain its former range.

Further studies are needed to determine the likely impacts of climate change on this species and the *Lobarion* community in general, especially to trial and monitor adaptation techniques. Since this species can be slow to respond to more favourable conditions, a long view of habitat provision and management is needed, and population monitoring will be key to adapting management regimes.

Actions to promote resilience include:

- Optimise habitat conditions at existing sites. For example, maintain light levels through sufficient grazing and control of young ivy growth (Sanderson & Wolseley 2001; Lamacraft *et al* 2016). The exclusion of grazing animals from woodlands and/or non-intervention conservation policies that lead to a reduction in woodland grazing would very likely negatively impact on this species due to increased levels of shade. A more natural approach would be to restore large tracts of grazed woodland, creating a varied woodland structure with many open areas (Sanderson 2012).
- Maintain the structural diversity of tree stands and the availability of potential host trees (Jüriado *et al* 2011). Sustained conservation depends not only on old and large trees but also a wide range of tree sizes and ages (Kiebacher *et al* 2017).
- Restore former pasture woodland sites. Extend or link existing wood pasture/parkland sites to increase available habitat, including wider cohorts of trees to address age gaps.
- Encourage nitrogen mitigation where relevant to the site, such as through a Shared Nitrogen Action Plan (SNAP) (refer to the IPENS Atmospheric nitrogen theme plan for further details).
- Consider supplementing populations through conservation translocations, the creation of local reinforcement colonies, and site reintroductions within its former range (Scheidegger 1995; Scheidegger, Frey & Walser 1998; Gustafsson, Fedrowitz & Hazell 2013). If the species cannot keep pace with its climate envelope, consider introductions to sites beyond the known historical range. Follow the IUCN guidelines for reintroductions and other conservation translocations (IUCN/SSC 2013).

Actions to accommodate change include:

- Conserve a wider range of tree species (native and non-native) that are known to provide suitable substrate (Ellis *et al* 2014). For example, mature/post-mature sycamore provides an excellent substrate for this species.
- To address enhanced vegetation growth caused by elevated CO_2 levels and maintain light levels, increase grazing pressure if necessary, create additional glades or rides, and control (and monitor) ivy growth (Zotz, Cueni & Körner 2006; Coxson & Stevenson 2007).
- Where the loss of substrate trees is not compensated for by natural regeneration, a programme of tree planting (using a mix of species) may help to maintain continuity of epiphyte habitat. Priority should be given to known substrate trees (native and non-native) and, in relation to climate change, matching the tree species and provenance with the relevant site (Broadmeadow, Ray, & Samuel 2005).

Relevant Countryside Stewardship options

The most relevant Countryside Stewardship options for tree lungwort are listed below:

BE1: Protection of in-field trees on arable land

BE2: Protection of in-field trees on intensive grassland

BE6: Veteran tree surgery

PA2: Feasibility study

SB2: Scrub control - difficult sites

SB6: Rhododendron control

SP4: Control of invasive plant species supplement

SP6: Cattle grazing supplement

SP9: Threatened species supplement

SW2: 4m to 6m buffer strip on intensive grassland

TE1: Planting standard hedgerow tree

TE11: Tree surgery

TE2: Planting standard parkland tree

TE9: Parkland tree guard - welded steel

WD3: Woodland edges on arable land

WD4: Management of wood pasture and parkland

WD5: Restoration of wood pasture and parkland

WD6: Creation of wood pasture

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