Impacts of Ash Dieback *Hymenoscyphus fraxineus* (Chalara) on priority lichens and potential mitigation options

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Further information

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Executive summary

The rapid spread of Ash Dieback (*Hymenoscyphus fraxineus*) poses an existential threat to Ash and the species dependant on it. The impact of Ash Dieback on lichen and received very little attention despite Ash supporting significant lichen assemblages. Thus, the extinction risk to lichen species and the mitigation available was largely unknown. To this end, Natural England commissioned a report to:

(i) Undertake a vulnerability assessment of Section 41 (Natural Environment and Rural Communities Act 2006) lichen species with varying dependencies on Ash; and
(ii) Identify and evaluate the scope and potential approaches to Ash Dieback mitigation for these species.

In addition, the report also addresses a number of Section 41 actions around mitigating Ash Dieback; trialling the translocation of lichen; and assessing ecological data and mitigation options for *Cryptolechia carneolutea* which was already considered to be at high risk from Ash Dieback.

Twenty Section 41 species have been evaluated and their extinction risk assessed as:

- **Very high risk:** *Caloplaca flavorubescens*, *Catapyrenium psoromoides*, *Pseudocyphellaria intricate*, *Wadeana dendrographa*.
- **High risk:** *Anaptychia ciliaris subsp. Ciliaris*, Collema fragrans, *Cryptolechia carneolutea*, *Parmelina carporrhizans*.
- **Medium-High risk:** *Bacidia subincompta*.
- **Medium risk:** *Arthonia anglica*, *Bacidia incompta*, *Lecania chlorotiza*, *Ramonia nigra*, *Schismatomma graphidioides*, *Teloschistes flavicans*.
- **Low risk:** *Nevesia sampaiana*, *Physcia tribacioides*.
- **Unknown risk:** *Caloplaca virescens*, *Lecidea erythrophaea*, *Leptogium cochleatum*.

In mitigating for the impact of Ash Dieback on threatened lichen, it is recommended that general good practice guidelines regarding Ash Dieback should be followed as a starting point. These include:

- Retain existing Ash trees as long as possible.
- Avoid coppicing, re-pollarding out-of-cycle pollards or tree surgery on veteran Ash.
- Encourage suitable replacement trees.
- Consider treatment of dead Ash. Dead wood is an important resource in woodland ecology, and a proportion of deadwood should be retained (standing and fallen).

However, in terms of epiphytic lichens there are some issues with most general advice for Ash Dieback mitigation, notably:

- a limited appreciation of the time required for newly regenerated/planted trees to become suitable for colonisation by most threatened lichen species which is likely to be more than a century in normal circumstance.
- advice is lacking for grazed woodland habitats or parklands, both of which are key habitats for lichens.

Additional factors that must be considered for mitigating the impact of Ash Dieback on epiphytic lichens:

- knowledge; specifically, a lack of recent knowledge for many sites/lichen species.
- adherence to general good practice management for lichen to optimise conditions for existing populations.
- the most vulnerable areas need to be managed to create/maintain optimum conditions for their lichen interest to give best chance of adaptation, especially maintaining and restoring open well-lit but sheltered conditions around veteran trees within traditionally grazed habitats.
- recognise the important role other native, non-native broadleaves and rock habitats can play. The best mitigation is likely to involve several components, no one tree could really replace Ash.
- adjust management approach to recognise this and encourage/promote a range of Ash alternatives.

Five case-studies are presented which discuss the application of these approaches to specific sites and issues. These are Gowbarrow/Glencoyne Park in Cumbria, Bovey Valley in Devon, Horner in Somerset, Dunsland Park in Devon and Arlington Court in Devon.

Contents

Foreword

The pace at which Ash Dieback has spread through the UK has been sobering. We are now seeing large scale loss of Ash trees directly from the fungus but also through reactionary felling of trees baring symptoms. This poses a worrying threat to all species dependant of Ash trees. It is critical that Natural England understand what the extinction risk is as a result of Ash Dieback and what mitigation is available to support dependant species. This review collates data on the lichen species associated with Ash, focussing on the extinction risk to those species already considered threatened and listed as Priority Species under Section 41 of the Natural England and the Commission for Rural Communities Act 2006.

Until now, very little has been published on the impact of Ash die-back on lichen. We encourage landowners and tree managers to consider how lichen will be impacted by management for Ash Dieback. The mitigation options and case studies presented here offer an optimistic future for these threatened lichen species.

Natural England regularly commissions a range of reports from external contractors to provide evidence and advice to assist in delivering its duties. The views in this report are those of the authors and do not necessarily represent those of Natural England.

Introduction

1.1 Brief

1.1.1 Outline

Ash Dieback is now confirmed present in 68% of English hectads (FC website, Mar 2019). 536 lichen species have been recorded from Ash, representing over 25% of the British resource (Simkin 2012); of these 78 are of Conservation Concern (CR-NT[1]) (Edwards 2012). Currently there is a dearth of advice on what can be done to mitigate the impact on Ash-dependent epiphytic lichens.

Although some lichens have alternative tree hosts and the degree of Ash-dependency varies, tree planting does not represent a 'quick fix' since many Ash-specialists can only colonise trees that are 200+ years old. Instead, there is a need to reappraise tree resources at a landscape scale and to retain existing mature trees that have similar bark characteristics to Ash e.g. Sycamore and Norway Maple. Identifying such trees/stands as future veterans and documenting these in management plans etc. is seen as a priority.

The need for this work is reflected in the actions for 15 S41 species, one of which is already at 'high extinction risk'. A further five S41 lichens for which Ash is a significant host lack an Ash-Dieback action. Section 41 actions that this project aims to address:

(i) Mitigate Ash-Dieback impact. Ensure veteran Ash trees are not felled even if infected (evidence suggests that old Ash trees die more slowly). Encourage site managers to adopt existing mature trees as the next generation of veterans - e.g. Sycamore, Norway Maple, Sallow, Hazel, Aspen and Field Maple (varies regionally). As a last resort, plant alternative host tree species.

(ii) *Some species have the additional clause:* 'Consider trial translocation'.

[1] CR-NT = Near Threatened, Vulnerable, Endangered, or Critically Endangered

(iii) *Cryptolechia carneolutea*: Re-assess existing data on ecology and distribution in view of potential threat from Ash Dieback, to determine if any mitigation is possible (*Cryptolechia carneolutea*).

The project has high relevance to designated sites, especially woodland SSSIs with an epiphytic lichen interest. Ash is often a key host tree at such sites, supporting many threatened/rare lichens that were once more widespread, occurring on Elm before the arrival of Dutch Elm Disease. However, the project has relevance beyond protected sites to England's wider tree-scape, wherever lichen-rich Ash trees occur, and clearly represents a landscape scale approach.

The ultimate aim of the project is to provide evidence-based, sound and practical advice to site managers and landowners, especially those who manage or oversee the management of lichen-rich Ash woods in England.

1.1.2 Key Objectives

(i) A vulnerability assessment of each of the S41 lichens listed (in an English context).

(ii) Potential approaches to Ash Dieback mitigation for epiphytic lichens scoped and evaluated.

(iii) A technical report produced covering 1 and 2.

(iv) A leaflet for site managers and landowners published which distils key messages from the report.

1.2 Project species

The initial list of project species provided is given in **Table 1**. These were derived from three sources: 1) Section 41 Priority Species Action Spreadsheet (2014), 2) Smith et al. (2009), and 3) British Lichen Society Rare/Threatened Lichens England dataset (1980-2015). As well as Section 41 species, other significant lichen assemblages impacted by Ash Dieback are considered in the report.

Table 1: **Section 41 lichen species (NERC Act 2006) considered by this Project**

Section 41 lichen species	GB Red List (Woods & Coppins 2012)[2]	Provisional (p) England Red List (British Lichen Society, in prep.)[3]
Anaptychia ciliaris* subsp. *ciliaris	EN, NS	pEN
Arthonia anglica	EN, NR	pEN
Bacidia incompta	VU	pVU
Bacidia subincompta	VU, NS	pCR
Caloplaca flavorubescens	EN, NS	pEN
Caloplaca virescens	EN, NS	pEN
Catapyrenium psoromoides	CR, NR, Sc8	pEN
Collema fragrans	EN, NR, IR	pEN
Cryptolechia carneolutea	EN, NS, IR	pEN
Lecania chlorotiza	NT, NS, IR	pNT
Lecidea erythrophaea	VU, NR	pVU
Leptogium cochleatum	VU, NS	NE
Nevesia sampaiana	NT, NS, IR	pCR[4]

[2] See section 2.4 for definitions of the abbreviations

[3] Abbreviations as in section 2.4, addition of 'p' for provisional e.g. pEN = provisionally assessed as Endangered

[4] Listed by NE as a 'high extinction risk' in England

Section 41 lichen species	GB Red List (Woods & Coppins 2012)[2]	Provisional (p) England Red List (British Lichen Society, in prep.)[3]
Parmelina carporrhizans	VU, NS	pVU
Physcia tribacioides	VU, NS, Sc8	pVU
Pseudocyphellaria intricata	NT, NS, IR	pCR
Ramonia nigra	CR, NR, IR	pEN
Schismatomma graphidioides	VU, NS, IR	pEN
Teloschistes flavicans	VU, NS, S8	pVU
Wadeana dendrographa	NT, NS, IR	pVU

1.3 Ash Dieback

1.3.1 The Disease

Ash Dieback is a fungal disease caused by *Hymenoscyphus fraxineus* a small ascomycete fungus, which is decimating Common Ash *Fraxinus excelsior* in Europe. *Hymenoscyphus fraxineus* is closely related to the native European fungus *Hymenoscyphus albidus*, which is a harmless leaf fungus on Common Ash. *Hymenoscyphus fraxineus* appears to have been introduced to eastern Europe and was first detected in about 1995 (Baral et al 2014). *Hymenoscyphus fraxineus* is a native of temperate eastern Asia, where it is observed to be a harmless leaf fungus of Manchurian Ash *Fraxinus mandshurica* and *Fraxinus chinensis* subsp. *rhynchophylla*. The fungus does cause brown lesions on the leaves of Manchurian Ash but the tree shows strong tolerance and has low levels of shoot symptoms, unlike Common Ash (Nielsen et al 2017). Manchurian Ash (section *Fraxinus*) is ecologically and evolutionary close to Common Ash.

1.3.2 The Impact on Ash

Unlike on co-evolved Ash species such as Manchurian Ash, Common Ash has little tolerance of *Hymenoscyphus fraxineus* infections. Infections are not limited to the leaves and the fungus spreads much more easily into the shoots, and eventually into the trunk leading to the death of the tree. All Common Ash trees appear to be impacted by the fungus but the degree of tolerance varies greatly. Kjær et al (2011) found most trees to be highly susceptible, with only an estimated 1% of trees having the potential of producing offspring with expected crown damage of <10%. The speed of impact of the disease is very variable. Trees with a low level of tolerance can die very quickly and even large trees die in a few years. More tolerant trees can survive for long periods. Additional stresses appear to increase susceptibility. Mortality is often from secondary infections, especially Honey Fungus (Reid et al 2015). A recent meta-analysis of surveys of Ash mortality by Coker et al (2018) has produced some slightly more optimistic results. In woodlands they found a maximum recorded mortality between 4 and 20 years (which may have missed some dead trees) of 70%. Modelling suggested that long term survival of a minority of existing trees in woodlands may continue into the future. The results in Ash plantations were different, with higher maximum mortality and modelling suggesting a greater chance of the total loss of existing Ash trees. In contrast, regeneration within infected stands had very variable mortality but with the some of the lowest levels of mortality recorded found in sites with the longest exposure to Ash Dieback. The data was limited for regeneration but the observations suggested that rapid selection for resistant strains of Ash may have occurred in some stands.

Trees showing 0-25% of their crowns affected, can be considered as having a good level of disease tolerance where they are within a known area of infection and surrounding trees are more severely affected. Sometimes it can take several years following the arrival of Ash Dieback at a site to identify the more tolerant trees. Tolerant trees can still produce good annual growth increment. Trees with more than 50% of the crown affected will show little or no annual growth increment and are likely to die (Reid et al 2015, Stokes & Jones, 2019).

As a result of the likely serious impact on Ash *Fraxinus excelsior*, it has been listed by the IUCN as Near Threatened Globally (Barstow et al 2018).

1.4 The Ash tree

1.4.1 Ecology

Ash *Fraxinus excelsior* is a canopy tree of temperate woodland with a sub-Atlantic European distribution. It avoids strongly acid soils and grows best on damper soils. It is relatively short lived as a maiden tree, with 150 – 200 years given by Rameau et al (1989) compared to 150 – 300 years for Beech, 300 – 500 years for Sycamore, to 500 years for Small-leaved Lime and 500 – 1000 years for Sessile and Pedunculate Oak. Pollards and especially coppice stools, however, are much more long lived (Rackham 2003). As a canopy tree at 20 – 30m it equals trees such as Sycamore, Small Leaved Lime and Wych Elm in height, but is over topped by Sessile and Pedunculate Oak and especially Beech (at 30 – 40m) (Rameau et al 1989). It regenerates readily on fertile soils but is light demanding and the mature canopy casts a lighter shade than most of its competitors. The foliage is readily eaten by browsing mammals, similar to species such as Elm and Lime, in contrast to trees with higher tannin levels such as Alder, Beech, Hornbeam and Oak. It can, however, regenerate well on the most fertile soils in the presence of grazing, by using the shelter of Bramble and thorny shrubs, for example on floodplains (Bakker et al 2004), but tends to be more reduced in extent in grazed woodland on poorer soils (Tubbs 2001).

Ash is a rapidly colonising mid succession tree of fertile soils but with poor competitive ability against longer lived shade baring late succession species (Thomas 2016). The ecological function of Ash in a UK context is reviewed in Mitchell et al. (2014).

1.4.2 History

Ash appears to have been widespread in the Atlantic wildwood, but only locally common. It responded to Neolithic disturbance, increasing in abundance, and is likely to have been prominent in secondary regrowth after early clearances (Rackham 2003). Since then it has been a major component of both woodland and farmland on fertile soils. It was an increasing tree in the landscape in the 20thcentury before the arrival of Ash Dieback (Thomas 2016).

1.4.3 Landscape, Ash and Lichens of Conservation Interest

Ash is a significant constituent of nearly all ancient coppices and recent woodlands on suitable soils, except where out-competed by Beech or Hornbeam. Coppices and recent woodland, however, are generally poor habitats for rare lichens. An exception is where Ash standards have been retained out of cycle in old coppices, as can be seen in some of the coppices derived from Cranbourne Chase, Dorset/Wiltshire (Sanderson 2003).

Habitats with Ash trees of lichen interest are those that include veteran trees or are otherwise little disturbed. These include field and parkland trees, which support some very rare species. The field tree specialists are southern species, which are typically tolerant of exposure to sunshine and higher nutrient levels. Ash pollards in fields and pasture in the highly oceanic and wet conditions of the Lake District, however, can support more shade dependant woodland species. Otherwise lichen interest on Ash is mainly associated with various old growth woodland stands, especially in pasture woodlands, i.e. traditionally and sustainably grazed woodlands (Harding& Rose 1986). The term pasture woodland (Chatters & Sanderson 1994) is preferred to the nebulous term 'wood pasture', which can be interpreted as including landscape parks and even orchards. The lichen assemblage associated with old

Ash in these habitats is very much a woodland one, dependant on high humidity and shelter from strong summer sunshine.

Old Ash in pasture woodlands is localised by several factors. Ash only regenerates well in pasture woodlands on high fertility soils such as flushed base rich slopes and floodplains. In pasture woodland, it tends to be lost from intermediate soils where it would survive in ungrazed woodlands. This is compounded by the short life span of Ash compared to Oak. The latter can survive much longer periods of poor regeneration than Ash. Finally the sort of fertile soils in which Ash can resist grazing and survive well in old growth woods, have historically been preferentially converted to other uses such as enclosed farmland or intensively used coppices. Lichen-rich old Ash woods are very much a feature of woodland in the uplands; Ash is rare in pasture woodland in the lowlands. It is a particular feature of what were described as winter grazed pasture woodlands by Harding& Rose (1986). These can occur in unenclosed land as at Horner Combe in Exmoor and widely in the Scottish Highland but are more typical of the enclosed fringe land; the outbye of the Lake District and the ffridd in Wales.

1.5 Lichens

1.5.1 Ecology of Rare Epiphytic Lichens

Ash supports a sizable portion of the British assemblage of lichens and associated fungi, Edwards (2012) gives at least 536 species of lichen recorded from Ash in the BLS database, 27.5% of the British lichen flora. The majority of these are common species with numerous alternative substrates but there are many rare and threatened species. Edwards (2012) gives species of conservation interest found on Ash as including 49 Threatened species (=9.1% of all 'Ash species') and 42 Near Threatened species (=7.8%), along with 36 Section 41 species (these include both Threatened and Near Threatened species). For many reasons, however, only a small proportion of Ash trees support important lichen assemblages.

Rare and threatened epiphytic lichens occupy specialised niches on trees. These are many and varied but their development is associated generally with veteran trees. More specifically these specialist lichens are associated with slow tree growth and limited bark expansion. Fast growing young trees are colonised by rapidly colonising pioneer species and not until bark expansion slows do the niches develop that rare species use. Important habitats of Ash trees, however, can also include suppressed young trees, which also have slowly expanding bark.

In addition to the scarcity of niches, dispersal limitation is also a very important factor in lichen rarity. Ecological continuity has long been recognised as an important factor in epiphytic lichen diversity(Rose 1992). Frequent observations demonstrate that old growth stands with a long continuity are very rich in rare lichens (Gustafsson et al 1992, Fritz et al 2008, Wolseley et al 2016). Ellis & Coppins (2007) demonstrated that epiphyte species richness at a less than hectare scale was positively related to woodland extent and negatively related to woodland fragmentation; however, that richness was explained better by historic woodland structure at a $1km^2$ scale, than by modern woodland structure. The richest 1ha stands tended to be found in woods that were large in the 19th century, even where the wood had since reduced in size. The limited ability for dispersal of some lichens has been demonstrated for the Tree Lungwort *Lobaria pulmonaria* with a maximum distance between identical genotypes of 230m in Switzerland (Walser 2004) and a recorded maximum dispersal distance of 75m in Sweden (Öckinger et al 2005). Kiebacher et al (2017) showed, in a Sycamore pasture woodland in the Alps, that local dispersal was important for rare lichens, whereas long distance dispersal seems to be more important for colonisation by rare bryophytes. Essentially veteran and old growth dependent lichens are good at colonising short distances between suitable trees but have not evolved efficient mechanisms for long distance dispersal.

However, it should be noted that some rare species in Britain are mobile edge of range species that are restricted here by climatic restraints and are actually rapid colonisers within the core of their ranges. A prime example is *Teloschistes chrysophthalmus*, which appears to have periodically colonised southern England since the early 19th century from France during periods of hotter summers as at the beginning of the 19th century and in the current decade.

In addition to the natural constraints on specialist epiphytic lichens there are also negative anthropogenic pressures on these species. As well as obvious direct losses of old growth stands and veteran trees to land use changes, there are more insidious threats. Pollution, both acidifying by sulphur and latterly nitrogen oxides and over enrichment by ammonia has, and is having, a major impact on threatened and rare lichens. This is not just total loss as seen in the highest areas of pollution, but includes subtler impacts on population viability where pollution levels are lower. For example, a significant impact of acidifying pollution for base-demanding lichens is the loss of species from more poorly buffered (i.e. more naturally acidic) trees, such as Oak, Beech and Hazel, and their differential survival on trees with higher buffered (i.e. less acidic/more basic) bark such as Ash and Elm (Farmer et al 1992). Ash is a particularly significant tree for the survival of base-demanding lichens in mildly acidified regions (Edwards 2012& Woods 2012). Another pressure is the past impact of Elm Disease. Like acidification, this removed the main habitat for several already restricted specialist lichens of wound tracks on old trees. Ash was the main alterative substrate for several of these species. Finally, acidification has declined in recent decades, an increasing pressure is from eutrophication from excess nitrogen. The main impact on rare Ash lichens is from ammonia pollution from intensive farming, which disproportionately impacts on parkland and field trees (van Herk, 1999 & Wolseley et al, 2006), an important habitat for many Threatened lichens.

A particularly pervasive threat is the decline in openness in woodland and forest due to the reduction or removal of traditional woodland grazing (Rose 1992, Leppik et al 2011, Paltto et al 2011 & Jönsson & Thor 2012). Fritz et al (2008) described reducing lichen diversity in silviculturally managed woodlands due to dense shading of retained veteran Beeches by dense cohorts of beech saplings. All lichens are light demanding, although the tolerance of exposure to strong sunshine is very variable. Some veteran tree specialist are specialists of open grown sunny trees but the majority are essentially woodland species that avoid exposure to strong summer sun and long periods of high desiccation (Gauslaa et al, 2006 & Mafole et al, 2017).

Rare and threatened lichen diversity is usually highest in sheltered, humid locations with woodland with frequent glades or broken canopies combined along with more open park like stands maintained by variable grazing pressure (Sanderson& Wolseley 2001). Extensive grazing appears to be the only practical method to maintain such lichen rich habitat in the long term. Both under grazing and over grazing are a threat to such habitats. Under grazing can rapidly result in increasing shade and losses of rare lichens, usually by dense regeneration and expansion of the existing shrub layer (Coppins& Coppins 1998, Sanderson 2009a, Sanderson 2017b& Sanderson 2018a). In the long term, ungrazed unmanaged woods become dominated by late succession shade baring trees (Vera 2000) with a very limited lichen assemblage. This can be seen in the biggest non-intervention Beech wood in Europe - Uholka–ShyrokyiLuh in the Carpathian Biosphere Reserves, Ukraine - where the interior of the reserve is described as being very poor in lichens, with typically about five species on the lower trunk (Dymytrova at al 2013). In contrast, surviving pasture woodlands and better lit cliff and riverside stands are among the richest Beech stands in Europe (Vondrák et al 2018).

Over grazing has a much longer term impact, gradually opening up the wood and leading to the loss of the habitat from the lack of replacement trees and can actually increase lichen diversity in the earlier stages. Controlled stock grazing is the ideal way of maintaining habitat quality in lichen rich woods. In the absence of stock, however, wild deer grazing can help maintain habitat quality in lichen rich woods.

1.5.2 Ash as a Lichen Substrate

Ash bark has a relatively high pH and even in high rainfall areas rarely supports diverse acid bark lichen assemblages (‘substrate’ is defined under 2.4.4). In contrast, assemblages of mesic and base rich bark can be very rich on Ash (Edwards, 2012). Oak bark can be as base rich as Ash but such trees are less frequent. In comparison to the two native Oak species the overall species diversity is lower on Ash bark, as strongly acidic habitats are missing, but Ash can support larger populations of base demanding species as the range of bark pH is narrower than Oak. From field experience the bark pH range of Ash appears similar to that of Sycamore but is lower than that found on Norway Maple and Elm species.

The bark of older Ash trees is water retentive and this favours bryophyte cover and larger more competitive lichens over crust forming species. The latter can be more diverse on trees with harder bark such as Hazel, Hornbeam and Beech. Smooth bark specialist lichens are most prominent on young slow growing suppressed Ash trees, which have a harder and smoother bark. Mature Oak bark is typically more water retentive than Ash and this is probably part of the reason why Oak has a marked lower diversity of lichens of conservation interest in very wet western Highlands hyperoceanic rainforests than Ash (Coppins & Coppins, 2005). The importance of Ash in this area is emphasised by the coincidence map in Edwards (2014) of records of rare and threatened lichens from Ash (**Map 1**). This is in contrast to the situation further south where summer dry southern Atlantic oceanic woods. Here Oak is more diverse, especially in crust forming species. The latter can be quite striking, with Ash equalling or exceeding Oaks for larger foliose lichens of conservation interest in south western woods but supporting markedly fewer rare crust forming species. An example of the extremes of this phenomenon are the Southern Atlantic-Mediterranean crustose species *Porina hibernica* (NT, S41) as compared to the large leafy hyperoceanic *Sticta canariensis* (Nb, Provisional England Red List pVU) in England. The latter has 156 records with substrates in the BLS database, of which none are on Ash and 89% are on Oak, *Sticta canariensis* has 26 similar records of which 42% are on Ash and 23% are on Oak.

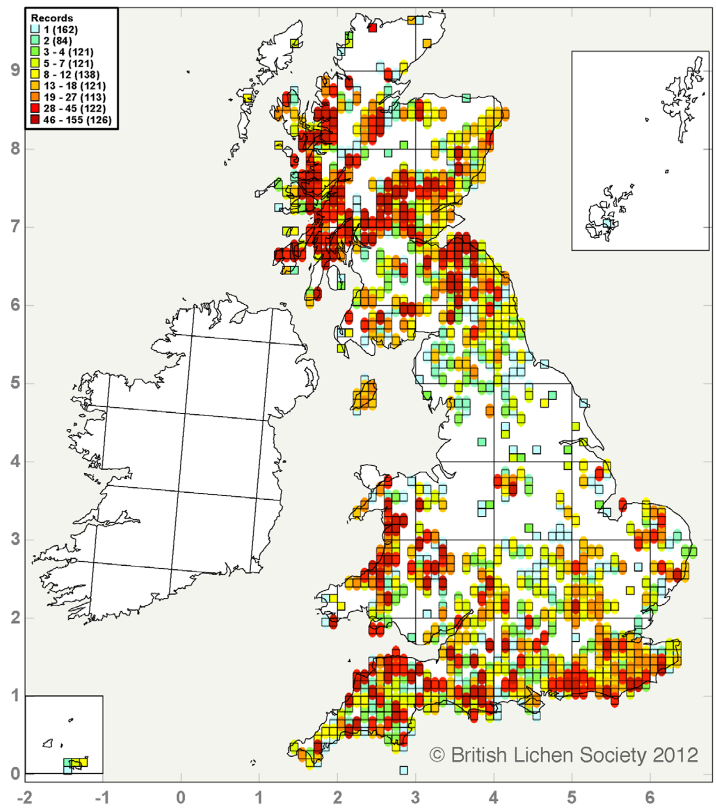
Ash supports distinct dry bark assemblages on parts of the trunks not reached by stem flow, typically on leaning or pollarded trees, similar to those of other large trees. The diversity of such habitats is higher than smooth barked trees but markedly poorer than Oak. This probably reflects the much longer life span of Oak and its greater ability to produce craggy dry bark on older Oak trees.

As a short lived tree the lignum is typically soft and non-persistent and has a relatively high pH. This makes it a much less diverse habitat than the lignum of species such as Oak or Scots Pine but it can support a few specialist species of higher pH lignum. In contrast, its poorer resistance to fungal damage (compartmentalisation) compared to Oak means that wound track habitats are much more frequent. This latter habitat was typically more developed in Elms than any other tree species but following Dutch Elm Disease, Ash is now one of the major substrates for such species. Locally Beech, Sycamore and Horse Chestnut can also support some of the former Elm wound track specialists.

MAP 1: The lichen-richness of Ash (From Edwards, 2012) showing all lichen recorded from Ash (A, above) and those of conservation importance (B, below). © British Lichen Society 2012. Reproduced with permission.

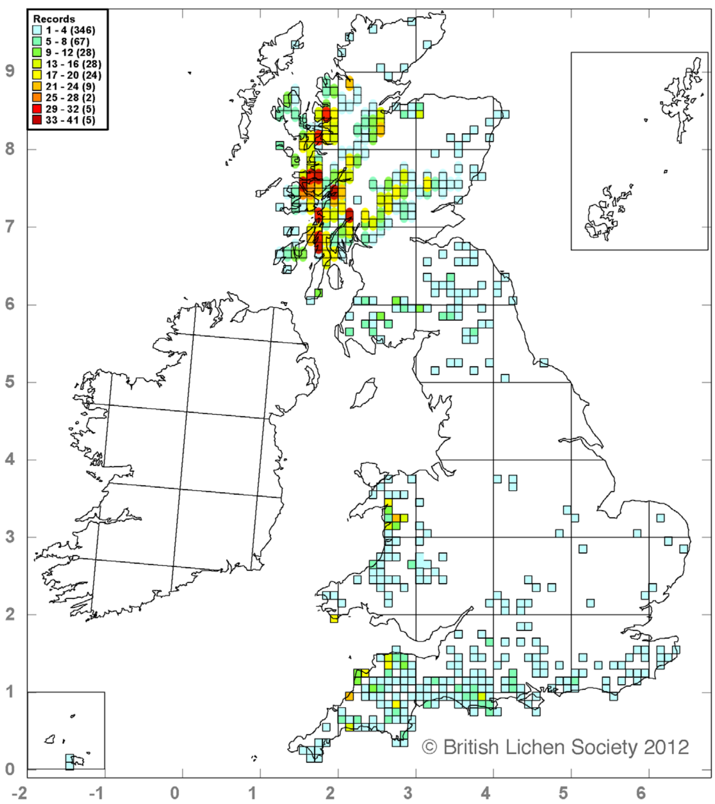
A

Lichen Species recorded on Ash



B

Lichen Species recorded on Ash (CR EN VU NT IR only)



Methods

2.1 Data

The lichen data used to analyse the potential threat of Ash Dieback to the Section 41 species listed in Table 1, was supplied by Janet Simkin, British Lichen Society Data Officer, from the BLS database on an Excel spreadsheet created on the 12/11/2018. This includes many duplicate records, both of the same record and later records from the same site, sorting these out was difficult, the different records do not always use the same site names or grid references. When calculating the proportion of trees occupied by Section 41 species etc., for species with many records the existence of duplicate records was ignored. The assumption was made that the duplicate records would not impact on the proportion of records from a particular site. For species with very few records, individual sites were determined because there was a risk of biasing the results with small data sets and differing recording practices between recorders. The treatment of duplicate records is stated in the species accounts. The British and Irish species distribution dot maps were also supplied by the BLS and were produced from the BLS database in December 2017.

2.2 Nomenclature

The scientific names of lichens are in considerable flux, mainly due to the recent results of DNA sequencing, and many more changes are in the pipeline. The nomenclature in this reports follows the usage on the BLS taxon Dictionary <http://www.britishlichensociety.org.uk/resources/lichen-taxon-database> at the time of writing (February 2019). This is the same nomenclature as used in Sanderson et al (2018).

2.3 Ancient woodland indicators

In the site accounts given as part of the baseline of the impact of Ash Dieback on the Base Rich Bark Woodland Assemblage (*Lobarion pulmonariae*) the Southern Oceanic Woodland Index (SOWI) was used. This is described in Sanderson et al (2018) and is an updating of the New Index of Ecological Continuity (Rose, 1992; Coppins & Coppins 2002). In this index, scores of over 20 can be regarded as being of national importance and those of over 30 are generally of international importance.

2.4 Definition of terms

High epiphytic lichen diversity is associated with older trees and old growth stands, the definitions of the these are discussed below.

2.4.1 Veteran Trees

Terms such as veteran trees are applied loosely and often in ways that are not useful for lichen ecology. Lichen-rich trees are usually slow growing trees, which can include older trees but this is complicated by smaller suppressed or slow growing stunted trees. Definitions of veteran trees based simply on sized are not very useful. In one comparison at Dinefwr Park, Carmarthenshire, a lichen survey followed a veteran tree survey that defined veteran trees as those over 3.00m girth (Sanderson, 2014). Of 160 trees defined as veteran by the previous survey as veteran, 62 were of high lichen interest but another 95 trees of high lichen interest were found that had girths less than 3.00m girth. For assessing the potential for lichen diversity the following definitions are more useful for defining veteran trees using the physiological age of the tree. These are based on Harding & Alexander (1993):

- Mature: a tree that has reached its full height and is still vigorous, heart rot likely to be absent.
- Post mature: a tree that is no longer vigorous and has started retrenching with branch die back. Heart rot will have commenced but will not be easily visible (Photo 1).
- Ancient: a tree with major branch die back and or extensive and visible heart rot (Photo 2).

The term ‘veteran tree’ is taken to include both post mature and ancient trees. This classification reflects the natural processes that older trees go through as a response to balancing their increasing size with the photosynthetic area available. The commencement of heart rot indicates the end of the commercial usefulness of timber trees and, in managed woodlands such trees, and their associated biodiversity, are likely to be rare features.

2.4.2 Old growth

The term old growth refers to stand age alone and is not synonymous terms with such as virgin woodland (Alexander et al, 2002), which also include assumptions about lack of human management. Old growth stands are late succession stands where veteran trees are prominent within the stand. Fully developed old growth stands will have trees living through to senescence and include much dead wood.

For Oak-dominated woods old growth features, such as post mature trees and increasing amount of large diameter dead wood begin to become significant in stands over about 200 years (Photos 3 & 4). Fully developed Oak dominated old growth woodland is likely to be develop in stands of 400 years or more. Old growth stand of other species can develop sooner that Oak stands, for example shrubs Sallow and Hazel which can be develop old growth conditions within 40 years.

The richest old growth stands (for lichens) also have long continuity beyond the age of the stand (Rose, 1992) but even developing old growth stands are likely to have higher lichen diversity than young growth stands (Sanderson, 2010a & Wolseley et al, 2016). Any stand with frequent post mature trees in the canopy can be regarded an old growth stand.

2.4.3 Rarity & Threat

The definitions of Red Data Book (RBD) status follows Woods & Coppins, (2012) and that of Notable species as given in Sanderson et al (2018). Abbreviations used in the text and tables are listed below:

CR = Critically Endangered Red Data Book species

EN = Endangered Red Data Book species

VU = Endangered Red Data Book species

NT = Near Threatened Red Data Book species

Nb = Notable species (NR, NS, IR or S41 species of conservation interest, which are not listed as CR, EN, VU & NT species)

NR = Nationally Rare

NS = Nationally Scarce

IR = International Responsibility species

S41 = Section 41 species (England; Natural Environment and Rural Communities Act 2006)

S7 = Section 7 species (Wales; Environment (Wales) Act 2016)

BAP = Biodiversity Action Plan species

Sc8 = Schedule 8 species

In addition, the following terms are also used in the text:

Threatened species = Red List Species (CR, EN & VU species)

Lichens of Conservation interest = Threatened, Near Threatened and Notable species.

2.4.4 Substrate

The surface on which a lichen grows is termed its substrate. In the case of woodland lichens this is usually tree bark, but can also be lignum (where bark has been removed), or rock. Bark pH and roughness are key tree characteristics in determining suitability for particular lichen species and communities (Ellis et al. 2015).

Photo 1. Great Wood, Gregynog, Montgomery left & Photo 2 Spye Park, North Wiltshire right. Left: post mature Ash, some branch Dieback but main trunk intact, with *Lecanora sublivescens* NT (NS/IR/S7) and *Enterographa sorediata* NT (NS/IR/BAP). Right: ancient Ash, with major limb loss and visibly hollow main trunk, with *Lobaria pulmonaria* Nb (IR) (Sanderson, 2008 & 2018c). © Neil A Sanderson

Photos 3 & 4: Ceunant Llennyrch, Meirionnydd, an oceanic ravine, with old growth pasture woodland with post mature Oak with mature Ash and patches of post mature Hazel in top picture and a young growth with immature Oak in a plantation in the lower picture. The former is exceptionally lichen rich, while the latter has a low lichen diversity (Sanderson, 2006). © Neil A Sanderson

Ash Dieback impact on lichens associated with Ash

3.1 Introduction

The impact of Ash Dieback on Ash lichen assemblages and priority species in England is assessed below. The Base Rich Bark Woodland assemblage (*Lobarion pulmonariae*) is treated separately (section 3.3) as it such a significant assemblage as far as Ash is concerned. Impacts on Section 41 (NERC Act 2006) species, as listed in the brief, are described in section 3.4. All the assessments are summarised in Table 4.

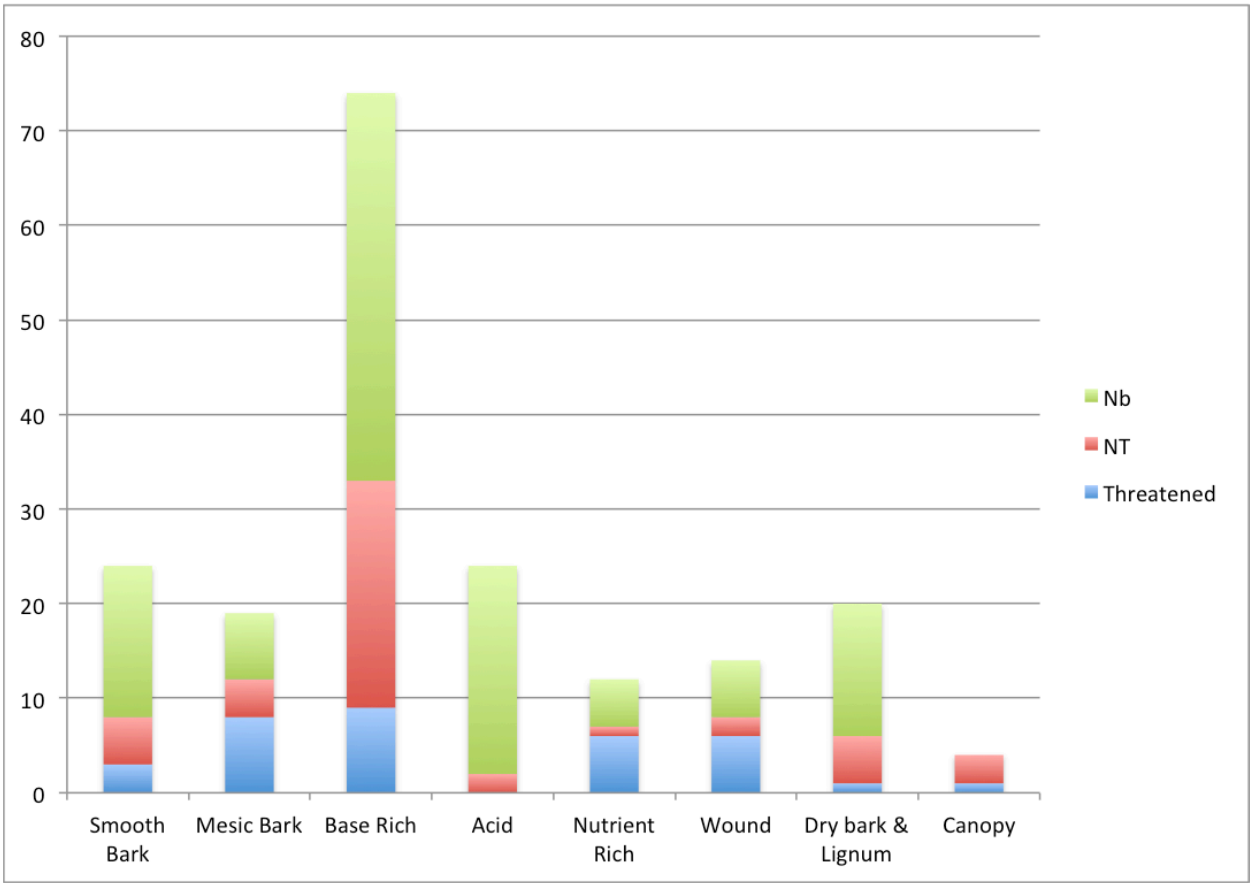
As well as assessing the impact, possible mitigation measures are considered. Most practical mitigation measures relate to habitat management and the potential solutions can be considered as adaptive disease management - i.e. building resilience by reducing other stresses.

3.2 Ash lichen assemblages

3.2.1 The importance of different epiphytic habitats on Ash

The number of species of conservation interest within each assemblage across the different epiphytic habitats found on Ash are compared below. The phytosociological classification mainly refers to James et al (1977), although the classification used here is based on pragmatically defined habitat assemblages rather than a strict phytosociological classification. The Threatened, Near Threatened and Notable species (Sanderson et al, 2018), listed in Edwards (2012) as found on Ash, were allocated to broad epiphytic habitats (Chart 1 & Table 2). The 2012 data, although slightly out of date, will nonetheless indicate the relative proportions of species of conservation interest within different epiphytic habitats on Ash. All but one species were judged to be exclusive to a single broad habitat. The only one not, *Teloschistes flavicans* VU (NS/S41), is characteristic of both mature mesic bark and canopy habitats.

Chart 1: Epiphytic lichens of conservation interest recorded on Ash by epiphytic habitat. Woodland dominated by trees with Base-Rich Bark is the most significant epiphytic habitat for threatened and notable species (the *Lobarion pulmonariae* assemblage).



3.2.2 Smooth Bark Communities

Smooth Bark Communities (*Graphidion: Graphidetum scriptae*, *Arthpyrenietum punctiformis*, *Pyrenula chlorospila – Pyrenula macrospora* nodum & *Pyrenula laevigata – P. occidentalis* nodum). These are communities on smooth bark of shrubs, especially Hazel, Rowan and Holly, and smooth barked trees in sheltered woodland conditions. The basic community is composed of widespread species, especially on young vigorous trees or bushes. On undisturbed Hazel bushes, ancient Holly, and slow growing suppressed young trees, including Ash, however, ancient woodland and uncommon species can occur. Several distinct communities occur in Britain, which include:

- ***Arthpyrenietum punctiformis***: a pioneer community of non-lichenised species occupying the younger branches. This can include species of conservation interest in woodlands.

Table 2: Epiphytic lichens of conservation interest recorded on Ash by epiphytic habitat including the total number of Section 41 species and those Section 41 species assessed in this report

Habitat	Threatened	NT	Nb	S41	S41 Assessed
Smooth Bark	3	5	16	2	1
Mesic Bark	8	4	7	5	3
Base Rich	9	24	41	14	6
Acid	0	2	22	0	0
Nutrient Rich	6	1	5	4	4
Wound	6	2	6	4	4
Dry bark & Lignum	1	5	14	2	0
Canopy	1	3	0	3	1

- ***Graphidetum scriptae***: a species rich in lichenised species on older stems in better lit and aerated conditions. In the south west of Britain this is the main community for species of conservation interest.

- ***Pyrenula chlorospila – Pyrenula macrospora* nodum**: a generally species poor undescribed community (but probably related to the *Pyrenuletum chlorospilae* Giralt, (Bricaud 2010)) dominated by *Pyrenula* species in damp humid conditions. This is very widespread as a species poor community. Rare rich examples occur in rain tracks on ancient Beech and Hornbeam trees in southern England and on Ash in Ireland (close to the French community *Pyrenuletum chlorospilae enterographetosum* Giralt (Bricaud 2010)).

- ***Pyrenula laevigata – Pyrenula occidentalis* nodum**: in very wet hyperoceanic climates, a very rich and unique assemblage displaces the above communities (Coppins & Coppins, 2012). It is primarily found in the west Highlands but outliers occur in the Lake District and North Wales. This assemblage is best developed on Hazel but does extend on to slow growing Ash.

Young Ash trees in humid habitats are characteristically dominated by smooth bark communities, especially by the species poor *Pyrenula chlorospila – Pyrenula macrospora* nodum but also the *Graphidetum scriptae* where better lit. Rare species do occur on Ash, for example *Arthonia anglica* EN (NR/IR/S41), but these are usually found on slow growing suppressed young Ash in *Graphidetum scriptae* communities. In Ireland *Enterographa elaborata* CR (NR/S41) has been recorded in the species rich *Pyrenula chlorospila – Pyrenula macrospora* nodum, and could potentially occur in such habitats in south west England. Some significant *Pyrenula laevigata – Pyrenula occidentalis* nodum species are also recorded from Ash in Scotland, including species such as *Arthothelium macounii* VU (NR/IR/BAP) and *Graphis alboscripta* NT (NR/IR/BAP). Ash is rarely the most important smooth bark substrate on individual sites but four Threatened, five Near Threatened species and 16 Notable species are recorded from Ash in Edwards' (2012) data, which are typical of smooth barked communities.

3.2.3 Mature Mesic Bark Community

Mature Mesic Bark Community (*Pertusarietum amarae* & *Parmelietum revolutae*). These are found on mature and less acidic bark on the wet side of mature to ancient trees. The basic community is composed of widespread lichen species, especially *Pertusaria* species including *Pertusaria hymenea*, *Pertusaria pertusa* and *Pertusaria amara* f. *amara* along with *Phlyctis argena*. This community occurs widely through the countryside on mature trees but additional ancient woodland species can occur in older woodland stands and in parks, especially on veteran trees. On well-lit bark, the dominant crust forming lichens are partly displaced by leafy "*Parmelia*" species. Two distinct communities occur on mesic bark:

- ***Pertusarietum amarae***: communities dominated by crust forming species occur in sheltered somewhat shaded conditions. A widespread habitat, which is locally significant for species of conservation interest. Best developed in southern and drier climates; it is displaced by moss-dominated communities in the most humid habitats. Rare species are mainly either southern old woodland species or a species of more open trees with a sub-oceanic distribution.

- ***Parmelietum revolutae***: communities in which the leafy species are much more prominent and that occur in more strongly lit situations. A ubiquitous habitat with few species of nature conservation interest.

This habitat does not include a large number of species of conservation interest in the British Lichen assemblage but the species in this assemblages are quite catholic in their choice of trees and most are found on older Ash trees. Ash is particularly important for some species such as *Arthonia zwackhii* NT (NS). It is also important for some of the sub-oceanic field tree species, such as *Caloplaca herbidella* VU (NR/S41) in polluted areas, where the preferred substrate, Oak is now too acidic. The south western species *Teloschistes flavicans* VU (NS/S41) also has Ash as a significant host as an epiphyte. A total of seven Threatened, five Near Threatened species and seven Notable species are recorded from Ash in Edwards' (2012) data, which are typical of mature mesic bark communities.

3.2.4 Base Rich Bark Woodland Community

Base Rich Bark Woodland Community (*Lobarion pulmonariae* & *Agonimion octosporae*): a very rich habitat best developed on veteran trees with base rich bark. Typically found on bark that is flushed by base rich water from above. Unlike many other communities the basic community is composed of ancient woodland species so any occurrence is of interest.

On damp bark with a high pH, base-demanding mosses are usually prominent. This moss community can occur in both shady and exposed conditions and in both situations the *Lobarion* lichens are absent. However, in intermediate light conditions a rich community of ancient woodland lichens can develop. There is a critical balance between light and humidity, which varies from east to west. Further west in humid climates light levels become more critical than shelter from summer sun. In western areas as well as old canopy trees the leafy species can also occur older bushes such as Sallow and Hazel. This may be associated with areas were the growth rate of the leafy species are fastest (Eaton & Ellis, 2014). With these rich assemblages can occur on much younger bushes than the typical old canopy trees. The requirement for high pH bark has made the community vulnerable to bark acidification caused by air pollution and some of the most sensitive species have declined drastically over the 20th century. The habitat shows a strong north to south gradient:

- ***Lobarion pulmonariae***: communities dominated by the classic large leafy species with fewer crust forming species in the north west. This assemblage is richest in wet hyperoceanic woodland (temperate rainforests) but extends well beyond this habitat in old growth woods and is a habitat of exceptional conservation interest.

- ***Agonimion octosporae***: this community replaces the *Lobarion* in shaded humid woods in oceanic Mediterranean and southern Atlantic climates, with *Agonimia octospora* NT (NS/IR) and crust forming *Porina* species, especially *Porina hibernica* NT (NS/IR/S41) prominent. A strongly south-western assemblage that is richest in the New Forest (Sanderson, 2010a).

The *Lobarion pulmonariae* communities are exceptionally well developed on older Ash trees, especially in temperate rainforests. Ash is important throughout the range of the habitat but can be the dominant substrate is woods in the north west (**Maps 1** & **2**) where Oak is often less important (Coppins & Coppins 2005). In the south Oak tends to be the most important tree but Ash is typically the second most important substrate in many sites. *Wadeana dendrographa* NT (NS/IR/S42) is particularly Ash-dependant but many rare leafy species have important populations on Ash. On the edges of polluted areas relic *Lobarion pulmonariae* communities are most likely to survive on Ash. A total of nine Threatened, 24 Near Threatened species and 35 Notable species are recorded from Ash in Edwards' (2012) data, which are typical of base rich bark woodland communities, very high totals.

3.2.5 Acid Bark Woodland Community

Acid Bark Woodland Community (*Parmelion laevigatae*). These are distinctive communities that develop on well-lit but sheltered acid bark in woodlands in oceanic areas. There is a large variation across rainfall gradients that is not fully described:

- ***Parmelietum laevigatae***: is characteristic of old growth high altitude "cloud forest" in very wet areas. Shrubby and leafy species are especially prominent.

- ***Loxospora elatina– Thelotrema lepadinum* Nodum**: undescribed communities of lowland woods both within high rainfall areas and extending deep into drier areas in humid locations. Crust-forming lichens are more prominent and there are specialist crusts not found in the classic *Parmelietum laevigatae*. Includes in part Community Type M, the *Hypotrachyna laevigata – Loxospora elatina* Community of Ellis et al (2015) and the *Cladonia – Thelotrema* Community mentioned by Sanderson (2010a).

Ash is not a major substrate for this habitat, but a good number of acid bark species have been recorded on Ash. A few species such as *Biatora vernalis* Nb (IR) and *Lecidea sanguineoatra* Nb (IR) of less acid transitional habitats in areas impacted by acidifying pollution such as the Lake District have relic population mainly on Ash. No Threatened, two Near Threatened species and 22 Notable species are recorded from Ash in Edwards' (2012) data, which are typical of acid bark woodland communities.

3.2.6 Nutrient Rich Bark Communities

Nutrient Rich Bark Communities (*Xanthorion*: *Physcietum ascendentis* & *Parmelietum carporrhizantis*). These are naturally nutrient enriched bark habitats exist and are exploited by specialist species that can include some rare and threatened species. Modern agriculture, however, has massively increased the extent of nutrient rich bark and the amount of nitrogen deposited on epiphytic habitats. As a result, communities of rapidly colonising species are now widespread and replacing more diverse lichen assemblages, of both oligotrophic and strongly enriched habitats. There are various identified communities, many of which lack rare species. The more interesting are:

- ***Physcietum ascendentis***: nutrient enriched assemblages with leafy lichens frequent, ubiquitous as a species poor community but older trees in the eastern lowlands support rare species such as *Anaptychia ciliaris* subsp. *ciliaris* NT (NS/S41).

- ***Parmelietum carporrhizantis***: to the south west richer nutrient rich bark habitats grade from the *Physcietum ascendentis* towards the *Parmelietum carporrhizantis* with the appearance of *Parmelina carporrhizans* VU (NS/S41) along with other south-western species such as *Physcia clementei* NT (NS) and *Physcia tribacioides* VU (NS/S41).

The habitat is not rich in rare species overall but has a stronger representation of Threatened species, reflecting the threats to field trees from agricultural intensification and tree disease. Ash is a significant host for species-rich variants of this habitat, especially with the loss of old Elms. All the Threatened species recorded from Ash have this tree as a significant or principle host (Edwards, 2012). A total of six Threatened, one Near Threatened species and five Notable species are recorded from Ash in Edwards (2012) data, which are typical of nutrient rich bark communities, this includes is a large proportion of the threatened species of this habitat.

3.2.7 Wound Track Assemblages

Wound Track Assemblages (*Xanthorion*: *Gyalectinetum carneoluteae*). Wound tracks on base rich veteran trees can support specialist species that tend to occur in single species stands. This assemblage was best developed on veteran Elms and has obviously declined in recent years. Many characteristic species are now red-listed as Threatened and/or listed as S41 species due to the total loss of veteran Elm in the lowlands. Ash is a very important host for surviving population of this habitat. A total of six Threatened and one Near Threatened species are recorded from Ash in Edwards' (2012) data, which are typical of nutrient rich bark communities, this includes a large proportion of the threatened species of this habitat.

3.2.8 Dry Bark and Lignum Assemblages

Dry Bark and Lignum on Veteran Trees (*Lecanactidetum premneae, Calicietum hyperelli* & *Calicietum abietinae*): dry bark and lignum support small but specialist lichen assemblages, rich in species of conservation interest. These habitats are best developed in old growth stands and on long-lived trees with hard and rot resistant lignum. The habitat is widely defined here and includes the following communities potentially of interest on Ash:

- **Ancient Dry Bark Community (*Lecanactidetum premneae*)**: a southern oceanic community, typical of warm and moist, but not too wet, areas. The community grows on rough bark only occasionally reached by stem flow and mainly absorbs water from dew on veteran Oaks. Can occur on Ash but is rare. Internationally, it is very rare, and otherwise known only from a few sites in France, but is widespread in southern and south western Britain (James et al, 1977).

- **Mature Dry Bark Community (*Lecanactidetum abietinae*)**: found on the rough bark on the dry sides of mature woodland trees, mainly Oak but also Ash. Usually very species poor and dominated by *Lecanactis abietina*, but occasionally ancient woodland species can occur, especially in the transition to communities of the wetter side.

- **Dry Bark Community (*Calicietum hyperelli*)**: communities on dry bark on trees in open conditions. A common community on Ash but with few rare species

- **Lignum Communities (*Calicietum abietinae*)**: communities on dry acid lignum exposed on live trees, on standing dead trees and on dry part of large fallen trunks, especially if propped off the ground. Rare on Ash, but related assemblages with specialist species of less acidic lignum can occur on Ash.

Ash is rarely a core habitat for this habitat due to its short live span and soft lignum and many occurrences of specialist species of these habitats are part of larger population on adjacent oaks. Exceptions are mainly species of less acidic lignum, one Threatened species being *Chaenotheca laevigata* EN (NR/BAP) found only in Scotland.

3.2.9 Canopy Communities

Canopy Communities. These contribute greatly to site lichen diversity, but the vast majority of species are mobile fast colonising species of little conservation significance. Some rare species can occur in the canopy, including the mesic bark species *Heterodermia obscurata* NT (NS) and *Teloschistes flavicans* VU (NS/S41), for which Ash is a significant host. Two specialist rare canopy species are the pollution sensitive Tree Beards, *Usnea articulata* NT (IR/S41) and *Usnea florida* NT (S41), occurring in the Sheltered sub-canopy Community (*Usneetum articulato-floridae* var. *ceratinae*). Ash is only a minor substrate for these Tree Beards.

3.3 Vulnerability of base-rich bark woodland assemblages

3.3.1 Introduction

Of all the lichen assemblages that occur on Ash, the Base Rich Bark Woodland assemblage (*Lobarion pulmonariae*), is considered to have the highest conservation value. Because of this and its high vulnerability to Ash Dieback, it is evaluated in detail in this section.

3.3.2 Ecology and distribution

As demonstrated in **Chart 1**, Base Rich Bark Woodland is the most significant epiphytic habitat for threatened and notable species (the *Lobarion pulmonariae* assemblage). Few of the English Section 41 species in Table 1 are specialists of this habitat, with field and parkland trees more prominent for this group. Species of the Base Rich Bark Woodland assemblage are largely oceanic species and many have large stable populations in the western Highlands but are in serious decline outside of this area and across Europe. For this reason, many *Lobarion* lichens have not been assessed as threatened in Britain (Woods & Coppins 2012) and yet are in decline and threatened in England. In contrast, field and parkland specialists are southern (European) species; all threatened lichens of this assemblage have a presence in England.

The main occurrence of the *Lobarion* is within woodland but some parkland SSSIs in England support significant assemblages (Greenaway & Wolseley, in press). In woodland it occurs in the better lit parts whilst in parkland it occurs in both the more sheltered and humid parts.

3.3.3 Potential Ash Dieback Impact

The importance of Ash within old growth woods with rich Base Rich Bark Woodland assemblages is very variable; some sites of international importance lack Ash altogether, while in others Ash is the main substrate for rare lichens. Impacts from Ash Dieback and any mitigation will be very site dependant. As such, a range of recent important sites with recent surveys are summarised in the Case Studies (section 5) to illustrate the range of threats. More useful information on the current condition of the *Lobarion pulmonariae* habitat is given in Greenaway & Wolseley (in press).

Common characteristics:

- The *Lobarion pulmonariae* communities are exceptionally well developed on older Ash trees, especially in temperate rainforests.
- Ash is important throughout the range of the habitat but can be the dominant substrate in woods in the north west, where Oak is often less important.
- In the south and south west, Oak tends to be the most important tree but Ash is typically the second most important substrate at many sites.
- On the edges of acidified polluted areas, relic *Lobarion pulmonariae* communities are most likely to survive on Ash.
- Leafy lichens with cyanobacteria as the main photobiont are more frequent on Ash, Hazel, Sallow than Oak but leafy species with green algae dominant tend to favour Oak (Greenaway &Wolseley, in press), while crust forming species strongly prefer Oak.

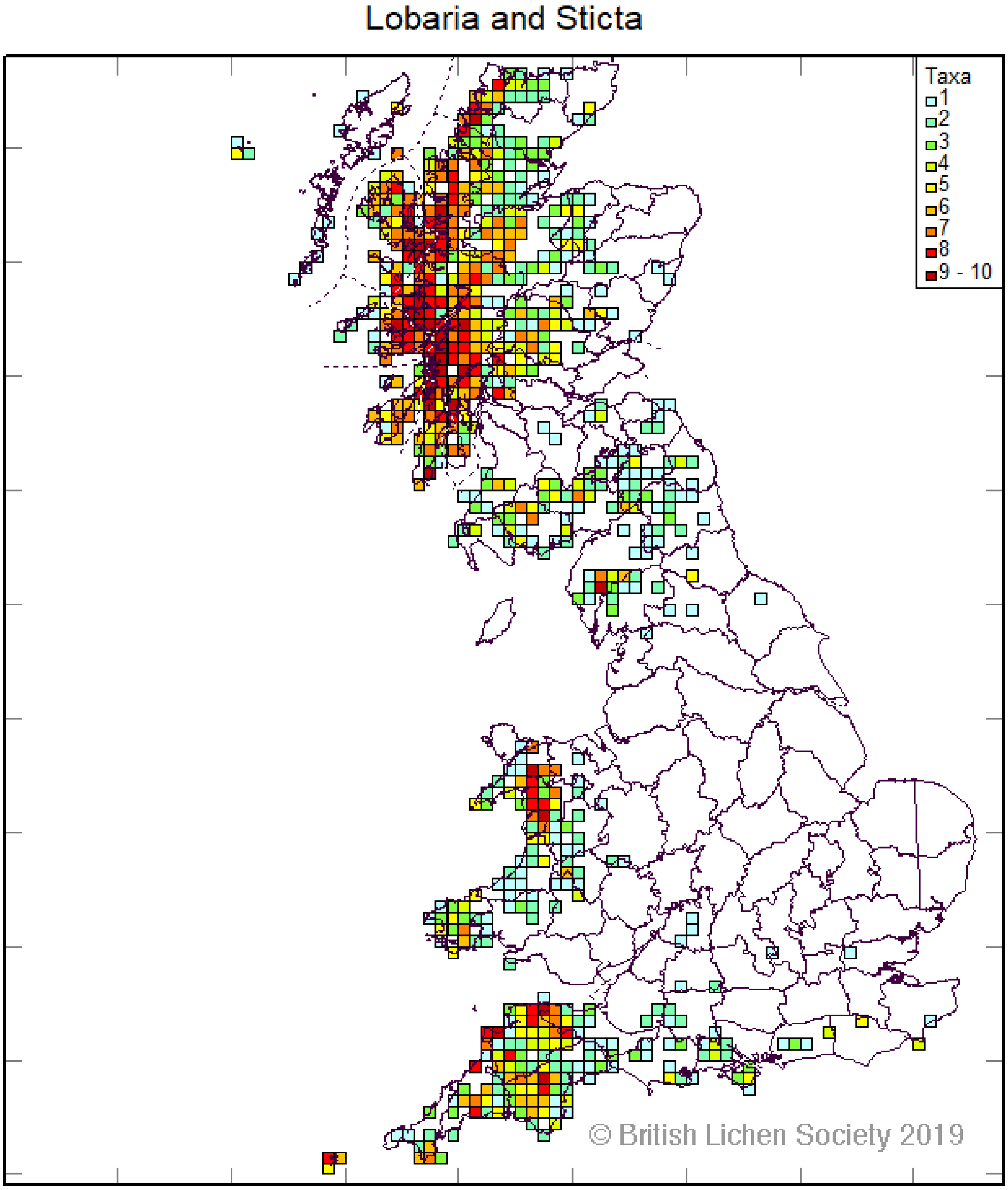
Greenaway &Wolseley (in press) give the English distribution of the main tree species supporting leafy *Lobarion* species post 2000. This shows that Ash occurs as an epiphytic substrate for this group of species through the surviving range of this group of species. Oak is nearly as widespread but the trees surviving furthest into areas impacted by acidifying pollution are invariably Ash. The native Field Maple supports these species where it overlaps with the surviving distribution of leafy *Lobarion* species, with recent records in the New Forest, Cranbourne Chase (Dorset), Eridge Park (Sussex) and Horner Combe (Somerset). The introduced Sycamore is a widespread substrate in Devon and Cornwall and rare in the western Lake District but is absent as a substrate beyond. Beech is very significant in The New Forest in native old growth Beech woods, but has also been colonised locally in Devon and Cornwall and rarely in the Lake District.

One significant group are the shrub species Sallow, Goat Willow and Hazel. In core *Lobarion* areas in the west these can be very significant and are important in that they can be colonised within decades as opposed to 100 or more years for canopy trees, an important factor in mitigation. They also support strong populations of the cyanobacteria-dominated *Lobarion* species that also prefer Ash to Oak as a habitat.

Greenaway &Wolseley (in press) show willows to be very significant as substrates in Devon, Cornwall and the far west of Somerset, while Hazel as a *Lobarion* substrate has a similar distribution in south west England, and is also rare in the Lake District. Given the importance of these substrates for mitigation the distribution of *Lobaria* and *Sticta* species was mapped across Britain on Sallow and Hazel (**Maps 2 – 4**). The distribution of all records of *Lobaria* and *Sticta* species (**Map 2**) was compared to records of these species from willow species (**Map 3**) and from Hazel (**Map 4**).

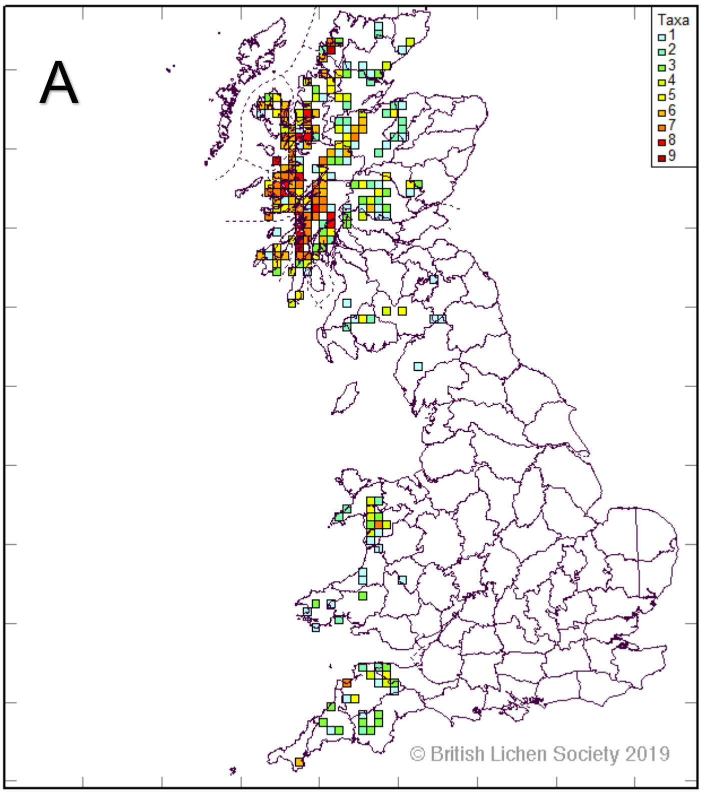
The distribution in the Scottish Highlands shows that both willows and Hazel support *Lobarion* assemblages throughout the range of the habitat but with Hazel richer than Sallow. This area is both unpolluted and has many little disturbed old growth woodlands. To the south this pattern is not repeated. Willow and Hazels are significant in south west England (Devon, Cornwall and the far west of Somerset) but are absent as hosts east of this along the south coast. Most strikingly, in the Lake District, Sallow is absent as a substrate and Hazel is very rare.

Map 2: Distribution of *Lobaria* and *Sticta* species in GB. Colours represent the number of species in each grid square. © British Lichen Society 2019. Reproduced with permission.

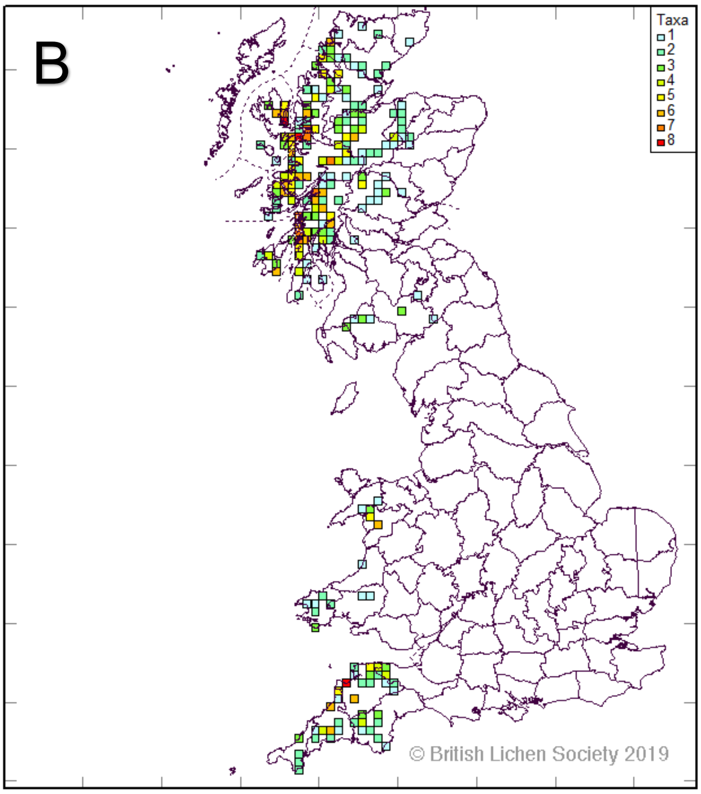


Map 3 (above) and 4 (below): Distribution of *Lobaria* and *Sticta* species in GB on Hazel (A, above) and Sallow (B, below). Colours represent the number of species in each grid square. © British Lichen Society 2019. Reproduced with permission.

Lobaria and Sticta on Hazel



Lobaria and Sticta on Sallow



The most likely factor explaining this is acidification; the Lake District was badly impacted by acidification and is still widely in exceedance for acid deposition (APIS Website), while other areas lacking *Lobarion* on willow or Hazel were badly impacted in the past. Some observations of recovery with de-acidification have been made. In Horner Combe, South Somerset, Hazel lacked leafy *Lobarion* species in the 1990s but *Sticta* species had colonised Hazels by 2012 (Sanderson 2017d). The Barle Valley to the south, which was less impacted by acidification always had *Sticta* species on Hazel. In the New Forest Sallow have generally lacked Base Rich Bark Woodland Community (*Lobarion pulmonariae* & *Agonimion octosporae*) species. Recently, although leafy *Lobarion* species have not colonised, new records of specialist Base Rich Bark Woodland assemblage crust forming species (mainly *Agonimion octosporae* species) from Sallow have been made: *Agonimia octospora* NT (NS/IR), *Leptogium lichenoides*, *Opegrapha corticola* Nb (IR), *Phyllopsora rosei* Nb (NS/IR), *Porina coralloidea* Nb (NS/IR) and *Porina rosei* NT (NS/IR).

Damp base-rich part shaded rocks, usually within woodlands are also a significant habitat in upland areas and have, at some sites, clearly acted as refugia for sensitive species during past periods of intensive woodland management. These are much more significant in Scotland than in England and Wales. The BLS database has 12,091 records of *Lobaria* and *Sticta* species (including duplicates), of which 11% were recorded on rock, with 14% on rock in Scotland, 9% on rock in Wales and 5% in England. All occurrences of leafy *Lobarion* species are vulnerable to loss due to increasing shade, especially from reductions in grazing pressure but rock sites are especially vulnerable. In England *Lobarion* has been recorded on rock in West Cornwall, East Cornwall, South Devon, North Devon, South Somerset, North Northumberland and Cumberland with most records from South Devon, followed by Cumberland. The rocky areas of woodland they occur in are both difficult to graze in the first place and the flushed base-rich rocks are fertile, so can support vigorous growths of Ivy and Bramble. At Gowbarrow Park in the Lake District, the richest rock *Lobarion* site in northern England was completely destroyed by fencing out of grazing from a rocky pasture woodland (Sanderson, 2017c) allowing Bramble overgrowth.

3.3.4 Management issues and potential solutions

Mitigation options for this assemblage must focus on optimising conditions of the habitat alongside provision of alternative substrates including trees and base-rich rock and will reflect many of the issues identified for other species above e.g. maintaining habitat quality, preventing shading by maintaining trees Ivy free and grazed habitats around surviving trees, both potentially resistant Ash trees and occupied alternative tree species.

3.3.5 Risk level assessment

The Base Rich Bark Woodland Assemblages, especially the *Lobarion pulmonariae* has been assessed as having a **HIGH** risk; the assemblages are very much linked to Ash and loss of Ash will inevitably result in local and possibly regional extinctions along with added pressures on already threatened assemblage.

3.4 Section 41 Species vulnerability assessments

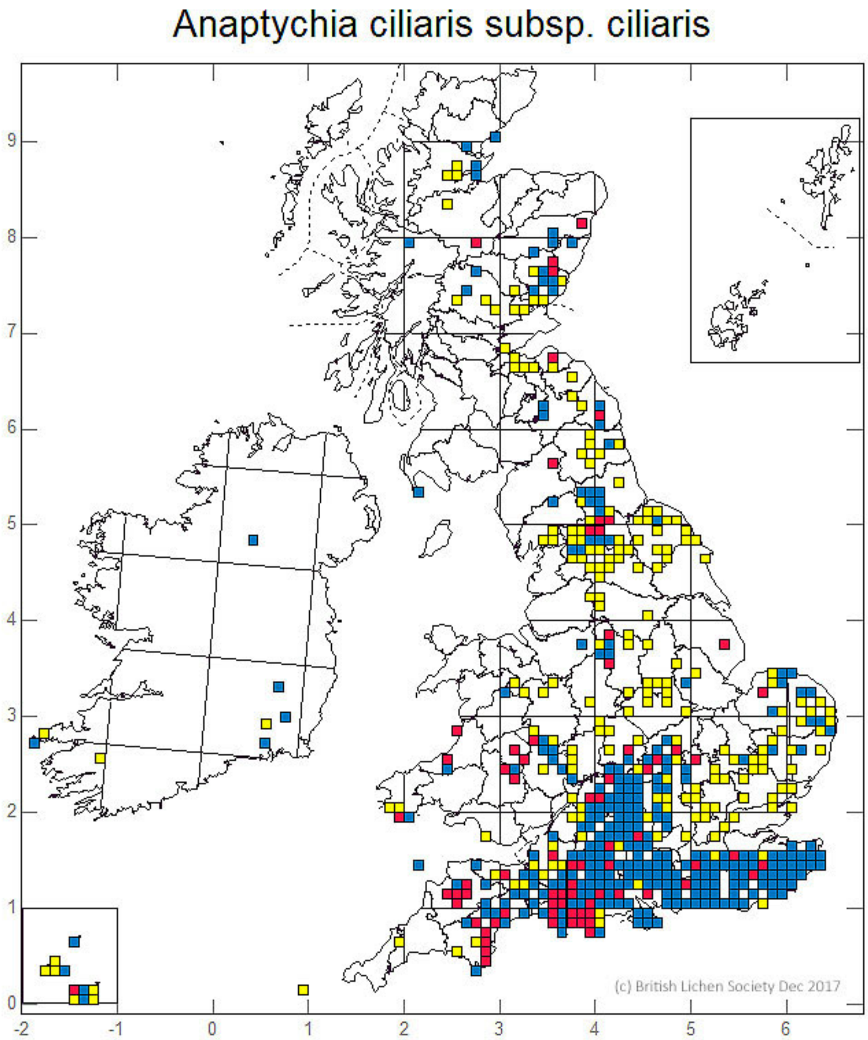
3.4.1 *Anaptychia ciliaris* subsp. *ciliaris* HIGH RISK

Ecology and Distribution

Anaptychia ciliaris subsp. *ciliaris* EN (NS/S41/S42/Sc) is a large prominent leafy lichen of sunny well lit nutrient and base rich bark on the trunks and upper branches of basic-barked trees, particularly Ash, Elm, Maple and Sycamore in high quality Nutrient Rich Bark Communities (*Physcietum ascendentis*). An eastern and southern lowland species (**Map 5**). Edwards (2007) describes it as having always been a species of agricultural landscapes and is most often found on old trees in parks, pastures and along roads and track ways. Over the last forty years subsp. *ciliaris* has undergone a significant decline and has become very rare or extinct in many counties, including some where it was formerly widespread such as Kent. Between 1960 and 1979 it was recorded from 259 10-km squares, but between 1980 and 2000 there are records from just 79 10-km squares. The reasons for this decline are a combination of the death of large Elms due to Dutch Elm disease, atmospheric and agricultural pollution and the continuing loss of old wayside trees. He describes the overall distribution of the species as having now shifted from south-east England to southern and south-west England with the largely rural counties of Devon and Dorset supporting the majority of the surviving populations. In the south-east it is largely extinct as an epiphyte, but survives very locally on memorials in old churchyards.

Before Ash Dieback, Edwards (2007) described it as remaining very vulnerable, as it is confined to just one or two trees at many of the surviving sites. At several sites it had been lost due to Ivy colonising the tree trunk. As the species occurs in otherwise improved landscapes it is poorly represented within Sites of Special Scientific Interest.

MAP 5: Distribution of *Anaptychia ciliaris* subsp. *Ciliaris.* Yellow = 1959 or earlier, Blue = 1960 – 1999, Red = Post 2000. © British Lichen Society 2017. Reproduced with permission.



Potential Ash Dieback Impact

The BLS database contained 97 English records with detailed substrate data recorded for *Anaptychia ciliaris* subsp. *ciliaris* from 2000 or later (including duplicate records but excluding two miss-dated Francis Rose records). Of these, 27% were on rock, mainly in churchyards (but also on stone walls) and 73% were on trees. Of the tree records, 47% had Ash present and 34% had only Ash. Otherwise 38% of the tree records were Sycamore and 30% were on Oak with small numbers of records from Field Maple, Beech and Walnut.

Ash is the most important tree supporting *Anaptychia ciliaris* subsp. *ciliaris* and a third of all records were from sites with only Ash. There is a distinct geographic concentration in the Ash records, which are all from the core area of survival for the species from East Gloucestershire, North Wiltshire, North Somerset, Dorset, North Devon and South Devon. North and east of this, recent records mainly on Oak in

Hampshire, and Sycamore to the north and east of this, or on rock. These records are very scattered and it seems unlikely that there are viable meta-populations beyond the core area of survival in the south west. The loss of Ash will lead to the total loss of many sites and significant population reductions within the core area and this area will become closer to the relict status of the rest of the country.

Management Issues and Potential Solutions

Anaptychia ciliaris subsp. *ciliaris* clearly has viable alternative substrates, particularly Sycamore and Oak. The latter is probably only suitable in areas distant from past acidifying air pollution and the lichen is only recorded from Oak in the south west, west of Hampshire. Additional threats to the lichen that should be tackled are the overgrowth of trees by Ivy, atmospheric and agricultural pollution and the continuing loss of old wayside trees. The threat from Ivy is under appreciated but results mainly from the mechanisation of hedge cutting; with hand cutting Ivy was routinely cut from hedgerow trees. The south western stronghold of the species, which also supports other threatened parkland and field tree species, requires specific targeting with measures to maintain high quality habitat on farmland trees.

Risk Level Assessment

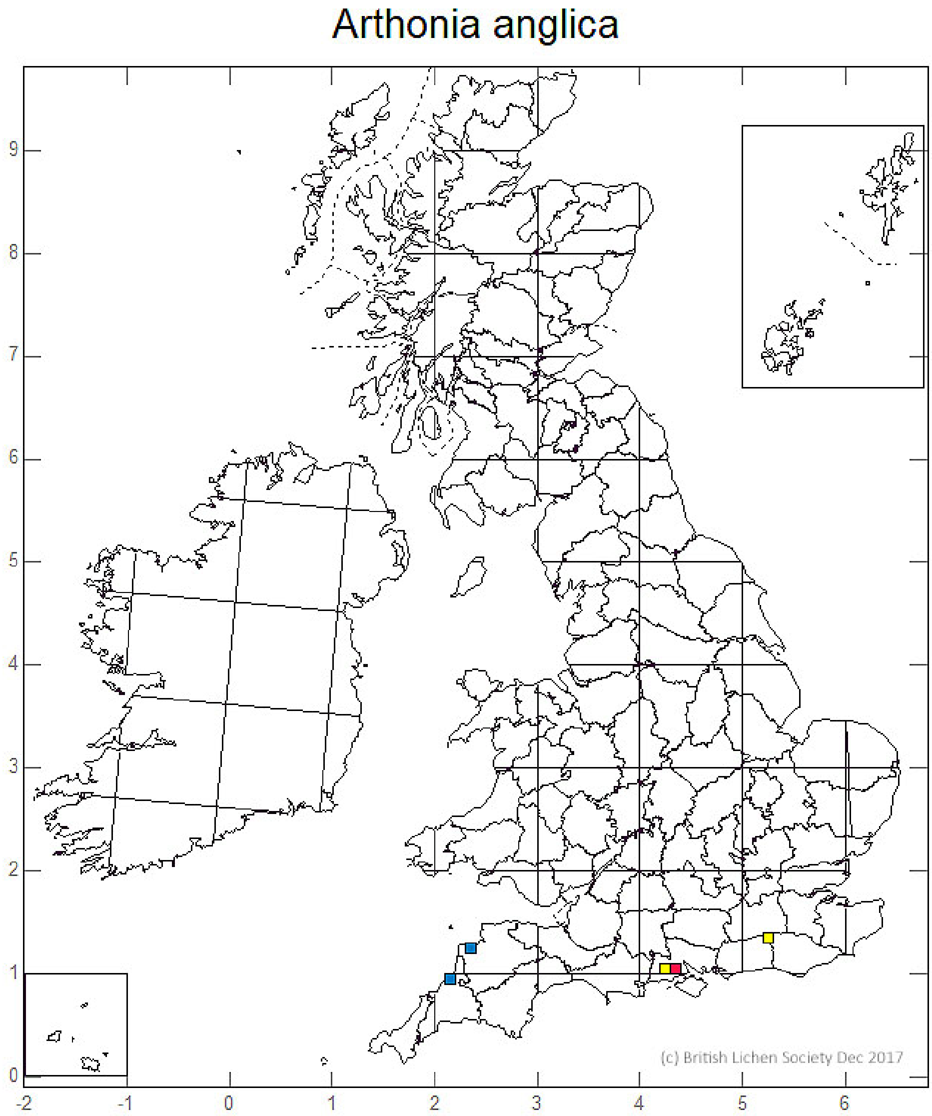
Anaptychia ciliaris subsp. *ciliaris* is assessed as having a **HIGH** level of risk due to Ash being its primary substrate and Ash sites supporting a third of the English population. It is a highly vulnerable species regardless of the threat of Ash Dieback.

3.4.2 *Arthonia anglica* MEDIUM RISK

Ecology and Distribution

Arthonia anglica EN (NR/IR/S41), is a crust forming species first collected from old Breeches in Sussex in the early 19th century and from Holly in the New Forest in the later 19th century. Not seen again until it was recorded from two areas in the north coast of Devon and north east coast of Cornwall between 1974 to 1998 on Holly, Ash and Hazel. Not seen from the latter area in the 21st century but refound on Holly in the New Forest in 2016 (**Map 6**). A southern oceanic – tropical species confined to species-rich Smooth Bark Communities (*Graphidetum scriptae*) in woodlands rich in rare woodland lichens. Confined to woods with a strong continuity of Smooth Bark Communities habitat, which are rare in the south west and mainly found in coastal woods on the north coast. The lichen looks similar to *Arthonia astroidestera*, except it lacks the white pruina on the stellate apothecia and is UV–. Certainly genuinely very rare but easy to overlook if the surveyor is not experienced with the species. Also very rare in Europe, but apparently frequent in eastern USA and reported from Africa.

MAP 6: Distribution of *Arthonia anglica.* Yellow = 1959 or earlier, Blue = 1960 – 1999, Red = Post 2000. © British Lichen Society 2019. Reproduced with permission.



Potential Ash Dieback Impact

All the BLS database records were analysed. This species appears very rare and vulnerable in the New Forest, but is confined to Holly there, with suitable Ash habitat absent. Although not recorded for 20 years from the north coast of Devon and Cornwall, it is still likely to be present, none of the sites being either recently surveyed, or specifically surveyed, for this difficult to spot species. It is obviously very rare in the south west as well, but it is not clear how rare without new surveys. Here it has been recorded from five separate locations in two areas:

- Hobby to Peppercombe SSSI - The Hobby (SS3224): 1974 on Holly
- Clovelly - cliff wood and park (SSSI) (SS3125): 1976 on Ash

- Peppercombe - Worthygate Wood (SS3623): 1977 on Holly
- Tamps Wood, Millook Valley (SX1899): 1989 on Ash
- Hobby to Peppercombe SSSI - Sloo Wood (SS3723): 1998 on Holly & Hazel

This data indicates that the lichen was confined to Ash at two out of five sites. No detailed reports have been seen on the habitat of *Arthonia anglica* and there appear to have been no recent surveys of the habitat in the Clovelly to Peppercombe area. The Millook Valley has been looked at more recently (Sanderson, 2011). This found rich Smooth Bark Communities (*Graphidetum scriptae*) to be best developed on old Hollies, but it also occurred on Hazel, Rowan and Birch, while Ash were rather species poor. It seems most likely that the *Arthonia anglica* was growing on suppressed young Ash, an ephemeral habitat, potentially having colonised from a stable habitat on an old Holly.

Management Issues and Potential Solutions

A survey of the Devon and Cornwall habitats is recommended, but from the current evidence it is likely that the main population is on Holly. Ash, however, is a significant host in this area, but potentially a more ephemeral one than old Hollies. Increasing shade within woods, especially where former woodland grazing has been removed (Sanderson, 2011a), is a threat.

Risk Level Assessment

Arthonia anglica is assessed as having a **MEDIUM** level of risk due to its main populations being on Holly, but Ash a regionally significant, if ephemeral, host.

3.4.3 *Bacidia incompta* MEDIUM RISK

Ecology and Distribution

Bacidia incompta (Vulnerable, NS/S41), was a widespread crust forming species on old Elms, and occasionally other species, in wound tracks and inside hollow trees (Wound and Rain Tracks Assemblages, the *Gyalectinetum carneoluteae*). It grew on both park, field and wayside trees and within old growth woodlands. These were mainly veteran trees, but it can rarely be found on suppressed, slow growing damaged young trees. It is now close to extinct on Elm due to Dutch Elm disease destroying veteran Elms. The New Forest has been the only place it has been recorded frequently in recent decades. Here it has been found mainly on old Beech and Holly in old growth pasture woodlands. Otherwise, it is still found on a thin scatter of trees in southern England, with Edwards (2006a), only recording eight sites as having two or more trees. The total is now higher with 102 records on the BLS database post 2006 outside of the New Forest, which included at least 12 additional sites with two or more trees supporting *Bacidia incompta*.

Outside the New Forest it is typically found on veteran Field Maple, Ash, Sycamore, and Horse Chestnut, mainly in the south west but with scattered recent records in the midlands, East Anglia, eastern Wales, northern England and eastern Scotland (**Map 7)**. A few relic populations survive on Elm mostly on the Isles of Scilly and in the far north of England, where old Elms have survived but there is an intriguing record from Elm suckers in Huntingdonshire, suggesting some ability to survive Dutch Elm Disease. Habitats include parkland trees, hedgerow and field trees and better lit woodland trees.

Edwards (2006a) describes the lichen outside of the New Forest as often restricted to just single trees, many of which are in a decrepit or senescent state. The most immediate threat to the species is the loss of the host trees through natural ageing, wind-throw or felling for safety reasons. In most sites tree continuity is a problem as there are not sufficient old wounded trees to support viable populations. He considered that only the New Forest meta-population of *Bacidia incompta* could be considered viable in conservation terms. Sanderson (2009b) estimated the New Forest population of *Bacidia incompta* in wound tracks on the lowest 2m of the trunks of veteran Beech as between 630 and 1260 trees. It also occurs widely on veteran Hollies and has also been recorded in small wound tracks on branches in the canopy of veteran Beeches here (Cross & Sanderson, 2012). *Bacidia incompta* is consequently likely to occur on over 2000 trees at any one time in the New Forest.

From post 2006 surveys, the author feels that the negative prognosis for sites outside of the New Forest is somewhat overstated in Edwards (2006a). There are a few parks and pasture woodlands with sizable populations and a potential succession of veteran trees. On the other hand, many other occurrences are single isolated trees that probably do represent the non-viable remains of former large Elm base meta-populations.

Potential Ash Dieback Impact

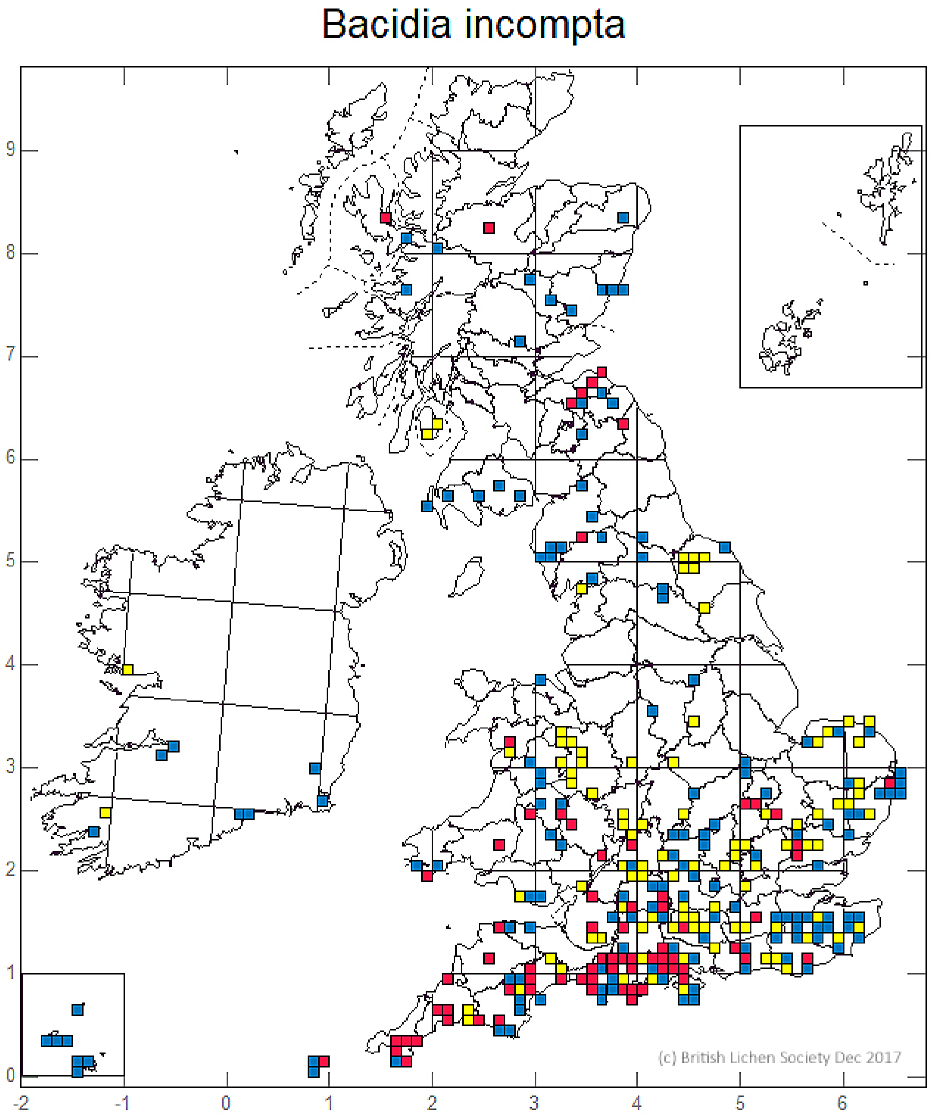
The BLS database contained 332 post-2000 English records of *Bacidia incompta* of which 292 have detailed substrate data (including duplicate records). Of the detailed records, 164 were made from the New Forest and 128 beyond the New Forest (Table 3).

Table 3: *Bacidia incompta* records post-2000 in BLS Database:

Substrate	Total	Beyond the New Forest	New Forest
Beech	122	14	108
Holly	61	7	54
Field Maple	33	32	1
Ash	**27**	**25**	**2**
Sycamore	16	16	0
Elm	14	14	0
Horse Chestnut	13	13	0
Oak	8	8	0
Fir	2	1	0
Aspen	1	1	0
Holm Oak	1	1	0
All records	292	128	164

Outside of the New Forest Ash is second only to Field Maple as a host, but with Sycamore and Horse Chestnut also significant. Ash with surviving *Bacidia incompta* is biased to the south being recorded in West Cornwall, South Devon, North Somerset, North Wiltshire, South Wiltshire, Dorset, West Sussex and North Essex. Ash is the only host at several sites, including Woodend Deer Park (Shute, South Devon), Spye Park SSSI (North Wiltshire), Langley Wood NNR (South Wiltshire), Sherborne Park & Lyscombe & Highdon Downs SSSI (Dorset). The occurrence of Field Maple in particular but also Sycamore and Horse Chestnut as alternative hosts at many other sites with *Bacidia incompta* on Ash is clearly an important buffer against Ash die back impact. Ash die back will create significant losses to a species already heavily stressed outside of the New Forest but it will survive in many sites and the existing pressures outlined by Edwards (2006a) will be made more acute.

MAP 7: Distribution of *Bacidia incompta*. Yellow = 1959 or earlier, Blue = 1960 – 1999, Red = Post 2000. © British Lichen Society 2017. Reproduced with permission.



Management Issues and Potential Solutions

Mitigation is similar to other field tree species; conserve populations of other suitable veteran trees and plan for future replacements. Maintain or restore the habitat in which they occur. This includes reducing agricultural pollution, retaining veteran trees until death and prevent increasing shading from adjacent trees or Ivy. Artificially wounding trees to provide new habitat has been attempted by Ray Woods. In woodlands, allow veteran Sycamore and Beech to develop where this does not compromise the conservation status of native woodlands.

Risk Level Assessment

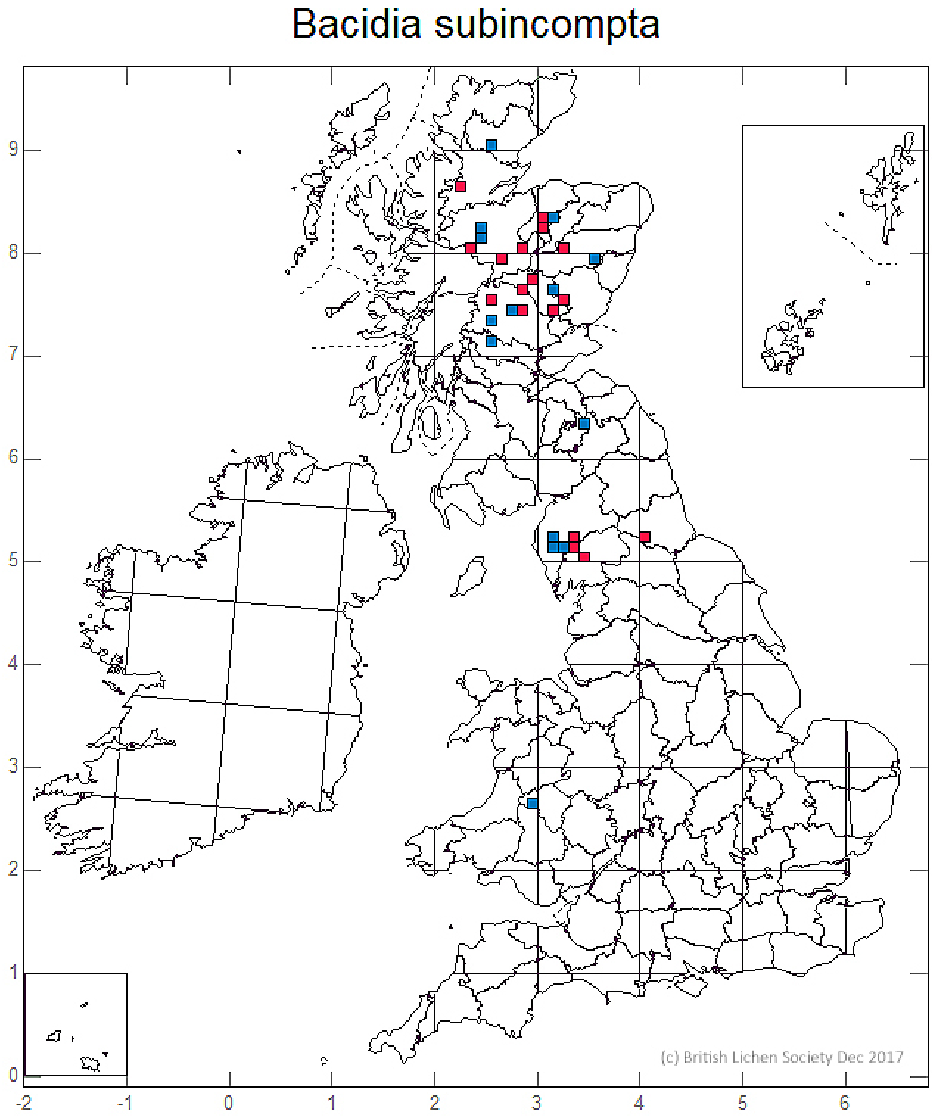
Bacidia incompta is assessed as having a **MEDIUM** level of risk; although Ash Dieback may have a significant impact beyond the New Forest it has a range of hosts alongside Ash and will likely survive in many sites because of this. The significant New Forest population is primarily on beech.

3.4.4 *Bacidia subincompta* MEDIUM-HIGH RISK

Ecology and Distribution

Bacidia subincompta (Vulnerable, NS/S41 & Draft Eng. Red List CR) is a crust-forming species found in wound tracks and rain tracks on base rich trees (Wound and Rain Tracks Assemblages, the *Gyalectinetum carneoluteae*). Woods & Coppins (2012) describe it as "confined to sites of ancient woodland or wood pasture, and growing on the bark of mature Ash, Elm, Birch and Oak. In Europe it occurs widely in such habitats where not severely affected by atmospheric pollution. Since its first British discoveries in 1969 at two sites in northern England, it has been found at a second locality in the Lake District, one in Wales, one in the Scottish Borders and 19 in the Scottish Highlands (**Map 8**). At all sites, its populations are small and confined to just one or a few trees. It is apparently extinct at its Welsh site owing to the loss of its host tree (an elm), and in Scotland there appears to be only 12 post-1990 records, and one of those was from a recently fallen Ash. The UK population appears to be less than 1000 and there is evidence of ongoing decline and total loss from Wales." Since then it was found in a further three 10km national grid squares in two further sites in the Lake District in 2016. It has been recorded from Ash, Oak, Aspen and Elm in temperate wood and on wounded ancient Birch trees in Scottish Boreal woodlands. In England it has been recorded only from Oak and Ash.

MAP 8: Distribution of Bacidia subincompta. Yellow = 1959 or earlier, Blue = 1960 – 1999, Red = Post 2000. © British Lichen Society 2017. Reproduced with permission.



Potential Ash Dieback Impact

The BLS database records *Bacidia subincompta* from one site in County Durham (Shipley and Great Woods SSSI), where it was found on Oak in 1996 and refound in 2007 and from four sites in the Lake District. The two original sites in the Lake District were recorded in 1996 at Scales Wood, Buttermere and Seatoller Wood, the latter on Oak, the former on an unspecified tree. These have not been refound since, and probably not looked for. In 2016 it was found on ancient Ash trees in Troutbeck Park (one tree) and Glencoyne Park (two trees) (Sanderson 2016 & 2017a). The discovery on three new trees in a single survey in the Lake District suggest the species is seriously under recorded in this area, which reflects a general lack of commissioned surveys of important pasture woodland sites in the Lake District this century.

Management Issues and Potential Solutions

The recent discoveries suggest that there is likely to be a significant population in the Lake District, with a significant proportion of this on Ash, but there is a lack of data due to under recording in this area in this century. It is difficult to quantify this threat from Ash Dieback without further survey. Other previous and ongoing threats to the species in the north are likely to be past acidifying pollution, withdrawal of grazing from pasture woodlands in the name of conservation management increasing shade, a decline in Ash pollarding and lack of replacement maturing trees.

Risk Level Assessment

Bacidia subincompta is assessed as having a **MEDIUM-HIGH** level of risk; it is known from Oak as well as Ash. However, this is difficult to quantify without further survey, and recent records from the Lake District suggest that Ash may well be the more significant host in which case its threat level should increase.

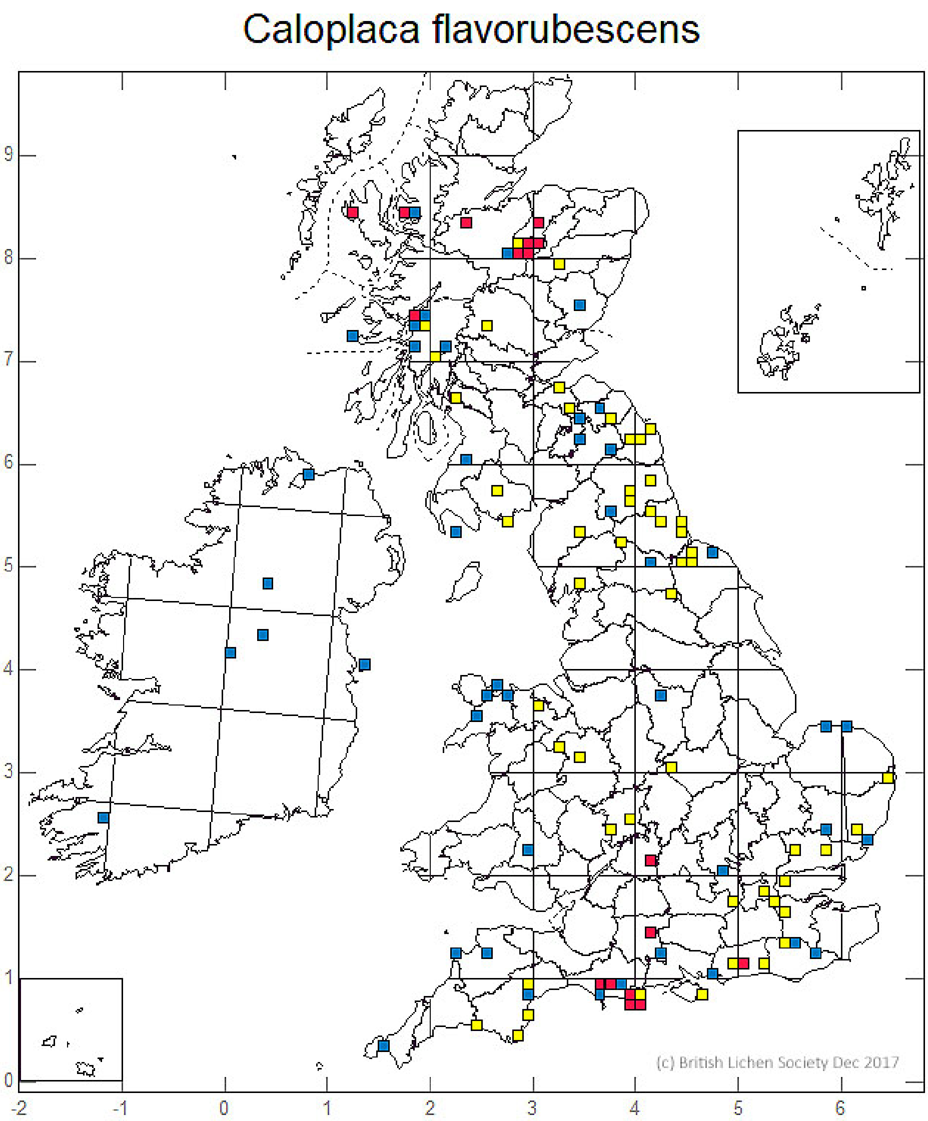
3..5 *Caloplaca flavorubescens* VERY HIGH RISK

Ecology and Distribution

Caloplaca flavorubescens (Vulnerable, NS/S41), was a widespread crust-forming species before the Industrial Revolution on base and nutrient-rich bark (Nutrient Rich Bark Communities, the *Physcietum ascendentis*) on wayside and parkland trees, mainly Ash, except in the Scottish Highlands, where is also occurs on Aspen (Fletcher & Laundon 2009). Of 36 pre 2000 separate site records with detailed substrate data two were recorded from Oak, two were 19th century records from Elm (at one site also found on Ash) and one was a doubtful record from fence rails but the rest were from Ash. This species has always been a very strict Ash specialist, even before the advent of Dutch Elm Disease. Its former distribution (**Map 9**) suggests it was a strongly sub-oceanic species of veteran trees dependant on Ash in the south and Aspen in the Highland of Scotland and that acidifying pollution from sulphur dioxide was the main cause of past losses. This seriously impacted nearly all of its core area of distribution, leaving only a strong meta-population on Aspen in Speyside and a thin scatter of sites in possibly sub-optimal climatic conditions of the edge of its range in the south west. The latter amounts to nine locations recorded on or after 2000.

There appears to have been no detailed assessment of the threats to the surviving populations of *Caloplaca flavorubescens* but these are likely to be very similar to those facing *Anaptychia ciliaris* subsp. *ciliaris*.

Map 9: Distribution of *Calopaca flavorubescens*. Yellow = 1959 or earlier, Blue = 1960 – 1999, Red = Post 2000. © British Lichen Society 2017. Reproduced with permission.



Potential Ash Dieback Impact

The BLS database contained only 10 records post-2000 of *Caloplaca flavorubescens*, of which one was a duplicate record. Of the nine recorded sites, at six the lichen was only recorded on Ash (three in Dorset, one each in South Wiltshire, West Sussex and East Gloucestershire), Oak at two (Dorset) and on one site on Sycamore (Dorset). The known surviving sites include three parks, with the rest being farmland trees. This lichen in England is clearly already in a very critical condition and the threat from Ash Dieback could not be higher. The population in England may already not be viable.

Management Issues and Potential Solutions

Other than Ash Dieback, the threats to this lichen will be the same as other parkland and field tree species: overgrowth of trees by Ivy, atmospheric and agricultural pollution and the continuing loss of old wayside trees. The threat from Ivy is under appreciated but results mainly from the mechanisation of hedge cutting; with hand cutting Ivy was routinely cut from hedgerow trees. The Dorset stronghold of the species, which also supports other threatened parkland and field tree species, requires specific targeting with measures to maintain high quality habitat on farmland trees.

Risk Level Assessment

Caloplaca flavorubescens is assessed as having a **VERY HIGH** level of risk; Ash is the most significant host and the species is already under a very high level of threat in GB. The loss of Ash will lead to local extinction and increase pressures on an already highly threatened and rare species.

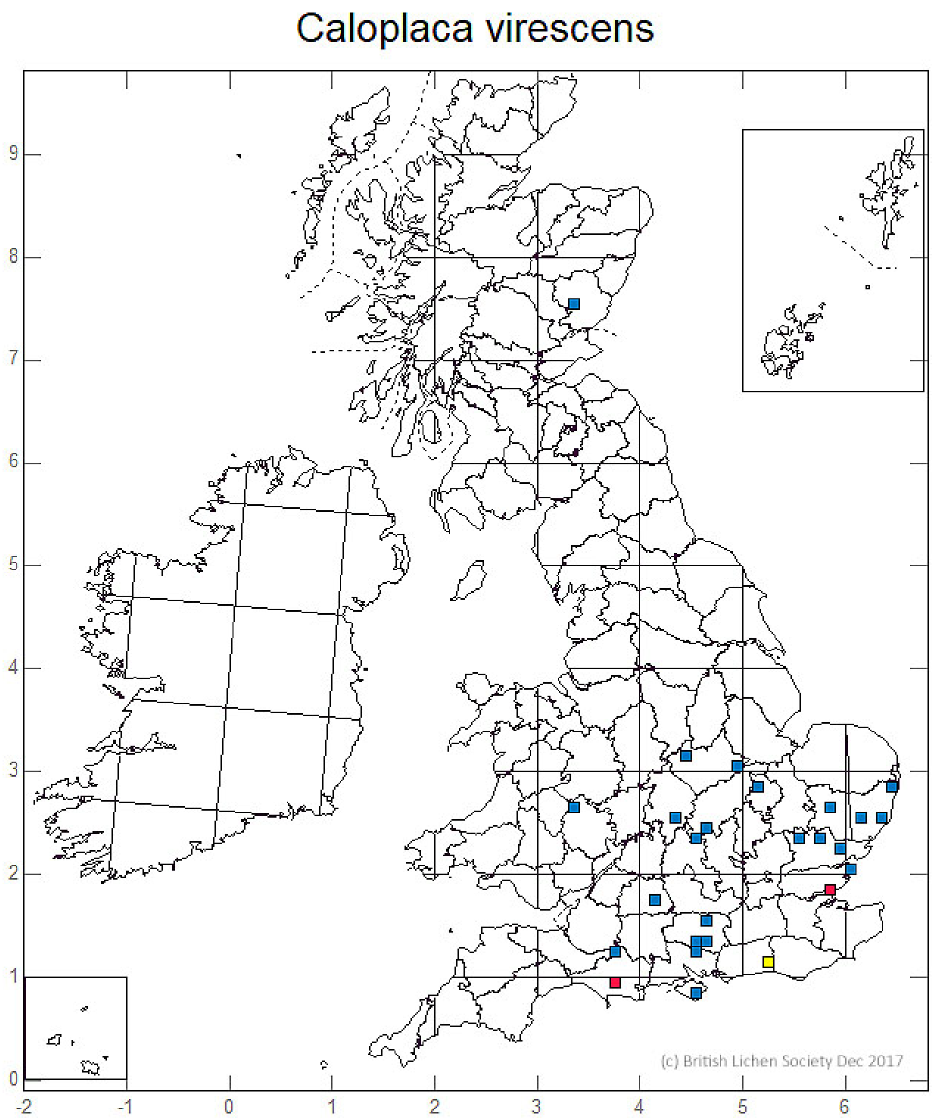
3.4.6 *Caloplaca virescens* UNKNOWN

Ecology and Distribution

Caloplaca virescens EN (NS/S41) is a usually sterile lichen that forms large patches of a thick, bluish-grey, densely granular-sorediate crust over the spreading bases of large parkland trees, especially Elm, but also Ash, Field Maple, Poplars and Sycamore. Found on veteran trees with base-rich and nutrient-rich bark (Nutrient Rich Bark Communities, the *Physcietum ascendentis*). Woods & Coppins(2012) state that "as the majority of its records are from elm, and given its distribution in England, it will certainly have suffered more than a 50% decline in the last 30 years, and trees supporting surviving populations are certain to number <250". A member of the *Caloplaca cerina* group, which is possibly a sterile morph of *Caloplaca monacensis* (Šoun et al, 2011), if this is the case *Caloplaca virescens* is the older name. There are 16 pre-2000 records in the BLS Database with detailed substrate data of which 10 were recorded from Elms (two on lignum), five from Ash and one from a Field Maple.

The species was strongly southern and eastern but there are very few modern records (**Map 10**). The locations recorded indicate a mixture of parkland and farmland trees. There appears to have been no detailed assessment of the threats to the surviving populations of *Caloplaca virescens* but these are likely to be very similar to those facing *Anaptychia ciliaris* subsp. *ciliaris*.

Map 10: Distribution of *Caloplaca virescens*. Yellow = 1959 or earlier, Blue = 1960 – 1999, Red = Post 2000. © British Lichen Society 2017. Reproduced with permission.



Potential Ash Dieback Impact

The BLS database contained only two post-2000 records of *Caloplaca virescens*, both from Essex with one given as occurring on a dead Elm, the other with no habitat. There is also a modern record from Dorset with no data. The probably conspecific *Caloplaca monacensis* has also been recorded from lignum on a tree in a churchyard in Somerset. Two of the non-Elm records in North Hampshire, one on Ash and one on a Maple, were recorded in the 1990s and both sites are thought to be extant but have not been visited since.

Management Issues and Potential Solutions

Caloplaca virescens, is clearly very threatened already, without the advent of Ash Dieback. There is a need to follow-up the few Ash and Maple records before any specific conservation measures could be suggested. Other than Ash Dieback, the threats to this lichen will be the same as other parkland and field tree species: overgrowth of trees by Ivy, atmospheric and agricultural pollution and the continuing loss of old wayside trees. The threat from Ivy is under appreciated but results mainly from the mechanisation of hedge cutting; with hand cutting Ivy was routinely cut from hedgerow trees.

Risk Level Assessment

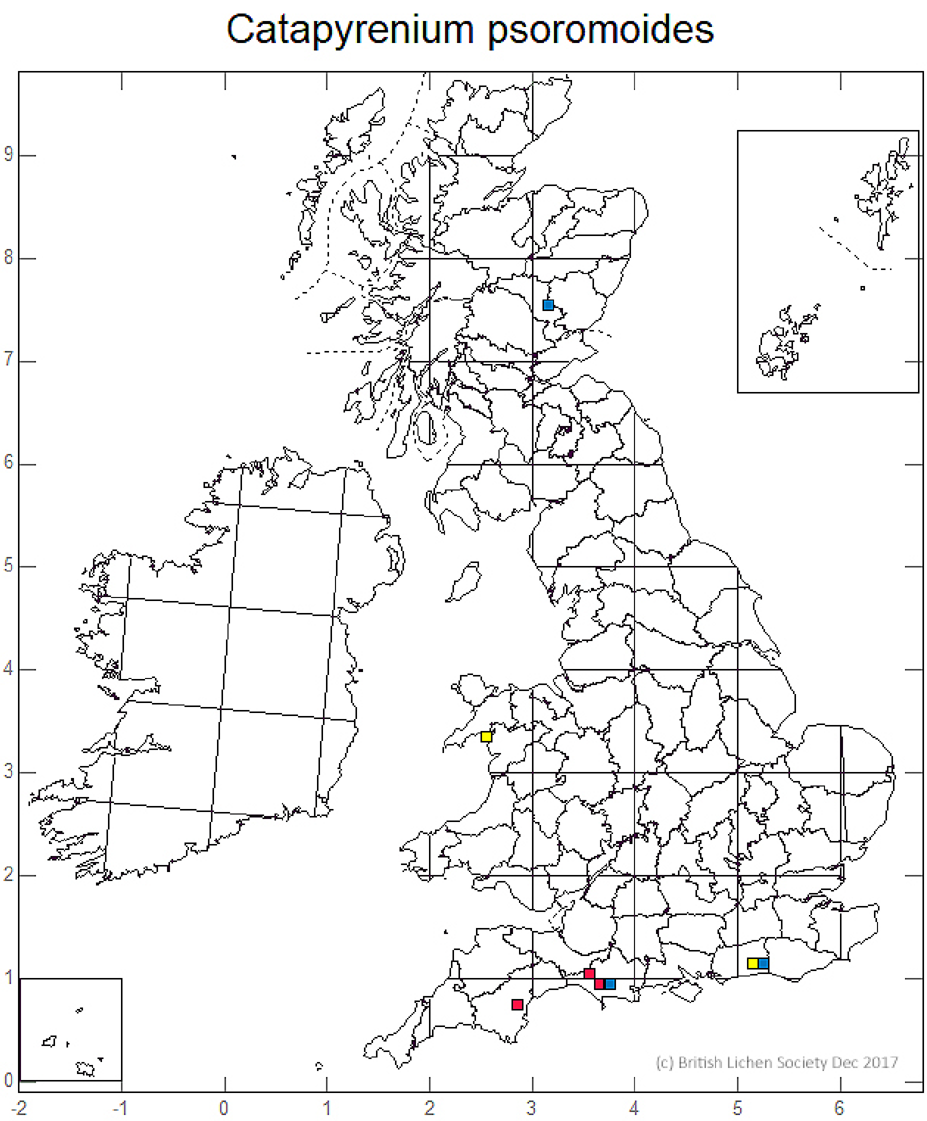
Caloplaca virescens is assessed as having an **UNKNOWN** level of risk; the taxon is too poorly known to assess, although it does appear to be known from hosts other than Ash.

3.4.7 *Catapyrenium psoromoides* VERY HIGH RISK

Ecology and Distribution

Catapyrenium psoromoides CR (NR/S41) is an internationally very rare lichen forming patches of appressed overlapping squamules on moss-and base-rich tree bark (Nutrient Rich Bark Communities, *Physcietum ascendentis*) and on calcareous rock. There are 19th century records from trees in West Sussex, but there are only modern records from a limestone outcrop in South Devon and three trees in Dorset (**Map 11**). The limestone site (Chudleigh Rocks) is a substantial one with a large population (Edwards, 2009) on two outcrops, but the three tree sites consist of populations on individual trees at each site, two Ash trees and an Oak.

Map 11: : **Distribution of *Catapyrenium psoromoides*. Yellow = 1959 or earlier, Blue = 1960 – 1999, Red = Post 2000.** © British Lichen Society 2017. Reproduced with permission.



Potential Ash Dieback Impact

There are only three recent records from trees, two of which are Ash trees and one an Oak in Dorset. Ash Dieback is therefore a severe threat to an already very rare species.

Management Issues and Potential Solutions

The large population at the limestone site in Devon is also in an ungrazed site and is dependent on active scrub management to maintain. The survival of the species in England certainly depends on continuing suitable management at Chudleigh Rocks and this should be secured (Edwards, 2009). As a squamulose species it may be possible to translocate the lichen from dying Ash trees, which could be a last ditch conservation measure. Otherwise the threats to this lichen will be the same as other parkland and field tree species: overgrowth of trees by Ivy, atmospheric and agricultural pollution and the continuing loss of old wayside trees. The threat from Ivy is under appreciated but results mainly from the mechanisation of hedge cutting; with hand cutting Ivy was routinely cut from hedgerow trees. The Dorset stronghold of the species, which also supports other threatened parkland and field tree species, requires specific targeting with measures to maintain high quality habitat on farmland trees.

Risk Level Assessment

Catapyrenium psoromoides is assessed as having a **VERY HIGH** level of risk; two of its three tree localities are on Ash, and being limited to just a small number of sites it is already at a high level of risk without the added threat of Ash Dieback.

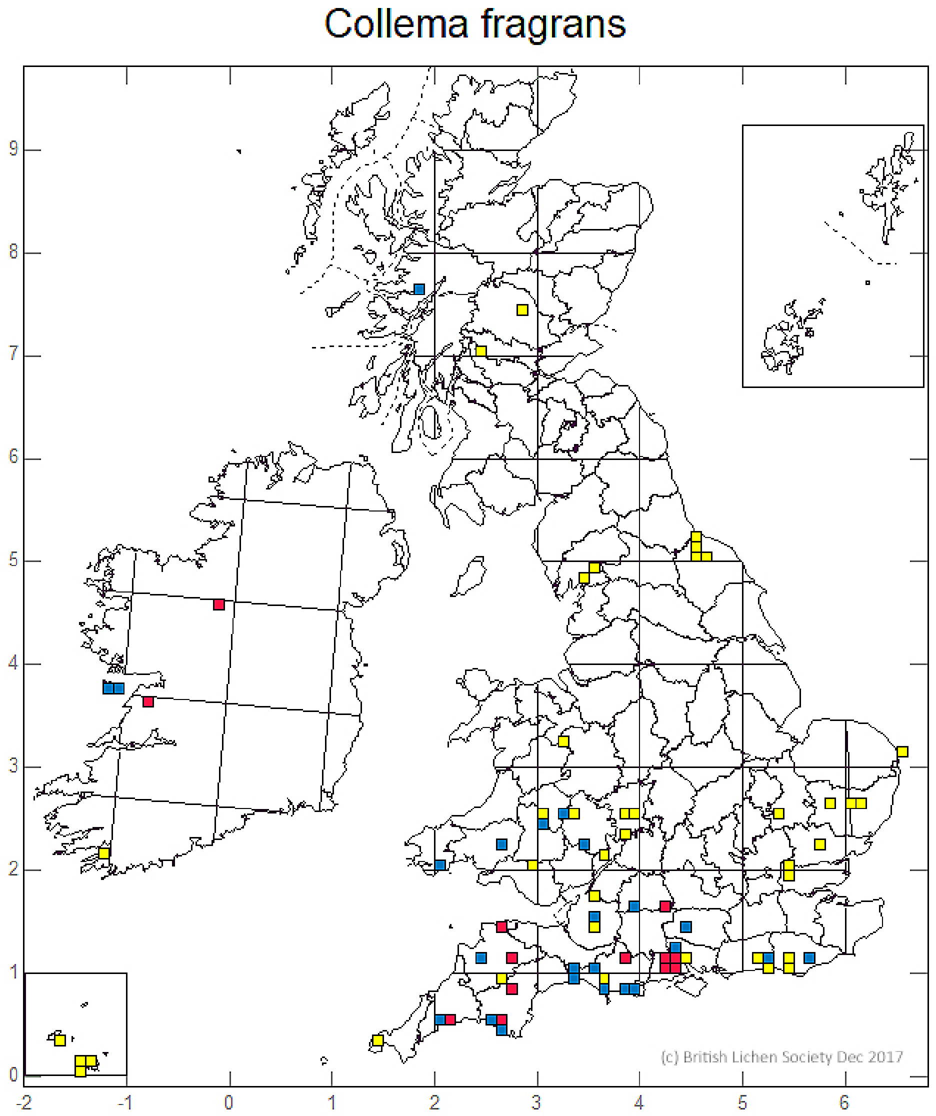
3.4.8 *Collema fragrans* HIGH RISK

Ecology and Distribution

Collema fragrans EN (NR/IR/S41) is a small black squamulose lichen, which is a specialist of wound tracks on veteran trees (Wound and Rain Tracks Assemblages, the *Gyalectinetum carneoluteae*). It was a southern lowland species (**Map 12**), which was especially characteristic of veteran Elm trees but has been completely lost from that habitat since the arrival of Dutch Elm Disease. Outside of the New Forest prior to 2000, of 35 records with detailed substrate data in the BLS database, 28 were from Elm, four from Ash and single records from Field Maple, Horse Chestnut, Beech and Oak. There is still a large population on wounded Beech trees in the New Forest but it is now very rare outside of the New Forest. Edwards (2005) found the species had been lost from 16 vice-counties and outside of the New Forest only recently recorded from four sites; two in Devon, one in Dorset and one in Savernake Forest, Wiltshire. At the first three sites the lichen was on Ash trees and the latter was on an Oak. Since 2005 *Collema fragrans* has been found at three new sites, in East Cornwall on Horse Chestnut, South Devon on Sycamore and South Somerset on Sycamore but has been lost from the final Dorset site, where it was on Ash (B. Edwards, pers. com.).

In contrast to the situation beyond, *Collema fragrans* is still widespread in the New Forest, with 18 woods with post 2000 records, often on more than one tree. These are nearly all on Beech but there are also two recent records from Ash and one on Holly. Sanderson (2009b) found the species less frequent in the New Forest than *Bacidia incompta*. The latter was found on 6.7% of Beech trees with wound tracks while *Collema fragrans* was on only 2.8% of these. The lower abundance of *Collema fragrans* suggests it has a narrower niche and/or is a poorer coloniser, which would explain its near extinction beyond the New Forest. Within the New Forest Sanderson (2009b) estimated this lichen was likely to occur on between 350 and 700 trees within 1000 to 2000 ha of suitable habitat. *Collema fragrans* is sometimes directly associated with the endangered Section 41 moss *Zygodon forsteri* in the New Forest.

Map 12: **: Distribution of *Collema fragrans*. Yellow = 1959 or earlier, Blue = 1960 – 1999, Red = Post 2000.** © British Lichen Society 2017. Reproduced with permission.



Potential Ash Dieback Impact

Outside of the New Forest since 2000 *Collema fragrans* has been recorded from three Ash trees, two Sycamores, one Horse Chestnut and one Oak but at least one of the Ash tees has already been lost. Ash Dieback would certainly be devastating to a population already in a perilous condition.

Management Issues and Potential Solutions

It is possible that this species can only maintain sustainable populations in large populations of veteran Elm and Beech. Currently the species survival in Britain appears entirely dependent on a continued abundance of senescent Beech with wound tracks within a single management unit, the New Forest. As such restoring other old growth Beech woods, which were formerly polluted, may be an effective long term method of creating new habitat. Savernake Forest, with a single relic population *Collema fragrans* on an Oak and numerous ageing Beech trees is an obvious target. Artificially wounding trees has been suggested as a conservation method for this species and *Bacidia incompta* and could be trialled at a suitable location.

Risk Level Assessment

Collema fragrans is assessed as having a **HIGH** level of risk; Ash is a significant host and the species is already in a perilous position outside of the New Forest. In the New Forest it remains relatively widespread and is primarily known from Beech.

3.4.9 *Cryptolechia carneolutea* HIGH RISK

Ecology and Distribution

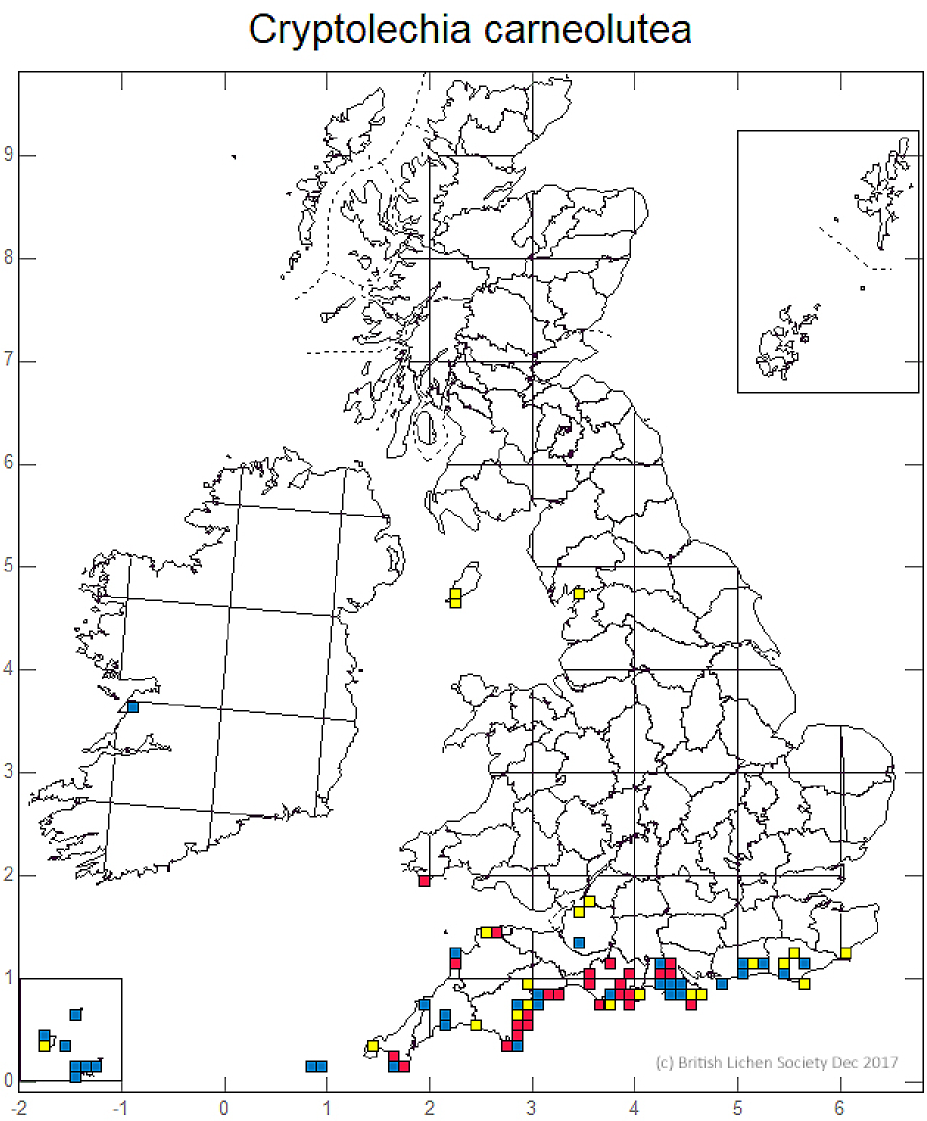
Cryptolechia carneolutea EN (NS/IR/S41) is a crust forming species of wound tracks on ancient trees with base rich bark (Wound and Rain Tracks Assemblages, *Gyalectinetum carneoluteae*). It was a strongly southern species (**Map 13**) particularly characteristic of veteran Elm trees, 55% of the pre 2000 records is the BLS Database are from Elm but with Ash also a significant substrate with 23% of records along with 11% of records on Beech. Minor substrates were Field Maple, Oak, Sycamore, base-rich rocks and Ivy. Since Dutch Elm Disease only a single population survives on a live Elm, causing widespread losses (Edwards, 2006b), but the reduced population is still widespread if rare west of the Isle of Wight and New Forest due to surviving populations on Beech in the New Forest and Ash elsewhere. Woods & Coppins (2012) state it is "estimated that it is now found on 50–75 trees, many of which are veterans and in poor condition". About 10 colonies are known at any one time in the New Forest on senescent Beech trees. The species appears quite mobile here, with new trees, including clear recent colonisation found, but also with known trees collapsing (Sanderson 2019). Sanderson (2009) estimated that *Cryptolechia carneolutea* occurred on between 10 – 26 trees in between 100ha to 250ha of suitable habitat in the New Forest. Edwards (2006b), lists 22 post 1990 sites outside of the New Forest, the majority on Ash, but with dead Elms, Sycamore, Horse Chestnut, Field Maple, Oak and Ivy also recorded. Since 2006 the BLS Database has eight records additional to those in Edwards (2006b) including a single record from an Elm in South Devon, but otherwise from Ash and Maple.

The habitat of the surviving trees is a mixture of field trees, parkland, veteran trees in recent woodland (as on coastal slopes) and in gazed ancient pasture woodlands. Edwards (2006b) describes the threats as: "although capable of surviving on trees other than Elm this species is still under threat. In Dorset, at many sites it is confined to single trees, and two sites have recently been lost as the trees have been blown down or died naturally. This species is fairly shade tolerant but like many lichens do not thrive in dense woodland and in the some sites is threatened from being smothered by Ivy."

Potential Ash Dieback Impact

The BLS database contained 49 post 2000 English records of *Cryptolechia carneolutea* with detailed substrate data (including duplicate records). Of the detailed records, 15 were made from the New Forest on Beech and 34 beyond, of which none were on Beech. Outside of the New Forest 47% of records were from Ash, 21% from Field Maple and 12% from Sycamore. Minor substrates were Elm (mostly dead), Norway Maple, Ivy over rock, Oak, Yew and Limestone. *Cryptolechia carneolutea* had retained what may have been sustainable populations, but the loss of Ash would likely jeopardise this. There will still be significant populations on maple species, but the species will have again been more than halved. A sustainable population will survive in the New Forest Beech woods but it is likely to need direct intervention to conserve beyond the New Forest.

Map 13: **Distribution of *Cryptolechia carneolutea*. Yellow = 1959 or earlier, Blue = 1960 – 1999, Red = Post 2000.** © British Lichen Society 2017. Reproduced with permission.



Management Issues and Potential Solutions

Mitigation is similar to other field tree species; conserve populations of other suitable veteran trees and plan for future replacements. Maintain or restore the habitat in which they occur. This includes reducing agricultural pollution, retaining veteran trees until death and prevent increasing shading from adjacent trees or Ivy. Woodland trees, which are more important for *Cryptolechia carneolutea* than some other parkland and field tree lichens, are especially vulnerable to Ivy invasion. The south west English stronghold of the species, which also supports other threatened parkland and field tree species, requires specific targeting with measures to maintain high quality habitat on farmland trees.

Risk Level Assessment

Cryptolechia carneolutea is assessed as having a **HIGH** level of risk; Ash is a significant host with approx. 50% of the population outside of the New Forest on Ash. The New Forest is likely to retain a sustainable population on Beech.

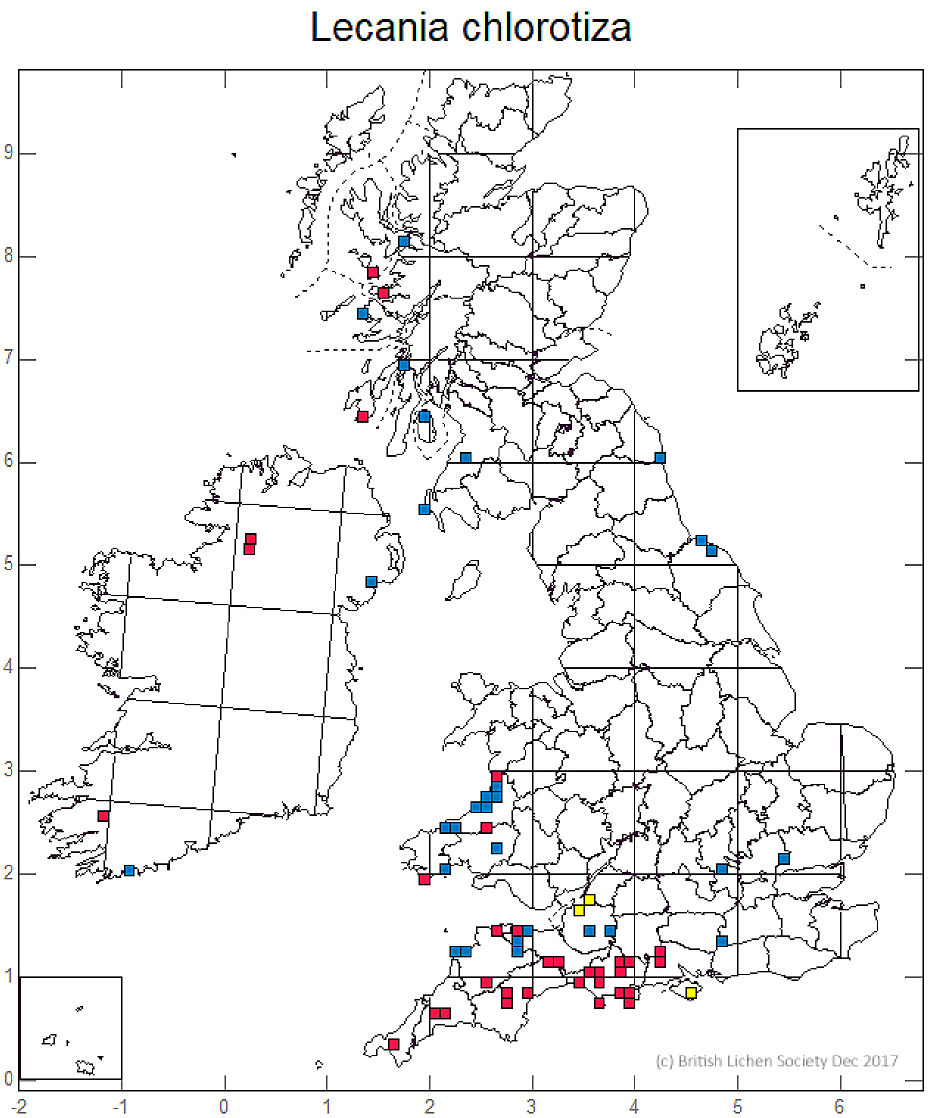
3.4.10 *Lecania chlorotiza* MEDIUM RISK

Ecology and Distribution

Lecania chlorotiza NT (NS/IR/S41) is a crust forming species of base rich bark in humid locations in the south east of Britain (**Map 14**). The BLS Database records with detailed substrate data (including duplicate records) indicate that Oak is the main substrate with 52% of the records, with 20% from Ash and 17% from Ash, other minor species include Field Maple, Yew, Horse Chestnut, Beech and Poplar. The woodland communities in which it grows are probably referable to the south-western form of the Base Rich Bark Woodland Community (*Agonimion octosporae*), probably grading to other communities in more open habitats.

It occurs in woodland, pasture woodland and veteran trees in ungrazed woods, and also trees in more sheltered areas of parkland and fields. The species is mainly south western in distribution, but there are outlying populations in ravine woodlands in the north east of England. Here all the records are from Elm or Ash but none are recent. Excluding these records Oak becomes even more important in the south west and accounts for 60% of the records as opposed to Ash and Elm 13% each.

Map 14: : **Distribution of *Calopaca flavorubescens*. Yellow = 1959 or earlier, Blue = 1960 – 1999, Red = Post 2000.** © British Lichen Society 2017. Reproduced with permission.



Potential Ash Dieback Impact

The BLS database contained 27 post 2000 English records of *Lecania chlorotiza* with detailed substrate data (including duplicate records), all from the south west. Of these 63% of records are from Oak, 22% from Ash and the rest are single records from Elm, Poplar, Yew, Beech and Horse Chestnut. Ash Dieback is likely to lead to local reductions in populations and some extinctions. The latter may also include regional extinction in north east England, although it has not been recorded here since the 1980s.

Management Issues and Potential Solutions

Mitigation would mainly be by ensuring that lichen rich habitats are well managed allowing colonisation of the alternative substrates. This includes preventing increasing shade on veteran trees in woodland and increasing habitat quality for field trees.

Risk Level Assessment

Lecania chlorotiza is assessed as having a **MEDIUM** level of risk; although Oak is the most significant host, loss of Ash will likely result in local reductions and some losses e.g. in north-east England (although it has not been recorded here for 40 years or more).

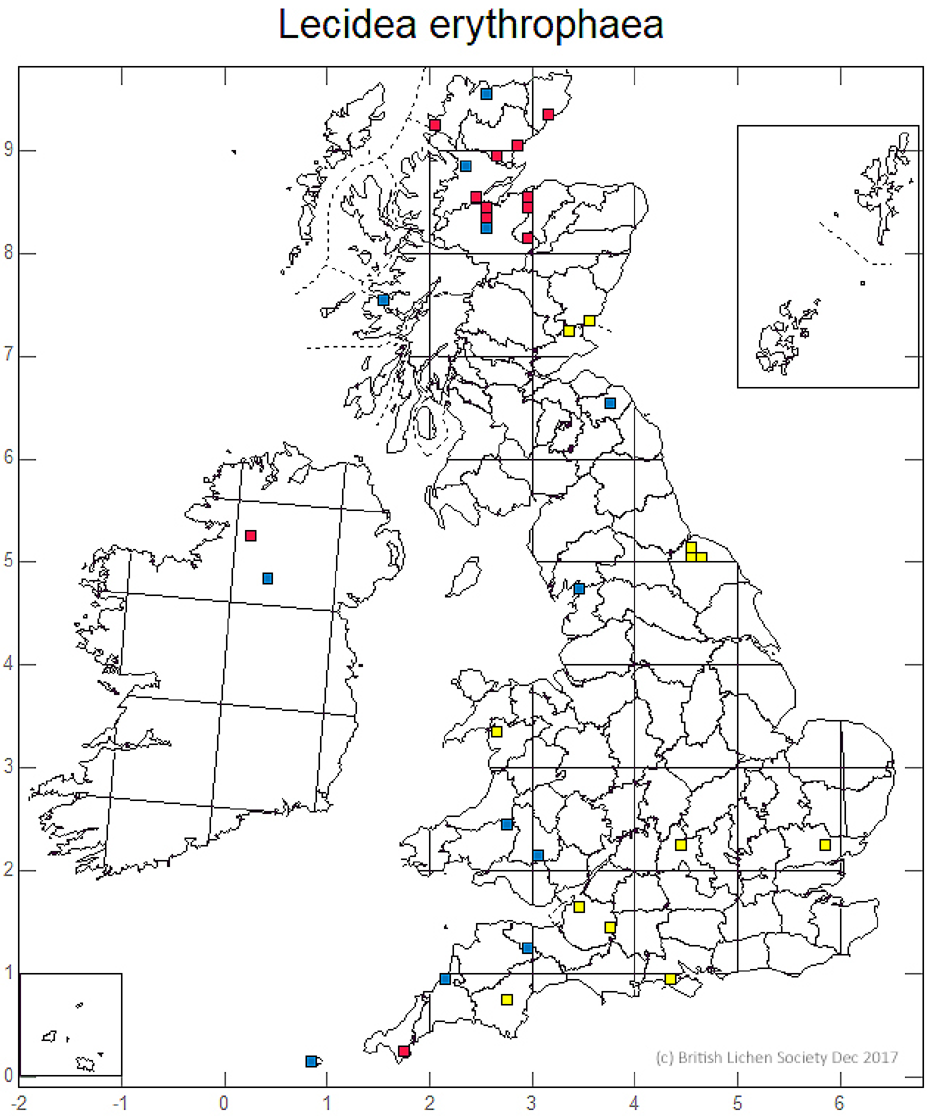
3.4.11 *Lecidea erythrophaea* UNKNOWN

Ecology and Distribution

Lecidea erythrophaea VU(NR/S41) is a small lichen with back disks on a white thallus, with few British records (**Map 15**). It has only recently been consistently recorded from eastern Scotland and only has very thinly scattered records from England, most of them old records. It is found on mainly young Ash but also on Hazel, Sallow and Aspen, in sheltered woodlands and, unlike most species considered here, has no association with veteran trees. There is only a single record from England after 2000, from Cornwall.

The species is easily overlooked but is certainly very rare in England. Given the lack of records is difficult to make an informed comment about the ecology of the species. The Scottish distribution suggests it may be a sub-oceanic species that has been lost to acidifying pollution from more favourable areas in the east of England.

Map 15: : **Distribution of *Lecidea erythrophaea*. Yellow = 1959 or earlier, Blue = 1960 – 1999, Red = Post 2000.** © British Lichen Society 2017. Reproduced with permission.



Potential Ash Dieback Impact

The only recent English record is from a fallen twig thought to be from an Ash. Of the few older records that have had the substrate noted previously it had been recorded on two other Ashes and a Sallow. Little definitive can be said about this species and Ash Dieback, it will certainly damage what population exists but it could survive on Sallow.

Risk Level Assessment

Lecidia erythrophaea is assessed as having an **UNKNOWN** level of risk; although Ash is probably the most significant host it is so poorly known that little definitive can be said.

3.4.12 *Leptogium cochleatum* UNKNOWN

Ecology and Distribution

Leptogium cochleatum VU (NS/IR/S41) is a hyperoceanic leafy species of sheltered frost-free locations in western Ireland and Scotland (**Map 16**) on base rich trees and rocks (Base Rich Bark Woodland Community *Lobarion pulmonariae*). In the past much confused with the more widespread fertile *Leptogium cyanescens* and all English records of *Leptogium cochleatum* are now known to be errors for *Leptogium cyanescens* (Gowbarrow, Westmorland), or lack voucher specimens, so cannot be accepted. It potentially could be found near the coast in the extreme south west but is most likely to occur on rocks there.

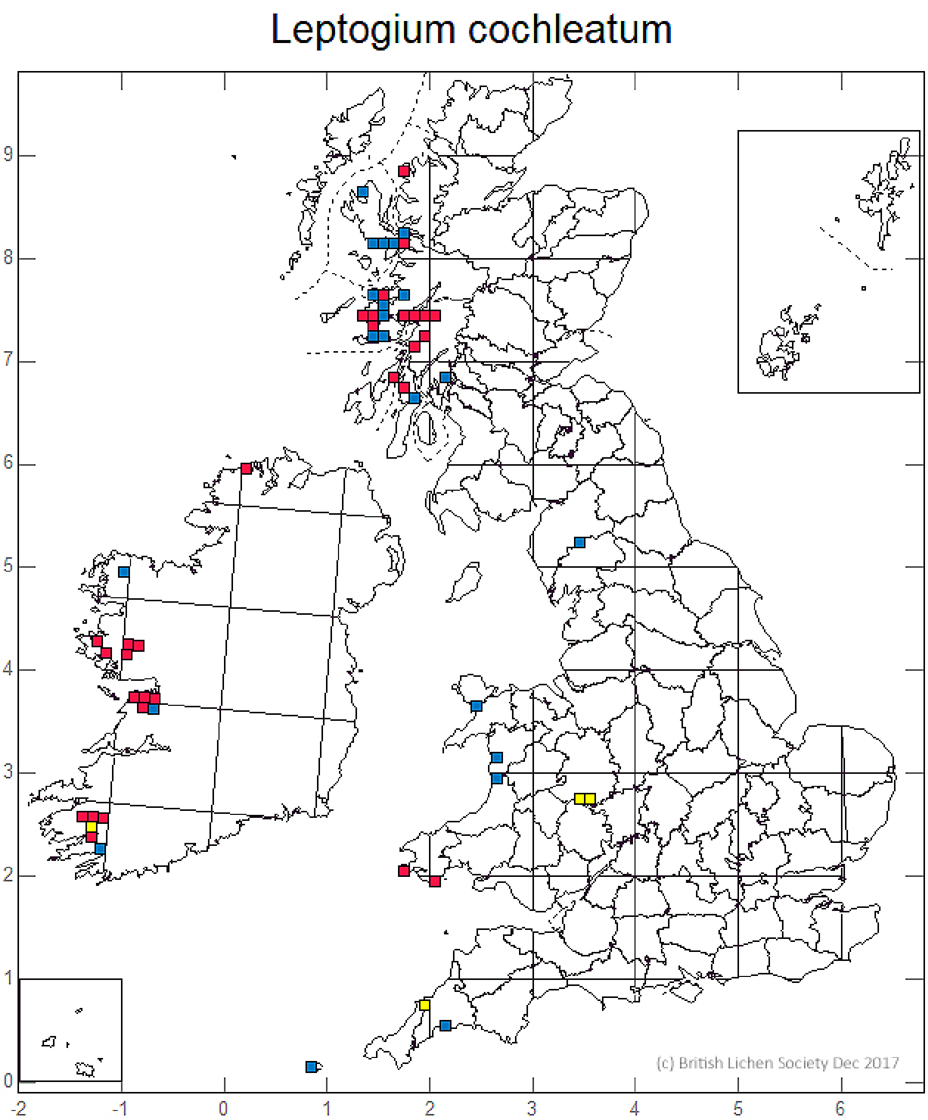
Potential Ash Dieback Impact

Ash Dieback is likely to be a serious issue for this species in western Scotland but the occurrence of the species is unproven in England.

Risk Level Assessment

Leptogium cochleatum is considered to have an UNKNOWN risk since there are no confirmed records from England.

Map 16: Distribution of *Leptogium cochleatum*. Yellow = 1959 or earlier, Blue = 1960 – 1999, Red = Post 2000. © British Lichen Society 2017. Reproduced with permission.



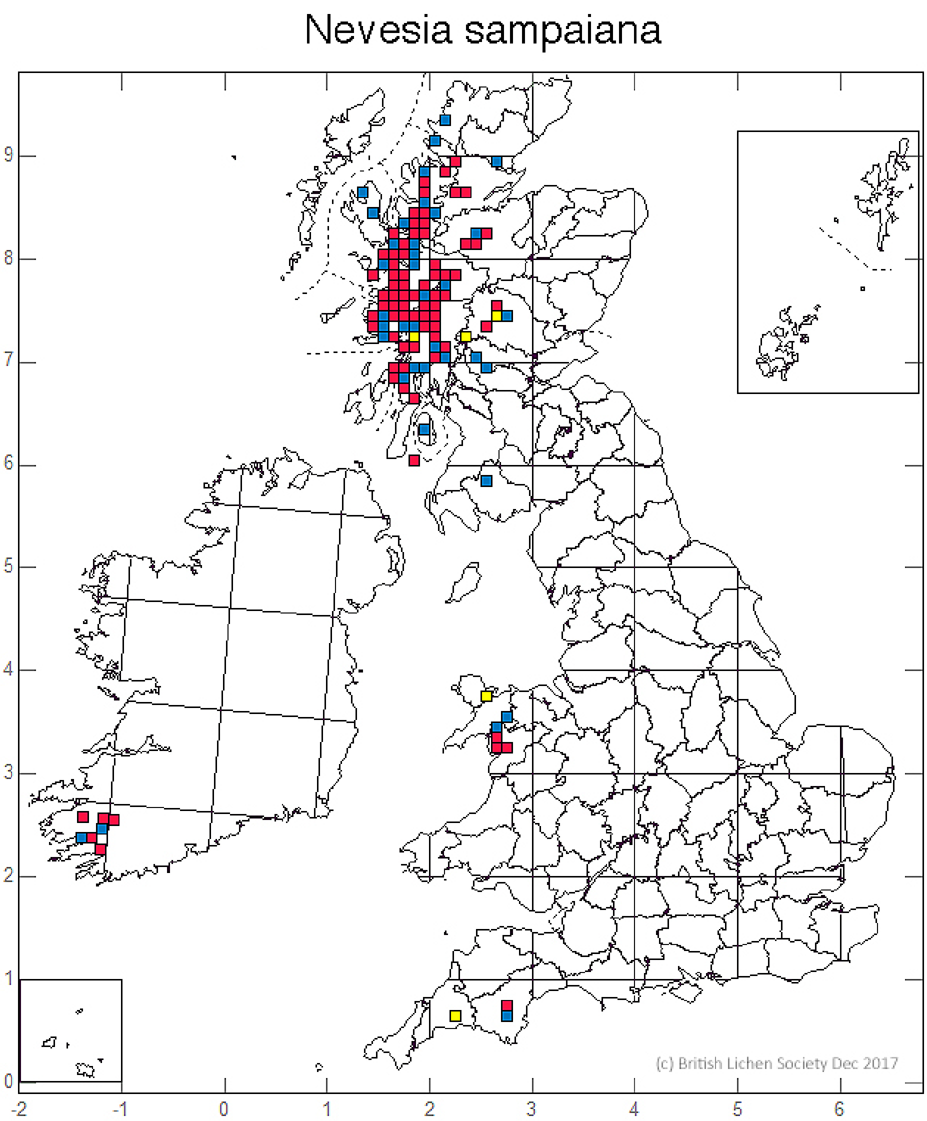
3.4.13 *Nevesia sampaiana* LOW RISK

Ecology and Distribution

Nevesia sampaiana (*Fuscopannaria sampaiana*) NT (NS/IR/S41) forms a pale red-brown crust of appressed rounded squamules and found in on base rich bark in hyperoceanic woodlands in western Britain (Base Rich Bark Woodland Community *Lobarion pulmonariae*) (**Map 17**). The main population is found in western Scotland typically on trees such as Hazel and Ash. Further south in North Wales Ash is joined by Oak and Lime as substrates. The species is very rare in England, the record from the New Forest appears to be a nomenclatural confusion with *Parmeliella testacea*, the two species were separated shortly after the discovery of *Parmeliella testacea* in the New Forest. Otherwise, the species has only been recorded from a very few sites in the southwest, most recently only on the south side of Dartmoor (Sanderson 2017b). Here it survives on two Oaks in the Holne Woodlands SSSI.

The species is a characteristic Ash species further north but shifts more to Oak in the south, an ecological change noted for other species as well.

Map 17: Distribution of *Nevesia sampaiana*. Yellow = 1959 or earlier, Blue = 1960 – 1999, Red = Post 2000. © British Lichen Society 2017. Reproduced with permission.



Potential Ash Dieback Impact

Ash Dieback is likely to be a serious issue for this species in western Scotland and North Wales but the species is not known from Ash in England.

Risk Level Assessment

Nevesia sampaiana has been assessed as having a **LOW** risk as it is not known from Ash in England.

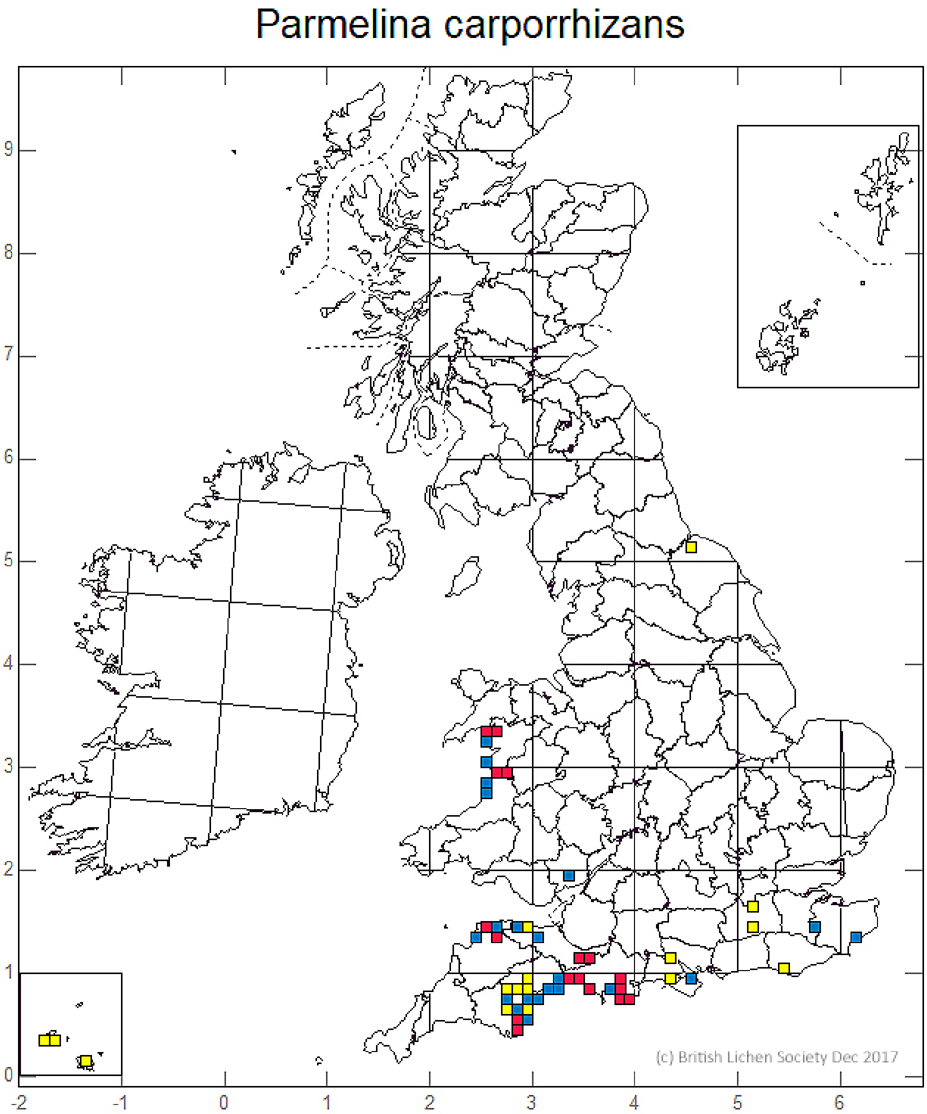
3.4.14 *Parmelina carporrhizans* HIGH RISK

Ecology and Distribution

Parmelina carporrhizans VU (NS) is a large leafy lichen with a strongly southern distribution (**Map 18**) (Nutrient Rich Bark Communities, the *Parmelietum carporrhizantis*). It is very much a lichen of field trees and parklands, where it is especially characteristic of horizontal boughs. Unlike other rare field tree lichens, it does not appear to be strongly associated with veteran trees and is recorded on mature trees. It grows on nutrient rich bark, including trees exposed to some sea spray in sunny and mild climates. The lichen is quite catholic about the trees it grows on. There are 60 records in the BLS database for England (including duplicates) with detailed substrate data. These show Ash as the most frequent, with 38% of the records, followed by Sycamore with 22% and then by Elm with 13%. Lime, Beech and Poplar records were between 5 to 10% of the records, while minor habitats were Oak, Walnut, Sallow, Apple, Alder and wooden palings.

The species has declined since the 19th century, being largely lost from east of Dorset and much of inland South Devon before 1959 and had retreated further by 1999, especially in South Devon (**Map 18**). The species was last recorded on Elm in 1977, but the species was clearly in decline before Dutch Elm Disease, as evidenced by the numbers of 10km national grid squares with pre-1960 records only. To the east it was certainly lost to acidifying pollution, but the decline in the south west must have other drivers. As a southern species on the edge of its range, climatic constraints may have been a factor in the early decline, but are unlikely to apply now. Latter losses probably driven by the standard threats to field tree and parkland species.

Map 18: Distribution of *Parmelina carporrhizans*. Yellow = 1959 or earlier, Blue = 1960 – 1999, Red = Post 2000. © British Lichen Society 2017. Reproduced with permission.



Potential Ash Dieback Impact

The BLS database contained 19 post 2000 English records of *Parmelina carporrhizans* with detailed substrate data (including duplicate records), all from Dorset, South Somerset and Devon. Of these 53% are from Ash and 32% from Sycamore, 15% from Lime and single records from Poplar, Oak and Beech. The species is now more Ash dependant than ever (Ash as a substrate accounts only 38% of all records), so Ash Dieback is likely to be more damaging to this lichen than Dutch Elm Disease. At the site with the highest number of trees recorded since 2000 (St. Gabriel's, Golden Cap Estate) all the trees supporting *Parmelina carporrhizans* were Ash, so significant site losses are to be expected. The species will survive, especially on Sycamore and Lime, it can grow high up on trees and is probably a good coloniser, so the actual population with be considerable larger than the known population, and some viable populations may survive Ash Dieback.

Management Issues and Potential Solutions

Mitigation is likely to be similar to other field tree species; conserve populations of other suitable mature to veteran trees and plan for future replacements. Maintain or restore the habitat in which they occur. This includes reducing agricultural pollution, retaining veteran trees until death and prevent increasing shading from adjacent trees or Ivy. The stronghold of the species in the Dorset – Devon area, which also supports other threatened parkland and field tree species, requires specific targeting with measures to maintain high quality habitat on farmland trees.

Risk Level Assessment

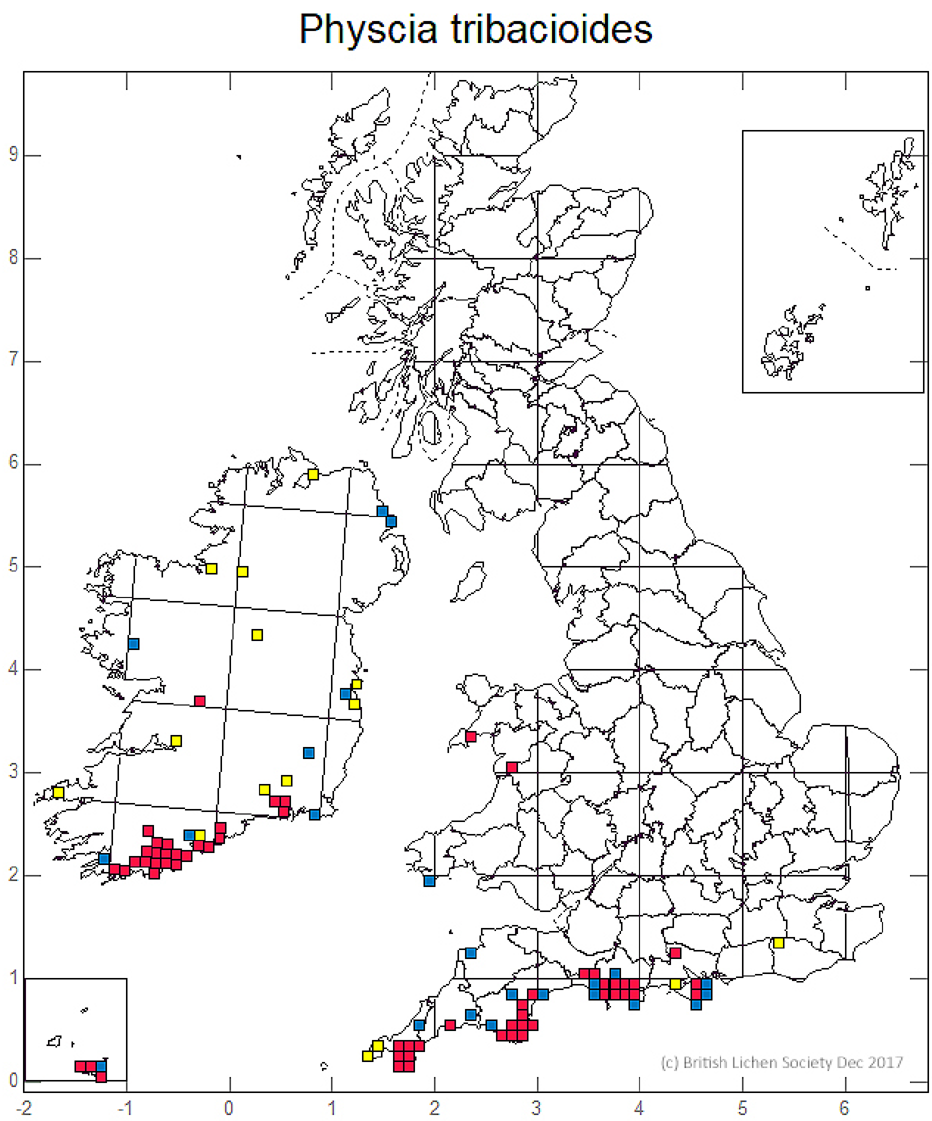
Parmelina carporrhizans has been assessed as having a **HIGH** risk as Ash is such a significant host and the species is highly dependent on it, although other hosts exist and it is thought that some viable populations may survive Ash Dieback.

3.4.15 *Physcia tribacioides* LOW RISK

Ecology and Distribution

Physcia tribacioides VU (NS/S41) is a strongly southern leafy lichen of field and parkland trees in well-lit situations on nutrient rich bark (**Map 19**) (Nutrient Rich Bark Communities *Parmelietum carporrhizantis*). It is not particularly associated with veteran trees. The species is quite catholic in its choice of substrate. There are 88 records in the BLS database for England (including duplicates). These show a great variety of trees are used with 26% of records from Ash and 22% of records from both Sycamore and Oak (including Turkey and Holm Oaks as well as native Oaks), Elm, Lime and rock with 6 – 7% of the records. There are rare records from Field Maple, Horse Chestnut, Beech, Walnut, Apple, and Sallow. The species was regarded very rare and assessed as Endangered by Church et al. (1997), but was downgraded by Wood & Coppins (2012) to Vulnerable. This was due to a considerable increase in records. The species was not frequent on Elm and was clearly not badly impacted by Dutch Elm Disease. The species is probably climatically controlled edge of range species, which has continued to spread, and Sanderson (2015) noted a large increase in occupied trees in Ethy Park, East Cornwall, since the previous survey in 2001. The species has also recolonised South Hampshire. Woods & Coppins (2012), however, stressed that in most sites it is restricted to a small number of trees and recent losses in Dorset have occurred where Ivy has smothered the trunk of the host trees, and trees have been felled owing to safety issues.

Map 19: Distribution of *Physcia tribacioides*. Yellow = 1959 or earlier, Blue = 1960 – 1999, Red = Post 2000.



Potential Ash Dieback Impact

The BLS database contained 40 post 2000 English records of *Physcia tribacioides* with detailed substrate data (including duplicate records), along the south coast from South Hampshire to West Cornwall. Of these 30% were recorded from Sycamore, 15% from Ash and 13% from Lime, along with 10% on rock and 8% from Oak and Beech and a few records from Horse Chestnut and Walnut. This differs from the figures given using all records, with much more Sycamore and less Ash and Oak. As an apparently expanding species with a catholic choice of trees, Ash Dieback is probably not a very high threat, but will have some impact.

Management Issues and Potential Solutions

Mitigation is likely to be similar to other field tree species; conserve populations of other suitable mature to veteran trees and plan for future replacements. Maintain or restore the habitat in which they occur. This includes reducing agricultural pollution, retaining veteran trees until death and prevent increasing shading from adjacent trees or Ivy. The stronghold of the species in the Dorset – Devon area, which also supports other threatened parkland and field tree species, requires specific targeting with measures to maintain high quality habitat on farmland trees.

Risk Level Assessment

Physcia tribacioides has been assessed as having a **LOW** risk as Ash is not such a significant host.

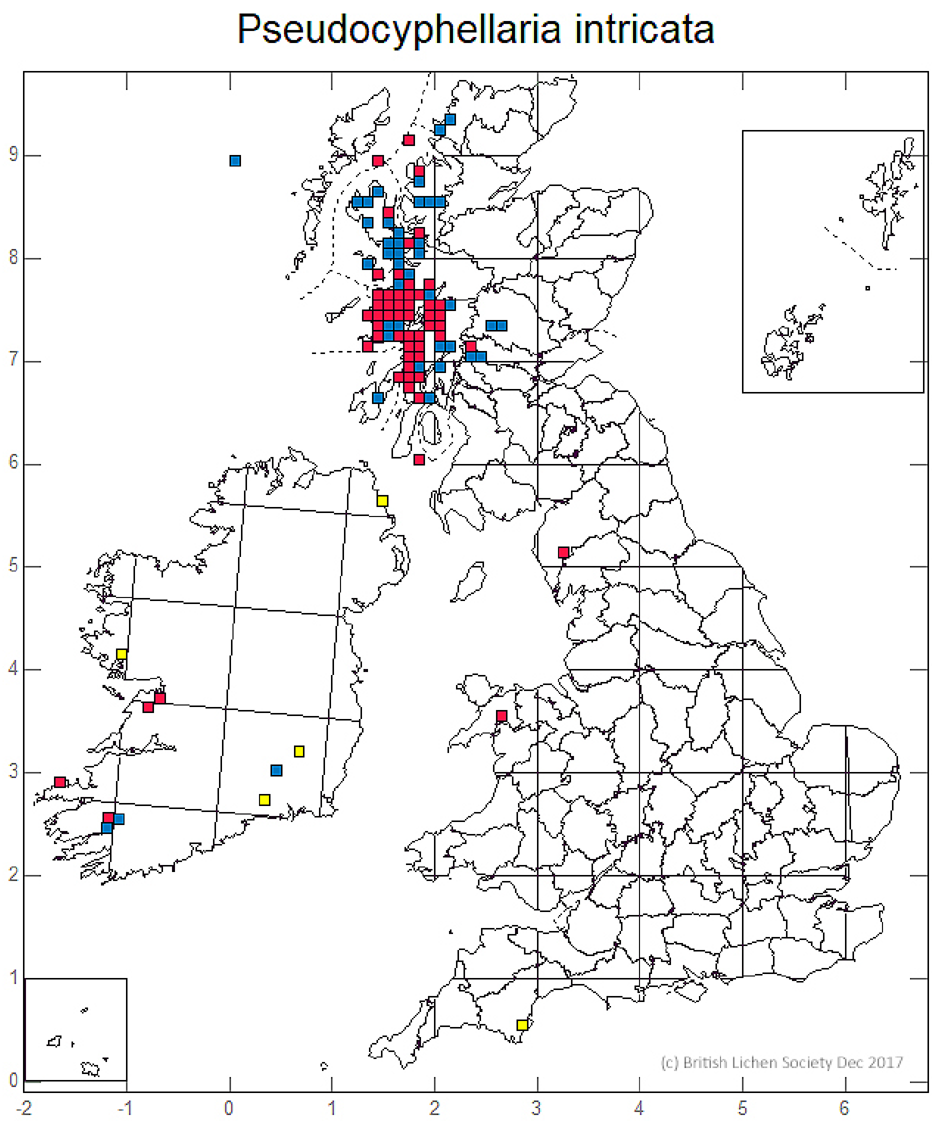
3.4.16 *Pseudocyphellaria intricata* VERY HIGH RISK

Ecology and Distribution

Pseudocyphellaria intricata NT (NS/IR/S41, Draft Eng. Red List CR) is a large leafy species of hyperoceanic Base Rich Bark Woodland Assemblages (*Lobarion pulmonariae*). It is locally frequent in western Scotland but is very rare beyond (**Map 20**), with s single extant site in England. In Scotland it is found on Hazel, Ash, Oak, Rowan and Sallow and on mossy rocks. The species is long extinct in Devon but is still extant in a single wood, at Seatoller (Borrowdale) in the richest site for hyperoceanic lichens in England. There are two recent records of what is presumably the same population, it was recorded an Ash in 2002 but on a rock in 2014. In 2014 the damp mossy outcrop was noted as being threatened by Bramble smothering the rock and the lichen colony.

Pseudocyphellaria intricata is clearly Critically Endangered in England, but the wood where it survives has not been surveyed in detail since the 1990s and the post 2000 records are confusing, but suggest that the lichen occurs on both rocks and Ash

Map 20: Distribution of *Pseudocyphellaria intricata*. Yellow = 1959 or earlier, Blue = 1960 – 1999, Red = Post 2000. © British Lichen Society 2017. Reproduced with permission.



Potential Ash Dieback Impact

Ash Dieback is clearly a very serious threat to *Pseudocyphellaria intricata* in England but it is fortunate that there is a refuge on rock. This is very typical for *Pseudocyphellaria* and similar *Lobarion* lichens, where rock refugia have been important in woods damaged by tree felling or acidifying pollution. This species is more frequent on Hazel than on Ash in Scotland, but few leafy *Lobarion* species have been found on Hazel in the Lake District; probably due to acidifying air pollution. The rock refuge, however, was threatened by Bramble overgrowth due to under grazing.

Management Issues and Potential Solutions

It is vital that the richest Lake District woods are systematically surveyed for lichens; the level of data from 1990s surveys are no longer useful for planning lichen conservation. The lack of a specialist condition assessments for lichens from some of the most important lichen rich woods is also a matter of considerable concern; the *Pseudocyphellaria intricata* colony seen in 2014 was threatened by Bramble resulting from under grazing. Further observation during a visit in 2018 suggested that the wood is actually in unfavourable declining condition due to under grazing, a conclusion at complete variance to the general condition assessment (Magic Website <magic.defra.gov.uk>). This suggested the wood was overgrazed. Simply reducing grazing here would risk eliminating *Pseudocyphellaria intricata* from England. A more sophisticated response, such as reducing the numbers of sheep but introducing cattle grazing is probably required.

In the long term further reductions in acid deposition; the site still exceeds the critical load (APIS Website <www.apis.ac.uk/>), which is likely to be inhibiting the colonisation of new substrates, including Hazel.

Risk Level Assessment

Pseudocyphellaria intricata has been assessed as having a **VERY HIGH** risk; only known from one site in England - an Ash-dominated upland woodland - where it has been recorded on Ash and on rock.

3.4.17 *Ramonia nigra* MEDIUM RISK

Ecology and Distribution

Ramonia nigra CR (NR/IR/S41, Draft Eng. Red List EN) is a tiny loosely lichenised crust with a distinctive small black ulcerate apothecia. It is found most in the New Forest, but has outlying records from south west England and the Lake District (**Map 21**). It has two habitats; flushed base rich rain tracks on lignum inside Hollow veteran trees (Wound and Rain Tracks Assemblages, the *Gyalectinetum carneoluteae*) and in patches of bare spongy base rich bark on Oak within Base Rich Bark Woodland Communities (*Lobarion pulmonariae*). In southern central England it is known from inside a variety of hollow trees and is most frequent inside old Hollies but has also been found inside Ash and Beech trees. Where it has also been found on Oak bark, it can only be easily found on this substrate when the bark is saturated.

Ramonia nigra was originally described from inside Hollow Ash trees in the Seatoller woods, Borrowdale, Lake District and was then found in the same habitat at Whiddon Deer Park in south Devon. The species was last recorded in 1998 at Whiddon Park (Edwards, 2008) but was refound in the Seatoller woods during a BLS meeting in 2014, while the 2018 BLS discovered three new sites in Borrowdale, at two inside hollow Ash pollards and at one on spongy Oak bark.

Potential Ash Dieback Impact

This species was originally thought to be a specialist of hollow Ash trees, but has since been found inside other hollow trees and on spongy bark on veteran Oak trees. Even in the Lake District, where hollow Ash pollards appear to be the main habitat it has recently been found on Oak bark as well.

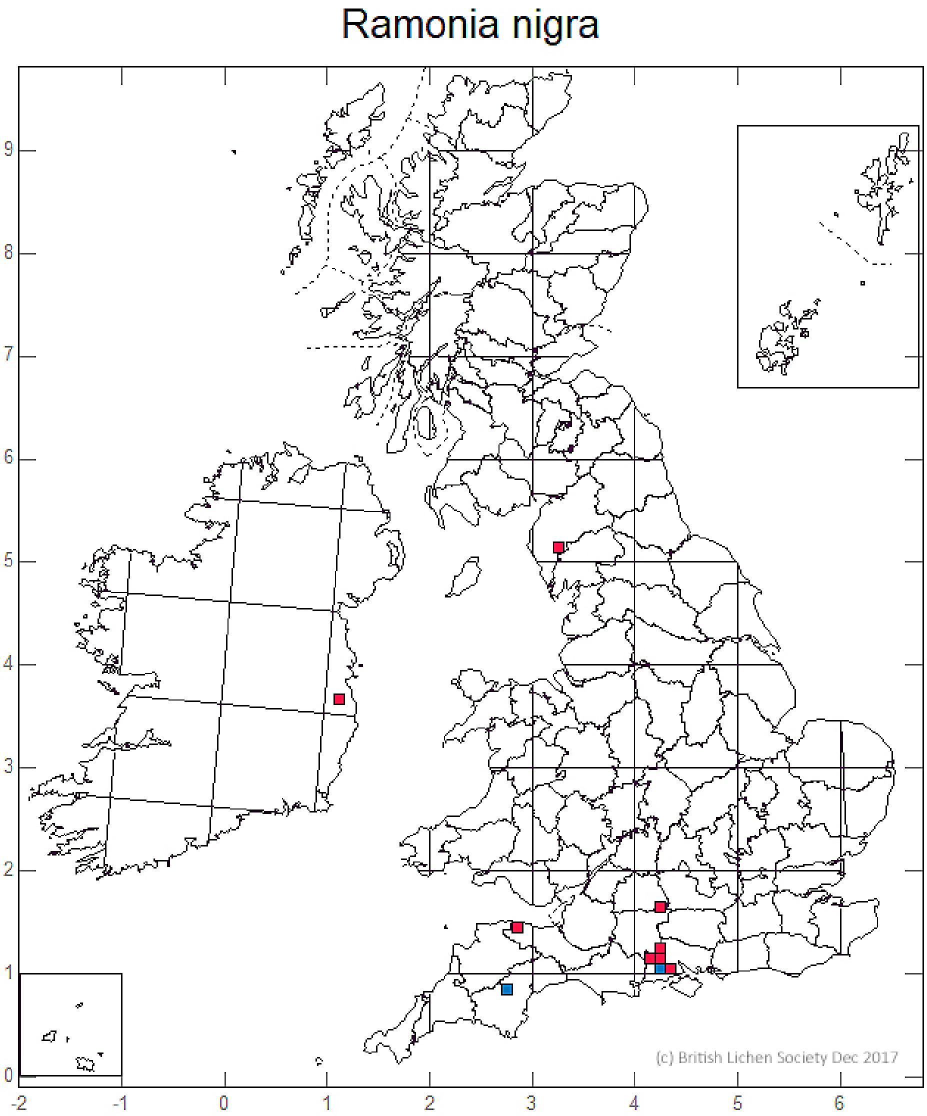
Management Issues and Potential Solutions

The finding of three new sites during non-systematic surveys during a BLS field meeting suggests that the species is much under recorded in the Lake District. Along with other rare lichens this is a result of the failure to commission modern lichens surveys from the Lake District and is a major hindrance to planning mitigation for Ash Dieback.

Risk level assessment

Ramonia nigra has been assessed as having a **MEDIUM** risk; although initially thought to be an Ash specialist (Ash is still a significant host), it also known from Oak and other broadleaved trees.

Map 21: Distribution of *Calopaca flavorubescens*. Yellow = 1959 or earlier, Blue = 1960 – 1999, Red = Post 2000.



3.4.18 *Schismatomma graphidioides* MEDIUM RISK

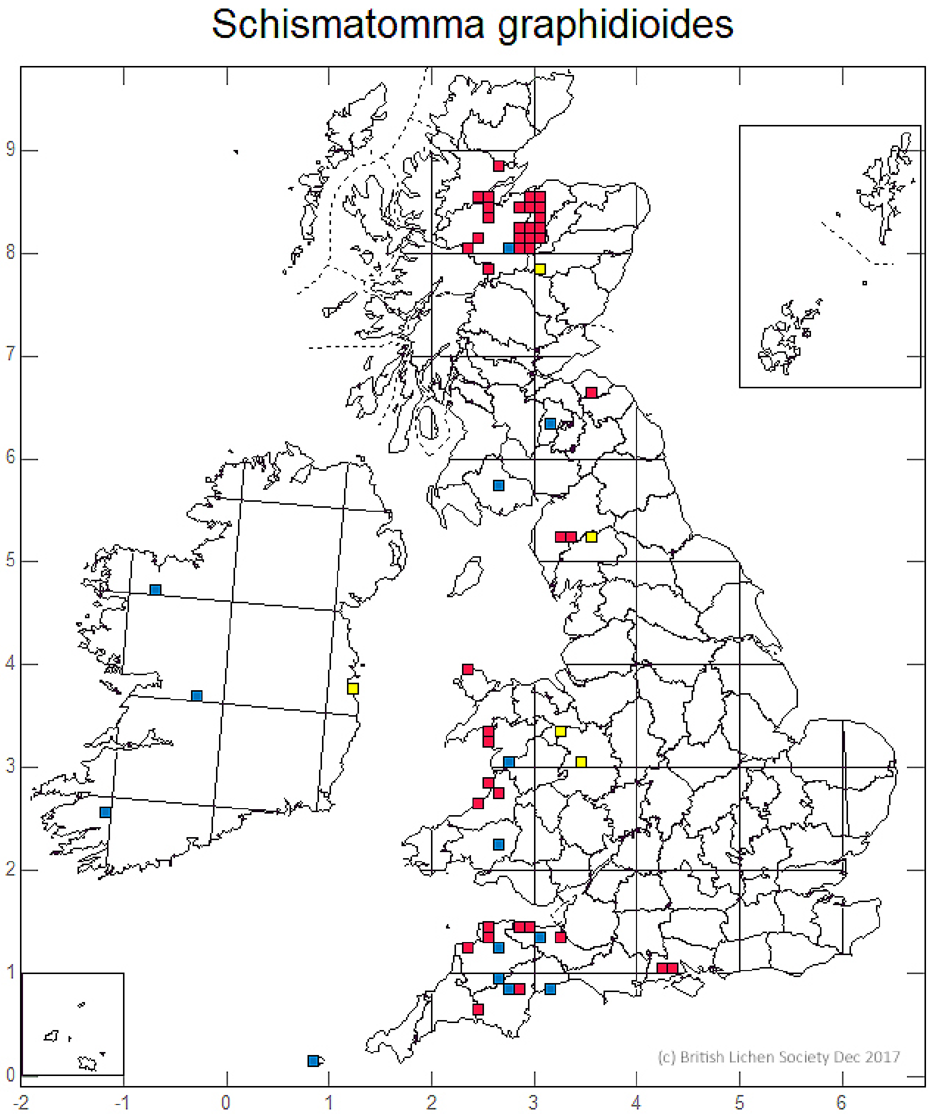
Ecology and Distribution

Schismatomma graphidioides VU (NS/IR/S41, Draft Eng. Red List EN) is a crust-forming lichen found on a great variety of trees. Recorded trees supporting the lichen in Britain include Sycamore, Hornbeam, Beech, Ash, Aspen, Oak, Sallow, Holly, Sweet Chestnut and Elm. Habitats in which it occurs are very varied as well, including pasture woodland and more sheltered parkland and field trees. The lichen was initially mainly found on rough bark on old mature trees, but more recently it has also been found on smooth bark areas on old and younger trees (see <http://wales-lichens.org.uk/species-account/schismatomma-graphidioides>). The habitat on bark is quite tight, being typically found on the drier edges of areas of flushed mesic bark(Mature Mesic Bark Community, the *Pertusarietum amarae*). Although found in very varied landscapes the local habitats are usually wood edge interfaces or well gladed woodland.

In England, pre-2000 records were nearly all from Ash, but with one from Horse Chestnut, with 20th century records from four sites in Devon and South Somerset. Nineteenth century records also exist from Shropshire and Westmorland. This century there has been a surge in records, with eight new sites found in the former range and five in a new area, the New Forest (**Map 22**). It has also been found in two new sites in the Lake District. At Horner Combe, as formerly Ash site in South Somerset, it was recently found on Oak, but was not refound on the original Ash trees. The tree species that support it in England are now much more varied, with Beech especially important in the south west, and Oak, Sallow, Sycamore, Hornbeam, Holly and Sweet Chestnut now also recorded.

Some of these new records are presumably due to the species being overlooked, but there is a possibility that the species, although it has exacting habitat requirements, may be quite mobile. Threats to this species appear to be mainly though increasing shade; there are documented losses from Horner Combe due to increased shade associated with reductions in grazing pressure (Sanderson, 2017d).

Map 22: Distribution of *Schismatomma graphidioides*. Yellow = 1959 or earlier, Blue = 1960 – 1999, Red = Post 2000. © British Lichen Society 2017. Reproduced with permission.



Potential Ash Dieback Impact

The known pre 2000 distribution suggested a species, which was very vulnerable to Ash Dieback, but the recent increase in records from other trees presents a different picture. The BLS database contained 32 post 2000 English records of *Schismatomma graphidioides* with detailed substrate data (including duplicate records). Of these 34% were recorded from Beech, 17% from Ash and 13% from Oak and Sallow along with some records from Holly, Hornbeam, Sweet Chestnut and Sycamore. As an apparently expanding species with a catholic choice of trees, Ash Dieback is probably not a very high threat, but will have an impact and may cause significant losses at some individual sites, although the only known site with both recent records and only Ash as a substrate is Dunster Park & Heathlands SSSI, South Somerset.

Management Issues and Potential Solutions

The most effective mitigation will to maintain good condition with sites supporting this lichen, especially preventing increased shade within and on the edge of woodlands.

Risk Level Assessment

Schismatomma graphidioides has been assessed as having a **MEDIUM** risk; although Ash is still a significant host, it is now known from a wide range of trees.

3.4.19 *Teloschistes flavicans* MEDIUM RISK

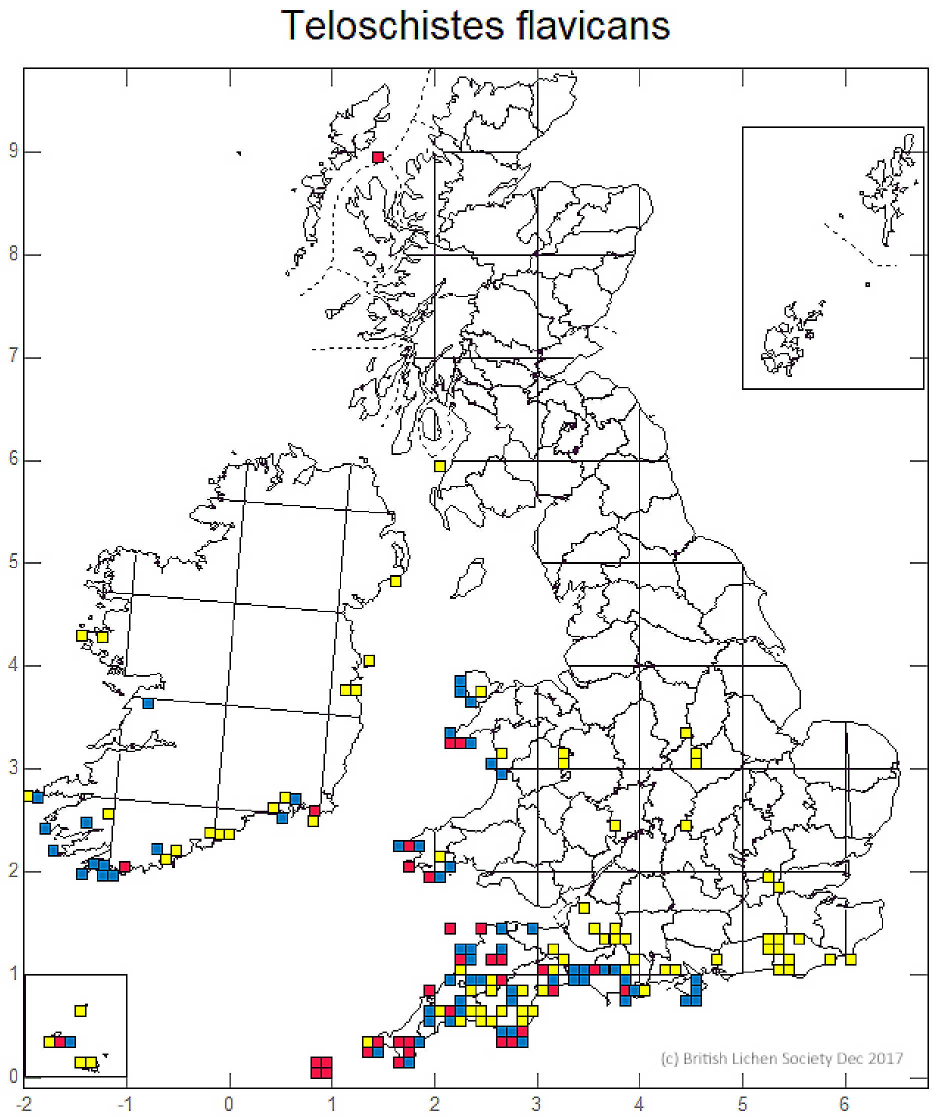
Ecology and Distribution

Teloschistes flavicans VU (NS/S41) is a distinctive yellow shrubby lichen found in two very different habitats in the south west. The lichen has survived best on coastal slopes in short maritime grasslands and rock slabs. It was also a widespread epiphyte extending well into midland England, but this population has crAshed dramatically since the 19^{th} century, initially due to acidifying air pollution. This caused the complete loss of the species from north and east of North Somerset and Hampshire before 1960. As an epiphyte this retreat has continued and the lichen rare even in the south west, with recent records from only Cornwall, Devon and a single one from Dorset (**Map 23**). The two habitats merge, with the lichen colonising Blackthorn scrub close to terricolous sites. On trees *Teloschistes flavicans* grows on mesic mildly nutrient enriched bark (Mature Mesic Bark Community *Pertusarietum amarae*) in well lit locations, which are also quite humid. It appears to avoid strongly nutrient enriched bark; more so than most other field tree and parkland species. It grows in both mature bark on trunks but can also colonise twigs and grows in canopy. As such the species is likely to be quite mobile in favourable conditions.

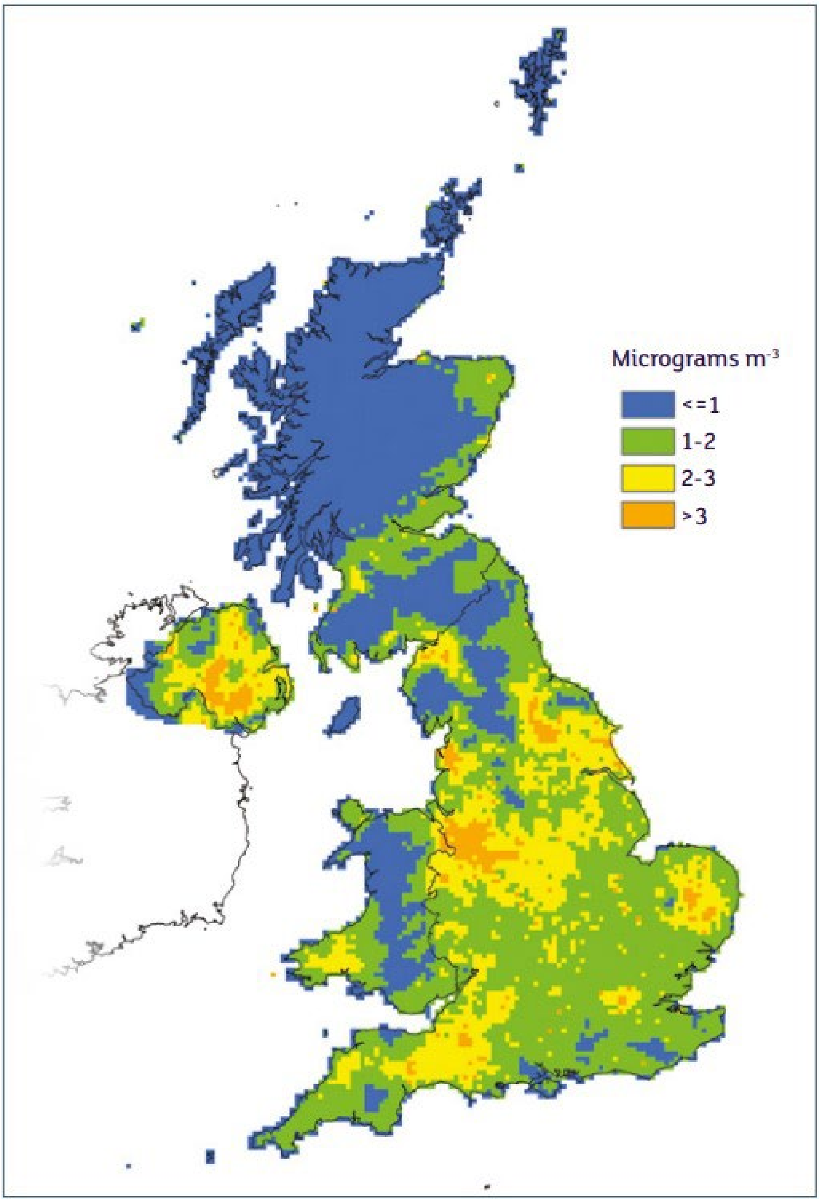
Away from coastal slopes, the lichen is found on parkland and field tree and shrubs and woodland edge trees and shrubs. Ash is the most numerous tree substrate in all the records at 42%, with 22% of the records from Sycamore and 17% from Oak, along with Apple, Blackthorn and Hawthorn significant minor habitats with rare records from other trees and bushes.

Acidifying pollution is no longer likely to be strong threat to the epiphytic population in the core area of survival but has probably been replaced by the threat of enrichment ammonia (**Map 24**).

Map 23: Distribution of *Teloschistes flavicans*. Yellow = 1959 or earlier, Blue = 1960 – 1999, Red = Post 2000. © British Lichen Society 2017. Reproduced with permission.



Map 24: Ammonia concentrations between 2010-2012. (Plantlife, 2017). © UK Centre of Ecology and Hydrology (UKCEH). Reproduced with permission from UKCEH.



Potential Ash Dieback Impact

The BLS database contained 36 post 2000 English records of *Teloschistes flavicans* with detailed substrate data (including duplicate records). These show a decrease in records from Ash (33%) and an increase in Sycamore (39%), with minor species including Oak, Sallow, Blackthorn, Hawthorn and orchard trees. Ash is significant host and Ash Dieback will increase the threat to the species.

Management Issues and Potential Solutions

Teloschistes flavicans , however, is a potentially quite mobile twig species, and nutrient enrichment from ammonia is likely the main negative pressure on this species. Inland in the south west the background is above the critical concentration for epiphytic lichens of 1 mg/m^3 of ammonia inland throughout the surviving range of the species (**Map 23**). Coastal sites will generally be below this. In cleaner air conditions *Teloschistes flavicans* is likely to be able recover well in the absence of Ash. Increasing shade is also potential threat.

Risk Level Assessment

Teloschistes flavicans has been assessed as having a **MEDIUM** risk; Ash is a significant host and it will increase the threat to the species, however it is known from a wide range of substrates and its main populations are on rock.

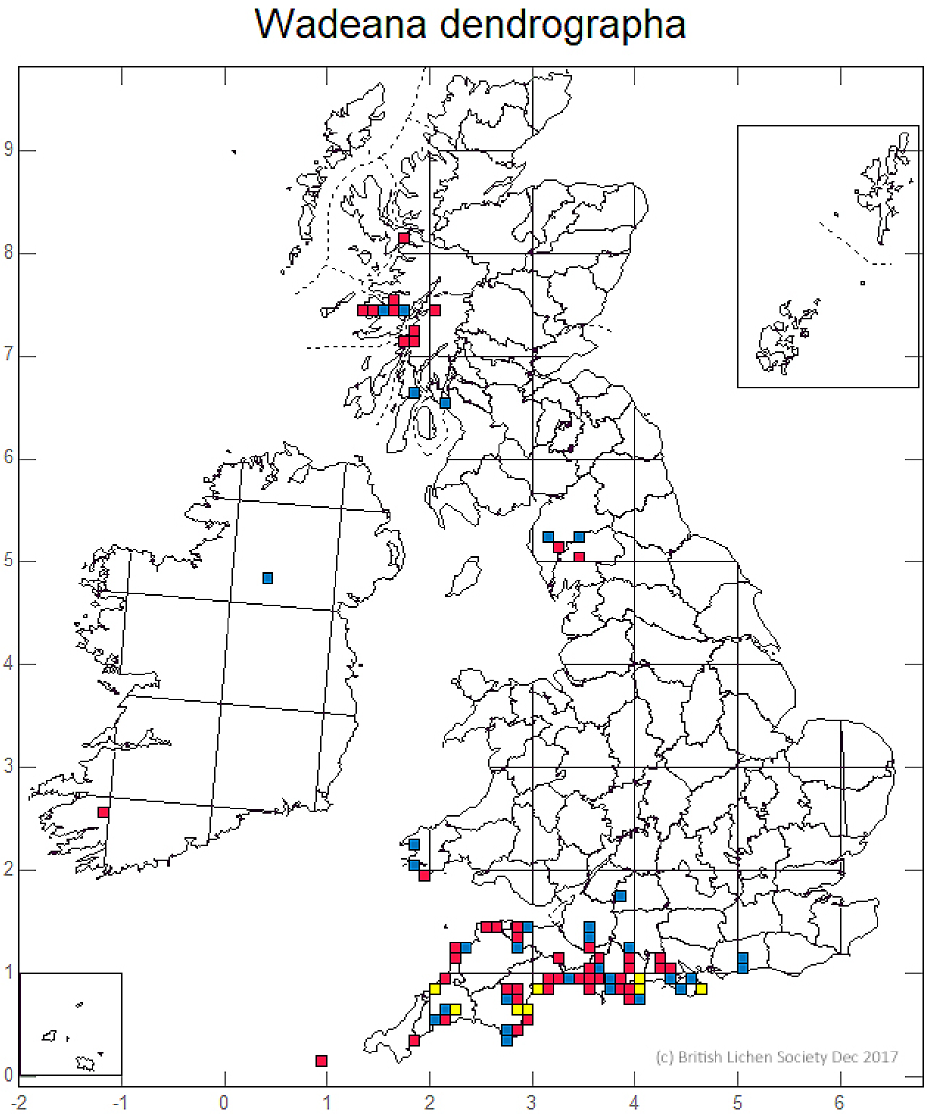
3.4.20 *Wadeana dendrographa* VERY HIGH RISK

Ecology and Distribution

Wadeana dendrographa NT (NR/IR/S41) is a lichen with distinctive 'mouse dropping" like lirellate black apothecia, that are typically vertically aligned, and found mostly in the transition between base-rich flushed bark (Base Rich Bark Woodland Community (*Lobarion pulmonariae* or Nutrient Rich Bark Communities, *Physcietum ascendentis*) and dry bark on veteran trees. It is very much an Ash specialist, with 80% of records on the BLS database (including duplicates) from Ash. It also occurs rarely on Oak, Elm and Sycamore. The database has records from what appears to be 17 individual Oaks and one Sycamore. The lichen occurs both in pasture woodlands and in sheltered field or parkland trees. In areas where it occurs, it appears quite efficient at finding senescent Ash trees; it can occur on nearly all suitable trees. It would make sense that a species dependent of senescent individuals of a relatively short lived tree is quite efficient at colonising.

It is a south-western species with widespread records from Hampshire to Cornwall and a few records from the Lake District (**Map 25**). Existing threats include the continuity of old senescent Ash trees within meta-sites and increasing shade. Recorded losses from increased shade include Ivy spread on a boundary tree in parkland fenced off from grazing in Ethy Park, Cornwall (Sanderson, 2015) and expanding shrub layers in fenced off pasture woodland at Gowbarrow Park, in the Lake District (Sanderson, 2017c).

Map 25: Distribution of *Wadeana dendrographa*. Yellow = 1959 or earlier, Blue = 1960 – 1999, Red = Post 2000. © British Lichen Society 2017. Reproduced with permission.



Potential Ash Dieback Impact

There are alternative substrates for *Wadeana dendrographa*, but these are rarely occupied and the species is no longer known on Elm. Oak has been recorded with this lichen in East Cornwall, South Somerset, Dorset and South Hampshire with concentrations in Dorset and the New Forest. Of the 17 Oak trees recorded with this lichen five have post 2000 records and the only Sycamore was recorded in 2003 from North Devon.

Management Issues and Potential Solutions

Mitigation options for this species are limited, maintaining habitat quality, especially preventing shading by maintaining trees Ivy free and grazed habitats around surviving trees, both potentially resistant Ash trees and occupied alternative tree species.

Risk Level Assessment

Wadeana dendrographa has been assessed as having a **VERY HIGH** risk; the species is very much an Ash specialist.

Table 4: Summary of Ash Dieback Impact on Section 41 Species and the Base-rich Bark Assemblage

Section 41 species/ assemblage	GB Red List[5]	Habitat	Assemblage	Risk	Mitigation
Base Rich Bark Woodland Assemblages		Oceanic woodlands	Base rich woodland[6]	High	Optimise conditions of the habitat e.g. maintain open conditions and control Ivy, alongside provision of alternative substrates including trees and base-rich rock.
Anaptychia ciliaris* subsp. *ciliaris	EN, NS	Southern field trees	Nutrient rich bark	High	Improve management of field trees, reduce nitrogen impacts e.g. to avoid farmyard manure being spread onto trees and/or reduce inputs, control Ivy. Provision of future mature-veteran trees is important in field/parkland situations but management of the existing habitat is fundamental due to the likely age gap of suitable host trees. Translocation may be required.
Arthonia anglica	EN, NR	Southern oceanic woodland	Smooth bark	Medium	Optimise woodland management, maintaining openness and controlling Ivy.

[5] See section 2.4 for definitions

[6] In England this assemblage also occurs in sheltered and humid locations in parkland situations.

Section 41 species/ assemblage	GB Red List[5]	Habitat	Assemblage	Risk	Mitigation
Bacidia incompta	VU	Southern field trees and woodland	Wound track	Medium	Improve management of field trees, reduce nitrogen impacts e.g. to avoid farmyard manure being spread onto trees and/or reducing inputs, control Ivy. Provision of future mature-veteran trees is important in field/parkland situations but management of the existing habitat is fundamental due to the likely age gap of suitable host trees. In woodland habitats, optimise conditions and accept veteran Sycamore and Beech in native woodlands (but note that this process has to be managed carefully).
Bacidia subincompta	VU, NS	Northern sub-oceanic woodland	Wound track	Medium	Optimise conditions of the habitat e.g. maintain open conditions
Caloplaca flavorubescens	EN, NS	Sub-oceanic field trees	Nutrient rich bark	Very High	Unlike other lichen species considered here there are no known alternative substrates in England. Management of field/parkland trees is fundamental to the species survival in England. Improve management of field trees, reduce nitrogen pollution e.g. to avoid farmyard manure being spread onto trees and/or reducing inputs, control Ivy. Provision of future mature-veteran trees is important in field/parkland situations but management of the existing habitat is fundamental due to the likely age gap of suitable host trees. Note that the population on Aspen in Scotland is more secure.
Caloplaca virescens	EN, NS	Southern field trees and woodland	Nutrient rich bark	Unknown	Improve management of field trees e.g. to avoid farmyard manure being spread onto trees and/or reducing inputs, control Ivy.

Section 41 species/ assemblage	GB Red List[5]	Habitat	Assemblage	Risk	Mitigation
Catapyrenium psoromoides	CR, NR, Sc8	Southern field trees, rock	Nutrient rich bark	Very High	Improve management of field trees, reduce nitrogen impacts e.g. to avoid farmyard manure being spread onto trees and/or reducing inputs, control Ivy. Provision of future mature-veteran trees is important in field/parkland situations but management of the existing habitat is fundamental due to the likely age gap of suitable host trees.
Collema fragrans	EN, NR, IR	Southern field trees and woodland	Wound track	Very High	Improve management of field trees, reduce nitrogen impacts e.g. to avoid farmyard manure being spread onto trees and/or reducing inputs, control Ivy. In woodlands accept veteran Beech in native woodlands (but note that this process has to be managed carefully). Provision of future mature-veteran trees is important in field/parkland situations but management of the existing habitat is fundamental due to the likely age gap of suitable host trees.
Cryptolechia carneolutea	EN, NS, IR	Southern field trees and woodland	Wound track	High	Improve management of field trees, reduce nitrogen impacts e.g. to avoid farmyard manure being spread onto trees and/or reducing inputs, control Ivy. In woodlands, improve woodland management, maintaining openness and controlling Ivy. Provision of future mature-veteran trees is important in field/parkland situations but management of the existing habitat is fundamental due to the likely age gap of suitable host trees.
Lecania chlorotiza	NT, NS, IR	Southern oceanic woodland	Base rich woodland	Medium	Maintain open conditions in woodland and around field trees, including Ivy control.

Section 41 species/ assemblage	GB Red List[5]	Habitat	Assemblage	Risk	Mitigation
Lecidea erythrophaea	VU, NR	Sub-oceanic woodland	Mesic bark	Unknown	No evidence of a stable population in England
Leptogium cochleatum	VU, NS	Hyper oceanic woodland	Base rich woodland	Unknown	The occurrence of this species in England is unproven
Nevesia sampaiana	NT, NS, IR	Hyper oceanic woodland	Base rich woodland	Low	Not currently known from Ash in England (although known from Ash in Wales and Scotland)
Parmelina carporrhizans	VU, NS	Southern western field trees and woodland	Nutrient rich bark	High	Improve management of field trees, reduce nitrogen impacts e.g. to avoid farmyard manure being spread onto trees and/or reducing inputs, control Ivy.
Physcia tribacioides	VU, NS, Sc8	Southern western field trees and woodland	Nutrient rich bark	Low	Improve management of field trees, reduce nitrogen impacts e.g. to avoid farmyard manure being spread onto trees and/or reducing inputs, control Ivy
Pseudocyphellaria intricata	NT, NS, IR	Hyper oceanic woodland, rock	Base rich woodland	Very High	Only known from one Lake District site. Optimise conditions of the habitat e.g. maintain open/unshaded conditions alongside provision of alternative substrates including trees and base-rich rock; grazing will be key.
Ramonia nigra	CR, NR, IR	Southern oceanic woodland	Base rich woodland	Medium	Optimise conditions of the habitat e.g. maintain open/unshaded conditions and control Ivy. Note that survey of potential Lake District sites is required

Section 41 species/ assemblage	GB Red List[5]	Habitat	Assemblage	Risk	Mitigation
Schismatomma graphidioides	VU, NS, IR	Field trees and woodland	Mesic bark	Medium	Optimise conditions of the habitat e.g. maintain open/unshaded conditions and control Ivy.
Teloschistes flavicans	VU, NS, S8	Southern field trees, rock	Mesic rich bark, Canopy	Medium	Improve management of field trees, reduce nitrogen impacts e.g. to avoid farmyard manure being spread onto trees and/or reducing inputs, control Ivy
Wadeana dendrographa	NT, NS, IR	Southern field trees and woodland	Base rich woodland	Very High	Mitigation options limited, maintaining suitable habitat conditions is key e.g. preventing shading through grazing and controlling Ivy.

Mitigation options for lichen

4.1 General approaches to mitigation

The loss of large numbers of Ash will be potentially very damaging to the epiphytic lichen assemblage of Britain. The death of the majority of older Ash trees appears inevitable, and even if greater tolerance is found in Ash than has been estimated to date, a move towards a younger demographic of Ash trees is probable in the short to medium term. Mitigation, therefore, will need to involve indirect strategies including improving general habitat conditions, promoting suitable replacement tree species and emergency translocation of some of the leafy non crust-forming species.

As a starting point, general good practice guidelines regarding Ash Dieback should be followed e.g. Reid et al (2015). These include:

- Retain existing Ash trees as long as possible.
- Avoid coppicing, re-pollarding out-of-cycle pollards or tree surgery on veteran Ash. Current advice on the management of in-cycle pollards is somewhat contradictory. Bengttssom (2014) shows that lapsed pollards (30 + years since the last cutting) are more resistant to the disease than maiden trees and suggests that in-cycle pollards are kept in cycle. The suggestion in Alsop (2014) of a conservative approach involving staging the work of in-cycle pollards and monitoring how a tree responds would seem sensible.
- Encourage suitable replacement trees. For lichens, these may not always be the same as recommended for other objectives, including for nature conservation. Advice to plant or regenerate replacement species is particularly problematic for many species due to the time taken for the replacement trees to reach post maturity and become suitable for lichens.
- Sycamore is one of the closest trees to Ash in its ecology and especially in its bark pH; an important factor for epiphytic lichens. As a European native tree, in most circumstances where already present it should be treated as a near native species and retained.
- The treatment of dead Ash. Dead wood is an important resource in woodland ecology, and a proportion of deadwood should be retained (standing and fallen).

4.2 Additional considerations for lichens

In terms of epiphytic lichens there are some issues with most general advice for Ash Dieback mitigation. In particular, there is limited, or surprisingly often no, appreciation of the time required for newly regenerated/planted trees to become suitable for colonisation by most Threatened or Notable lichen species. This is likely to be more than a century in normal circumstance, far too long for new trees to be any use in mitigation at all. In addition, advice is lacking for grazed woodland habitats or parklands, key habitats for lichens.

The factors that should be considered when mitigating the impact of Ash Dieback on epiphytic lichens are listed below:

- Survey data: effort needs to be concentrated in the most important and vulnerable areas. This could be a limiting factor at many important sites. In England, the Lake District stands out in particular as lacking up to date surveys of many important sites. Field tree habitats are also difficult to assess due to access difficulties and further survey/sampling should be a priority in areas where Ash is an important substrate in field tree habitats.
- Within important areas, assessments of the tree resource in terms of tree species and age classes are required, including a landscape scale approach in considering potential mitigation.
- Building resilience for woodland lichens; general good practice, in terms of management of woodlands or individual trees, for lichens, should be adopted to optimise conditions for existing populations.
- Building resilience for field tree and parkland lichens; general good practice, in terms of management of farmland or parks with concentrations of veteran trees or individual trees, for lichens, should be adopted to optimise conditions for existing populations.
- The most vulnerable areas need to be managed to create/maintain optimum conditions for lichen interest to give best chance of adaptation.
- Recognise the important role other native, including Hazel, Sallow, Wych Elm, Field Maple and old Beech, non-native broadleaves, especially near native species such as Sycamore & Norway Maple, and rock habitats can play. The best mitigation is likely to involve several components; no one tree can really replace Ash.
- Short to medium term mitigation will mainly involve existing mature to veteran alternative tree species. Adjust management approach to recognise this and encourage/promote a range of 'Ash alternatives', especially existing mature to veteran trees currently in suboptimal conditions.
- Similarly, where rock habitats are important ensure rock outcrops are managed to promote well-lit condition and not smothered e.g. by controlling bramble growth.
- Tree planting is a long term mitigation for canopy trees species but planting could provide important medium tern mitigation when using rapidly maturing shrubs such as Hazel and Sallow.
- Translocation of larger macro lichens is a potentially effective mitigation for dispersal limited species in the face of dying Ash trees
- Review management approach to recognise all the above.

- Encourage/promote a range of 'Ash alternatives'.

Different approaches are recommended for woodland, and parkland/field trees, which are discussed in sections 4.5 and 4.6 respectively.

4.3 Assessing the lichen risk

The following questions will allow a general assessment of the lichen interest.

a) What is the general lichen interest of the site in terms of lichen communities/assemblages (e.g. Smooth Bark, Mature Mesic Bark, Base Rich Bark Woodland, Acid Bark Woodland &Dry Bark and Lignum on Veteran Trees)?
b) What are the key substrates - tree species / rocks?
c) Are there any particularly important lichen species?
d) What are they growing on?
e) Is the site in optimum condition for the lichen interest?

The answers to these will help to inform management decisions - e.g. relating to the significance of Ash for lichens, and suitable alternatives substrates.

4.4 Habitat management decision framework

Following the quick assessment above, there is a range of scenarios with differing levels of risk and management action:

1. Sites dominated by species such as Oak, Birch, Hazel or Beech, often on more acidic soils, with old Ash absent or rare. If Base Rich Bark Woodland community interest is significant, then it may well be found largely on other tree species such as Oak or Beech. In this instance there is little or no risk of lichen impacts from Ash Dieback, at most the loss of young Ash will reduce the diversity of future potential substrates.
2. Sites where Ash is a component (but not a key one) with plenty of other tree species present and the lichen interest spread across tree species +/- rock. A low risk scenario. Continue to manage site in general way to promote lichen interest (see sections 4.9 - 4.11).
3. As above, but Ash supports particularly important species: here make a particular effort to improve the condition of alternative habitats near to existing Ash trees of interest e.g. alternative host trees and rock (see below) and ensure management generally is favourable for the lichen interest. Monitor condition of Ash trees: if showing signs of Dieback consider translocation of important foliose species to alternative trees if there is abundant material. With lichens that are scarce on the site or recognised as nationally important - e.g. IUCN Threatened taxa, material should only be translocated once the Ash trees are clearly dying. Adopt general measures to promote suitable alternative trees (+/- rock) which may include planting of alternative trees.

4. Sites dominated by Ash. Identify any other potential substrates: trees and rocks (cliffs, block screes, boulders) and ensure these are managed optimally to allow spread. High Ash dominance is often the result of the loss of tree species diversity. Planting of rapidly maturing species such as Hazel and Sallow, where ecologically appropriate, may be an option but also consider other canopy-forming species depending on site conditions e.g. Sycamore and Oak (the latter especially where acidification is less of an issue). This is particularly so in high rainfall areas with limited acidification (**Maps 2** – **4**). With Ash dominated woods the regeneration of other tree species may also be an issue to maintain woodland characteristics. The impact of Ash Dieback, in terms of numbers of Ash lost, is likely to increase with the abundance of Ash (Goldberg & Scott, 2019), which will compound the impact in this site type.

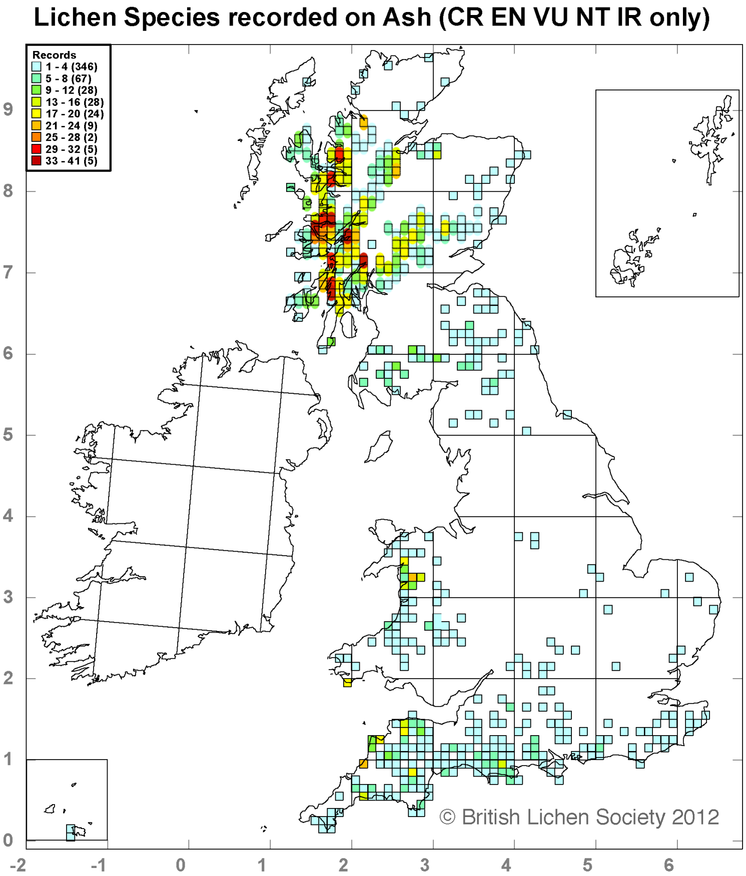
4.5 Additional considerations for woodland lichens

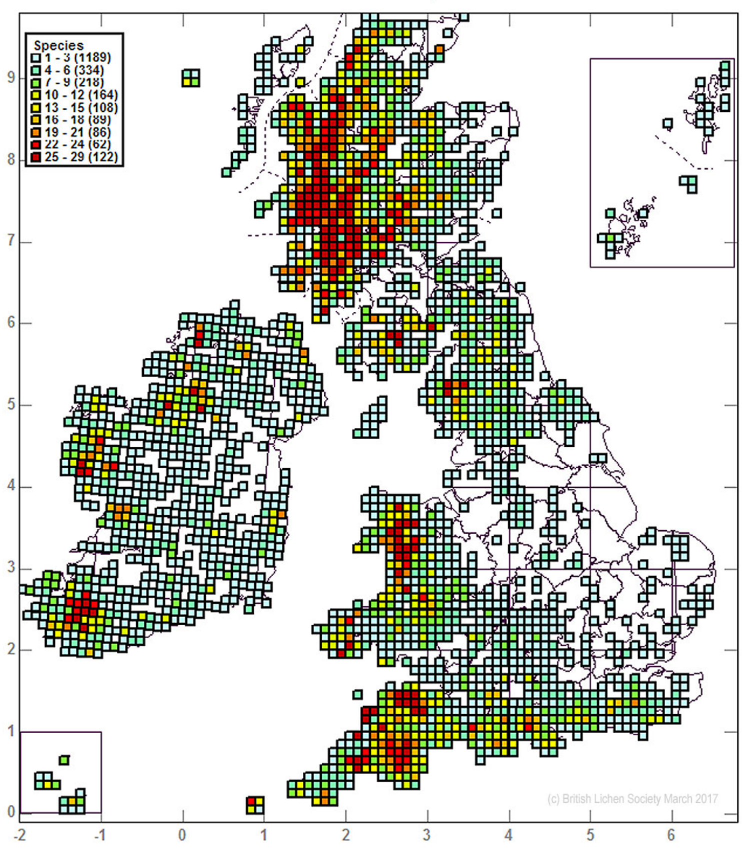
It is essential in dealing with lichen-rich woods impacted by Ash Dieback to bear in mind the needs of the lichens. Much Ash Dieback advice promotes achieving the maximum degree of regeneration by removing browsing animals but this is guaranteed to destroy the lichen interest. Mitigation within lichen rich woodlands will require a more nuanced response involving reduced grazing/browsing pressure where necessary rather than its complete removal.

4.5.1 Survey/knowledge

The knowledge of lichen rich woodlands is much better than for field tree assemblages but there are still large gaps and no review of the resource since Fletcher et al (1982). A general overview of the areas where Ash is important for lichens and where lichen rich woodlands occur is given in **Maps 26** and **27**. These maps show areas that are likely to be a high priority. Ideally all lichen rich SSSIs with Ash as a significant component should at least be fully surveyed. One glaring gap is in the Lake District, where oceanic woodland, frequent old Ash and acidification that has increased the importance of Ash but there have been few detailed surveys since the 1990s.

Map 26 (above): the occurrence of rare lichens on Ash (Edwards, 2012) and Map 27 (below): the occurrence lichens typical of lichen rich woodlands (Sanderson, 2018d). © British Lichen Society. Reproduced with permission.





4.5.2 Management Options

It is important to appreciate that relatively short periods of grazing removal, as little as five years, can damage the lichen interest, while recovery by recolonisation by lichens is on a much longer time scale.

With the exception of Hazel and Sallow, most suitable replacement trees will take more than 100 years to even begin to be colonised by veteran dependent species. Beyond Hazel and Sallow, tree planting is not even a medium term mitigation measure.

In contrast, improving conditions around existing older alternative trees and/or rock habitat, with this planned at a landscape scale, is a much more practical approach for lichens in the short and medium terms.

4.5.3 Alternative Substrates

Potential useful alternative trees and other habitats, which could act as substrates for Ash dependant lichens are listed below (and the most important discussed further in 4.7):

- Sycamore: a major near-native alternative habitat throughout Britain, which grows well in the same habitats as Ash, especially in ravines. Any shade issues for lichens are also caused by dense Ash stands anyway and in lichen rich sites can be dealt with by browsing to maintain openness. Greatly compliments Oak as better for the leafy species that thrive more on Ash than on Oak. From a lichenological view of point it would be best to treat Sycamore as a naturalised honorary native, and its impact on sites assessed to no longer be automatically treated as an undesirable invasive exotic[7] (See 4.7.5).
- Norway maple: an even better substitute for Ash in lichen terms, but one that is much rarer in British Woodland and more definitively non-native. Planting would most likely to be required which may raise concerns around e.g. SSSI condition. Perhaps better suited to more 'artificial' situations e.g. parkland.
- Oak: native Oaks are a major alternative in areas without significant acidification, much poorer where acidified or in very heavy rainfall areas.
- Hazel: very important in high rainfall areas with low acidification. It can support rare lichens within a few decades under favourable conditions (see 4.7.1).

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[7] The view of Natural England is different (Kirby, 2009); in general terms where sycamore is already present it is left, perhaps controlled/capped at an upper limit, and only removed if it is perceived to be causing damage. It is not however policy to allow it to spread to new sites.

- Sallow: similar to Hazel but grows in wetter sites, and very important in high rainfall areas with low acidification. It can support rare lichens within a few decades under favourable conditions. In lichenological terms *Salix cinerea* and *S. caprea* are very similar as lichen substrates, although *Salix cinerea* is more frequent in western woods and lichen rich *S. caprea* is more a feature of boreal woods (see 4.7.2).
- Aspen: a very effective Ash replacement in northern woods, especially in the Eastern Highlands. Occasionally of high interest to the south as well, as can be Poplar cultivars were planted in to ancient woodlands. All have potential for Ash Dieback mitigation as relatively rapidly aging trees.
- Rowan: not a very significant tree in the south but can be rich in the north west, especially Scotland including for *Lobarion* species. Unlikely to be a very significant species for Ash Dieback mitigation.
- Wych Elm: slow growing suppressed young trees have recently been noted as being recolonised by *Lobarion* species and furthermore Wych Elm is also now surviving longer than it has been doing in recent years; just possibly the beginnings of a recovery from Dutch Elm Disease. If this does occur, it would be very useful in the medium – long-term recovery from Ash Dieback.
- Beech: old growth Beech woods within the trees native range are very lichen rich but the tree has a poor reputation as a lichen habitat beyond this. The native distribution in Britain is not climatically limited but dispersal limited so widespread colonisation far to the north of its native range is occurring. The beginnings of the development of a rich lichen assemblage on Beech in non-native sites have been observed in south west of England. Stands with existing old Beech have potential in the south of Britain, but Beech is likely to be a problematic species to naturalise in the north due to its highly competitive nature and the deep shade it casts (see 4.7.3).
- Field Maple: a southern species with limited overlap with unpolluted lichen rich old growth woodland, but can be a good species where it occurs, and supports an assemblage similar to Ash.
- Hornbeam: another southern species with currently very little overlap with unpolluted old growth woodland. Very like Beech but with a consistently less acidic bark, so actually potentially a rather rich lichen tree. Like Beech, also strongly dispersal limited and not at its full climatic limit in Britain. However, the potential range is much more limited than Beech.
- Rocks: damp but not too wet base rich siliceous rock within woods are a significant alternative habitat for leafy *Lobarion* species in upland woods. They have acted as refugia for *Lobarion* lichens allowing them to survive intensive management in the past. In some woods they will have the ability to also act as refugia during Ash Dieback impact. Care is need with management, such base rich

rocky locations have proved to be very vulnerable to smothering by Bramble and Ivy and some very rich sites have been destroyed by this following grazing reductions for conservation reasons. Rock refuges are probable the most vulnerable lichen habitat to being damaged by advice to accelerate regeneration in response to Ash Dieback.

4.6 Additional considerations for parkland and field tree lichen

Parkland is an artificial habitat that maintains conditions similar to those found in the more open parts of pasture woodlands. They also provide habitats for specialist lichens of very well-lit veteran field trees that are now rare in the general countryside. The main difference with woodland habitats is that natural regeneration is unlikely to occur and new generations of trees need to be provided by tree planting. Alternatively, parks could be rewilded and managed more extensively to allow natural regeneration. In this case grazing/browsing levels would need to be sufficient for parkland lichens and yet allow patch natural regeneration. The latter would often be beneficial for lichens but would usually be in conflict with the preservation of designed landscapes.

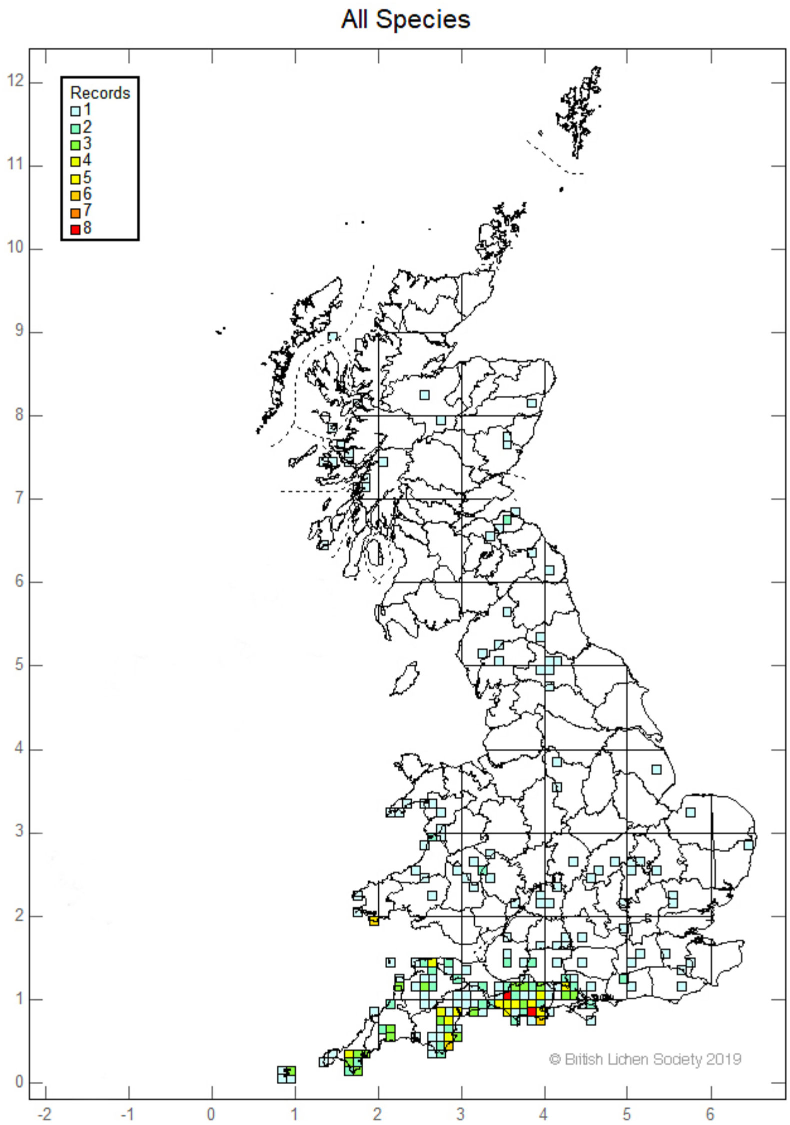
Some landscape parks have elements of woodland assemblages inherited from medieval or early modern deer parks. However, a distinctive element of the lichen interest of landscape parks is the survival of specialist field tree lichens e.g. many of the Section 41 species discussed above in section 3.4. These favour well lit, often mildly nutrient enriched, mature to veteran trees. Some were always quite scarce, but others were widespread on old hedgerow, field and wayside trees. Parks are now a refuge for such species although they still occur outside of parklands. Pressures on trees outside of landscape parks are a greater intensity of agricultural intensification, loss of veteran trees and lack of replacements and especially the overgrowth of trees by Ivy e.g. the latter is now prevalent in hedgerow trees due to the shift from hand cutting of hedges (when Ivy on tree trunks was cut) to mechanical hedge cutting (when cannot easily be cut) (B. Edwards pers. com.). The recent practise of erecting replacement fences outside of hedges is exacerbating this by pushing gazing animal further from tree trunks.

4.6.1 Survey/knowledge

This is a particularly difficult habitat, many old trees are on private land and will never have been looked at by lichenologists. Threatened species (Woods & Coppins 2012) are not well represented within the current English SSSI series (Wilkins pers. comm.). Additional survey and greater recognition of lichen-rich veteran field trees which are often not associated with other high quality habitats, are needed. What data exists, however, will indicate areas and regions likely to be of higher importance. Locating farmland and parks rich in veteran trees and applying general mitigation approaches, perhaps through agri-environment schemes may be the most efficient approach.

From the review of Section 41 species in this report, the importance of the south west of England for field tree specialists was apparent (**Map 28**). The area escaped the worst of the 20th Century acidifying pollution, so there were far more individual trees of a greater variety of species surviving with base rich bark than in the east of England after the impact of Dutch Elm Disease. This area is an obvious priority for agri-environment schemes aimed at improving condition on mature to veteran trees.

Map28: A coincidence map of Section 41 specialist field tree lichens, which have strongholds in the south west of England. This shows the concentration of records from Dorset westwards. The concentration in the New Forest represents a woodland rather than a field tree hot spot. (Post-2000 records of *Anaptychia ciliaris* subsp. *ciliaris*, *Bacidia incompta*, *Catapyrenium psoromoides*, *Cryptolechia carneolutea*, *Lecania chlorotiza*, *Parmelina carporrhizans*, *Physcia tribacioides*, *Teloschistes flavicans* and *Wadeana dendrographa*, BLS data 2019). © British Lichen Society 2019. Reproduced with permission.



4.6.2 Management Options

Parks are more likely to be negatively impacted by agricultural intensification and the resultant ammonia pollution than woodlands. Extensive grassland management with no or minimal fertiliser applications is required. Parks brought into arable production in the 20th century should be put back to permanent grassland. Parks are much more likely than woodlands to suffer from tree generation gaps. In most parks, little tree planting occurred between the agricultural depression of the 1870s and the 1960s. In parks with particularly serious generation gaps simply planting trees now with not solve the problem; many of the current veteran trees will be lost before the planted trees are old enough to be colonised by rare lichen species. In these situations, there may be solutions involving land adjacent to the surviving open parkland. There was often tree planting in adjacent woods during the gap in parkland planting and mature 19th century Oak in adjacent habitats could be promoted as new veteran trees to bridge the gap. In many parks there has also been a tendency to fence off denser areas of veteran trees and patches of pasture woodland from the wider parks over the 19th and 20th centuries. Ideally, conserving or restoring the lichen interest of such areas would involve thinning any dense post-enclosure regeneration around the older trees, removing fences, and restoring grazing.

In heavily grazed parks individual trees or groves are sometimes fenced off to prevent direct damage to the trees from the stock. Ideally the grazing intensity should be reduced rather than fencing off the trees. If trees must be fenced off, then it is absolutely essential that the grazing be replaced with grass cutting, scrub control and Ivy control to maintain the parkland conditions around the lower trunks.

Management for the mitigation of the likely impacts of Ash Dieback cannot be isolated from a number of other issues - the 'management package' should include the following where relevant.

- Removing and controlling Ivy spread on mature and veteran trees would be a major gain for improving the habitat for declining field tree and parkland. This would massively increase the numbers of suitable trees available for colonisation.
- Excessive levels of ammonia in the air from intensive agricultural units and spreading manure and fertiliser are a threat to rich lichen assemblages on veteran trees. Most of the species involved are not highly sensitive and slightly enhanced levels of ammonia are part of their habitat requirements, so the critical background concentration of $1 \mu g\ m^3$ given by APIS for epiphytic lichens is potentially rather strict for this habitat, but observations suggest it ideally should be below $2 \mu g\ m^3$. Areas with concentrations of trees, especially in historic parklands, would ideally be managed as low intensity grassland. In fields beyond this, general measures to reduce ammonia impacts should be applied (Sutton et al 2011 & Plantlife 2017).
- The preservation of veteran trees within farmland should be encouraged. As well as not felling, this should include advice to avoid

damaging activities, such as deep ploughing within the root run of old trees.

- In the long term programmes for replacement trees, both by planting and by promoting trees from hedgerows are required to provide a succession of trees.

4.6.3 Alternative Substrates

Potential useful alternative trees in parkland or in-field situations which could act as substrates for Ash dependant lichens are listed below:

- Sycamore: a major alternative habitat throughout Britain in farmland.
- Norway Maple: an even better substitute for Ash but is much rarer in the countryside.
- Oak: native Oaks are also a significant in areas of the south west where they have not experienced acidification. They are currently rather poor beyond these areas but may improve with declining acidification.
- Field Maple: large well lit old trees appear rare, but where they occur they are especially important.
- Horse Chestnut: frequent in parklands, where it can host wound track specialists.
- Exotic parkland trees: numerous other non-native tree species can be of lichen interest, where they occur as veterans in parklands but are not frequent in farmland. These include Lime (*Tilia* spp.), Turkey Oak (*Quercus cerris*), Poplar (*Populus* spp.), Beech (*Fagus* spp.) and Holm Oak (*Quercus ilex*). Not all these species are suitable for wider planting, e.g. Turkey Oak is not regarded as an appropriate species to grow near to high value native woodland (Kirby, 2009).

Photos 5 & 6: Melbury Park, Dorset, the top picture shows former hedgerow trees left behind when a hedge was removed, these mature and post mature Oaks support a major population of *Anaptychia ciliaris* VU (NS/S41). The picture below shows a nearby ancient Ash with the trunk and lower canopy overwhelmed by Ivy. This tree lacks any lichen interest (Sanderson, 2009c). In earlier times, this tree would have been browsed by passing stock driven along the lane with any surviving Ivy cut. © Neil A Sanderson

4.7 Alternative host tree species

4.7.1 Hazel

Hazel is an important habitat for two epiphytic assemblages that are also significant on Ash: Smooth Bark Communities (*Graphidion*) and Base Rich Bark Woodland Community (*Lobarion pulmonariae*). The former is generally better developed on Hazel than Ash but the Base Rich Bark Woodland Assemblage can be exceptionally well developed on both. Hazel can be a significant alternative host for most leafy *Lobarion* specialist species found on Ash but not usually for the crust forming *Lobarion* lichens. The ecology of lichen diversity on Hazel is quite different from the ecology of lichens on tall trees. This has been explored in depth by Coppins & Coppins (2012), covering the richest habitats in Western Scotland but also useful is Coppins & Coppins (2014) covering some Hazel stands in Wales. As a multi-stemmed bush, the growth form of Hazel is very different from canopy trees and this is the key factor in the lichen ecology. With uncut Hazel bushes, which are not hard grazed, the stool is potentially immortal, with old shoots being replaced by new shoots. This produces continuity for slow colonising lichen, which can colonise a very short distance from between older and maturing stems. For either Smooth Bark or Base Rich Bark Woodland assemblages it is important that there is no heavy canopy over the Hazel; the epiphytic assemblages on shaded Hazels are typically species poor.

Traditional full scale coppicing is extremely damaging to Hazel lichen diversity (Gilbert, 1984) and the best lichen assemblages are found in areas such as the Highlands. Here Hazel had mainly been treated as a component of pasture woodlands, where cover for sheltered grazing was at least as important as producing wood and timber, and systematic coppicing was not a standard part of traditional woodland management (Smout et al, 2005). South of the Scottish Highlands nearly all Hazel has been coppiced in the past but undisturbed Hazel woods have developed in the last 100 years or so. Chronosequences in Marlbank, Co Fermanagh, (Sanderson, 2012) indicated that here, sites that retained old trees through the low point in woodland cover in the 18th and early 19th century were distinguished by the combination of rich Smooth Bark and Base Rich Bark Woodland assemblages. Beyond this rich smooth bark communities were absent in more recent Hazel woods but those predating 1906 had been well colonised by Base Rich Bark Woodland assemblages. Younger Hazel woodlands were still species poor. It seems that Hazel woods in the area require more than 100 years for *Lobarion* communities to full develop, with colonisation initiated after 50 years. Diversity was highest in old woods closest to relic sites and distant sites less well colonised. Colonisation within sites is also clearly much faster. This applies to the relatively fast colonising Hazel and Sallow; the only rich Ash trees recorded were in woods present in either 1834 or 1857. More than 150 years is probably required for *Lobarion* floras on Ash trees to start to establish in new woods. Although ancient undisturbed Hazel stands are the richest stands, significant colonisation by the Base Rich Bark Woodland Community (*Lobarion pulmonariae*) species can occur on a much shorter time scale than for trees, as long as here are nearby sources of *Lobarion* species to colonise.

Much attention has been paid to pure Atlantic Hazel woods, i.e. the most extreme stands lacking any trees other than Hazel; these are the richest in specialist Hazel species. However, for the purposes of Ash Dieback mitigate a second transitional type of Hazel woodland is much more significant. These still have Hazel as a dominant, but tall canopy trees also occur as scattered emergent trees. Such Hazel woods with scattered emergent trees are actually more widespread in the western Highlands than true Atlantic Hazel wood, and are even found in pasture woodlands as far south as Dorset in southern England. These woods have a distinctive ecology and are essentially a form of pasture woodland (Sanderson, 2005 & 2012) consisting of groves of dense Hazel with glades. The continuous canopy of Hazel within the groves prevents the establishment of Ash trees here and grazing of the glades prevents establishment of large numbers of Ash trees there. The Hazel bushes in contrast are self replacing with new sun shoots growing up within the protection of the centre of the Hazel stool. These woods are perfectly capable of becoming normal Ash woods with a Hazel understory if grazing is removed, but this has a strong negative impact on the lichen flora. Hazel with an overstorey is too shaded in strongly oceanic climates carry a rich lichen flora. Even the shade of a full Hazel canopy without Ash produces heavy shade; hence the importance of maintaining the glades.

Photos 7 & 8: Marlbank, Co Fermanagh, the top picture with gladed grazed Hazel wood with rich Base Rich Bark Woodland assemblages including *Lobaria pulmonaria* on the well lit bushes. Bottom picture shows a Hazel wood with Ash that has recolonised around an ancient relic Ash pollard. © Neil A Sanderson

Photos 9 & 10: Coille Thogabhaig, Skye, the top picture shows a formerly heavily grazed Hazel tree in a grazing exclosure, the abundant sun shoots have heavily shaded the old trunk, which is dying due to resource reallocation. Leafy *Lobarion* species can survive on the old grazed stems but cannot survive shading and rapid death of the old stem. The lightly grazed bush on a protective bank in the picture below, is in a healthy condition with the old stems vigorous and a few, but adequate, replacement stems. Leafy *Lobarion* species survive well on such bushes. © Neil A Sanderson

Heavily grazed Hazel fails to produce sun shoots and develops into tree-like forms (Coppins & Coppins 2012). Such tree form Hazel is usually poor in smooth bark specialists, but can still be important for leafy Base Rich Bark Woodland Community (*Lobarion pulmonariae*). Such Hazels can be regenerated by reducing or removing the grazing pressure but the way this is done is critical to the survival of the *Lobarion* species (Sanderson 2010c). Drastic removal of grazing produces numerous sun shoots around the old stems. These sun shoot can rapidly shade out rare species and the stool soon diverts resources to the new shoots and kills the old stems long before the rare lichens can colonise the new shoots. In contrast, if grazing is reduced to allow only a few shoots to escape, the old shoots to carry on growing and remain well lit and the lichen interest survives.

Hazel could be an important alternative to Ash and as a mitigation for Ash Dieback, but requires to be managed appropriately:

- Hazel can support many leafy *Lobarion* species that thrive on Ash but are not as prominent on Oak. Ancient stands of Hazel are rare south of the Scottish Highlands, but where old Hazel is allowed to develop close to rich *Lobarion* sites, it is readily colonised.
- Rich Hazel requires to be unshaded by any canopy and well gladed to be well enough lit enough to be to lichen rich, this requires moderate grazing.
- Heavily grazed Hazel can continue to support rich leafy *Lobarion* assemblages, but care is required in allowing the stools to regenerate; removing grazing totally is likely to lead to the loss of the lichen interest. Grazing reductions are better.
- Hazel bark appears more sensitive to acidification than Ash, so is less effective as an Ash replacement in areas such as the Lake District where acidification is still a serious problem (**Map 4**).
- Coppicing of Hazel is inimical to the survival of rich lichen assemblages.

4.7.2 Sallow

Lichen rich Sallow (*Salix cinerea*) scrub is a distinctive habitat, where open collapsing Sallow bushes in sheltered humid locations become rapidly colonised by rich assemblages typically consisting of a mixture of species of both acid and base rich bark habitats (*Lobarion* & *Parmelion laevigatae*). Unlike the occurrence of the same communities on post mature and ancient canopy trees, this is a relative rapidly developing community but potentially quite ephemeral. The rich communities are rapidly lost if the Sallow canopy thickens and shades the branches below and a certain amount of grazing is usually required to maintain conditions within the stands for the long term. Similar to Hazel this habitat is a significant alternative host for most leafy *Lobarion* specialist species found on Ash but not for crust forming lichens. Like Hazel, developing lichen rich stands of Sallow need to both develop a suitable gladed structure and be close to a lichen-rich old growth stand as a source of the propagules of rare lichens. Suitable conditions are actually quite rare in the south west (Rose, 1995) due to the requirement for nearby refuges of the rare *Lobarion* species, although suitably structured wet Sallow woods are frequent. Where conditions are good then impressive large populations of rare and declining species can build up rapidly (Sanderson, 2018b). Goat Willow (*Salix caprea*) has a similar value to Sallow for lichens, but more often occurs as single bushes on drier ground.

Sallow could be an important alternative to Ash and important in mitigation for Ash Dieback, but requires to be managed appropriately:

- Sallow can support many leafy *Lobarion* species that thrive on Ash but are not as prominent on Oak. Most rich stands are secondary stands of Sallow developed with existing lichen rich sites
- Rich Sallow requires to be un-shaded by any canopy and to be well gladed to be well enough lit enough to be to lichen rich, this requires light to moderate grazing.
- Sallow bark appears more sensitive to acidification than Ash, so is less effective as an Ash replacement in areas such as the Lake District where acidification is still a serious problem (**Map 3**).

Photo 11: The Fish Pond, Arlington Court, North Devon, the stem of a collapsed and regrowing Sallow with a rich and vigorous assemblage of leafy *Lobarion* species with cyanobacteria as the main photobiont. With *Sticta sylvatica* Nb (IR), *Sticta fuliginosa* s. str. Nb (IR) & *Peltigera collina* Nb (IR) in picture. The sallow thicket here has established over 150 years in the head of a fish pond within an landscape park. It is now exceptionally rich in lichens after clearance. © Neil A Sanderson

4.7.3 Beech

Beech is potentially a very rich substrate for lichens and can support species from both Base Rich Bark Woodland Community (*Lobarion pulmonariae*) and Wound Track Assemblages (*Gyalectinetum carneoluteae*) for which Ash is currently an important habitat.

Beyond its current native distribution, however, the tree has a reputation as a serious conservation problem, invading woods and impacting on rich lichen assemblages. It is a complex issue compounded by the introduced stock beyond its native range in Britain actually being nearly all of native British stock (Sjölund et al 2017). It is clearly well adapted to grow well beyond its native range; its current restricted native distribution is a very clear example of postglacial dispersal limitation (Svenning & Skov 2007). It is a late succession shade-casting species and quite a thug, and can totally displace species such as Oak unless heavily managed by thinning or quite hard pasture woodland grazing (Vera 2000). Essentially any wood invaded by Beech becomes a Beech woodland ecosystem. In addition, the species is a likely replacement for Ash by natural regeneration throughout much of Britain after Ash Dieback (Broome et al, 2018). This is not dependent on anthropogenic climate change as the northern limit of Beech is not climate controlled in Britain (San-Miguel-Ayanz, 2016). It has, however, begun to assume significant lichen interest in the south and south west of England beyond its native range (Sanderson 2010b, Sanderson 2015 & Greenaway & Wolseley in press). Here Beech may become a valuable substitute tree for Ash, especially for wound tack specialists, if managed as open structured grazed old growth pasture woodland stands. Otherwise the impact of Beech invasion is likely to be negative for lichen diversity for the immediate future in most of Britain. A particular complication is that high lichen diversity develops quite late in the tree's life cycle and this diversity is often threatened by its own dense regeneration (Fritz, 2008). For the maximum lichen diversity within Beech woods it is important to maintain other species such as Oak as veteran trees (Wolseley et al 2016), which is not achieved in non-intervention old growth stands (Vera 2000).

The key challenge is to naturalise Beech without damaging existing lichen assemblages but it is not a simple process:

- Beech invasion represents a "phase shift", in the functioning of woodlands. Beech woods, even if mixed, do not behave in a similar way to normal Oak or mixed upland woodlands; much more disturbance or management is required to maintain diversity.
- This leads to an invasion phase of up to 250 years, where Beech is displacing much diversity, but is also a poor lichen habitat. Without management to maintain other tree species as veterans in good lichen habitat over this period much lichen diversity could be lost.
- Beech is an important substrate for rare epiphytic lichens, but becomes lichen-rich later in its life than Oak, taking up to 200 to 250 years, although it has a shorter life span of about 350 to 450 years

Beech in old growth woodlands is showing signs of becoming a significant lichen habitat in south west England and its naturalisation is most likely to be successful in this area. In many currently rich lichen woods, however, the best management policy will still be to prevent Beech invasion although note Natural England's current approach in Kirby (2009). Dealing positively with Beech, however, may be less optional further north, given the strong invasive ability of Beech.

Maintaining lichen diversity within Beech woods requires:

- High browsing pressure to prevent Beech overwhelming other tree species and to prevent deep shade developing from a closed canopy and dense shrub layers of young Beech and Holly.
- Within the existing rich old growth stands during a transition to a mixed oceanic Beech woodland, it would be best to thin to leave fewer Beech trees in these important areas.
- In any areas of planned developing old growth woodland, Beech can be allowed to be more prominent, but should not be allowed to totally dominate.
- Sites with frequent existing mature to veteran Beech are likely to be the best sites to naturalise Beech.

Photo 12: Boconnoc Park, East Cornwall, a developing old growth Beech stand well west of the accepted native range, with rich colonising Base Rich Bark Woodland and Mesic Bark habitats, supporting *Lecania chlorotiza* NT (NS/IR/S41), *Melaspilea lentiginosa* NT (NR/IR/S41) and *Thelopsis rubella* (Sanderson 2010b) © Neil A Sanderson

Photo 13: Ethy Park, East Cornwall, a well-lit Beech in a sheltered humid location, well west of the accepted native range. This tree supported with one of the richest Base Rich Bark Woodland Assemblages in the park with *Pannaria conoplea* Nb (IR), *Sticta fuliginosa* Nb (IR), *Sticta limbata* Nb (IR) and *Sticta sylvatica* Nb (IR); a typically Ash assemblage in this area. The stunted Holly below supported *Arthonia ilicinella* NT (NS/IR), new to England (Sanderson, 2015). © Neil A Sanderson

4.7.4 Non Native and Near Native Tree Species

Some tree species, which are not native to Britain, are known to support rich epiphytic lichen assemblages in suitable conditions. These include Sycamore and Norway Maple, both of which are native European trees which failed to reach Britain before the English Channel reformed. These are also regarded as very good hosts for Base Rich Bark Woodland assemblage (*Lobarion pulmonariae*) both in Britain and within their native range. Another, Sweet Chestnut, is in contrast regarded as a very poor lichen habitat in Britain but can be rich in southern Europe. Similar are Beech and Hornbeam, which are native to the south of Britain and can be exceptionally lichen rich, but are regarded as nuisance species beyond, being invasive late succession species which greatly reduce lichen diversity by casting dense shade when young. Sycamore and Norway Maple are among the most similar trees to Ash in terms of the lichen assemblages they support (Kiebacher et al 2017, Mitchell et al 2014a & Stern 1989). Mitchell et al (2014) state that Sycamore and the native Oak species combined would support 85% of all Ash-associated lichen species; essentially Oak supports more generalist species, while Sycamore provides a suitable habitat for some Ash specialist lichens, especially leafy *Lobarion* species with cyanobacteria as their main photobiont that perform less well on Oak. For trees of any species to be lichen rich, the individual tree typically needs to be at least post-mature and not too heavily shaded.

Photo 14: Mark Ash Wood, New Forest, a well grazed ancient Beech old growth woodland in the heart of its native range. This exceptionally rich Beech wood with some Oak, Holly and Ash, has had 288 epiphytic taxa recorded since 1967, including 17 Section 41 or BAP species, and has strong populations of wound track specialists including *Bacidia incompta* VU (NR/S41), *Collema fragrans* EN (NR/IR/S41) and *Cryptolechia carneolutea* VU (NS/IR/S41), all former Elm specialist now threatened by Ash Dieback outside of the New Forest. Grazing is preventing mass regeneration by Beech and Holly, but Bramble growth around fallen woody debris is also allowing patchy regeneration to survive. © Neil A Sanderson

In Europe, although some faster colonising trees are at their climatic limits throughout their range, for many species the native distribution is limited by post-glacial dispersal limitation as much as climate (Svenning & Skov 2007). This can clearly be seen in San-Miguel-Ayanz (2016), where the modelled potential distributions of species such as Sycamore, Beech and Hornbeam and in the real life evidence of these species readily regenerating beyond their current natural distributions. A better approach than a strict emphasis on current natural distributions, would be a wider acceptance of a concept of “near native” for European species whose distributions have still not recovered from the last ice ages. This is reinforced by the potential impact of anthropogenic climate change, which will further change the climate envelopes of all European tree species. This includes both those trees with stable distributions fully recovered from the last ice age and those trees that were still recovering. The acceptance of a species at a site should be on an assessment of its actual impact not a binary decision on native or non-native status.

A general rule, noted originally by Dr Francis Rose, is that old exotic tree species with base rich bark are readily colonised by Base Rich Bark Woodland (*Lobarion pulmonariae*) and Nutrient Rich Bark (*Physcietum ascendentis*) assemblage species, but acid bark old exotic trees are much less readily colonised by specialist species of acidic habitats. The reasons behind this are not clear but means that many exotic species in situations such as parkland can be colonised by many lichens characteristic of Ash.

4.7.5 Sycamore

For Ash Dieback, the perception of Sycamore is the main issue. There have been several reassessments of Sycamore recently (Broome et al 2018, Morecroft et al 2008, Reid et al 2015, Stern 1989, Townsend 2008, Waters & Savill 1991) which indicate that negative issues with Sycamore have been exaggerated or can be ameliorated with appropriate management. Sycamore does appear to slot well into the ecosystems of many woodland habitats simply assuming the usually subsidiary role it has in European woodland. For lichens, Sycamore needs to be allowed to develop into a mature-veteran tree and be in reasonably well lit grazed habitat to reach its full diversity. It is potentially a species of value for lichens throughout its range.

Photo 15: Ethy Park, East Cornwall, a large ancient Sycamore in parkland on the edge of Ethy Wood, with a large population of *Collema subflaccidum* and with *Leptogium cyanescens* Nb (IR) on the edge. *Bacidia incompta* VU (NS/S41) was located in the base of the large rot hole to the left. These are all typical Ash species in the area. © Neil A Sanderson

Photo 16: Fedw Felen, Parc Nannau, Gwynedd an ancient Sycamore in upland pasture woodland, supporting *Lobaria amplissima* Nb (IR), *Lobaria pulmonaria* Nb (IR), *Nephroma laevigatum* Nb (IR) and *Sticta sylvatica* Nb (IR). Sycamore supported the richest Base Rich Bark Woodland Assemblages in this wood and had previously been threatened with felling for conservation purposes i.e. to remove non-native trees from the wood. © Neil A Sanderson

4.8 Translocation of lichens

Translocation of larger leafy lichens is possible but is difficult and success is not guaranteed (Gilbert 1991& Scheidegger 1995), while it is untested for crust forming lichens. For some Ash-dependant rare lichens transplanting lichens may be the only possible last ditch action applicable to Ash trees that are dead or dying. Further research is being carried out on this by Plantlife and the results of this should inform the use of translocation as an Ash Dieback mitigation measure.

4.9 General habitat management for woodland lichen assemblages

Ecosystems and habitats in good condition are likely to be more resilient to change, while those in poor condition are likely to be less resilient. Similarly, large species' populations are likely to be more resilient than small ones (Natural England & RSPB, 2014). By improving and optimising the woodland habitat for lichens, species' populations will be better able to cope with Ash Dieback.

The best conditions for woodland lichen assemblages are typically found in extensively grazed pasture woodland with a mixture of open high forest, glades and savannah like stands (Sanderson & Wolseley 2001). The main positive features appear to be:

- Many trees surviving to senescence.
- Varying, but generally good light levels (with different lichen species having widely different tolerances).
- Shelter producing humid conditions.
- Slow woodland dynamics.

The basic mechanism driving this is a varying browsing pressure on tree regeneration that suppresses regeneration for long periods. A major interaction is between the shrub layer and the browsers; this can rapidly and drastically change the light and humidity levels without immediately altering the canopy layer (Coppins & Coppins 1998). Interactions between browsers and the canopy are much more long term, but frequent glades are required. Glades need to be dynamic but permanent features and slow dynamics are crucial. Coppins & Coppins (2002b), as an initial guide, suggest a requirement for at least 30% glades within the canopy of lichen rich woodlands and that the glades have a permanence of at least 30 years. In contrast, tree cover of less than 20 to 30% will result in the loss of woodland conditions and the resultant loss of the old growth dependent lichen assemblages. Exceptions to the latter are found in parklands with veteran trees with wide spreading crowns in very sheltered valley bottoms or humid areas. In very wet oceanic areas, woodland conditions can also be maintained with less shelter and in more open areas. In these special conditions woodland lichen assemblages can survive in more open conditions.

There is no reason why such conditions could not be created by management outside of pasture woodlands, but this would not be easy. In particular, it is important to appreciate the scale of management required. Rare lichens typically have very low rates of occupation, as they require specialised niches found on only a few veteran trees. As a result, they tend to occur on very small numbers of trees within large populations of veteran trees. Each veteran tree will have different combinations of niches. Rather than just maintaining a few especially rich trees, sustainable management requires the maintenance of good conditions around dozens or hundreds of trees (depending of the size of the site), both veteran and maturing. To imitate browsing impacts fully, management would also be required to be annual. Without browsing, coppice regrowth around haloed veteran trees (trees with shrubs and maturing trees cut from around them) can cast a very dense shade on the lower trunks within three years or so. Extensive grazing appears to be the only practical method of maintaining large blocks of nationally or internationally important lichen rich woodland in the long term. Suitable conditions are unlikely to be found in woodlands managed efficiently for timber. Neither are they likely to be found within true non-intervention woodland with low browsing levels.

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- Full scale regeneration within old growth stands producing a full range of replacement generations within stands will inevitably result in stands that are too dark for highly diverse lichen assemblages to survive.
- Rich lichen assemblages are associated with some degree of regeneration failure, which is a difficult concept in conventional conservation-based woodland management. Replacement regeneration needs to be patchy and to have some degree of spatial separation with the oldest stands that are starting to open up. New trees need to be growing *near* the rich stands, and not *within* these stands. This is encompassed within the theories of Vera (2000), although the scale may not always be as large a scale as represented by him and may more resemble delayed gap phase regeneration.
- It is important to scale the need for regeneration with the lifespan of the trees involved. Essentially only three generations are required. Young trees, mature trees and post mature trees. For Oak this means regeneration is only required about once every 100 years and about one every 75 years for shorter lived trees.
- The best stands will be little-managed (as in little mechanical intervention) pasture woodland old growth stands, where any timber production will tend to reduce lichen diversity. Separation between lichen-rich old growth and managed young growth is best.
- Conventional silvicultural thinning is very damaging to lichen diversity as it removes slow growing suppressed trees, which are a valuable resource. Restoration thinning for lichens within dense woodland is more effective if very uneven and patchy.

The following is a guide for assessing grazing impact in pasture woodlands:

Hard Grazing Impact: potentially acceptable for periods and will maintain good conditions for epiphytic lichens, but will require reducing periodically for the long term health of the woodland. Indicators:

- No tree regeneration.
- On less acidic soils, no Bramble.

- On acid soils, Bilberry grazed very short and moss mats overwhelmingly dominant.
- Hazel often growing in a single stemmed tree like form; under long term heavy grazing, no regeneration of Hazel bushes by the growth of sun shoots from the base.
- No Ivy on trees.

Moderate Grazing Impact: grazing and browsing levels allow some regeneration, while generally maintaining good conditions for epiphytic lichen assemblages but some occasional management of shading shrubs or regeneration may be required. Indicators:

- Suppressed (browsed) tree regeneration surviving and occasionally escaping.
- On less acidic soils, Bramble present, especially around fallen wood debris but Bramble patches contained by browsing.
- On acid soils, Bilberry forming an open canopy with moss mats surviving.
- Hazel bushes perpetuated by some sun shoots escaping browsing but no mass growth of sun shoots. The sun shoots not shading the old shoots, which are remaining healthy.
- Rare to occasional Ivy on trees.

Low Grazing Impact: grazing and browsing are not containing regeneration and rich epiphytic assemblages are likely to be under threat. Survival of lichen assemblages will require large scale intervention. Indicators:

- Tree regeneration not significantly constrained by browsing.
- On less acidic soils, Bramble extensive and tending to dominate in open areas.
- On acid soils, Bilberry forming a dense and tall canopy with moss mats being shaded out.
- Many sun shoots growing from the base of Hazel bushes, casting heavy shade on older stems and old stems often dying prematurely.
- Ivy widespread on trees and tending to dominate well lit trunks.

Rich lichen assemblages are likely to set the lower levels of grazing and browsing levels but other interests and criteria are likely to set the upper limits. In most habitats, varied levels of grazing over time, rather than one particular browsing level is likely to be ideal.

Photo 17: Beaulieu River, New Forest, Alder & Ash regeneration on a log in grazed ancient riverine pasture woodland. Ash regeneration is frequent despite the quite high level of grazing in this dynamic environment. The Ash regeneration here was studied by Bakker et al (2004). © Neil A Sanderson

Photos 18 & 19: Sideway Wood, Horner Wood NNR, Exmoor, moderately grazed pasture woodland in a river valley. Open grazed areas around the Ash tree in the centre, which supports the only known surviving colony of *Lobaria scrobiculata* Nb (IR) at Horner. The grazing constrained Bramble thickets are protecting tree regeneration (Sanderson, 2017d). © Neil A Sanderson

Photo 20: Great Stubby Hat, Busketts Wood, New Forest, old growth Beech pasture woodland with a fairly recent dense Holly shrub layer which thickened up during slightly lower grazing pressure. Here the Holly was coppiced and pollarded in 1995 to provide winter food to ponies and deer and to open up the lichen rich old Beech. Young Beech regeneration that was shielded by the Holly was left during the cutting. © Neil A Sanderson

Photo 21: south of Allt Coire nam Bò, Ruigh Aiteachian, Uppe Glen Feshie, Cairngorms, ancient boreal pasture woodland with Scots Pine along with a pollarded Mountain Goat Willow (*Salix caprea* ssp *sphacelata*), with a *Lobarion* community. Long a part of sustainable seasonal cattle summer pastures, until the late 18th century (bò = cow and ruigh = summer pasture), but since then hard grazed by deer. More sustainable grazing was being established, without fencing, when the photograph was taken. © Neil A Sanderson

4.10 Ivy issues

Ivy control can be controversial; Ivy on trees is regarded as of general benefit to wildlife, and cutting Ivy a bad thing. Ivy, however, is also major threat to epiphytic biodiversity (Sanderson & Wolseley 2001, Edwards 2006b & 2007). In most areas the visceral reaction against Ivy control is anachronistic; Ivy is now mostly uncontrolled across the countryside. Universal Ivy cutting is a problem of the 1950s, not the 21st Century. In grazed woodland Ivy is a major winter browse, originally presumably this also occurred in the wild wood. This results in most trees being clear of Ivy, but with occasional trees with canopy Ivy where Ivy has escaped browsing and has got into the crown of the tree. Sanderson (2001) recorded 10 to 18 trees per ha with crown Ivy (4 – 12% of the numbers of canopy trees) in two ancient grazed pasture woodlands in the New Forest. Even on these trees the lowest 2m of the trunks, the richest area for lichens, were kept clear of Ivy leaves. Large scale coverage by Ivy of trunks is not a natural feature but the complete absence of Ivy on trees, once a widespread feature, now a rarity, was also an artefact of human management. Climatic warming and air pollution may be additional drivers of increasing Ivy prevalence (e.g. Zotz et al. 2006). In both woodland and on field trees, Ivy is an increasing threat and needs to be dealt with (see Case Study 5, Arlington Court, North Devon, for an example of the problems).

Photo 22: James Hill, New Forest, anciently grazed woodland with small amounts of Ivy escaping browsing. The trunk of this Beech tree supports the very rare *Megalaria laureri* VU (NR/IR/S41) below the Ivy browse line. © Neil A Sanderson

In terms of conflicts with other biodiversity interest, unfortunately there is no information on how much Ivy is needed for the biodiversity benefits of Ivy on trees; presumably not every tree. To achieve a balance, it is recommended that only areas of high lichen interest with an actual Ivy problem are treated. This will leave the Ivy in the vast majority of the trees untreated. In sites of national and international importance for epiphytic lichen assemblage it is a more than reasonable compromise that Ivy should be controlled in areas of high lichen interest but be left in other areas.

The following general protocol is suggested for controlling Ivy in lichen rich woodlands and trees:

- Within delimited lichen-rich areas where Ivy is a definite problem, most Ivy stems would be cut.
- Within these areas, all small diameter Ivy on trunks would be cut, with the aim of killing off most of the crown Ivy in the stand.
- Any long established and large diameter Ivy climbing up trunks should be left.
- The aim should be to retain a scatter of trees with crown Ivy within the stand, preferably leaving less than 15% of trees with Ivy.

Photos 23 & 24: Florence Court, Co Fermanagh, this fenced off Poplar supported strong colonies of *Lobaria scrobiculata* (by and right of pen tip) and *Lobaria pulmonaria* (green thallus lower right) in 1990, by 2011 these had nearly been lost to Ivy spreading up the tree (Sanderson, 2011b). © Neil A Sanderson

4.11 Air pollution

The major form of air pollution that impacted epiphytic community composition from the 19th to late 20th century was acidifying sulphur dioxide derived pollution. Sulphur dioxide is directly highly toxic to most lichens and this was the main proximate impact (Hawksworth& Rose 1976). The acids derived from sulphur dioxide also acidify substrates thus changing their ecology and this impacted much further from the source of the sulphur dioxide as acid rain (Farmer et al 1992). In the fringes of the areas affected by acid rain, the highly buffered bark of Ash provided a refuge for acid intolerant lichens, especially rare Base Rich Bark Woodland Community (*Lobarion pulmonariae*) species. Tree species more severely acidified than Ash included Oak, Sallow and Hazel. This has increased the vulnerability to Ash Dieback of many acid intolerant lichens in high rainfall areas in the uplands of Britain south of southern Argyll. Some areas, especially the Lake District, are still being impacted by acid rain, although it has declined everywhere. Acid rain is caused by long lasting pollutants and mitigation can only be achieved by national policy reducing the distant sources of acid deposition.

Sulphur dioxide pollution has greatly declined in recent decades and in most lowland areas has been replaced by nitrogen pollution as the main impact on lichen diversity. In high rainfall areas nitrogen oxides are now the main cause of continuing acidification, but in other areas the main impact of nitrogen pollution on lichens is from dry deposition of gaseous ammonia. This is a short range pollutant, which is mainly produced by intensive agriculture, including both spot sources from intensive livestock units and generally from fertilised fields (van Herk 1999& Wolseley et al 2006). Ammonia has a much greater enriching effect on vegetation in general than nitrogen oxides (Sheppard et al 2011 & Sheppard et al 2009). The impact on lichens appears not to be directly related to nitrogen uptake but through osmotic tolerance against (or not) the salt effects of nitrogen compounds, with nitrogen-intolerant species having a low osmotic tolerance. Nitrogen tolerant species are typically drought tolerant species and characteristic of regions with low humidity (Frahm 2013). Ammonia also raises the pH of bark so lichens of acidic habitats are especially sensitive.

The critical concentration for epiphytic lichens of 1 mg/m^3 of ammonia modelled back ground levels (APIS website), with very sensitive acid bark species such as *Usnea florida* and *Bryoria fuscescens* probably only thriving at lower levels than this. Woodland lichen sites ideally should always below the critical concentration. Of the specialist field-tree species *Teloschistes flavicans* VU (NS/S41) appears to be particularly sensitive to ammonia. Many other rare specialist field- tree species are southern drought tolerant species and are somewhat more resistant to raised ammonia concentrations, but field observations suggest that background levels of more than 2 mg/m^3 of ammonia is also damaging to these species.

As ammonia is rapidly scrubbed out of the air local mitigation is possible. High value sites such as woodlands and historic parks can be protected by non-intensively managed buffer zones of a few hundred meters (Dragosits 2006 & Sutton et al 2011). Tree belts are particularly effective at scrubbing out ammonia. In the wider countryside measures to use fertilisers more efficiently (avoiding surplus use) would reduce the losses that high atmospheric ammonia levels represent (Plantlife 2017).

Case studies

The following case studies illustrate many of the points made throughout this report, but also how they can be applied to a site's conservation management o mitigate the likely impacts of Ash Dieback.

5.1 Case Study 1 Glencoe Park and Gowbarrow Park, Lake District

5.1.1 Site Description

Site: two parks above Ullswater in the eastern Lake District, originally part of the same large upland Deer Park (NY3819 to NY4120). The whole site supports an internationally important lichen assemblage but only a small part is notified as an SSSI. Owned by the National Trust. It is an example of a site in an area impacted by acidification, where as a result Ash is more important than it would have been in clean air and many alterative species such as, Oak, Hazel and Sallow are less lichen rich than they would have been.

Survey: the description is based on two systematic surveys for the National Trust (Sanderson, 2016a & 2017c)

Habitat: the parks included large areas of moorland higher up but have extensive areas of groves of veteran trees in open parkland, with Ash dominant on the steeper slopes above and more Oak on the lower slopes. Denser stands of grazed and formerly grazed woodland also occur around cliffs (Yew Crag) and in ravines (High Force). Elm was once important at Yew Crag and a single ancient Wych Elm pollard survives within the site. Ash is significant on the higher slopes of Glencoyne Park, parts of High Force ravine and Yew Crag.

Lichen Assemblage: the combined site scores 36 in the Southern Oceanic Woodland Index, with four Vulnerable and three Near Threatened species. Seven Section 41 species have been recorded. The Base Rich Bark Woodland Assemblages (*Lobarion pulmonariae*) and associated wound track habitats are the primary feature of interest Ash forms a high proportion of the trees of interest for these habitats. Also important are Acid Bark Woodland Assemblages (*Parmelion laevigatae*) in the High Force ravine, for which Ash is of moderate importance, while additional rare species occur in Lignum, Dry Bark, Smooth Bark Communities and Mature Mesic Bark habitats, but not on Ash.

Air Pollution: the area has suffered from high levels of acid deposition and the modelled background deposition in APIS exceeds critical levels. The park is situated on a steep gradient of ammonia deposition rising from east to west but does not exceed critical levels. Field survey confirmed this, observing impacts from acidification but no evidence of strong eutrophication.

- Ammonia Concentration: 0.55 – 0.95 µg m^3

- Total N deposition: 41.44 – 45.78 Kg N/ha/year
- Acid Deposition: 3.33 – 3.76 keq/ha/yr

Management: large parts of the site are grazed and had just been converted to more sustainable grazing with seasonal cattle grazing introduced to allow some regeneration and manage the extensive unimproved grassland better. Some important areas in Gowbarrow, however had been long fenced off, including the very rich Yew Crag, which had been seriously damaged by the removal of grazing with the loss of some rare lichen species and the elimination of the best rock *Lobarion* communities in the Lake District by increased shade. Grazing is now being reintroduced to this area.

5.1.2 Ash as a Lichen Host

The Importance of Ash: the parks have important surviving base rich bark assemblages on many veteran Ash and Oak, along with occurrences on Wych Elm. Hazel, Rowan, Small Leaved Lime and Holly. The area has been stressed by acidifying pollution, but still has many charismatic and sensitive leafy species. Ash disproportionately supports the most acid-sensitive leafy species over Oak, reflecting the impact of acidification. Even some acid bark woodland assemblage rare species especially *Biatora vernalis* Nb (NS) are highly dependent on Ash due to acidification. An important population of the wound track species *Bacidia subincompta* VU (NS/S41) is completely constricted to old Ash.

Gowbarrow 2016: Ash is a significant substrate for lichens of conservation interest at Gowbarrow Park and the loss of Ash would have a serious impact on the lichen interest. Ash was the tree of interest at 12 locations where systematically recorded lichens of conservation were recorded out of a total of 40 locations, that is 30% of the waypoints. This was not evenly distributed across the site with far more Ash at Yew Crag (56%) and below Hind Crag (67%) as opposed to 18% in the Aira Force area (Table 5). In terms of species, eight were confined to Ash. Seven others had part of their population on Ash.

Table 5. The Importance of Ash for Lichens of Conservation Interest at Gowbarrow Park 2016

Species or Site	Ash	Total No. Waypoints	% on Ash
Aira Force area	5	28	18%
Hind Crag	2	3	67%
Yew Crag	5	9	56%
Total	**12**	**40**	**30%**
Biatora britannica	1	1	100%
Collema subflaccidum	2	2	100%
Leptogium cyanescens	2	2	100%
Lobaria amplissima	2	2	100%
Nephroma laevigatum	1	1	100%
Parmeliella triptophylla	3	3	100%
Sticta ciliata	2	2	100%
Sticta sylvatica	3	3	100%
Nephroma parile	2	3	67%
Lobaria pulmonaria	5	8	63%
Mycobilimbia epixanthoides	4	7	57%
Biatora vernalis	2	4	50%
Lobaria virens	1	2	50%
Mycobilimbia pilularis	1	2	50%
Sticta limbata	1	3	33%
Agonimia allobata	0	2	0%

Species or Site	Ash	Total No. Waypoints	% on Ash
Bacidia circumspecta	0	1	0%
Bacidia incompta	0	1	0%
Biatora chrysantha	0	2	0%
Caloplaca lucifuga	0	1	0%
Cetrelia cetrarioides	0	3	0%
Chaenothecopsis nigra	0	1	0%
Cresponea premnea	0	1	0%
Gyalecta flotowii	0	2	0%
Lecidea sanguineoatra	0	4	0%
Lopadium disciforme	0	8	0%
Microcalicium ahlneri	0	1	0%
Pachyphiale carneola	0	7	0%
Parmeliella parvula	0	1	0%
Schismatomma quercicola	0	2	0%

The threatened species include both large leafy species and smaller crust forming species. The former can potentially be translocated but the latter cannot. Of the latter, only one, the relatively widespread *Biatora britannica* Nb (NS) was confined to Ash. In the worst case scenario, translocation of leafy species from dying Ash trees to other suitable trees may be the only possible rapid mitigation measure. At Gowbarrow Park, more base rich Oak, Hazel and Sycamore are the best existing potential translocation trees. Otherwise ensuring that suitable alternative fast maturing substrates such as Sallow and Hazels are promoted, in open locations should help in the medium term. To be effective substrates for *Lobarion* lichens on bushes, both Hazel and Sallow, need to have no or limited over canopy of tall trees. The main alternative tree substrate, Sycamore, is rare as an old tree but at least one tree with base rich bark was spotted west of Yew Crag. Also continuing reductions in acid deposition are likely to make Oak a more widespread substrate for *Lobarion* lichens. At Yew Crag there were indications that some Wych Elms might be now surviving long enough to be colonised by some of the Ash specialists. Also at Yew Crag, several of the species now restricted to Ash were also found on bounders close to the rich trees in the 1980s. This would have been an important refuge habitat but appears to have been lost to shade after the grazing removal here. Restoring more open conditions here may allow this habitat to recover. In the very long term any resistant local Ash should be retained and promoted, including potentially collecting seed and locally growing on, for planting out.

Glencoyne Park 2016: Ash is a significant substrate for lichens of conservation interest at Glencoyne Park and the loss of Ash would have a serious impact on the lichen interest. Ash was the tree of interest at fifteen locations where systematically recorded lichens of conservation were recorded out of a total of 44, that is 34% of the waypoints (**Table 6**). In terms of species, four were confined to Ash including the very threatened *Bacidia subincompta* (VU (NS/S41) (pE–VU). Four others had part of their population on Ash.

5.1.3 Potential Mitigation Options

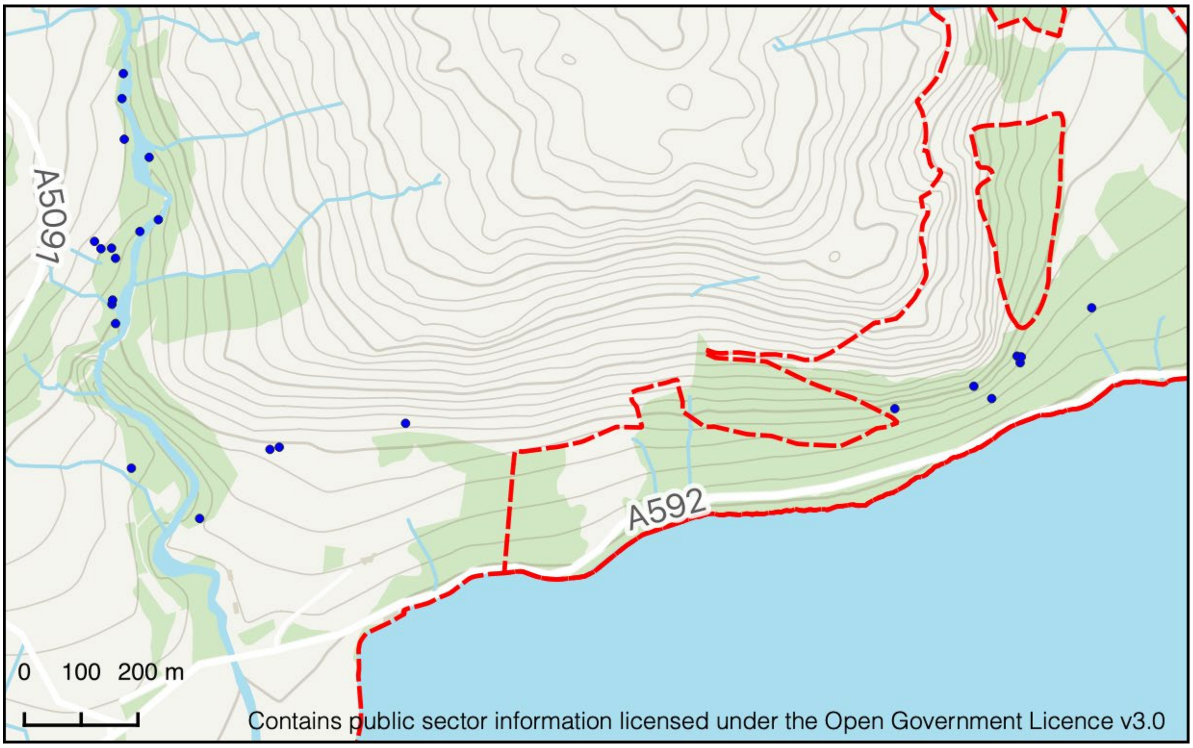
The threatened species include both large leafy species and smaller crust forming species. The former can potentially be translocated but the latter cannot. The latter include important species such as *Bacidia subincompta* (VU (NS/S41). In the worst case scenario, translocation of leafy species from dying Ash trees to other suitable trees may be the only possible rapid mitigation measure. At Glencoyne Park, more base rich Oak, Hazel and Sycamore are the best existing potential translocation trees. Otherwise ensuring that suitable alternative fast maturing substrates such as Sallows and Hazels are promoted, in open locations should help in the medium term. To be effective substrates for *Lobarion* lichens on bushes, both Hazel and Sallow, need to have no or limited over canopy of tall trees. One of the main alternative tree substrate, Sycamore, is rare but locally important for lichens already in the area. Also continuing reductions in acid deposition are likely to make Oak a more widespread substrate for *Lobarion* lichens. In the very long term any resistant local Ash should be retained and promoted, including potentially collecting seed and locally growing on, for planting out.

Table 6: The Importance of Ash for Lichens of Conservation Interest at Glencoyne Park 2016

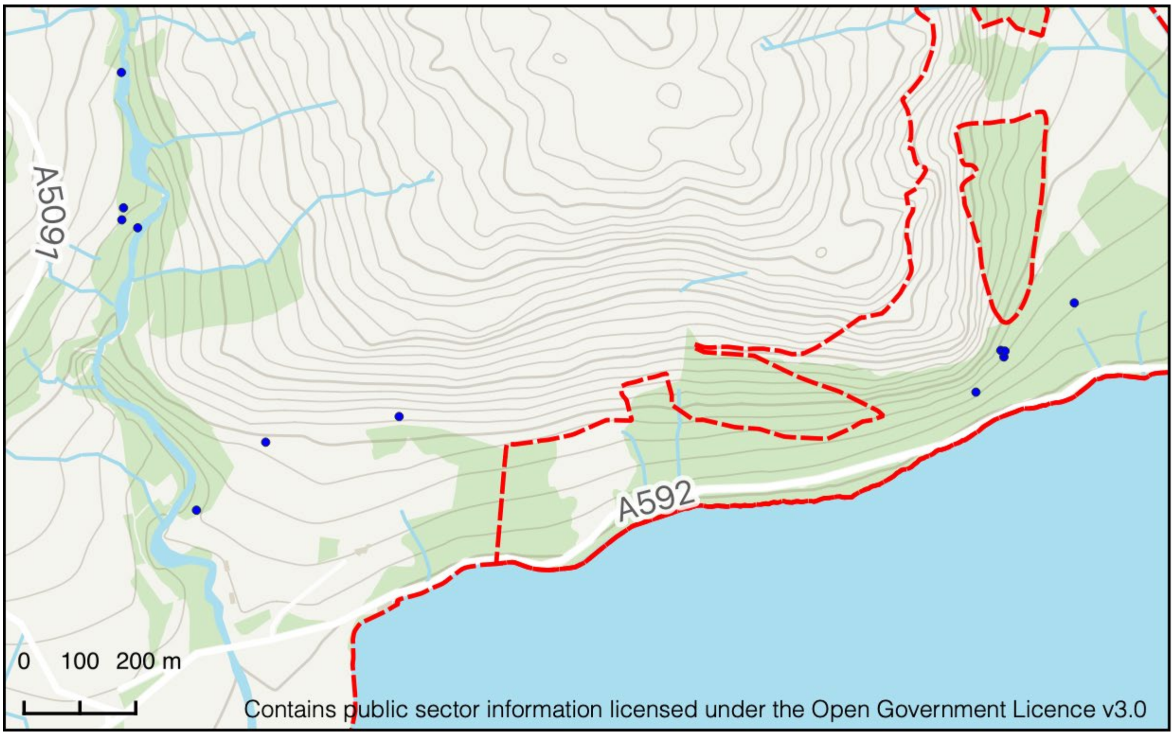
Species	Ash	Total No. Waypoints	% on Ash
Ash	15	44	34%
Bacidia subincompta	2	2	100%
Cetrelia cetrarioides	5	5	100%
Mycobilimbia pilularis	1	1	100%
Parmotrema crinitum	1	1	100%
Sticta limbata	3	4	75%
Mycobilimbia epixanthoides	2	4	50%
Lobaria pulmonaria	2	5	40%
Lopadium disciforme	1	3	33%
Agonimia allobata	0	4	0%
Bactrospora corticola	0	1	0%
Biatora chrysantha	0	3	0%
Chaenothecopsis nigra	0	4	0%
Chaenothecopsis pusilla	0	1	0%
Lobaria amplissima	0	1	0%
Microcalicium ahlneri	0	1	0%
Mycoporum lacteum	0	1	0%
Nephroma parile	0	1	0%
Pachyphiale carneola	0	6	0%
Protoparmelia oleagina	0	2	0%

Species	Ash	Total No. Waypoints	% on Ash
Rinodina isidioides	0	1	0%
Schismatomma graphidioides	0	1	0%
Thelopsis rubella	0	7	0%

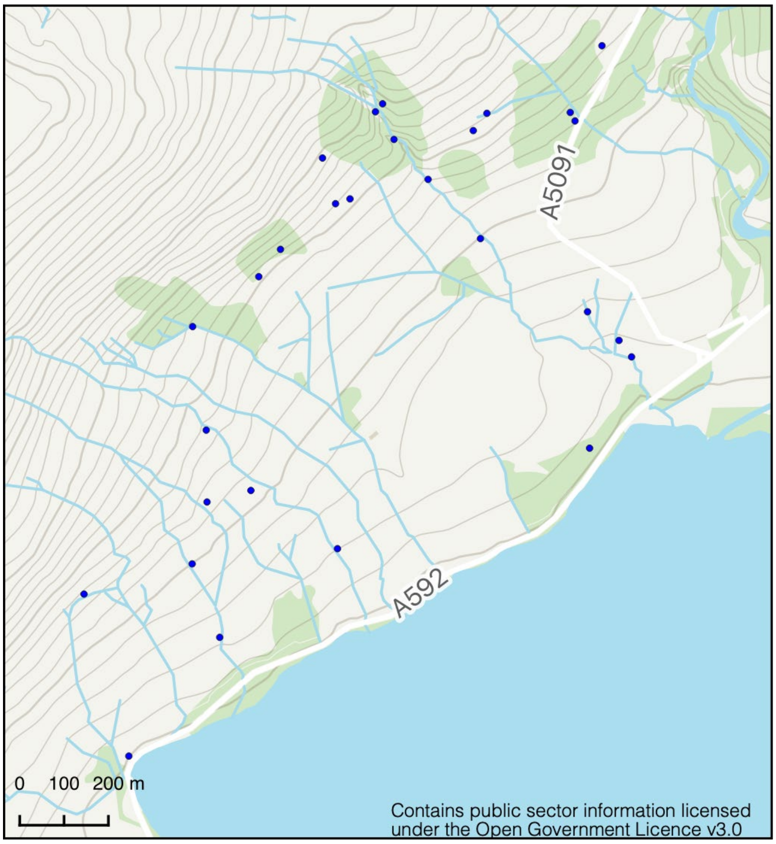
5.1.4 Maps



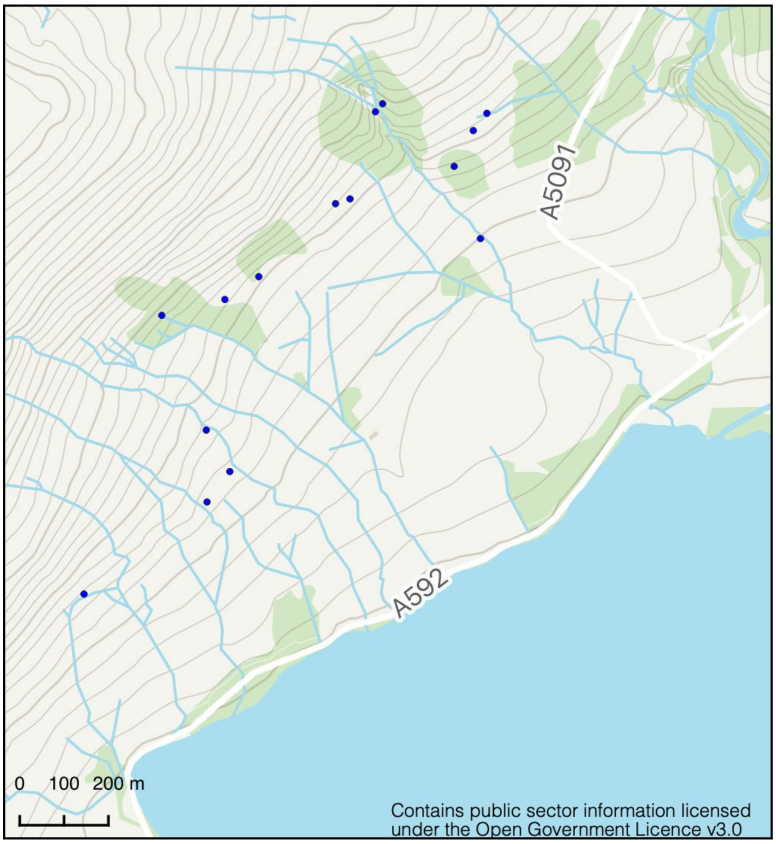
Gowbarrow Trees with high base rich bark interest (blue circles).



Gowbarrow Ash trees of high lichen interest (blue circles), the ravine to the west has a greater variety of trees with base rich bark but Ash is the main tree of interest to the west.



Glencoyne Park Trees high base rich bark interest (blue circles).



Glencoyne Park Ash trees of high lichen interest (blue circles). Ash is the main tree of interest high on the slopes, but Oak is also important lower down.

5.1.5 Photographs

Photos 25 & 26 Yew Crag, Gowbarrow, to the left is a photo taken in January 2001, showing a rich ancient Ash tree set in an open glade in a pasture woodland after a long period of grazing removal, when it was recommended that grazing was restored by Day (2000). This did not occur and in 2016 the photo location was relocated, showing the glade to be much infilled and the tree much more shaded and had lost some lichen interest, while *Lobarion* on the rocks was totally lost. © Neil A Sanderson.

Photo 27. Glencoyne Park, cankerous ancient Ash on edge of open grove (centre right), with *Bacidia subincompta* VU (NS/S41), an Ash-dependant species in England. © Neil A Sanderson

5.2 Case Study 2
Bovey Valley, Dartmoor, South Devon

5.2.1 Site Description

Site: an extensive woodland SSSI occupying the valley of the Bovey River for four kilometres (SX7879 to SX7582). The SSSI supports an internationally important lichen assemblage. It is largely owned by Natural England and the Woodland Trust and is within the East Dartmoor Woods and Heaths NNR, but includes areas of private woodland as well. It is an example of an upland fringe site where Ash is currently locally very important for epiphytic lichens but the site is well buffered from Ash Dieback by the variety of tree species present. It is also a site where there are plenty of opportunities for mitigation by improving habitat conditions for lichens.

Survey: the description is based on an extensive survey for Natural England and the Woodland Trust, which systematically surveyed the known hot spots and carried out transects though less well known areas (Sanderson, 2018e).

Habitat: the Bovey Valley has a complex woodland history with the lichen rich woodlands found in a complex landscape of enclosed rough land between the common land and the (agriculturally) best fields. The common land was treeless in the 19th century, so, although now well wooded, has young growth woodland currently of no lichen interest. The enclosed woodlands included large conventional woodlands, which had been coppiced or converted to Oak plantations in the 19th century and were generally of low lichen interest. Areas of lichen interest included larger areas of pasture woodland, which were probably relatively recently enclosed from common land, wet bottom land with small areas of surviving veteran trees and large areas of slow growing wet and bog woodland, woodland by a long famed scenic waterfall were old trees had been left for aesthetic reasons, and complex areas of abandoned in-filled small fields with veteran boundary trees and patches of ancient pasture woodland in areas dominated by granite tors. The pasture woodland in the tors probably survived from before enclosure and appears to have been a significant factor in the long term survival of rare lichens within the site. This sort of complex history is typical of lichen rich upland fringe woodland is the south west of England.

Lichen Assemblage: SSSI site scores 55 in the Southern Oceanic Woodland Index for the SSSI, with one Critically Endangered, and 11 Near Threatened species. Six section 41 species have been recorded. Individual habitats contributing strongly the international importance of the lichen assemblage include the Base Rich Woodland Assemblage (*Lobarion pulmonariae* and *Agonimion octosporae*), Acid Bark Woodland Assemblage (*Parmelion laevigatae*) and Standing Dead Wood Assemblage (*Calicietum abietinae*). The first has significant occurrences on Ash, but the others did not. Other habitats also of interest were dry bark on veteran Oaks, smooth bark, sheltered twigs and branches and Mature Mesic Bark Assemblage (*Pertusarietum amarae* and *Parmelietum revolutae*). Only the latter habitat had important species on Ash.

Air Pollution: the site is on the boundary between upland moorland and lowland farmland and the background ammonia concentration is just under levels of exceedance for epiphytic lichens but is clearly quite low in the centre of the large woodland block. The acid deposition is lower than further west, deeper into Dartmoor.

- Ammonia Concentration: 0.88 – 0.92 µg m^3
- Total N deposition: 29.54 – 30.24Kg N/ha/year
- Acid Deposition: 2.32 – 2.26 keq/ha/yr

Management: the woodlands had experienced a long term removal of grazing resulting in increasing canopy cover, denser shrub layers including Holly invasion and increasing Ivy cover. Within the NNR, prior to the lichen survey, some grazing restoration was under way, but many of the most important and threatened areas were not yet grazed. Control of invading Holly had been extensively carried out and conifer removal carried out from adjacent plantations. Sanderson (2018e) recommended further areas to be restored to grazing and that Ivy was controlled.

5.2.2 Ash as a Lichen Host

The Importance of Ash: at Bovey Valley SSSI, Ash is locally very important at Hisley Wood, both below Boveycombe and by the Bridge, Rudge Wood and at Cleave Hill. Overall Ash was a tree of interest at 29 locations where systematically recorded lichens of conservation were found, out of a total of 146, that is 20% of the waypoints (Table 7). In 2018, three lichens had all occurrences on Ash trees, while fourteen others had part of their populations on Ash, with five having more than 50% on Ash. All but one of these were Base Rich Bark Woodland Community species. *Fuscopannaria mediterranea* Nb (NS), *Pannaria conoplea* Nb (IR), *Parmeliella triptophylla* Nb (IR) and *Lobaria pulmonaria* Nb (IR) are species of particular concern as rare slow colonising species with large proportions of their current populations on Ash.

Table 7: The Importance of Ash for Lichens of Conservation Interest at Bovey Valley SSSI 2018

Species	Waypoints with Ash	Total No. Waypoints	% on Ash
Ash	29	146	20%
Cetrelia cetrarioides	1	1	100%
Heterodermia obscurata	2	2	100%
Phyllopsora rosei	1	1	100%
Fuscopannaria mediterranea	2	3	67%

Species	Waypoints with Ash	Total No. Waypoints	% on Ash
Lecania chlorotiza	2	3	67%
Pannaria conoplea	1	2	50%
Parmeliella triptophylla	7	14	50%
Ramonia chrysophaea	1	2	50%
Lobaria pulmonaria	5	11	45%
Mycobilimbia pilularis	4	9	44%
Sticta fuliginosa s. str.	4	10	40%
Nephroma laevigatum	1	3	33%
Sticta ciliata	3	14	21%
Sticta limbata	2	10	20%
Lobaria virens	1	6	17%
Porina rosei	3	28	11%
Agonimia octospora	1	13	8%
Opegrapha corticola	1	25	4%
Abrothallus welwitschii	0	1	0%
Arthonia invadens	0	9	0%
Arthonia thelotrematis	0	4	0%
Bacidia subturgidula	0	3	0%
Biatora chrysantha	0	4	0%
Calicium victorianum	0	1	0%
Chaenotheca hispidula	0	1	0%

Species	Waypoints with Ash	Total No. Waypoints	% on Ash
Cresponea premnea	0	15	0%
Lecidea sanguineoatra	0	2	0%
Leptogium cyanescens	0	9	0%
Lobaria amplissima	0	1	0%
Micarea hedlundii	0	1	0%
Micarea pycnidiophora	0	11	0%
Micarea stipitata	0	1	0%
Opegrapha fumosa	0	16	0%
Parmotrema crinitum	0	2	0%
Parmeliella parvula	0	2	0%
Peltigera collina	0	1	0%
Porina coralloidea	0	2	0%
Rinodina roboris	0	1	0%
Schismatomma niveum	0	5	0%
Thelopsis rubella	0	14	0%

5.2.3 Potential Mitigation Options

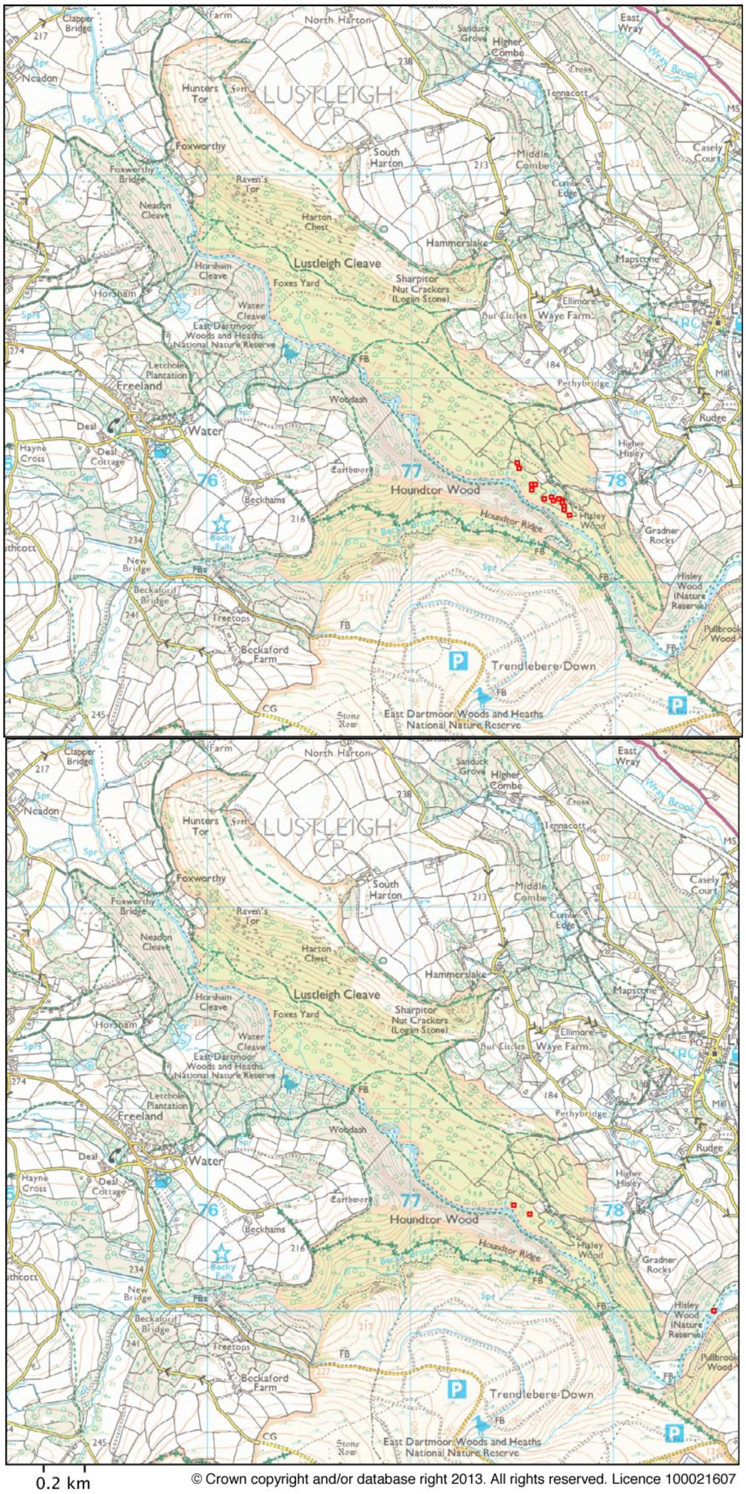
At Bovey Valley, the more base-rich Oak, along with Sallow, Hazel and Sycamore are the best existing potential translocation trees. Otherwise, ensuring that suitable alternative fast maturing substrates are available for natural colonisation such as Sallows and Hazels are promoted, in open locations should help in the medium term. To be effective substrates for *Lobarion* lichens on bushes, both Hazel and Sallow, need to have no or limited over canopy of tall trees. For Sallow this has already been demonstrated spectacularly on the older Sallow by the track east of Boveycombe, which is one of the most important trees in the SSSI and has visibly improved since being opened up by conifer removal. Planting some new Sallow clumps in humid locations should be relatively simple. Hazel is also already an important species with the SSSI and could be increased in importance by maintain open gladed stands of old Hazel without much over storey. Opening up the trunks of existing suitable but shaded old trees to allow natural colonisation is also likely to be a viable option. This should include Ivy removal as well as felling competing younger trees or bushes. In the very long term any resistant local Ash should be retained and promoted, including potentially collecting seed and locally growing on, for planting out.

5.2.4 Maps

0.2 km


0.2 km

Bovey Valley SSSI: all trees with Base Rich Bark Woodland Assemblages (*Lobarion pulmonariae* and *Agonimion octosporae*) (above) and the distribution of Ash trees with significant lichen communities (nelow). Ash is an important tree in the concentration of trees with *Lobarion pulmonariae* trees to the south east (Hisley Wood complex) but Oak, Hazel, Sycamore and rocks are also occupied by this habitat here. The other major concentration to the west is mainly found on Oak and rock, with minor occurrences on Ash and Sycamore. © Crown copyright and/or database right 2013.



Bovey Valley SSSI: the distribution of Hazel bushes with significant lichen communities (above). The distribution of *Fuscopannaria mediterranea* Nb (IR), a highly threatened species in England, which was found on two Ash trees and an Oak in 2018 (below). Hazel is a good substrate for many Ash dependant species in this site, such as *Sticta* species, given the relatively low levels of acid deposition Oak is a good substrate for other species such as *Fuscopannaria mediterranea*, which do not grow on Hazel or Sallow. © Crown copyright and/or database right 2013.

5.2.5 Photographs

Photos 28, 29 & 30: Bovey Valley SSSI, Hisley Wood, the top left hand photograph shows an Ash stool with three trunks on rocky ground in the ancient valley bottom woodland. The Ash supports *Lobaria pulmonaria* Nb (IR) (high up), *Lobaria virens* Nb (IR), *Porina rosei* & *Sticta fuliginosa* s. str. Nb (IR) but has much Ivy growth. The left hand top picture shows a very rich Sallow by a track. This is a rare habitat in Hisley Wood but is one of the richest *Lobarion* trees in the wood, with *Sticta limbata* Nb (IR), *Sticta fuliginosa* s. str. Nb (IR) and *Sticta ciliata* were recorded in 2011, while *Parmeliella parvula* Nb (IR) and frequent *Nephroma laevigatum* Nb (IR) were new in 2018. The lower picture shows a small glade with old Hazel on the edge. The glade is the remains of a small field within woodlands. The Hazel supports *Sticta ciliata* and lichen rich Hazel is locally widespread in the lower part of the wood where the Hazel are not too shaded. © Neil A Sanderson

Photo 31, 32 & 33: Bovey Valley SSSI, Hisley Wood, the top picture shows an old Hazel on rocks and a rather sickly Oak, the Hazel supported *Lobaria pulmonaria* Nb (IR), *Parmeliella triptophylla* Nb (IR) and *Sticta limbata* Nb (IR), while the Oak supported an important find of a *Fuscopannaria mediterranea* Nb (IR) colony. The lower pictures show a small suppressed and broken Ash in open flushed woodland supports *Fuscopannaria mediterranea* colony (bottom right), along with *Parmeliella triptophylla* Nb (IR) and *Sticta ciliata* Nb (IR). The variety of trees suitable for *Lobarion* species in the core of this site is a buffer for Ash Dieback, but some vulnerable species such as *Fuscopannaria mediterranea* are still likely to be threatened. © Neil A Sanderson.

5.3 Case Study 3
Horner Wood, Exmoor, Somerset

5.3.1 Site Description

Site: Horner Combe is an extensive upland pasture woodland within the larger unenclosed moorland grazing of Dunkery Hill. The woodland occupies a long deep combe (SS8743&SS8945), with a significant gradient in rainfall from the very wet high ground inland. The site is owned by the National Trust and is designated as Horner Wood NNR. The SSSI supports an internationally important lichen assemblage. The site is an example of an upland pasture woodland with very varied habitats but with Ash locally important in woodlands on more the more base-rich soils.

Survey: the description is based on two systematic lichen surveys of the NNR covering the west (Sanderson, 2012a) and the east (Sanderson 2017d) of the NNR.

Habitat: the woodlands are open to the moorland grazing above and parts are old growth pasture woodland including frequent ancient trees, both maidens and pollards, which is where the lichen interest is concentrated. Large areas, especially on the south facing slopes, were heavily coppiced until the early years of the 20th century and these are of low interest for lichens. The old growth areas include acidic woodland on the slopes with large populations of veteran Oak and more diverse woodland on less acidic soils on alluvial flats and abandoned old hay meadows. The richer soils have mixtures of veteran Oak and Ash over and open Hazel and Hawthorn shrub layers with rare Filed Maple and Sallow, along with stands of old Hazel.

Lichen Assemblage: the NNR site scores 60 in the Southern Oceanic Woodland Index for the SSSI, with one Critically Endangered, three Vulnerable and 17 Near Threatened species. Thirteen section 41 species have been recorded. Individual habitats contributing strongly the international importance of the lichen assemblage include the Base Rich Woodland Assemblage (*Lobarion pulmonariae*) and Dry Bark Communities of Veteran Oaks (*Lecanactidetum premneae, Lecanactidetum abietinae* and *Calicietum hyperelli*) & Associated Dry Lignum (*Calicietum abietinae*). The first has significant occurrences on Ash, but Ash is rare for the latter. Other habitats also of interest were Acid Bark Woodland Assemblage, Woodland Rocks and Tree Beard *Usnea* spp Rich Sub-Canopy Communities. The first occurs rarely on Ash but the others do not.

Air Pollution: the upland area Horner Combe is set in buffers it from intensive farmland, so the ammonia concentrations are low and well below the level that damage epiphytic lichens. Acid deposition was high in the later 20th century as the combe is more exposed to industrial south Wales that areas deep into Exmoor. It has now declined but is still relatively high. The decline in acidification is evident with *Lobarion pulmonariae* species now colonising Hazel, from which it was conspicuously absent in the 1990s, and in addition, recent colonisation of Ash by *Lobaria pulmonaria* Nb (IR) and *Lobaria amplissima* Nb (IR).

- Ammonia Concentration: 0.67 µg m^3

- Total N deposition: 33.6Kg N/ha/year
- Acid Deposition: 2.59 keq/ha/yr

Management: the woodland is grazed by sheep, ponies, cattle and wild red deer along with the moorland above. Grazing impact has changed in recent decades with a decline in grazing having notable impacts. In the woods Hazel, Hawthorn and Holly shrub layers have expanded, increasing the shade on veteran tree trunks producing serious declines in leafy Base Rich Woodland Assemblage species in particular. The decline in grazing pressure probably reflects a decline in cattle wintered on the grazings, which had also impacted on the quality of the woodland edge Bracken habitats and rare butterflies, and red deer being increasingly disturbed in the valley bottoms by recreation use. This decline in habitat condition is being dealt with by an ongoing programme of clearing shading shrubs way from veteran trees and grazing levels have increased again.

5.3.2 Ash as a Lichen Host

The Importance of Ash: old Ash at Horner Wood NNR is very important as a substrate for rare *Lobarion* species, with significant percentages of some species found on Ash (Table 8). This was even more marked in the areas looked in 2016 than in 2012, where Ash was more frequent. Leafy *Lobarion* species such as all *Sticta* species, *Lobaria scrobiculata* and *Leptogium cyanescens* are highly dependent on Ash at Horner. Other groups of lichens are much more dependent on Oak.

Table 8. The Importance of Ash for Lichens of Conservation Interest at Horner Wood NNR

Species	Waypoints with Ash	Total No. Waypoints	% on Ash
Ash	101	871	11.6%
Lobaria scrobiculata	1	1	100.0%
Megalospora tuberculosa	1	1	100.0%
Wadeana dendrographa	1	1	100.0%
Biatora britannica	13	16	81.3%
Sticta limbata	5	7	71.4%
Leptogium cyanescens	2	3	66.7%
Lobaria amplissima	2	3	66.7%
Sticta sylvatica	11	20	55.0%

Species	Waypoints with Ash	Total No. Waypoints	% on Ash
Sticta fuliginosa s. lat.	14	30	46.7%
Sticta ciliata	11	25	44.0%
Parmeliella triptophylla	3	7	42.8%
Lobaria pulmonaria	54	132	40.9%
Sticta fuliginosa s. str.	1	3	33.3%
Chaenotheca hispidula	1	4	25.0%
Nephroma parile	1	4	25.0%
Mycobilimbia epixanthoides	13	72	18.1%
Lobaria virens	7	47	14.9%
Opegrapha fumosa	1	7	14.9%
Phyllopsora rosei	10	91	11.0%
Mycobilimbia pilularis	7	2	10.9%
Porina rosei	1	12	8.3%
Cresponea premnea	7	468	1.5%
Agonimia allobata	0	3	0
Arthonia anombrophila	0	2	0
Arthonia arthonioides	0	18	0
Arthonia atlantica	0	6	0
Arthonia thoriana	0	10	0
Bactrospora corticola	0	5	0
Calicium lenticulare	0	6	0

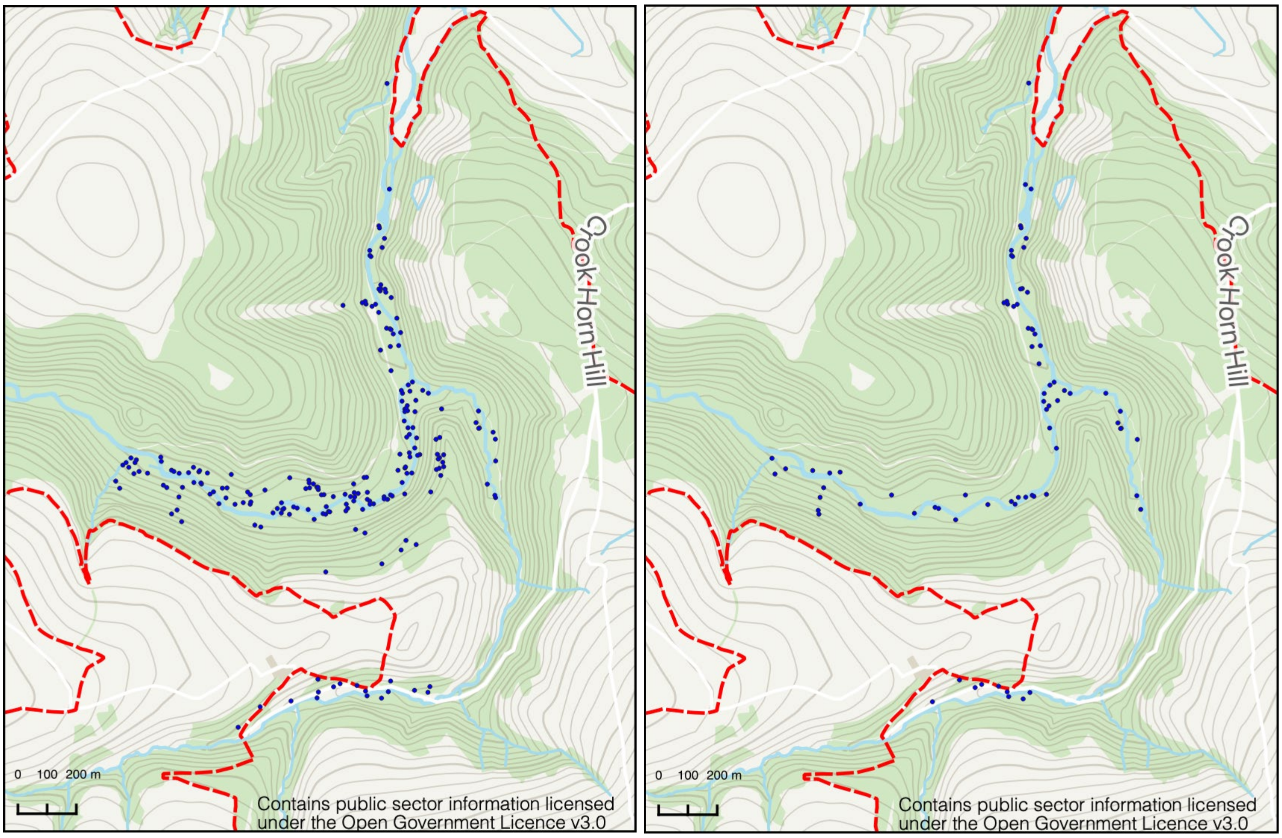
Species	Waypoints with Ash	Total No. Waypoints	% on Ash
Chaenotheca brachypoda	0	1	0
Chaenotheca chrysocephala	0	11	0
Chaenotheca trichialis	0	27	0
Chaenothecopsis nigra	0	5	0
Chaenothecopsis sp	0	5	0
Enterographa sorediata	0	3	0
Graphina pauciloculata	0	5	0
Graphina ruiziana	0	30	0
Gyalideopsis muscicola	0	1	0
Lecanactis subabietina	0	15	0
Lecania chlorotiza	0	3	0
Lecidea sanguineoatra	0	11	0
Llimonaea sorediata	0	2	0
Micarea alabastrites	0	13	0
Micarea hedlundii	0	1	0
Micarea xanthonica	0	8	0
Microcalicium ahlneri	0	3	0
Nephroma laevigatum	0	1	0
Opegrapha corticola	0	18	0
Opegrapha lithyrga	0	1	0
Opegrapha trochodes	0	2	0

Species	Waypoints with Ash	Total No. Waypoints	% on Ash
Opegrapha xerica	0	4	0
Parmeliella parvula	0	1	0
Peltigera collina	0	1	0
Porina coralloidea	0	1	0
Ramonia chrysophaea	0	19	0
Ramonia nigra	0	1	0
Schismatomma cretaceum	0	22	0
Schismatomma graphidioides	0	1	0
Schismatomma niveum	0	7	0
Schismatomma quercicola	0	7	0
Schismatomma umbrinum	0	1	0
Sphaerophorus globosus	0	1	0
Sticta fuliginoides	0	1	0
Thelopsis rubella	0	5	0
Usnea articulata	0	2	0
Wadeana minuta	0	1	0

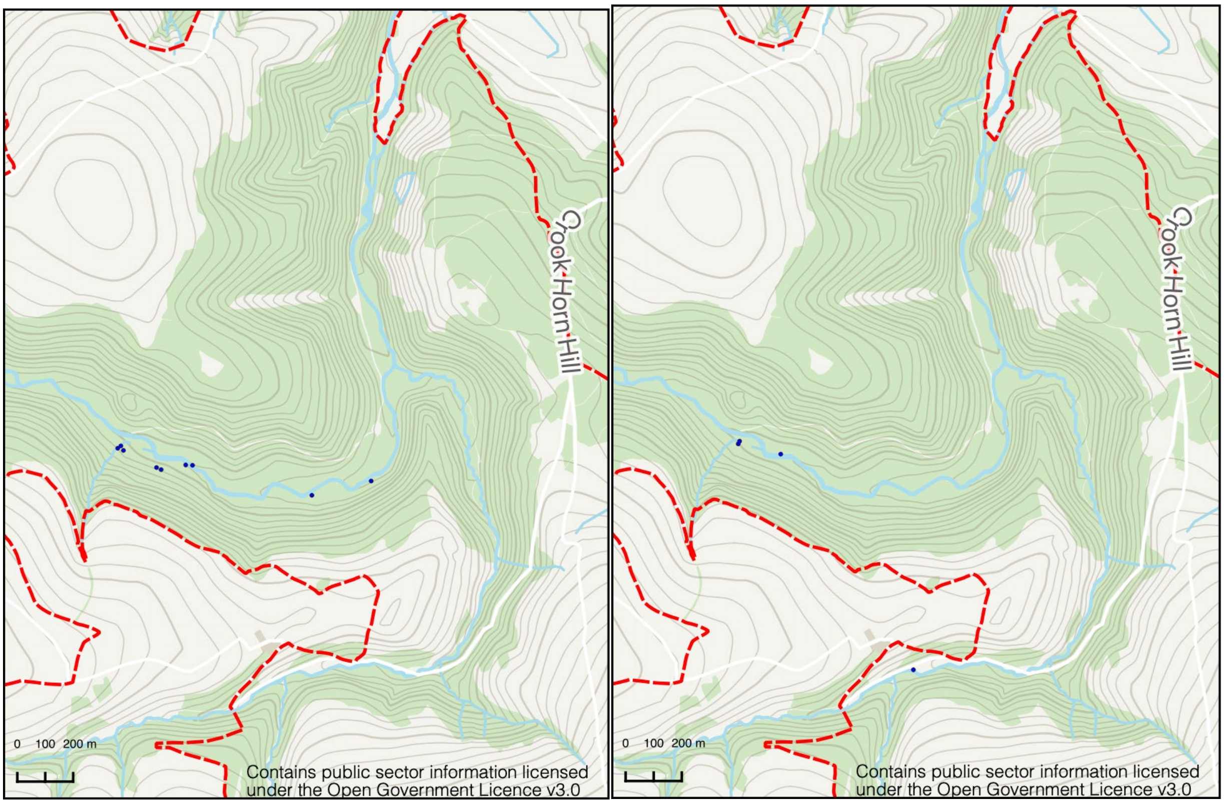
5.3.3 Potential Mitigation Options

Most of the species with high percentages of occupied Ash trees are leafy *Lobarion* species. In the worst case scenario, translocation from dying Ash trees to other suitable trees may be the only possible rapid mitigation measure. Well lit old Hazel may provide a good substitute, it has already begun to be colonised by *Sticta* species, which were previously nearly totally confined to Ash. The current programme of opening up the alluvial flats, where shaded by recently expanded shrub layers, will also be increasing the number of potential trees to colonise and will be increasing the vigour of surviving colonises of rare lichens. Two crust forming species, *Megalospora tuberculosa* NT (NR/IR/S41) and *Wadeana dendrographa* NT (NR/IR/S41) are only known from Ash and are very vulnerable to Ash Dieback. More medium term mitigations will be to develop new open stands of old Hazel. In addition, the few old Sallows are also very rich and encouraging a some more small Sallow stands would also be a an effective medium term mitigation. In the very long term any resistant local Ash should be retained and promoted, including potentially collecting seed and locally growing on, for planting out.

5.3.4 Maps



Horner Wood NNR, Eastern Combes, Trees with Base Rich Bark Assemblages (left) and Ash (right) with systematically recorded species. Ash is very important on the alluvial flats for Base Rich Bark Assemblages but the assemblages is also locally frequent on the slope above on Oak. Red dash line shows NNR boundary.



Horner Wood NNR, Eastern Combes, Hazel (left) and Sallow (right) with systematically recorded species. These bushes can support Base Rich Bark Assemblages species and grow in the same valley bottom habitat as the Ash trees but rich bushes are not nearly as widespread at present. Red dash line shows NNR boundary

5.3.5 Photographs

Photos 34 & 35: Horner Wood NNR, Cloutsham Ball, a young suppressed Ash on a glade edge, with *Sticta ciliata* Nb (IR). Such small slow growing Ash trees are very vulnerable to loss from Ash Dieback but can be replaced by Hazel or Sallow. © Neil A Sanderson

Photos 36 & 37: Horner Wood NNR, Horner Wood, East of Goss's Rocks, an Oak (left) with *Ramonia chrysophaea* NT (NS/IR/S41) and an Ash (right) with *Lobaria pulmonaria* Nb (IR) and *Sticta sylvatica* Nb (IR) threatened by shade from Holly on an alluvial flat. The ongoing programme of cutting will open up these trees. © Neil A Sanderson

Photo 38 & 39: Horner Wood NNR, Ten Acre Cleeve, The Queen of Horner in 2009 above, and in 2016 below. A huge Ash on the boundary of an abandoned hay meadow. The reduction in grazing by 2009 was resulting in the descent of the browse line and increasing shade. By 2016 grazing levels were back up and the browse line was reforming. This rich Ash is the only known tree in Horner for the Ash specialist *Wadeana dendrographa* NT (NR/IR/S41) and also supports *Lobaria pulmonaria* Nb (IR), *Lobaria virens* Nb (IR), *Parmeliella triptophylla* Nb (IR) and *Sticta sylvatica*. © Neil A Sanderson

5.4 Case Study 4
Dunsland Park, North Devon

5.4.1 Site Description

Site: a small but rich park in the lowlands of North Devon (SS4004 to SS4005), created around a now raised stately house and set within enclosed productive farmland. It is owned by the National Trust and is a SSSI. As is typical of many lowland parks, the veteran trees are dominated by Oak and older Ash are a small component of these. Young slow growing suppressed Ash in scrubbing up formerly open habitats, however, are important along with associated Sallow and Hazel.

Survey: the description is based on a systematic survey carried out as part of a condition assessment of the SSSI for English Nature in 2015 (Sanderson, 2016b).

Habitat: the north of the park is a conventional parkland, with ancient Oaks and Limes in open parkland and no Ash trees of high lichen interest. Here there is also high interest in wooded fringes to the park and a rich swampy Sallow Wood in an old in-filled pond. To the south an old wet meadow with surviving pasture woodland, which includes some interesting older Ash, has been partly in-filled with Sallow scrub, which is now very lichen rich, along with scrubby young woodland in a former walled garden, which is also being colonised by lichen of interest.

Lichen Assemblage: the SSSI scores 55 in the Southern Oceanic Woodland Index for the SSSI, with thirteen Near Threatened species. Five section 41 species have been recorded. Individual habitats contributing strongly to the international importance of the lichen assemblage include the Base Rich Bark Woodland Assemblages (*Lobarion pulmonariae*), where Ash is locally significant and Ancient Dry Bark assemblages (*Lecanactidetum premneae*) and Acid Bark Woodland Assemblages (*Parmelion laevigatae*), for which Ash was not significant a habitat.

Air Pollution: the park is set in a region of intensively managed grassland and as a result the background ammonia concentration is well in exceedance for the critical level for epiphytic lichens of 1 µg m^3. The park is well buffered by tree belts from the background levels but, although *Lobarion* species are thriving, some more sensitive acid bark species such as *Usnea florida* NT (S41) were absent. Acid deposition is also modelled as quite high but has no visible impact.

- Ammonia Concentration: 2.12 µg m^3
- Total N deposition: 33.88Kg N/ha/year
- Acid Deposition: 2.54 keq/ha/yr

Management: the park was in rather poor condition, although the management of the grazed areas had been reduced in intensity previously, large areas were fenced off from grazing and there was no planting of successor Oaks, the main tree of interest in the parkland. Following a negative condition assessment in 2009, the management has changed a great deal, with grazing restored to the very rich southern area and planting of Oak carried out. One peculiar situation pertinent to Ash Dieback is the situation in the walled garden. This had been colonised by Hazel – Ash scrub, which had been well colonised by leafy *Lobarion* species. This was rather inexplicably clear felled and replanted with Ash during an earlier Countryside Stewardship scheme in 1990. Recently the more suppressed Ash in the unthinned plantation have in turn been recently colonised by *Lobaria pulmonaria* Nb (IR), *Sticta ciliata* Nb (IR), *Sticta fuliginosa* s. str. Nb (IR) and *Sticta limbata* Nb (IR) from the few trees that survived the 1990 felling. This has greatly increased the numbers of Ash of lichen interest within the park by replacing a lichen rich Hazel stand with an lichen rich Ash stand.

5.4.2 Ash as a Lichen Host

The Importance of Ash: threat of Ash Dieback is very variable across Dunsland Park. In some habitats Ash is absent or only of limited importance as a significant lichen habitat. Ash is only a significant tree for lichens in the southern parkland. In the other areas Ash is mainly present as young trees that would have contributed to the future lichen interest, if not killed by the disease.

In the southern parkland, Ash is much more significant, with the tree being recorded as supporting systematically recorded lichens at 47 locations out of the total of 70 locations recorded. At 36 locations Ash was the only tree with recorded lichen interest. Of the locations with Ash supporting lichens of interest, 28 of the locations with Ash were within the young Ash stands within the walled garden. The other Ash sites were mainly along the river, with a few trees on the slopes above. Many species were not found on Ash at all, but some have substantial populations on Ash, including *Lobaria pulmonaria* Nb (IR), *Mycobilimbia epixanthoides* Nb (IR) and *Sticta ciliata* Nb (IR) (Table 9). A few are confined to Ash: *Dactylospora lobariella* Nb (NS), *Gyalideopsis muscicola* Nb (NS/IR), *Lobaria scrobiculata* Nb (IR) and *Mycobilimbia pilularis*. The important lichen assemblages of the park would survive the loss of all Ash trees but some species would experience substantial population decline and a few would be lost.

Table 9. The Importance of Ash as a Lichen Host at Dunsland

Recorded at GPS Locations	All GPS Locations	GPS Locations With Ash	GPS Locations With Only Ash	% Only Ash
No of Locations	109	47	36	33.0%
Dactylospora lobariella	1	1	1	100.0%
Gyalideopsis muscicola	1	1	1	100.0%
Lobaria scrobiculata	1	1	1	100.0%

Recorded at GPS Locations	All GPS Locations	GPS Locations With Ash	GPS Locations With Only Ash	% Only Ash
Mycobilimbia pilularis	2	2	2	100.0%
Mycobilimbia epixanthoides	5	3	3	60.0%
Lobaria pulmonaria	58	38	30	51.7%
Sticta ciliata	41	29	19	46.3%
Sticta fuliginosa s. str.	3	1	1	33.3%
Sticta limbata	25	13	7	28.0%
Phyllopsora rosei	10	3	2	20.0%
Sticta sylvatica	18	10	3	16.7%
Peltigera collina	8	5	1	12.5%
Usnea articulata	11	1	1	9.1%
Nephroma laevigatum	12	5	1	8.3%
Abrothallus welwitschii	3	1	0	0
Arthonia astroidestera	1	0	0	0
Arthonia ilicina	1	0	0	0
Arthonia invadens	4	0	0	0
Cetrelia olivetorum	1	0	0	0
Enterographa sorediata	5	0	0	0
Heterodermia obscurata	6	0	0	0
Hypotrachyna sinuosa	1	0	0	0
Lecanographa lyncea	2	0	0	0
Lobaria amplissima	2	0	0	0

Recorded at GPS Locations	All GPS Locations	GPS Locations With Ash	GPS Locations With Only Ash	% Only Ash
Lobaria virens	1	0	0	0
Melaspilea amota	4	0	0	0
Opegrapha fumosa	4	0	0	0
Pannaria rubiginosa	1	0	0	0
Phaeographis lyellii	5	1	0	0
Phlyctis agelaea	5	3	0	0
Porina coralloidea	8	0	0	0
Thelopsis rubella	1	0	0	0
Tylophoron hibernicum	4	0	0	0

5.4.3 Potential Mitigation Options

Several of the species with significant percentages of their populations on Ash trees are leafy *Lobarion* species. Rare crust forming species or small shrubby species are generally more frequent on other species trees. In the worst case scenario, translocation from dying Ash trees to other suitable trees may be the only possible rapid mitigation measure. Otherwise ensuring that suitable alternative fast maturing substrates such as Sallows and Hazels are promoted, in open locations should help in the medium term. To be effective substrates for *Lobarion* lichens on bushes, both Hazel and Sallow need to have no or limited canopy of tall trees above them. The main alternative tree substrate, Sycamore, is present but not in significant numbers. In the very long term any resistant local Ash should be retained and promoted, including potentially collecting seed and locally growing on, for planting out.

The area which would be most affected is inside the walled garden with is numerous suppressed young Ash planted being colonised by leafy *Lobarion* species as described above. In the worst case of total Ash loss, it could simply be restored to its condition prior to the clear felling and planting of Ash, by replanting with Hazel and Sallow. Potentially these bushes should be established before the current Ash trees are lost.

5.4.4 Photographs

Photo 40. Dunsland Park, Southern Parkland: Ash is only significant in the south west of the southern park. This includes some older Ash, as here, on the edge of the over grown meadow, supporting frequent *Lobaria pulmonaria* Nb (IR) parasitised by the very rare *Dactylospora lobariella* Nb (NS) and some *Nephroma laevigatum* Nb (IR) and *Sticta ciliata*. © Neil A Sanderson

Photo 41 & 42. Dunsland Park, Walled Garden: the majority of the Ash of interest, however, is found in the walled garden. The pictures show the maturing of a *Lobaria pulmonaria* Nb (IR) colony that survived the 1990 felling from 2009 (left) to 2015 (right). By 2015 many suppressed Ash the nearby, planted in 1990, were being colonised by *Lobaria pulmonaria* and *Sticta* species. © Neil A Sanderson

Photo 43: Dunsland Park, Southern Parkland: collapsing and re-growing Sallow patches in an overgrown meadow are outstandingly rich and an effective buffer to Ash Dieback. This stand supported *Heterodermia obscurata* NT (NS), *Phlyctis agelaea* NT (NS) and *Usnea articulata* NT (IR/S41) along with frequent *Lobaria pulmonaria* Nb (IR), *Sticta ciliata* Nb (IR) and *Sticta sylvatica* Nb (IR) and rarer *Peltigera collina* Nb (IR), *Nephroma laevigatum* Nb (IR) and *Sticta limbata* Nb (IR). © Neil A Sanderson

Photo 44. Dunsland Park, Southern Parkland: a view of a very rich stand of Aspen in a partly over grown meadow. Includes vigorous *Lobaria pulmonaria* Nb (IR) and in 2015 an exciting new record was found: *Pannaria rubiginosa* Nb (IR), new to the park and the only recent Devon record. Aspens and poplars can be a useful substitute for Ash in some locations. © Neil A Sanderson

5.5 Case Study 5
Arlington Court, North Devon

5.5.1 Site Description

Site: a complex site in low hills in North Devon, north of Barnstaple, consisting of a core area notified as Arlington Court SSSI (SS6039, SS6040&SS6140) set in a wider estate with areas of equal lichen interest. The both the SSSI and the wider site supports an internationally important lichen assemblage. Owned by the National Trust and consisting of woodland and wooded meadows derived from an old medieval/early modern deer park to the south and a younger modern landscape park to the north by the house. The site is an example of the buffering to Ash Dieback provided by a high diversity of habitats and tree species, especially of the power of established but secondary wet Sallow wood as a conservation measure for *Lobarion* species with cyanobacteria as the main photobiont. It is also an example of the severe damage that can be done uncontrolled Ivy to rare epiphytic lichens.

Survey: the description is based on a systematic survey of the SSSI for English Nature (Sanderson, 2018b)

Habitat: The SSSI includes three distinct habitats, ancient wooded meadows with veteran Oak and younger infill of Ash, Hazel and Alder, with some planted Poplars. This is derived from part of an old deer park. A long established swampy Sallow wood developed over 150 years of silting of a fishpond in the landscape park, which is still expanding. Finally, the northern landscape park includes a great variety of veteran trees but lacks the oldest Oaks seen to the south

Lichen Assemblage: SSSI site scores 52 in the Southern Oceanic Woodland Index for the SSSI, with six Vulnerable and thirteen Near Threatened species. Fourteen section 41 species have been recorded. The SSSI supports outstanding examples of Base Rich Bark Woodland Assemblages (*Lobarion pulmonariae*), where Ash is locally significant and Acid Bark Woodland Assemblages (*Parmelion laevigatae*), which Ash is a rare tree of interest. Other important habitats were Dry Bark on veteran Oaks, Wound Assemblages on veteran trees in parkland lignum on fallen and standing dead wood, sheltered twigs and branches, smooth bark and mature mesic bark grading to nutrient rich bark habitats but none of these are significant on Ash.

Air Pollution: this site has a more typically lowland west county air pollution regime, with the background Ammonia concentration in exceedance for epiphytic lichens but acid deposition low. Within the site the southern wooded meadows are well buffered by surrounding woodland and are probably not in exceedance for Ammonia but the northern landscape park is more obviously stressed by Ammonia pollution.

- Ammonia Concentration: 1.34 – 1.35 µg m^3
- Total N deposition 26.6 – 29.4Kg N/ha/year

- Acid Deposition2.01 – 2.24 keq/ha/yr

Management: the SSSI did have problems but much management work had been carried out recently. Serious Rhododendron invasions had been eliminated from the wooded meadows and the fishpond Sallow wood. The wooded meadows were partly abandoned but grazing was under restoration, with denser infill around old trees opened up. The landscape park grazing has been made more extensive, to counter earlier grassland improvements. The wet Sallow wood was grazed by wild Red Deer. A major remaining problem that had not been tackled was Ivy over growing tree trunks that had been fenced off from grazing for various reasons. This problem had been pointed out as a developing issue in 1994 but had not been acted on. Sanderson (2018b) detailed the work that was required to rectify this.

5.5.2 Ash as a Lichen Host

The Importance of Ash: at Arlington SSSI, numerically Ash is not an abundant substrate for the more significant lichen species overall, but is locally frequent. Ash was the tree of interest at 19 locations where systematically recorded lichens of conservation were found, out of a total of 114, that is 17% of the waypoints (Table 10). Of these, only single Ash trees were recorded as important habitats in both the landscape park the Fish Pond, the rest (17) were in the wooded meadows. In the latter area it does provide a preferential substrate for some important species. Two lichens had all occurrences on Ash trees, while eight others had part of their populations on Ash. All but two of these are Base Rich Bark Woodland Assemblage species. Of the exceptions, *Opegrapha fumosa* Nb (NS/IR), was found on a single acid Ash in the SSSI, but will almost certainly occur on acid Oaks in Deerpark Wood and/or Woolley Wood off the SSSI. The other *Cresponea premnea* Nb (IR), an Ancient Dry Bark Community specialist, was found on a single Ash and 16 Oaks and will also grow on potentially 100's of Oaks in Deerpark Wood and Woolley Wood off the SSSI. The other species are more significant, especially *Pannaria conoplea* Nb (IR) currently only known on a single Ash within the SSSI. The frequency of *Phyllopsora rosei* Nb (NS/IR)on Ash reflects the importance of Ash as a developing substrate for the Base Rich Bark Woodland Community (*Lobarion*) in the wood meadows. The loss of younger Ash trees will also impact the future of this site.

5.5.3 Potential Mitigation Options

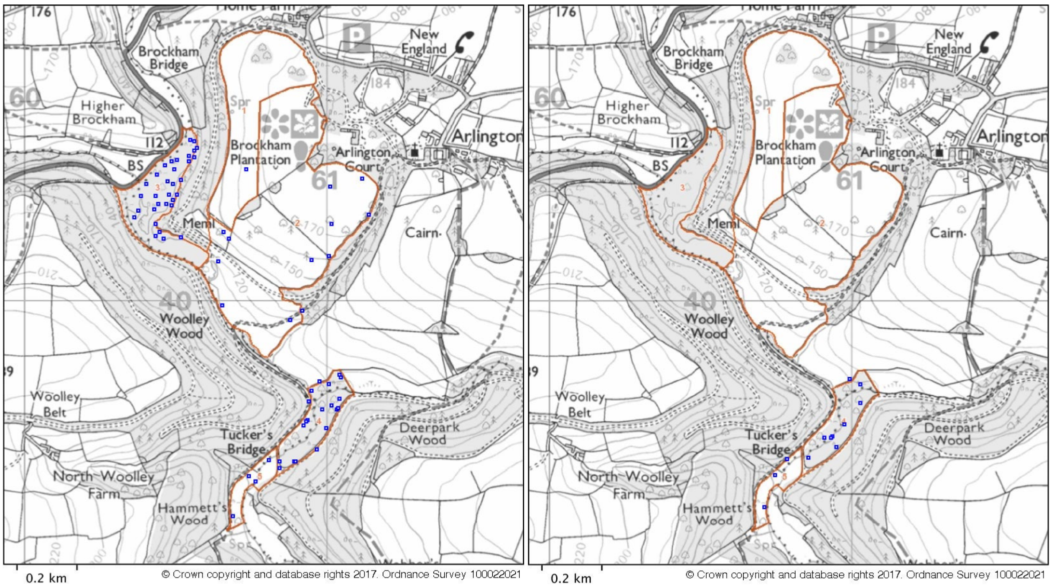
At Arlington estate, the more base-rich Oak, along with Sallow, Sycamore, Poplar, Lime and Hazel are the best existing potential translocation trees. Otherwise, ensuring that suitable alternative fast maturing substrates are available for natural colonisation such as Sallows and Hazels are promoted, in open locations should help in the medium term. To be effective substrates for *Lobarion* lichens on bushes, both Hazel and Sallow, need to have no or limited over canopy of tall trees. For Sallow this has already been demonstrated spectacularly at Arlington by the swampy Sallow wood at the Fish Pond. Planting some new Sallow clumps in humid locations should be relatively simple. Hazel shows some colonisation by *Sticta* species but may not be as effective as Sallow at Arlington. Opening up the trunks of existing suitable but shaded old trees to allow natural colonisation is also an option. This could include Ivy removal as well as felling competing younger trees. All of this can as well occur off the SSSI as on it.

Table 10. The Importance of Ash for Lichens of Conservation Interest at Arlington

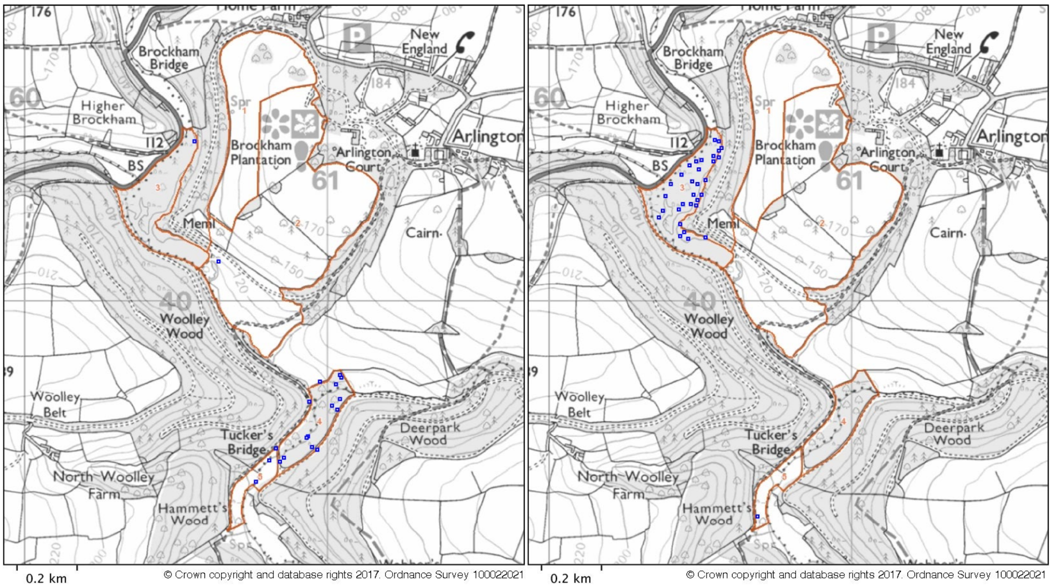
Species	Waypoints with Ash	Total No. Waypoints	% on Ash
Ash	19	114	17%
Opegrapha fumosa	1	1	100%
Pannaria conoplea	1	1	100%
Phyllopsora rosei	9	21	43%
Mycobilimbia epixanthoides	1	3	33%
Lobaria pulmonaria	7	27	26%
Sticta fuliginosa s. str.	3	20	15%
Peltigera collina	1	7	14%
Nephroma parile	1	9	11%
Sticta limbata	2	23	9%
Cresponea premnea	1	17	6%
Abrothallus welwitschii	0	7	0%
Agonimia allobata	0	1	0%
Agonimia octospora	0	1	0%
Arthonia astroidestera	0	1	0%
Arthonia fuscopurpurea	0	2	0%
Arthonia invadens	0	4	0%
Bacidia incompta	0	3	0%
Buellia hyperbolica	0	1	0%

Species	Waypoints with Ash	Total No. Waypoints	% on Ash
Cetrelia olivetorum s. lat.	0	5	0%
Chaenothecopsis nigra	0	1	0%
Enterographa sorediata	0	1	0%
Graphina pauciloculata	0	1	0%
Heterodermia obscurata	0	11	0%
Hypotrachyna endochlora	0	5	0%
Hypotrachyna sinuosa	0	2	0%
Leptogium subtile	0	1	0%
Lobaria virens	0	2	0%
Nephroma laevigatum	0	3	0%
Parmeliella parvula	0	6	0%
Porina hibernica	0	1	0%
Ramonia chrysophaea	0	3	0%
Stenocybe nitida	0	2	0%
Sticta ciliata	0	24	0%
Sticta sylvatica	0	25	0%
Strigula phaea	0	1	0%
Tylophoron hibernicum	0	5	0%
Usnea articulata	0	23	0%
Xerotrema quercicola	0	2	0%

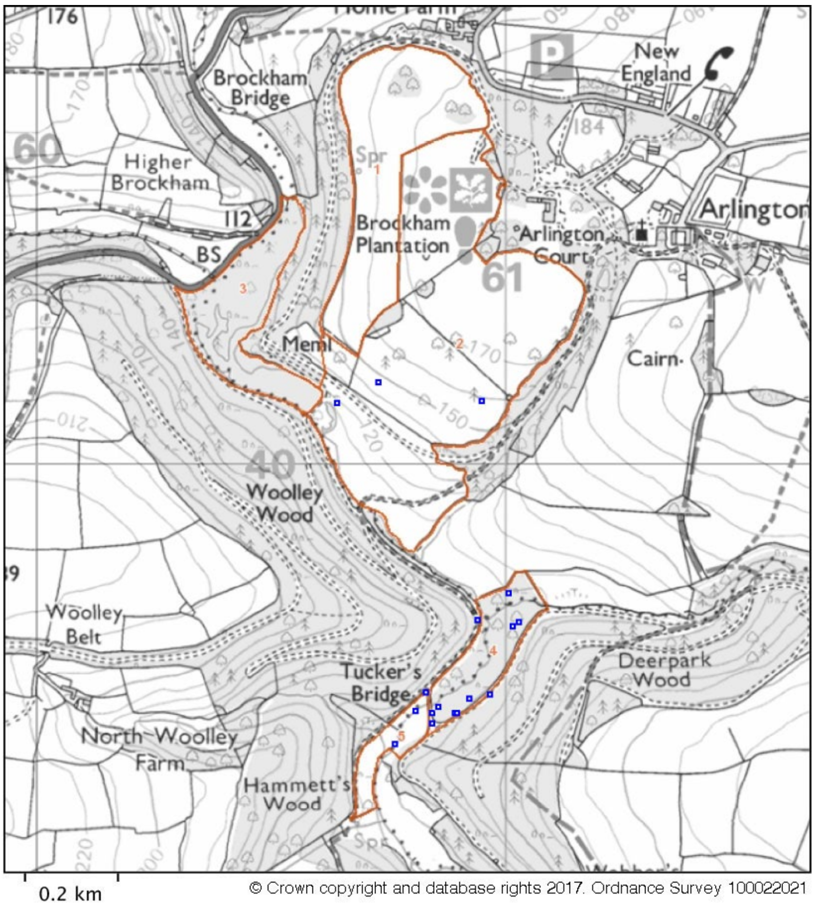
5.5.4 Maps



Arlington Court: all trees with Base Rich Bark Woodland Assemblages (*Lobarion pulmonariae*) to right, Ash is significant in the southern area of interest in the wooded meadows, with Sallow in the fish pond to the north west. To the right are transitional communities to the *Lobarion pulmonariae* with *Phyllopsora rosei* Nb (NS/IR), here predominantly on younger Ash. © Crown copyright and database rights 2017.



Arlington Court: the left hand map shows Ash trees with significant lichen communities, a mixture of well-developed Base Rich Bark Woodland Assemblages (*Lobarion pulmonariae*) and more acidic transitional communities. The right hand map shows the Distribution of Sallow bushes with significant lichen communities, all well-developed Base Rich Bark Woodland Assemblages. The Sallow is now more important habitat than Ash for the *Lobarion* at Arlington Court but both Ash and Sallow are strongly localised at different locations within the site. New lichen rich Sallow habitat could be created within a few decades. © Crown copyright and database rights 2017.



Arlington Court: trees with significant lichen communities threatened by Ivy. There is a major concentration in the formerly abandoned wooded meadow to the south, with a scatter of trees elsewhere, which had been fenced off from grazing for various reasons. The problem in the wooded meadow had been noted first in 1994, and is now being dealt with. Restoring trees other than Ash is potentially significant Ash Dieback mitigation measure. © Crown copyright and database rights 2017.

5.5.5 Photographs

Photos 45 & 46: Arlington Court, the landscape park: an ancient Sycamore fenced off from grazing, from a period when the grazing was more intensive. The upper picture shows two *Lobaria pulmonaria* Nb (IR) thalli (arrows) in the Sycamore, which are highly threatened by Ivy growth. There was also a threatened *Peltigera collina* Nb (IR) colony on this tree. © Neil A Sanderson.

Photos 47 & 48: Arlington Court, The Fish Pond: the lower picture shows a group of Sallows in former pond, in a more open area, with a rich *Lobarion* assemblage, including a strong *Lobaria pulmonaria* population. Along with two *Nephroma* species, *Peltigera collina* and three *Sticta* species. The upper picture shows a rich assemblage of *Lobarion* lichens with cyanobacteria as their main photobiont, includes a single of *Peltigera collina* (smooth thallus with rucked up edges) in abundant *Sticta fuliginosa* s. str. (large thalli with few dissections, dull surface) and *Sticta sylvatica* (well dissected thalli, shiner thallus surface). The biomass of rare and declining *Lobarion* lichens in the swampy Sallow stand far outweighed the rest of the site. This astonishing richness has only reached this peak after *Rhododendron* control about decade ago. © Neil A Sanderson

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