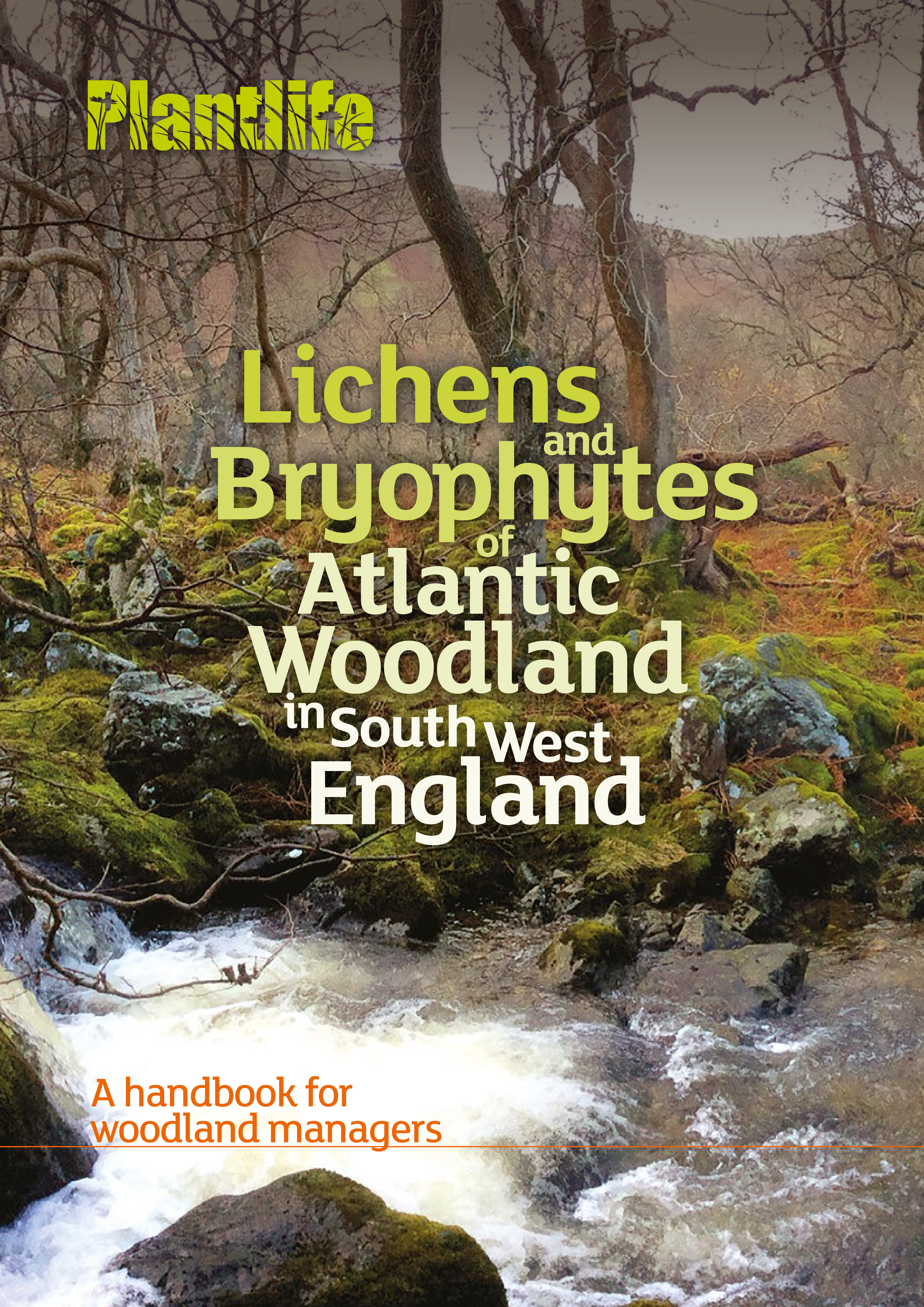

Plantlife

Lichens and Bryophytes of Atlantic Woodland in South West England

A handbook for woodland managers

Contents

Scope

The Atlantic woodlands of South West England are internationally important for their rich lichen and bryophyte communities.

Due to their global conservation significance, many sites are Important Plant Areas (IPAs) and designated as Sites of Special Scientific Interest (SSSIs) or Special Areas of Conservation (SACs), and a number of the species they support are listed on Section 41[1].

Yet, despite their international importance, Atlantic woodlands face a number of threats ranging from site-specific issues such as increasing shade and a loss of grazing, to wider problems such as climate change, atmospheric pollution and tree disease; favourable management and monitoring is essential to their conservation.

Written for landowners and land managers of Atlantic woodlands,

this publication will help to:

- Raise awareness of important lichen and bryophyte species and communities and the key conservation issues that can be managed for
- Provide a framework for assessing a site's interest for lichens and bryophytes and identifying priority areas for management
- Provide a framework for planning effective habitat management for lichens and bryophytes in and around Atlantic woodlands
- Provide management guidance and advice for deciding on appropriate management for different scenarios, to address a range of issues and threats

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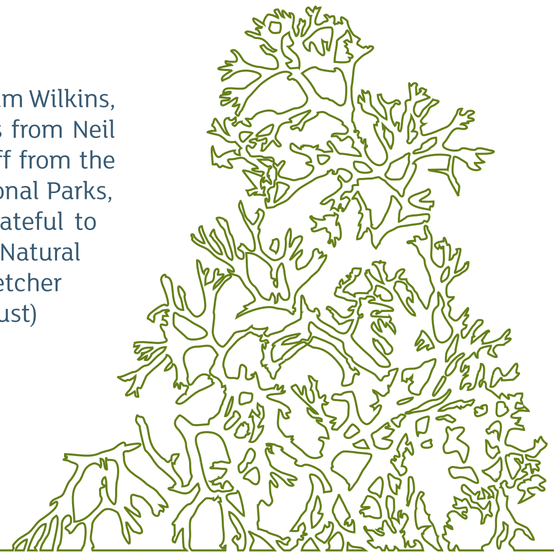


[1] Section 41 of the Natural Environment and Rural Communities (NERC) Act 2006 lists those species considered to be of 'principal importance for the purpose of conserving biodiversity' in England. See http://www.legislation.gov.uk/ukpga/2006/16/section/41

Atlantic woodland is one of Britain and Ireland's most important habitats. It supports unique species assemblages of high conservation value and occurs in oceanic climatic conditions close to the Atlantic Ocean.

1. Our Celtic rainforest: an introduction to Britain's Atlantic woodland

Atlantic woodland is characterised by:

- **Wetness** i.e. high annual rainfall, high numbers of wet days, wetness during summer season, low potential water deficit.
- **Temperature** i.e. little annual temperature variation and low incidence of frost and snow cover, due to the influence of the Gulf Stream.

The high humidity provides ideal conditions for lichens, bryophytes (mosses and liverworts) and ferns to flourish. The bryophytes themselves help to maintain and regulate the micro-climate.

In Britain, Atlantic woodland is largely confined to the west coast, with hotspots in South West England, North West England, North Wales and the Western Highlands where it is perhaps at its most luxuriant.

There is considerable variation within Atlantic woodland. Sessile oak is often seen as the defining tree species but its dominance is usually an artifact of relatively recent management, and other trees and woodland types are equally important.

Climate and topography influence the characteristics of Atlantic woodland in a number of ways:

- High wind speeds resulting in wind driven disturbance patterns, and in coastal areas dwarfing of trees including salt effects
- Steep environmental gradients with proximity to coast and increasing elevation lead to strong landscape-scale variation
- Soils show clear patterns of leaching and flushing according to topographic position, with corresponding variation in woodland and plant communities
- The often highly incised topography, including ravines and raised coastlines, leads to unusual habitats and habitat network patterns.

Figure 1: At a global scale Atlantic woodlands are best considered as part of the coastal temperate rainforest biome, which has a very restricted global distribution.

Within Europe, temperate rainforests may be found wherever native semi-natural forest occurs within the Atlantic-oceanic climate zone.

1.1 **Atlantic woodland in South West England**

Atlantic woodland in the South West tends to be less wet and more sunny than its counterparts elsewhere in the UK, and is therefore important for a number of 'southern-oceanic' lichen and bryophyte species that are rare or absent elsewhere in the UK and Europe, so increasing the conservation importance of these sites (see figure 2).

Of around 1,850 species of lichen found in the UK, over 500 have been recorded in Atlantic woodland.

British Atlantic woods support an internationally important lichen flora with significant proportions of European and/or global populations. Of all the red-listed[2] woodland lichens for which the UK has an International Responsibility[3], around 70% are found in Atlantic woodland.

A recent Plantlife study of **lichen** interest in British Atlantic woodland showed that many of our threatened oceanic and hyper-oceanic species are even more threatened in Europe (Sanderson 2008). A good number of these species are listed in Section 41 (see Appendix 2).

The **bryophyte** flora of Britain's Atlantic woodlands is amongst the most diverse on the planet, rivaling the montane cloud forests of the tropics. Britain's bryophyte interest includes near-endemics and some species which are rare or restricted in Europe but relatively common in Britain e.g. the liverworts straggling pouchwort *Saccogyna viticulosa* and prickly featherwort *Plagiochila spinulosa* (see Plantlife's guide to Mosses and Liverworts of Atlantic woodlands of South West England).

Figure 2:

Hyper-oceanic temperate woodland species: confined to areas of extreme and very wet oceanic climates, these constitute distinctive assemblages of bryophytes, lichens and ferns, which occur most extensively in the Western Highlands but with outliers in the Lake District and North Wales (Hodgetts 1997).

Oceanic temperate woodland species: species that extend into, or are confined to, sunnier southern oceanic areas in the South West. There is a rich assemblage of southern Atlantic, or more widely distributed oceanic lichens and bryophytes.

[2] Woods & Coppins (2012) A Conservation Evaluation of British Lichens and Lichenicolous Fungi
[3] UK populations considered internationally significant i.e. supporting 10% or more of global populations

1.2 **Important Plant Areas in South West England**

Important Plant Areas (IPAs) are the most important places for wild plants in the world. Indentifying and managing IPAs is a fundamental part of the *Global Strategy for Plant Conservation*, of which the UK is a signatory.

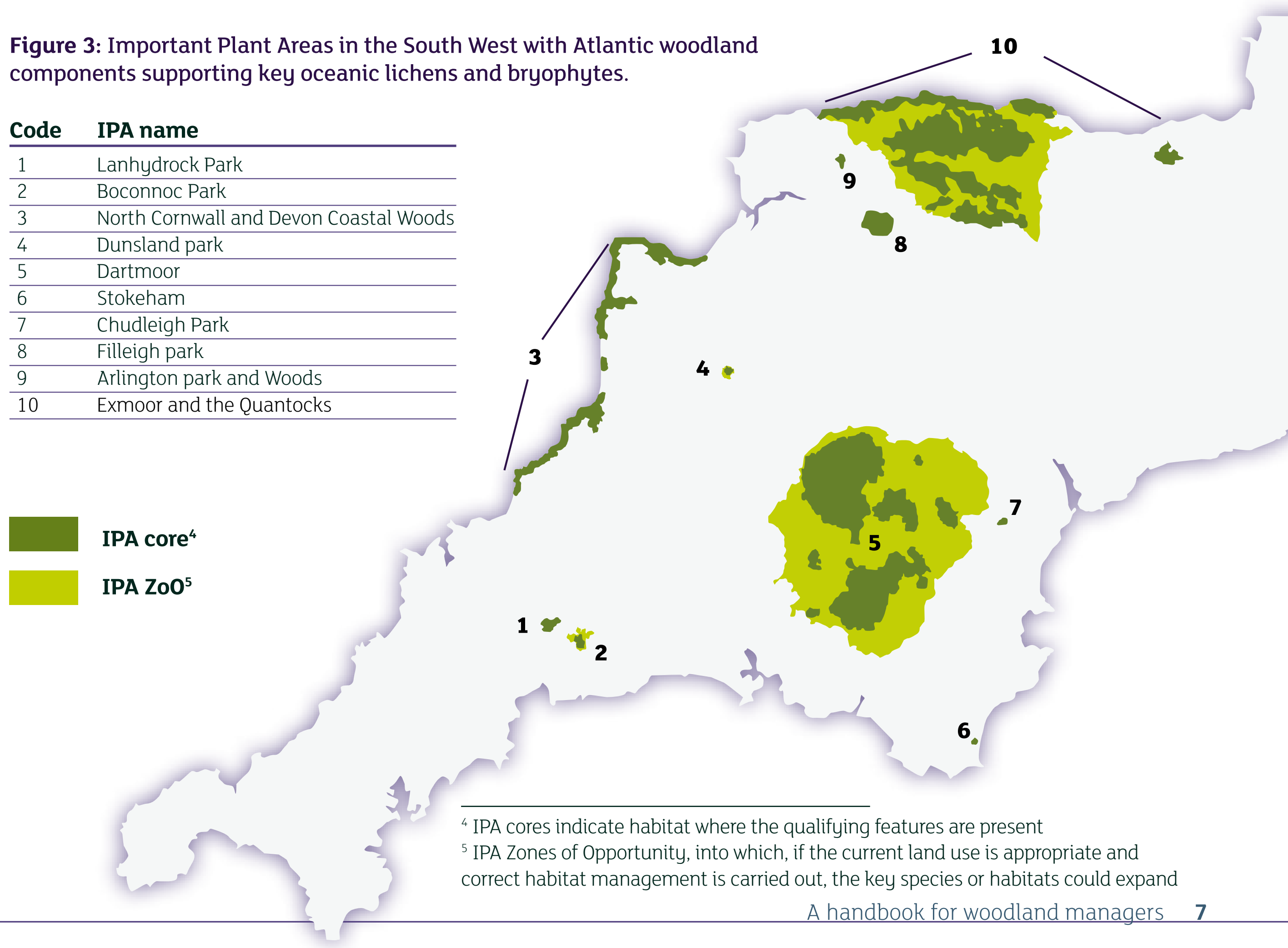
165 IPAs have so far been identified in the UK by Plantlife and partners – exceptional sites holding rare and diverse communities of flowering plants, bryophytes, lichens, stoneworts and algae.

All IPAs have been identified using at least one of three internationally agreed criteria:

- Significant populations of one or more species of global or European conservation concern
- Exceptionally rich flora in a European context in relation to its biogeographic zone
- Outstanding examples of a habitat type of global or European plant conservation and botanical importance

Figure 3: Important Plant Areas in the South West with Atlantic woodland components supporting key oceanic lichens and bryophytes.

Code	IPA name
1	Lanhydrock Park
2	Boconnoc Park
3	North Cornwall and Devon Coastal Woods
4	Dunsland park
5	Dartmoor
6	Stokeham
7	Chudleigh Park
8	Filleigh park
9	Arlington park and Woods
10	Exmoor and the Quantocks



[4] IPA cores indicate habitat where the qualifying features are present
[5] IPA Zones of Opportunity, into which, if the current land use is appropriate and correct habitat management is carried out, the key species or habitats could expand

2 **Lichen and Bryophyte interest in the Atlantic Woodlands of South West England**

2.1 **Lichen interest**

Lichen communities and niches

Lichens do not grow randomly, but in distinct communities which vary according to substrate e.g. on trees, rock or soil. A key factor determining where different lichens grow is the chemistry of the substrate; different community of lichens will grow on trees with acid bark than will grow on trees with base-rich bark. Table 1 shows typical bark chemistry for common trees. It is worth noting though that bark chemistry can be influenced by local conditions such as atmospheric deposition, and the bark chemistry of some species changes over time - notably oak which becomes more base-rich with age. Many lichens are also specific to certain niches on trees e.g. twigs, bare lignum, old dry bark, sap-runs etc.

Table 1: Tree bark chemistry

Bark chemistry	**Species**
Low pH (acid bark)	Alder, beech (young)*, birch, hawthorn, hornbeam, oak (young), pine, rowan, spruce, sweet chestnut
Medium pH (more base-rich bark)	Ash, beech (old)*, hazel, lime, oak (old), sycamore, willow
High pH (base-rich bark)	Elm, field maple

* Old beech can become more base-rich and support *Lobarion* species in some circumstances in the UK (this is more common in Europe where old beech is more frequent).

There are eight woodland lichen communities associated with these specific tree niches that are particularly important in South West England. These are given in Table 2 below and explained in detail on pages 9-15.

Table 2: Lichen communities associated with tree niches in SW England:

1	Ancient dry bark on old and veteran trees: supports a specialist range of species and is the South West's most important community in global terms
2	Base-rich bark: supports the *Lobarion* community (see Plantlife Guide 1)
3	Acid bark: supports the *Parmelion* community (see Plantlife Guide 2)
4	Smooth bark: supports the *Graphidion* community
5	Shaded mesic[6] bark on mature trees: supports a specialist range of crust-forming (crustose) species.
6	Dead wood and dry lignum[7]
7	Wound-tracks[8] on ancient trees: supports some specialist and very rare species.
8	Well-lit, sheltered canopy branches: highly significant for the 'beard lichens' (Usnea species)

[6] Moderately moist i.e. neither wet nor very dry; typically referring to the relative humidity of a habitat
[7] The wood of the tree, beneath the bark
[8] Sap-runs arising from damage to the tree

1 **Ancient dry bark community** (on veteran trees)

This is the single most important lichen community in the South West and is globally important, having its world headquarters between East Cornwall and the New Forest.

The community consists of mosaics of grey-white or grey-brown crustose species found on craggy bark on the dry sides of ancient trees, especially oak and ash. Such bark is sheltered from direct wetting by rain or the flow of water down a tree (so remaining largely dry) and the lichens get their water from dew precipitated directly onto their surface.

The community is confined to warm temperate oceanic climates, where there are frequent dews but the climate is not so humid that moss can invade. The community is not restricted to woodland but occurs equally on sheltered but well-lit old oaks in pasture woodland, parkland and on field trees.

Characteristic species: Most are internationally rare or very restricted and some are Section 41 species e.g. *Enterographa sorediata*, *Lecanographa amylacea* and *Tylophoron hibernicum*. Further east, especially on Exmoor, dry lignum and bark communities rich in pinhead lichens[9] appear, adding to the diversity.

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© Neil Sanderson

Figure 4: The pinhead lichen *Chaenotheca stemonea*

Figure 5: A veteran oak with the dry bark lichen community visible as white patches on the lower trunk. This community occupies areas sheltered from direct rainfall and the flow of rainwater down the trunk, which can be seen here (the wet areas can be seen where there is green bryophyte growth). Different species grow in different niches within the dry bark e.g. some grow in the recesses of the craggy bark that can be seen as a darker patch within the white area.

[9] Small crustose lichens whose fruiting bodies are held on small stalks, looking like miniature golf-tees or pins.

2 Base-rich bark community (the *Lobarion* - 'lungs of the forest')

This is considered the climax community[10] of trees with base-rich bark in the UK and includes some of our most conspicuous epiphytic[11] lichens e.g. tree lungwort *Lobaria pulmonaria* (pictured below).

The *Lobarion* community needs:

- Base-rich substrate (normally trees, occasionally rock)
- Long-standing habitat continuity
- High humidity
- Medium to high light levels
- Low/no airborne pollution (particularly sulphur dioxide and ammonia/nitrogen)

© Ray Woods

Characteristic species:

See Plantlife's Lichens of Atlantic Woodlands in South-West England Guide 1 available from our website.

Since the *Lobarion* is a climax community, an earlier 'pre-*Lobarion*' stage has been defined which may signal that the habitat is sub-optimally managed but has *Lobarion* potential. Pre-*Lobarion* beacon species, all included in the guide, include:

- Orange dimple lichen *Dimerella lutea*
- Elf ears *Normandina pulchella*
- Barnacle lichen *Thelotrema lepadinum*

Figure 6: Formerly widespread in the UK, *Lobarion* declined drastically through the 19th and 20th centuries, primarily as a result of air pollution, which continues to have an impact today.

3 Acid bark community (the *Parmelion* - grey lobes and whitish crusts)

This community occurs on trees with acidic bark, such as alder, birch and young oak, growing either directly on bark, or on mats of bryophytes overgrowing the bark. Some species can also be found on mossy boulders and rocky outcrops but only in the most humid conditions. Good indicators of this community are an abundance of pale grey/grey-green leafy lichens and whitish crusts on tree trunks.

This community requires similar conditions to the *Lobarion* community (but a different bark chemistry):

- Acidic substrate (trees and/or rock)
- Long-standing habitat continuity
- High humidity
- Medium to high light levels
- Low/no airborne pollution (particularly sulphur dioxide and ammonia/nitrogen)

In high rainfall, upland oakwoods: Species such as the tailed loop-lichen *Hypotrachyna taylorensis*, speckled sea-storm lichen *Cetrelia olivetorum* and the smooth loop-lichen *Hypotrachyna laevigata* are characteristic. These high altitude oakwoods are scarce in the South West, being largely restricted to: the edges of Bodmin Moor at c.220-230m; exposed parts of Dartmoor at c.360-440m, e.g. Black Tor Copse, Wistman's Wood, Piles Copse and Dendles Wood; upper parts of valley oak woods on Exmoor and the Quantock Hills; stretches of old sessile oak wood along the Tintagel-Marsland-Clovelly coast; and some woodlands along the River Camel.

Lowland community on rough-barked trees, e.g. ash and oak in parkland and open woodland: Typified by an abundance of leafy species such as heather rags *Hypogymnia physodes*, wrinkled sulphur lichen *Flavoparmelia caperata,* grey crottle *Parmelia saxatilis, P. sulcata,* and more shrubby species such as oak moss *Evernia prunastri* and shaggy strap lichen *Ramalina farinacea*. The sea-storm lichen *Parmotrema perlatum* only occurs where air pollution levels are very low.

Characteristic species:

See Plantlife's Lichens of Atlantic Woodlands in the South-West Guide 2 available from our website.

Figure 7 below: The tailed loop lichen *Hypotrachyna taylorensis* is one of the scarcer *Parmelion* in the South West. A distinctive characteristic is the rolled up tubes – or tails - that form on well developed thalli.

© Plantlife

[10] A historic term that expressed a biological community which, through the process of succession had reached a steady state. More recently the term is used to refer to mature or old-growth communities.

[11] Typically growing on trees and shrubs

4 Smooth bark community
(the *Graphidion* community - ‘dots and squiggles’)

This is made up of crustose species, appearing as a mosaic of white, pale grey, and brownish patches with small spots, pimples, warts and scribbles (fruiting bodies) e.g. the barnacle lichen *Thelotrema lepadinum* and bloody comma lichen *Arthonia cinnabarina*, which occur on smooth barked trees such as hazel.

The very wet hyper-oceanic hazel woods of North Wales and West Scotland are internationally important for this community and home to some very rare species, whilst the smooth-bark communities of South West England differ, reflecting the drier and warmer climate.

Characteristic species:

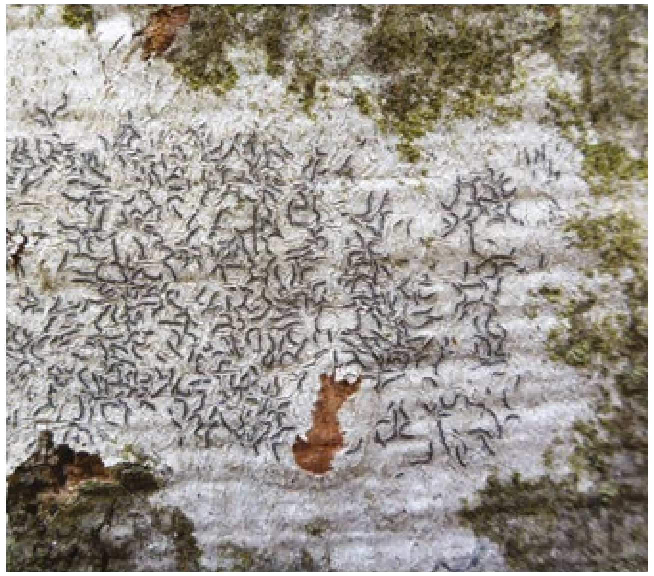
In shaded, humid situations in the South West the community is dominated by the pox lichens *Pyrenula* species, with their small volcano-like fruiting bodies. In better-lit areas a more varied community is found including the script lichens e.g. the common script lichen *Graphis scripta* and the dark-spored script lichen *Phaeographis dendritica*, along with the comma lichens *Arthonia* species.

The community does support some very rare species in the South West e.g. *Arthonia anglica* and *Melaspilea lentiginosa*, which is parasitic on the dark-spored script lichen *Phaeographis dendritica*; and the script lichen *Graphina pauciloculata*, which often grows on another lichen, *Graphina ruiziana*.

Figure 8: A *Graphidion* community dominated by the pox lichens *Pyrenula macrospora* (large black dots) and *P. chlorospila* (small black dots).

© Andy Acton

Figure 9: The script lichen, *Graphis scripta*, one of the most characteristic species of the community.



© Andy Acton

5 Shaded mesic mature bark community (specialist crustose species)

© Dave Lamacraft

Figure 10: This community is technically part of the *Graphidion* and is also found on smooth bark, as well as rougher bark, in shaded locations. It is a southern community in the UK, not as prominent in more northerly oceanic areas, and is typically best developed on oak, beech and ash. The community is widespread and rarely supports species of high conservation interest except in old growth woodland and parkland with veteran trees, such as those found in South West England e.g. Clovelly and Whiddon Deer Park. In these situations special species can occur e.g. the rimmed wart lichen *Pertusaria velata* and *Schismatomma graphidioides*.

6 Wound-tracks or seepages on veteran trees

Wound-tracks on veteran trees are a rare habitat that can support significant species in the South West. This habitat supports the Section 41 dot lichens *Bacidia circumspecta* and *Bacidia incompta*. The former is strictly a woodland species in the area, while the latter also occurs in parks and on field and hedgerow trees.

Figure 11: the track of a seepage can be seen here as a dark stain running down the trunk from the base of a lower branch of this ash tree. This dark stain is the rare lichen *Bacidia incompta*.

© Neil Sanderson

7 Dead wood and dry lignum community

Dead wood is not typically regarded as an important habitat for lichens in Atlantic woodland and there is often little dead wood in the former oak plantations that occur across much of South West England. However, it will accumulate in plantations that have not been thinned for a long time, and old pasture woodlands can have large amounts of dead wood.

In the damp climate of the South West the dead wood is typically occupied by acid bark communities (the *Parmelion*, see above) e.g. black-eyed susan *Bunodophoron melanocarpon* (see Lichens of Atlantic Woodlands in the South West Guide 2), which is found on standing dead wood in the Barle valley.

Figure 12: Standing deadwood providing niches - including bare wood or lignum- for an important group of lichens.

There are also specialist species of damp lignum in western woods, including *Xerotrema quercicola* and the internationally very rare dot lichen *Bacidia subturgidula*. In the most oceanic areas and sheltered woods, the lignum is also occupied by *Parmelion* species, but the dry bark of old oaks will be occupied by the ancient dry bark community (see above).

8 *Usneion* community of tree canopies in well-lit situations

The most characteristic variety of this community in the South West consists of spectacular growths of the beard-lichens *(Usnea species)*, which have a markedly southern and south-western distribution in Britain. It occurs on well-lit twigs and canopy branches, and on sloping or horizontal boughs of trees.

Figure 13: *Usnea articulata*

Figure 14 (left)**:** *Usnea florida*

The community contains two species for which the South West is particularly significant: the string-of-sausages lichen *Usnea articulata* (Fig 13) and witches' whiskers *Usnea florida* (Fig 14). These species are highly sensitive to atmospheric pollution, especially sulphur dioxide, and this is probably responsible for their loss from northern England and the Midlands.

Additional thanks for the images by Jenny Seawright:
www.irishlichens.ie and www.dorsetnature.co.uk/Dorset-lichen.html

2.2 **Bryophyte Interest**

There are a number of habitat features and species that can indicate a site with good bryophyte interest (annotated below). See appendix 1 for more detailed lists of species indicative of interest in particular micro-habitats.

Woodland with a long-established cover of broad-leaved trees, particularly oak, can support luxuriant bryophyte cover'. For species photos see Plantlife's guide 'Mosses and Liverworts of Atlantic Woodlands in South West England.

One of the best indicators of an important oceanic flora are rocks and trees with greater whipwort *Bazzania trilobata* and cushions of Prickly featherwort *Plagiochila spinulosa*.
The latter is endemic to Europe and rare outside of western Britain and Ireland, making these populations globally significant. Other good indicators are the spotty featherwort *Plagiocila punctata* and western earwort *Scapania gracilis*, usually mixed with the common mouse-tail moss *Isothecium myosuroides* var *myosuroides.*

A variety of rocky substrates will support a richer bryophyte flora. The rare rock fingerwort *Lepidozia cupressina*, a small liverwort with finely divided leaves rather like fingers, can form large cushions on acidic rocks.

The very rare *Jamsoniella autumnalis* may occur on fallen dead wood and tree stumps. *Lepidozia cupressina* can also grow here.

Rocky ravines are an important habitat for bryophytes. In South West England, this habitat feature alone is likely to indicate significant bryophyte interest.

Many species, particularly those intolerant of desiccation, will occur only within close proximity to streams and rivers that have a woodland canopy, such as Hutchins' hollywort *Jubula hutchinsiae* (which is endemic to Europe, with its most significant populations in Britain).

A luxuriant carpet of moss on the woodland floor, with wefts of little shaggy-moss *Rhytidiadelphus loreus*, turfs of greater fork-moss *Dicranum majus* and other common species. Where grazing is limited, this ground layer will often be out-competed by vascular plants.

The translucent-leaved Wilson's filmy fern *Hymenophyllum wilsonii* and Tunbridge filmy fern *Hymenophyllum tunbrigense* are often considered 'honorary bryophytes' and their presence on rock faces and tree trunks is usually indicative of a site rich in bryophytes

3. Ideal conditions for lichens and bryophytes

Many factors influence the abundance and distribution of lichens and bryophytes, and these operate at both the woodland and at the substrate level i.e. the features of the individual tree, rock-face or boulder on which they are growing.

3.1 Habitat requirements at the woodland level:

Diverse topography:

A range of woodland habitats with a diversity of light and humidity regimes will ensure optimum conditions for a range of lower plants and promote a diverse flora.

Aspect can be important; for example well-lit, south-facing slopes will have a different flora from shadier, north-facing slopes. Particularly important topographical features include river valleys and ravines, rocky outcrops, flushed slopes, flat terraces, boulders, rocky slopes and boulder scree slopes (see 2.2 and case study on page 19).

Structural diversity:

A diverse structure including areas with closed canopy, dappled shade, glades, a patchy understory including hazel (with some denser stands), standing and fallen deadwood and veteran trees provide a variety of light/shade and humidity regimes.

For epiphytic lichens, tree trunks need to be kept free of ivy and shading shrubs; a patchy, diffuse understory is best. The basic mechanism driving this is a varying browsing pressure on tree regeneration that suppresses regeneration for long periods, see pages 42-44.

A variety of substrates:

Rocky outcrops and boulders:

These are of overwhelming importance for oceanic bryophytes because of the lack of competition. The cycle of accumulation of plants on a rock-face and subsequent sloughing off provides a steady supply of new, open habitat for the smaller species to colonise.

They also provide an important refuge for lichens and bryophytes in disturbed woodland. Steep rocky terrain is often less intensively managed and can support a greater diversity of tree and shrub species and their associated lichen and bryophyte flora. These stands can be an important source for re-colonisation, with some lichens (e.g. *Lobaria*) taking refuge on the rocks themselves.

Diverse tree and shrub communities:

A diversity of tree and shrub species and age classes is important for providing a range of niches (see 2.1 and 2.2). Saplings are generally of low importance and can pose a threat to lichens (through shading). However, some saplings and young trees are desirable to provide future habitat and as a niche for early colonising species.

Woods with a high proportion of veteran/ancient trees are much more likely to support important epiphytic communities (see section 2 and 3.2). Relict trees including old open grown ancient pasture trees and boundary trees are often significant for the more light-demanding species. This interest isn't limited to large trees; old stools of hazel can be particularly important for lichens and bryophytes.

Resilient habitats

In addition to these conditions, ancient woods with a long history of habitat continuity, and those that are large and well-connected in the wider landscape, are likely to support better and more resilient lichen and bryophyte communities.

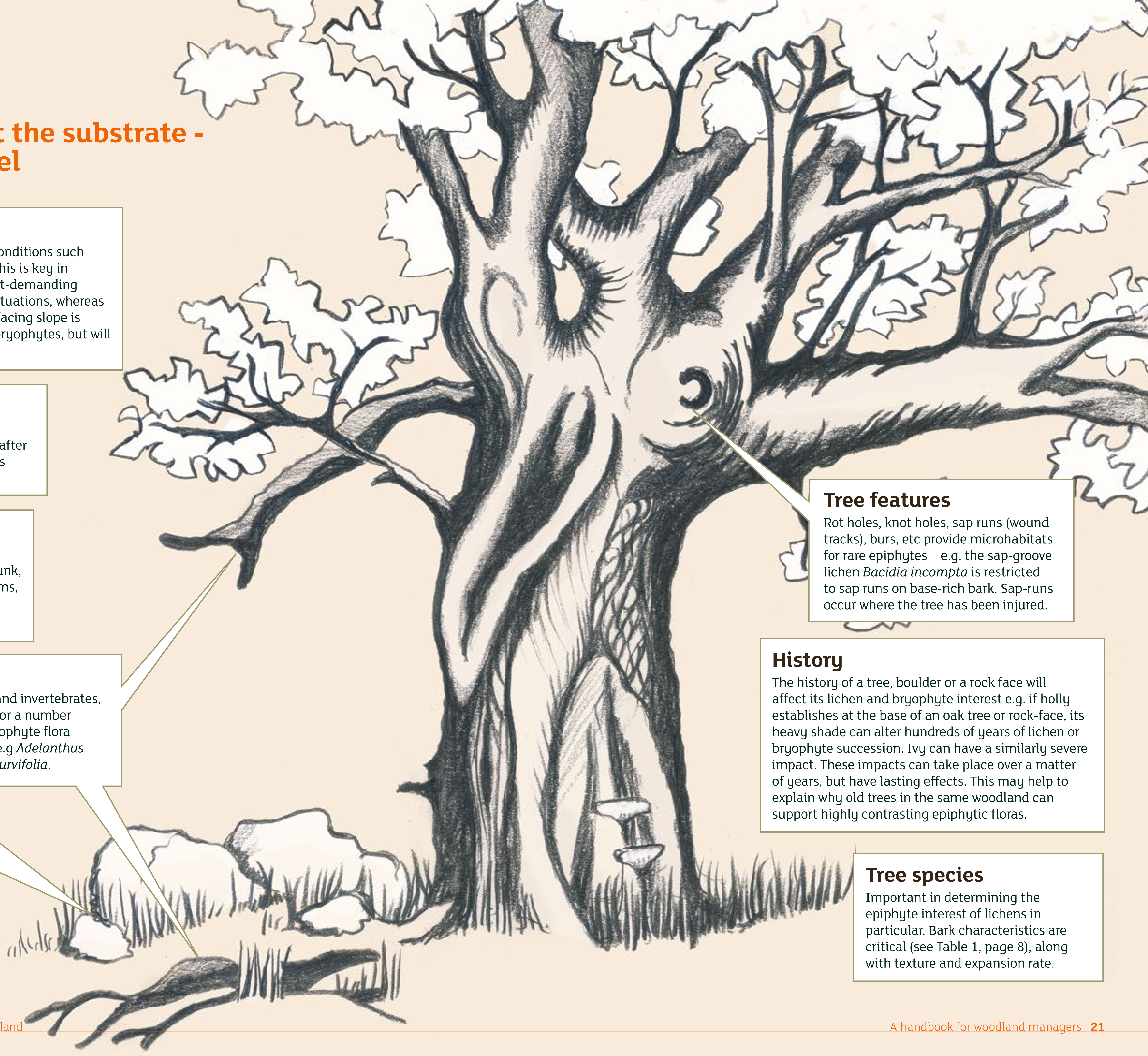
Many lichens and bryophytes, including many of conservation importance, are poor colonisers and require regular availability of suitable habitat niches. In some cases, apparently good old-growth woods may have low lichen interest suggesting that at some point in the past, the woodland has undergone quite severe disturbance (such as clear-felling or regular coppicing), disrupting the continuity of available niches.

Furthermore, small-scale habitat loss and fragmentation have been a major threat to woodland lichens and bryophytes. Research from the New Forest indicates that stands should be at least 100ha, as old growth stands of this size show no obvious loss of lichen epiphyte diversity even though they may have been isolated from at least the mid-medieval period. Conserving better, bigger and well connected habitats now forms a core theme of conservation policy in the UK (Lawton 2010).

Case study:
climate and bryophytes in the Barle Valley, Exmoor

The number of rain-days per year (those days with >1mm of rain) is a major variable governing bryophyte distribution. During 1961-2003 there were 154 rain-days per year (national average) and many of the strict Atlantic species occur mainly in areas with >180 rain-days per year. This is especially important for many of the more restricted Atlantic bryophytes (Ratcliffe 1968), and for the better quality NVC W17a (Rodwell 1991) oceanic woodland community. The Barle Valley SSSI in Exmoor received 166 rain days per year on average during this time, so whilst wetter than the national average, it is still relatively dry. Nonetheless, local topography can create good humid conditions for Atlantic bryophytes so that they can occur at sites outside their normal climatic zone. The Barle Valley is an example where areas of higher bryophyte interest are associated with west or north-west facing slopes, rocky slopes and the riparian corridor.

3.2 Habitat requirements at the substrate - individual tree or rock - level



Location

The locality of trees/rocks will influence conditions such as light, humidity and temperature, and this is key in determining epiphytic communities. Light-demanding lichens will require substrates in well-lit situations, whereas a semi-shaded rock face on a north-west facing slope is likely to have good potential for oceanic bryophytes, but will be less suitable for lichens.

Tree age

The stability and longevity of the substrate are important; epiphytic lichen diversity tends to rise after the tree reaches 150 years of age and some lichens appear limited to 400 year old oaks.

Tree architecture

Tree shape helps determine the range of microhabitats present and influences the way water flows down the trunk, influencing what species grow where. Asymmetrical forms, e.g. leaning or sinuous trunks may have little value as timber but support a greater species diversity.

Deadwood

Important for lichens and bryophytes as well as for fungi and invertebrates, standing deadwood provides the exposed lignum needed for a number of specialist 'pin head' lichens (see 2.1). An interesting bryophyte flora develops on rotting logs in South West Atlantic woodland e.g *Adelanthus decipiens* and the rare *Lepidozia cupressina* and *Nowelia curvifolia*.

Rock type

Rock pH and texture will influence what grows where on rock faces and boulders.

Tree features

Rot holes, knot holes, sap runs (wound tracks), burs, etc provide microhabitats for rare epiphytes – e.g. the sap-groove lichen *Bacidia incompta* is restricted to sap runs on base-rich bark. Sap-runs occur where the tree has been injured.

History

The history of a tree, boulder or a rock face will affect its lichen and bryophyte interest e.g. if holly establishes at the base of an oak tree or rock-face, its heavy shade can alter hundreds of years of lichen or bryophyte succession. Ivy can have a similarly severe impact. These impacts can take place over a matter of years, but have lasting effects. This may help to explain why old trees in the same woodland can support highly contrasting epiphytic floras.

Tree species

Important in determining the epiphyte interest of lichens in particular. Bark characteristics are critical (see Table 1, page 8), along with texture and expansion rate.

Each of these issues are discussed in more detail on pages 38-60, along with management options.

Table 3: An overview of the main habitat requirements for lichens and bryophytes and the management issues affecting them

Ideal habitat conditions		Habitat loss and fragmentation	Lack of tree species diversity	Lack of tree age diversity	Loss of veteran trees	Lack of grazing/browsing	Excessive regeneration	Lack of open space e.g. glades	Invasive non-native species e.g. *Rhododendron*	Invasive native/near-native species e.g. shade-casting beech and holly	Lack of deadwood	Climate change	Tree pests and disease	Air pollution	Inappropriate small-scale HEP schemes
		Issues affecting these conditions													
Extensive network of woodland habitats protected from loss and damage		●										●	●		●
Availability of suitable substrates e.g. trees and rocks with varying chemistry			●	●	●						●			●	
High humidity - canopy cover, especially in areas with particularly humidity sensitive species e.g. many bryophytes												●			●
Diverse species composition			●												
Diverse age composition				●	●										
Diverse structure including frequent glades of c30m				●	●	●	●	●	●	●					
Availability of successive generations of veteran trees				●	●										
Variety of light levels but mainly semi-shade i.e. generally well-lit				●		●	●	●	●	●					
Sparse regeneration and shrub layer						●	●		●	●					
Availability of standing and fallen dead wood				●	●		●		●	●					

4. A framework for planning management of Atlantic woodlands for lichens and bryophytes

This section sets out how woodland managers can arrive at a plan to manage Atlantic woodland for its lichens and bryophytes.

4.1 Landscape-scale management of woodlands for lichens and bryophytes

Aim:

The over-arching aim is to achieve landscape-scale management of Atlantic woodlands for lichens and bryophytes, in order to increase resilience, particularly in light of threats such as tree disease and climate change. Where possible, management decisions should be taken at a landscape-scale i.e. over areas of 10-100ha or more as well as at the scale of the individual woodland.

In general terms the aim should be to secure important populations and sites to ensure their resilience in the face of future change, by;

- Protecting and improving the best sites e.g. the IPA Core Sites (see figure 3. p.7).
- Improving adjacent sites e.g. in the IPA Zone of Opportunity.
- Expanding native woodland to connect and buffer these sites.

Issues to consider:

An Atlantic woodland which is 99% birch may appear undesirable but if the rest of the woods in the catchment are oak monocultures, it can add diversity, and whilst it is usually desirable to manage to achieve a variety of age classes and woodland structures, this is best done at a landscape scale rather than in small individual woodlands.

However, to take this approach will require control or influence over management across this landscape, as well as a shared vision, to ensure the management of individual sites are integrated. This may not be possible and in these cases the management decisions for individual sites should be taken with consideration given to adjacent land e.g. the presence of rare species on adjacent land may influence decisions on a site even though it may not currently support that species.

This will involve analysing the distribution and conservation value of woodlands in order to determine how they contribute to habitat networks and how networks can be improved. This allows the most important areas for conservation work to be identified. This is useful mainly for organisations involved in the setting of priorities at a regional scale.

The process of determining the best management approach at a site is summarized in figure 15 and detailed in 4.2.

Frequently Asked Questions:

1. What is the ‘right’ management?

Apart from the removal of *Rhododendron* and the securing appropriate grazing, few management options are *universally* viewed as the right thing. Managers need to be able to make a case for their chosen management interventions (or the lack of them) based on individual site characteristics.

2. Do I prioritise management for lichens or bryophytes?

Lichens and bryophytes can appear to have contrasting requirements - for more light and more shade respectively. In reality there is much overlap and it should be possible to manage for both, especially if management is informed by existing locations of species and communities e.g. canopy cover should be retained along ravines and watercourses or other areas with bryophyte interest such as rock faces. There will always be trade-offs e.g. choosing individual trees in a thinning operation (see Thompson 2005). Be informed by the process of identifying and mapping priority habitats, species and communities (see steps 1 and 2 below). A site managed to provide a range of conditions, informed by what is found where, should provide for lichens and bryophytes as well as other species of conservation interest.

3. When will I see the benefits of management actions?

Woodlands develop slowly, well beyond a human lifetime, and only some stages will be optimal for lichens and bryophytes at any one time. Sometimes short term losses of lichen and bryophyte diversity may occur that are followed by gains in the longer term e.g. when a wood is thinned in order to promote a new generation of older trees. The benefits or impacts of different management options should be assessed using time frames measured in decades or longer.

4. Should I intervene or let nature take its course?

Some managers prefer to rely on natural mechanisms to effect change, which typically act slowly and have relatively uncertain, though ‘natural’ outcomes. Others prefer to use more ‘interventionist’ techniques, which produce faster and usually (but not always) more certain outcomes. Recent decades have seen a preference for less interventionist approaches in general, but a greater acceptance of well thought-out management where benefits are proven e.g. controlled grazing and thinning of Atlantic oakwoods reported by Thompson (2005).

5. How quickly should I undertake management?

Grazing and/or browsing should be seen as the main management tool for Atlantic woodlands but where other intervention is required e.g. thinning, it is often best to take a gradual approach. Prioritise any urgent issues e.g. holly shading an important tree or rock face should be removed, as should dense regeneration surrounding a veteran tree. Beyond this, management such as thinning and glade creation is better done over a longer time-frame. Taking this approach will allow future management to be informed by developing lichen or bryophyte interest and other emerging issues.

4.2 Steps to planning effective management

Figure 15: A framework for planning management of Atlantic woodland for lichens and bryophytes

Step 1
Assess the lichen and bryophyte interest of the site

Step 2
Determine priority species and/or communities

Step 3
Assess and map the current state of the habitat and features influencing the woodland and its lichen and bryophyte interest

Step 4
Identify the management issues and actions to address these

Step 5
Prioritise management actions

Step 6
Consider the impacts on other conservation interests and objectives

Step 7
Consider the legal requirements of your planned management

Step 8
Implement management

Step 9
Monitor

Step 1:
Assess the lichen and bryophyte interest of a site

Aims:

- Identify the current importance of the site.
- Identify the potential of the site i.e. with appropriate or enhanced management.

Options:

A range of options are available for assessing lichen and bryophyte interest, and where possible a combination of these will yield the best information. The following options are discussed below:

1. **Desk-study to check existing site data**
2. **Detailed expert-led survey of lichen and bryophyte species at the site**
3. **Simple assessment of habitats to assess potential for lichen and bryophyte interest (can be undertaken by land managers with no species ID experience)**
4. **Simple survey to assess presence and abundance of key lichen and bryophyte species (can be undertaken by land managers with minimal species ID experience)**
5. **Assessment of site importance for lichens using Indices of Ecological Continuity (can be undertaken by land managers with more developed lichen ID skills)**

1 Desk-study:

The first step is to check what existing data is available. Many sites will have data in national datasets available on the National Biodiversity Network (NBN) Gateway, which contains records from the British Lichen Society, British Bryological Society and local records centres e.g. Devon Biological Records Centre.

Similarly, there may be detailed reports for sites. If detailed reports exist and are recent, then much of the hard work will be done as these will most likely have set out priorities and identified important areas. They are also likely to have identified management issues which will help with planning management.

Note that lichenology has advanced greatly in recent decades. Surveys pre-dating 1992 should be seen as historical sources in need of updating. Surveys pre-dating early 2000s are likely to be in need of updating, whereas surveys conducted from the mid-2000s onwards should provide adequate baselines.

❷ Expert-led survey:

If no data or detailed reports exist then it is worth considering commissioning one, especially if you suspect the site is likely to be important for lichens or bryophytes. Contact Plantlife or the relevant advisors at Natural England for a list of reputable expert consultants who are able to conduct surveys to the highest standard. However, a survey can be expensive, or thought not worthwhile until a better understanding of the interest or potential interest can be gathered. You may want to follow guidance below on how to assess your site initially using a simple survey or habitat assessment to get an idea of potentially rich areas.

If you are considering commissioning an expert-led survey, this guidance provided by Hill (2006) may be useful:

- The surveyor needs to be an experienced lichenologist/bryologist. However, the potential for mentoring or shadowing by less experienced lichenologists/bryologists should be considered and encouraged.
- Surveys should cover all habitats present, including poor ones, so as to fully characterise the range of interest present.
- Baseline assessments would be expected to record all the species seen on a site, but the detail can vary between common species and species of conservation interest. The former may only be recorded at a site or sub-site level. The most significant species would be recorded in much more detail, potentially down to individual occurrences.
- Recording technology: modern GPS recorders and digital cameras can be used to capture a great deal of data on the more significant species relatively quickly.
- Presentation of data: reports should include the full data recorded, at least in appendices, to guard against long term data loss. It is recommended that good practice is followed and records are added to the NBN gateway.
- It is a good idea to budget for a post survey meeting between the surveyor and land managers; the results can often be much more easily explained in the field.

❸ Simple survey of habitats to assess potential lichen and bryophyte interest

Simple assessments of habitat features can be easily carried out by woodland managers. No identification of lichen or bryophyte species is required, and the presence of the features described in Section 2 and 3 e.g. uneven age structure, veteran trees, good amounts of dead wood, absence of invasive species etc. will help to identify areas with good existing or potential interest for lichens and bryophytes. Use the table provided in Appendix 3 to record your results.

Habitats and niches suitable for important lichens and bryophytes can be inferred from woodland structure and topographic features and is sufficient to flag up areas of potential interest. These interest areas would ideally then be assessed using the species-focused assessments to verify the existence of any key indicator lichens and bryophytes.

Method:

- The woodland site (either as a whole, or split into sections for larger sites) is scored for each of the attributes in Appendix 3 by ticking the box in each row that best describes the site/site section.
- The site, or site section, is then ascribed to a category of likely value/interest (low, medium, high) by looking at the weighting of the ticks. Habitats scoring mostly 1's and 2's indicate areas with low interest/low current potential; habitats scoring mostly 3's indicate areas with medium interest/medium current potential; habitats scoring mostly 4's indicate areas with high interest/high current potential.
- Areas of medium to high interest should be investigated more fully using the species-focussed approaches above.
- For large varied sites, or those with different management units, the site should be divided up and mapped according to broad characteristics e.g. according to species composition, age etc and/or the management units, and then an assessment undertaken for each area.

OUTPUT:

Produce a map showing areas that meet the different assessment scores for habitat features, together with target notes indicating key features of interest (e.g. glades, veteran trees) or concern (e.g. presence of invasive species, areas of dense regeneration).

❹ Simple survey to assess presence and abundance of key lichen and bryophyte species

This requires identification of a small number of lichens and bryophytes using the Plantlife guides to 'Lichens of Atlantic Woodlands in the South West' (Guides 1 and 2) and 'Mosses and Liverworts of Atlantic woodlands in South West England'. Use the table in Appendix 3 to record your results. Most woodland managers wanting to identify characteristic lichens and bryophytes will be able to use this method.

Method:

- The woodland site (either as a whole, or split into sections for larger sites) is scored for each attribute in Appendix 3 by ticking the box in each row that best describes the site.
- The site (or site section) is then ascribed to a category of lichen and bryophyte interest by looking at the weighting of the ticks (low, medium, high). Areas scoring mostly 1's indicate low interest/low current potential; areas scoring mostly 2's indicate

medium interest/medium current potential; areas scoring mostly 3's indicate high interest/high current potential.

- Whilst additional species that indicate habitat quality will be present, it is sufficient to use the lichens and bryophytes shown in the guides for the purposes of this exercise.
- The areas where these species are present should be recorded e.g. with a GPS, and it can be useful to make a rough estimate of abundance e.g. using the DAFOR scale. Photographs are also useful.

OUTPUT:

A map showing areas of the site that meet the different assessment scores for lichen and bryophyte species, together with target notes indicating any particular species of interest.

❺ Assessing the importance of a site for lichens using the Indices of Ecological Continuity

This is another way to assess the interest of the site, but requires a level of identification skill. 'Indices of Ecological Continuity' have been devised to indicate the continuity of woodland using the richness of woodland lichen assemblages as a measure. They focus on lichens that are characteristic of good quality, undisturbed woodland sites, and are often the basis for which SSSI lichen features are notified.

There are two relevant indices for the South West; the New Index of Ecological Continuity (NIEC) and the Eu-Oceanic Calicifuge Index of Ecological Continuity (EUOCIEC). They were intended to be applied to patches of woodland of about 100ha in extent (Rose, 1992 & Coppins & Coppins, 2002). Further information and lists of species included in the indices are can be found on the BLS website.

Step 2
Determine priority species/communities

Once it has been established that there is lichen or bryophyte interest, or that the site has potential to be of interest, priority species/communities should be identified to focus management objectives.

Figure 16: Identification of priority areas for management:

Note that if recent expert surveys exist, priorities are most likely to have been identified already.

Where species interest has been identified, priority areas for management can be based on:

- The presence of SSSI lichen and/or bryophyte features, either independent species features or assemblages. Land owners should be aware if their woodland is a SSSI, and legal obligations will exist around these. Details on any designated lichen or bryophyte features can be obtained from Natural England. For an interactive map to determine if your site is designated see http://magic.defra.gov.uk/MagicMap.aspx.
- The presence of particular species: e.g. those listed as Section 41 species (see Appendix 2); those listed as Critically Endangered, Endangered, Vulnerable or Near Threatened in recent conservation evaluations of British lichens and bryophytes; species that are nationally rare and/or nationally scarce; species for which the UK has an 'International Responsibility'. See Woods & Coppins (2012) for lichens and Hodgetts (2011) and Preston (2010) for bryophytes.
- The presence of lichen or bryophyte communities described in section 2.1 and 2.2.

If there are no priority species or communities present in the woodland then identify priorities based on:

- The simple habitat assessment e.g. areas scoring 3's and 4's are likely to be of interest and can be managed to promote and extend those features that are of greatest benefit to lichens and bryophytes.
- If the site scored 1's and 2's then there is the potential to improve the conditions for lichens and bryophytes. This can be informed by the presence of priority species/communities on adjacent land e.g. it could be that the management priority becomes linking two areas of woodland that currently support a priority species by creating suitable conditions in between.

OUTPUTS:

- **A list of priority species/communities and a map of where these occur on the site.**
- **If there is no apparent species interest, map priority habitats where there is highest potential and consider management to enhance and extend these features.**

Step 3:
Assess the current state of key habitats for lichens and bryophytes and possible threats

Draw up a list of issues that are likely to affect your priority species/communities/habitats, and map these accordingly. Refer to Table 4 below for common issues affecting habitats and species.

OUTPUT:

- **A list of issues impacting on the lichen and bryophyte interest.**
- **Building on maps drawn up in Step 1, map where these issues occur.**

Step 4:
Identify the management options to address these issues

Determine the best management prescriptions to address the issues you have identified. Refer to Table 4 below and the management guidance on the relevant pages.

Table 4: Key management issues

Habitat fragmentation	See page **38**	Invasive non-native species	See page **47**
Lack of tree species diversity	See page **39**	Invasive native/near-native species	See page **49**
Lack of tree age diversity	See page **40**	Lack of deadwood	See page **53**
Loss of veteran trees	See page **41**	Climate change	See page **54**
Grazing/browsing	See page **42**	Tree pests and disease	See page **56**
Excessive regeneration	See page **45**	Air pollution	See page **58**
Loss of glades and open space	See page **46**	Small scale HEP	See page **60**

OUTPUT:

A list of management options, mapped accordingly.

Step 5:
Prioritise management actions

This should be done following the principles set out below:

Priority 1

Manage to address issues that are having the greatest impact on the priority species/ communities (or areas of good quality habitat) that you have identified in step 2.

Priority 2

Manage to address issues that are on the cusp of becoming more significant, e.g.:

- Regeneration: it is much easier and cheaper to deal with a small amount of young regeneration than it is to deal with 20-year old regeneration.
- Invasive species: as above it is much easier and cheaper to nip this in the bud early.
- Consider time-scales: e.g. whilst establishing conditions for future veteran trees will be an important issue to address on many sites, due to the time-scales involved this may be less urgent than sorting out grazing or regeneration.

Priority 3

Manage to enhance the condition of the remaining woodland for lichens and bryophytes where appropriate i.e. with consideration of other interests and objectives. Consider long-term resilience of the wood (e.g. addressing habitat fragmentation and future veteran trees).

OUTPUT

A prioritised list and map of the issues and management actions.

Step 6:
Integration with other management objectives

Managing for lichens and bryophytes should fit well with the management of Atlantic woodland for a broad range of conservation outcomes and objectives. However, management will need to be integrated with other management objectives.

Potential conflicts may be:

- Between lichens and bryophytes (see FAQs on p.25), although this should be entirely manageable if the process outlined here is followed.
- With species requiring a dense shrub layer e.g. dormouse, marsh tit. Any conflicts should be manageable, especially on larger sites, by identifying priority areas for management and managing for structural diversity across the site.
- Woodland expansion potentially threatening open habitats e.g. sites rich in grassland fungi. Conflicts should be easily resolved with adequate planning, and in cases such as this example, alternatives for woodland expansion/networks sought.
- With commercial management e.g.
  - Small scale timber production
  - Conversion of wood pasture to closed canopy woodland
  - Encouragement of natural regeneration in glades and other open space.

OUTPUT

Clarity about the effects that woodland management operations will have on *all* objectives for the site and to ensure that the overall outcome of proposed management is positive.

Step 7:
Consider the legal requirements of your planned management

There are a range of legal obligations on those owning, managing or working in woodlands. A non-exhaustive list of relevant legislation is given in Appendix 5.

Step 8:
Implement management

Case study:
National Trust management at Dolmelynllyn, Gwynedd.

The National Trust's Dolmelynllyn estate at Ganllwyd, Meirionnydd is one of the most important sites for Atlantic woodland lichens and bryophytes in Wales. It includes areas of ancient ash, sycamore and oak rich in *Lobarion* lichens as well as boulders and a ravine supporting internationally important bryophyte populations. It is one of the most significant of the core sites within the Meirionnydd Oakwoods Important Plant Area (IPA) and as such has been a focus of Plantlife Cymru's work in the IPA.

The estate has been well-surveyed and has identified priorities and management issues, the latter mostly arising from a lack of grazing/browsing in recent years.

One of the most important compartments on the estate is old pasture woodland that had been ungrazed for a period of time and vigorous regeneration was starting to become an issue. The National Trust had been planning to reinstate grazing and had erected new boundaries ahead of reintroducing stock, but some mechanical intervention was also required. This took two forms: firstly, a flush of sapling growth was controlled by volunteer work parties using hand tools. Secondly, some chainsaw thinning was undertaken to remove younger trees that were shading mature trees with important lichen communities, to maintain glades, and to help restructure an area dominated by c20-30-year old ash and sallow regeneration. The latter was restructured based on a principle of halo-thinning trees that had developing lichen interest and/or ones that were developing an interesting architecture e.g. forked trees, together with the aim of creating some glades in the long-term.

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Figure 17: Highland cattle at Dolmelynllyn: the calf in the foreground is browsing on bramble, while the heifer and second calf are visible in the background. They are grazing in the area of young ash and sallow regeneration that was thinned heavily (c30%) around trees with developing lichen interest.

A grazing regime was trialed in 2015 with three Highland cattle - a heifer and two calves - sourced from a local farmer. They were introduced into the 6ha old pasture woodland in spring, where they remained until early autumn, after which they were moved into a larger (13ha) block of oak plantation. The farmer was funded to cover costs involved with transporting the stock, veterinary and medical costs, supplementary feed and checking of stock, and National Trust staff also assisted with the stock checking and movements. All involved have been impressed with the impact that these cattle have. Plans are now being made to continue this in 2016 and beyond.

The estate also includes a small plantation (c.4 ha) that was created in the early-mid 1990s, made up of primarily ash, with some birch and sallow. Some trees existing at the time of the planting were either coppiced or left untouched; post-mature ash and sycamore on the boundary were left, as were two post-mature small-leaved lime, whilst a sallow and an alder were coppiced. A survey had documented the lichen interest on the post mature boundary trees, primarily the ash and sycamore; interest on these included *Lobaria pulmonaria, Sticta sylvatica, Nephroma laevigatum* and *Pannaria conoplea*. Further investigation of the plantation itself by Plantlife found *Lobarion* colonising these young trees, with species including *Fuscopannaria sampaiana, Lobaria pulmonaria, Leptogium brebisonnii, Sticta* and *Nephroma* species.

Although the coppiced sallow and alder (older trees but c20 year growth) were the richest, both 20-year old planted ash and sallow were becoming important especially for *Sticta* species and *Leptogium brebisonnii* respectively. A key factor appears to the development of bryophyte cover, with the better lichen trees also having better bryophyte cover. Presumably the bryophytes provide a means for *propagules* to become established initially as well as capturing moisture.

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Figure 18: One of the c20-year old ash trees being colonised at Dolmelynllyn NT estate.

Step 9: Monitoring

The effects of management operations aimed at improving the condition of woodland flora should be monitored. However monitoring anything but the most obvious changes quickly becomes time consuming, requires carefully planning and expert input.

Possible approaches include:

- Simple field observations: visit the sites of operations before, during and (periodically) after they take place and keep an informal diary of observations, backed up by photos, e.g: where thinning and removal of invasive species has been undertaken, and grazing introduced, this should enable the success of this work to be assessed (and to assess whether grazing intensity is appropriate).
- Fixed point photography: this can be used for important sites, to assess change in lichen and bryophyte composition and abundance over time. Whilst many lichens are very slow-growing there are certain species that respond to changes in conditions more quickly, and changes can be picked up over several years.
- Periodic surveys of managed areas using quadrats or transects to assess habitat conditions: engage an expert surveyor to advise on the design and execution of such work. Attributes being measured could include light levels, changes in ground flora composition, changes in lichen and bryophyte composition etc. with a view to assessing the impacts of different management approaches in different areas of woodland. This is usually only advisable in special situations.
- Grid mapping: A method to document the distribution and abundance of important bryophyte species developed by Des Callaghan (Callaghan 2013) which uses 10m or 100m grid squares to map their distribution across a site. Locations of target species are recorded using GPS and mapped using GIS software to produce a map of their distribution by grid squares.

Key issues and management solutions:

Issue 1: Habitat fragmentation

Problem:

Atlantic woodlands are often fragmented; small populations of species in small habitat patches are more vulnerable than larger populations in larger patches.

Solutions:

- Link smaller patches to form larger ones of >100ha.
- Where woodland of high lichen and bryophyte interest/potential is adjacent to open ground, consider establishing new woodland, or a mosaic of woodland and open ground.
- Restoration should aim to expand and join up existing relic areas of rich old Atlantic woodland, including boundary trees and hazel and sallow scrub in adjacent meadows. Such landscape-scale restoration should seek to achieve a wide range of tree ages.
- Expansion should be sought primarily by natural regeneration and should be achievable where suitable seed sources are present.
- Consider planting small numbers of species that are not appearing through natural regeneration, if it is considered they should naturally be a feature.
- For guidance on woodland expansion, see Rodwell and Patterson 1994, Thompson 2005.

Key considerations:

- An appraisal of the 'donor land' should be undertaken to avoid damage to important wildlife sites.
- If undertaking planting, ensure stock is from local provenance to limit potential for introducing tree pests and diseases. Consider translocation of saplings from adjacent woodland.
- Ensure any planting and/or sapling translocation is appropriate for the ground conditions.
- Bear in mind the desired future woodland structure and management required to achieve this - remember, for lichens and bryophytes, the objective should be a varied but generally open structure and a variety of tree species. More shaded areas should be in areas with best potential for bryophytes e.g. alongside ravines or around north-facing slopes
- Bear in mind that rare woodland lichens are renowned for their slow dispersal and colonisation rates.

Issue 2: Lack of tree species diversity

Problem:

- A lack of tree species diversity limits the availability of substrates for lichens and bryophytes.
- An under-representation of shrubs in woodland can limit niches for epiphytes.

Figure 19: A woodland dominated by even aged oak - little structural diversity, species diversity or age diversity can be seen towards the background; a candidate for intervention to diversify the woodland.

Key considerations:

Note that a dense understory of shrubs would probably not favour lower plants. A diverse structure with glades and open spaces is important (see issue 5 and issue 7).

Solutions:

- Identify areas (from small patches to whole stands) which would naturally carry certain species e.g. ash or wych elm in more base-rich areas.
- Diversify tree canopy species to reflect site conditions through selective thinning.
- Where seed sources for trees and shrubs exist and are being inhibited by grazing/browsing either adjust the grazing pattern (see issue 5) or search out established seedlings and protect from browsing with mesh stapled onto stakes. Focus on seedlings growing where canopy conditions are favourable e.g. on appropriate soils and in canopy gaps. Without seed sources consider same approach as above, but by planting of small numbers of tree/shrub seedlings of local provenance and origin in appropriate locations. These will act as future seed sources.
- Encourage development of shrubs if they are under-represented, ideally through natural regeneration, using approaches outlined above and resorting to small scale planting only when there is no realistic hope of natural colonisation due to distance to seed sources.

Issue 3:
Lack of tree age diversity

Problem:

Former oak plantations and coppice, such as those found across much of the South West, tend to have an even-age structure, limiting niches for lichens and bryophytes

Solutions:

- Aim for areas of irregular, patchy thinning, with some areas left and other areas partly thinned, along with patches of clear-felling to create new glades. Refer to thinning guidelines (Thompson 2005).
- For large woods plan for at least a third to be restored to old growth (>200 yrs) grazed woodland. In woods with high epiphytic interest over half of the wood should be restored.
- Aim to develop stands of trees >400 yrs that will be retained to their natural death. Old trees trapped in dense younger stands may require haloing to allow them to survive.

Key considerations:

- An alternative to thinning is to allow the stand to eventually fall apart as it ages. This may be the only practical method on steep difficult to access slopes. Whilst diversity in tree age will increase as natural mortality takes its course over the long term, a decision needs to be made as to whether these natural processes are adequate or whether active management intervention is desirable. The presence of important species and communities should favour the latter.
- Planning for long term continuity is important: existing 100-year old oaks are a more important resource than newly regenerated oaks for replacing existing 300 year old trees. In oak, a generation gap of 100 years is not problematic.
- Restoration of managed productive young growth including coppicing, i.e. for commercial purposes in accessible parts of a site, is acceptable, providing other areas are left to develop as old growth, and serious consideration is given to the existence of lichen and bryophyte interest on trees, rocks and the woodland floor (see Issue 4 regarding veteran hazel).
- Retain canopy cover in areas important for bryophytes, or potentially important bryophyte areas e.g. ravines, watercourse, rocky woodland floor, small crags.
- Avoid damage to rocks and boulders during operations, or by felling on top of rocks, crags and boulders.
- Avoid standard silvicultural thinning i.e. thinning that favours straight 'perfect' tree specimens; the 'wonky' trees are often the ones that support greatest lichen and bryophyte interest.

Issue 4:
Loss of veteran trees

Problems:

Loss and decline of current veteran trees (and encroachment from dense shrub growth, restricting lichen communities)	Lack of recruitment of future veteran trees	Potential loss of veteran hazel stands by inappropriate cutting / coppicing, which will result in the loss of key habitats for epiphytes

Solutions:

Loss and decline of current veteran trees:

- It is very important that the life of existing veterans is extended to enable a large overlap in life spans. This may require sensitive tree surgery to prolong their lives. Felling should be a last resort (if necessary for health and safety reasons).
- Halo thin or clear dense regeneration around veteran trees.
- Establish appropriate grazing as the most viable long-term way to control regeneration (see Issue 5).

Lack of recruitment of future veteran trees:

- Select existing middle-aged trees to replace current veterans. This can be done as part of thinning to diversify structure (Issue 3).
- Select trees with with features such as dead wood in the canopy, decay holes, fused stems, forks etc. See Read (2000) Chap 8 and Thompson (2005).
- When clearing regeneration/ creating canopy gaps, select young trees to be retained to develop into open grown veterans.

Potential loss of veteran hazel stands:

- Avoid coppicing hazel in Atlantic woodlands. Some of the rarest lichen species in the Barle Valley, Exmoor, were found on veteran hazel. Coppicing, if appropriate, should be limited to selected individual stems and should only harvest a low percentage of shoots.
- Avoid underplanting pure hazel stands with other species that will eventually over top and shade them out.

Key considerations:

- Consider creating suitable decay conditions on younger trees if there are no 'near veterans' e.g. by pollarding damaged trees, those in need of reducing or maiden trees, breaking branches, damaging bark to initiate sap-runs.
- Consider pollarding young trees if appropriate to the site
- If creating new woodland, include a component of open grown trees to become future veterans. This should be at spacing of 10m or more.
- For further guidance see chapter 8 in 'Veteran Trees: a guide to good management' (Read 2000).

Issue 5:
Grazing and browsing

The importance of grazing:

Grazing (and browsing to an extent) is probably the key management tool for Atlantic woodlands and its reduction or cessation is at the root of many other problems that develop. Studies have shown that long-term fencing out of Atlantic oakwoods to alleviate perceived overgrazing markedly reduces ground flora and bryophyte diversity, and sees a general shift from specialist species to generalist species (Barkham 1978; Perrin *et al.* 2011; Rothero 2006).

Reduction in grazing has led to the development of ground floras dominated by bilberry or bramble, which drastically reduce bryophyte cover. Similarly reduction in grazing has caused an increase in holly and ivy growth, which seriously affect light levels for lichen communities. Recent research (Cannell 2005 and Smout *et al.* 2005) shows that in the past upland Atlantic woods were generally grazed and sites with a long history of grazing are likely to support a more interesting epiphytic flora due to higher light levels; 92% of woodland lichens of conservation interest are found within pasture woodlands (Sanderson 2012). The continuity of this management over centuries has been fundamental to the development of species richness.

Extensive grazing appears to be the only practical method of maintaining large blocks of nationally or internationally important lichen and bryophyte rich woodland in the long term. Rather than just maintaining a few especially rich trees, sustainable management requires the maintenance of good conditions around dozens or hundreds of trees, both veteran and maturing. Without browsing, coppice re-growth around haloed veteran trees can cast a very dense shade on the lower trunks within just a few years.

Figure 20: The difference between grazed and ungrazed Atlantic woodland can be seen clearly here. To the right, the woodland is open with well-lit trunks of mature oaks supporting a range of lichens and bryophytes on their bases. Bryophytes can also be seen growing on the woodland floor, on deadwood and on boulders. To the left of the fence, these niches have all been smothered by ivy and bramble growth, and light is reduced by increasing regeneration of hazel. The removal of grazing is often done due to concerns about a lack of regeneration, yet there is no regeneration (other than hazel) in the compartment on the left, whilst ash and hazel are both regenerating on the slope to the right.

Whilst every wood is different, and the grazing and browsing issues should be assessed for each, Table 5 below will give a guide (after Sanderson 2015)

Table 5: Assessing whether grazing intensity is appropriate

Grazing too high	Grazing moderate (desirable)	Grazing too low
No tree regeneration *at all.*	*Occasional* tree regeneration, and quite a number of browsed down saplings surviving.	There is mass tree regeneration.
No young shoots are escaping from the bases of hazel bushes.	Some young shoots are escaping from bases of hazel bushes but not sufficient for this to kill the older shoots.	Masses of shoots are escaping from the bases of hazel, with older stems being killed off by this growth.
No bramble survives in more fertile areas.	Bramble survives in more fertile areas but is contained to discrete patches by browsing.	Bramble is spreading uncontained in more fertile areas.
Ground is dominated by bryophytes with very limited vascular plant cover (excluding bracken).	The ground is still dominated by bryophytes but vascular plant growth other than bracken is visible.	Vascular plant growth is smothering mats of mosses.
	Early succession communities on small boulders are being maintained by grazing animals knocking off late succession moss mats, and grasses are rare.	Small boulders are being smothered by late succession moss mats and colonized by grasses, with early succession communities absent.

Fig 21: How to address issues of grazing intensity

No grazing

Grazing levels too low

Grazing levels too high

Grazing should be reinstated/ increased as a matter of priority.

Implement a controlled grazing regime.

Deer and goat browsing can be a useful stop gap where traditional stock grazing has ceased.

Reduce grazing and/or deer and goat browsing levels.

Considerations:

- Availability of stock
- Ideal stock type and number
- Timing of grazing
- Health and safety
- Animal welfare
- Legal requirements e.g. TB testing and consent

See the Woodland Grazing Toolkit for more detailed guidance (Sumsion and Pollock 2005).

Considerations:

- Numbers may need to be controlled if they have a negative impact on the woodland /lichen and bryophyte interest.
- To achieve some tree regeneration deer/goat browsing should be widely dispersed (Gill and Morgan 2010).
- Providing areas of alternative forage e.g. bramble can help alleviate pressure on young trees (Moser *et al.* 2006).

Considerations:

- Tree shelters or temporary exclosures could be used if necessary (Mitchell & Kirby 1990).
- This should be a temporary measure only – it will be detrimental for lichens and bryophytes (and other wildlife) if it continues for more than a couple of years.
- Long-term exclosure should be avoided if at all possible in areas important for lichens and bryophytes.

Issue 6:
Excessive regeneration that cannot be addressed with grazing alone

Problem:

Regeneration is beyond the stage at which it can be controlled by grazing alone, or there is limited forage and access for stock to move around the site.

Solution:

Undertake some mechanical management e.g. thinning, haloing trees of interest and creating corridors for stock to move through the site. Some of this work may be required in any case as a means to address structural issues.

Key considerations:

Manual clearance should not be seen as a surrogate for grazing; unless repeated regularly it can lead to the establishment of even denser thickets of regeneration.

If undertaking bracken control, do not use chemicals in areas important for bryophytes, and use weed-wiping techniques if using chemical control elsewhere.

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Figure 22: The glade in which this ancient sessile oak stands has been rapidly filled by dense regeneration following a cessation of grazing. Much of the regeneration is oak, which is already shading the lower trunk and will only get worse without management. This level of regeneration is getting beyond the level which could be controlled through grazing/browsing alone and will need clearance e.g. with a chainsaw or bow saw.

Issue 7:
Loss of open space - glades & open space mosaics

Problem:

Bryophytes and lichens in particular thrive in woodlands containing a mosaic of canopy cover and open space in the form of glades, and there is the danger of these mosaics being lost e.g. due to excessive regeneration and a lack of grazing (Issue 5).

Solutions:

- Identify areas where glades are likely to be important e.g. based on the species and habitat assessments in Step 1, and consider what needs to be done to perpetuate them i.e. either
  - by cutting out unwanted regeneration of trees and shrubs

  and/or
  - instigating an appropriate grazing regime.
- Grazing/browsing will be essential to maintain glades in the long-term.
- Grazing goes hand-in-hand with any restructuring works; restoring controlled grazing *before or shortly after* any opening up, haloing, or glade and/or ride creation is essential to avoid exacerbating the original problem by simply encouraging dense regeneration or ivy growth in response to higher light levels.
- Research indicates that at least 30% of the wood should be made up of well lit glades (of c30m diameter) persisting for at least 30 years (Coppins & Coppins 2002).
- If undertaking bracken control, do not use chemicals in areas important for bryophytes, and use weed-wiping techniques if using chemical control elsewhere.

Issue 8:
Invasive Non-Native Species

Rhododendron x superponticum

Problem:

The impact of non-native species on biodiversity is well documented. In the South West, the most problematic species are broadleaved evergreen shrubs, especially cherry laurel (*Prunus laurocerasus*) and *Rhododendron* (*Rhododendron x superponticum*). They cast deep shade throughout the year and have a devastating impact on lower plants. In nearly all cases the aim should be total eradiation.

Solutions:

- Map the location, extent and density of *Rhododendron* and instigate a control programme.
- Refer to the management guidance on the Non-native Species Secretariat website: **http://www.nonnativespecies.org/** to identify the most appropriate control techniques.
- A long-term commitment is required to take control through the 'attack phase' to the 'maintenance phase', and hopefully eventually total eradication.
- On sites with priority bryophyte and lichens/ priority habitats still present, consider using stem treatment (Edwards 2007) if the bushes are mature (to avoid exposing lower plants to a sudden change in environmental conditions)
- Ensure that control is part of a strategic landscape-scale management plan to prevent re-invasion from adjacent sites.

Key considerations:

- The success and suitability of techniques varies between sites and regions, e.g. mechanical flailing is a recommended technique (Forest Research 2008) yet has not proved to be the best option in Snowdonia, where cut and burn (with foliar spray of regrowth) and stem injection are most effective (Jackson 2008 and D. Roberts *pers comm*).
- Research in Wales suggests the problem of *Rhododendron* does not end with its removal from a site; the plant has major impacts on soil condition and subsequent habitat restoration. Furthermore, ongoing research indicates that current favoured control methods could exacerbate the impact e.g. through spread of toxic leaf litter, the concentration of toxins on burn sites and the release of large quantities of carbon from burning. It seems likely that control techniques will be reviewed in light of this in coming years (S. Brackenbury *pers comm*).
- The S41 liverwort Irish Threadwort *Telaranea europaea* appears to benefit from the shelter and high humidity provided by *Rhododendron*, although in England is restricted to just one Cornish site.

Invasive non-native herbaceous plants

Problem:

Other species affecting Atlantic woodlands, particularly in riparian habitats important for bryophytes include *Fallopia japonica* (Japanese knotweed), *Impatiens glandulifera* (Himalayan balsam) and *Monbretia x crocosmiflora.*

Solution:

Roughly map the extent of the problem and identify areas where invasion of important plant communities is taking place. Take a strategic approach to control measures, targeting areas where holding back the advance of the invasives is achievable and might be permanent. Information on specific control measures is given at www.nonnativespecies.org.

Restoring conifer plantation to native woodland (including PAWS sites)

Problem:

Many old woodland sites have been converted to conifer plantations (Plantations on Ancient Woodland Sites or PAWS), or are adjacent to them. Often these sites contain relict ancient woodland or have isolated/boundary broad-leaved trees, which may have remnant lichen and bryophyte interest. It is often desirable to convert these to native broadleaved woodland e.g. to save the remaining interest or to expand native woodland cover.

Solutions:

Convert conifers to native woodland applying a gradual approach that maintains woodland cover

- This can be achieved by halo-thinning the surviving broad-leaved trees and other areas of potential e.g. rocky areas and stream-sides initially, then expanding thinning works outwards in subsequent years. This will avoid 'shocking' lichens and bryophytes by suddenly exposing them to radically different environmental conditions.
- A long term aim should be to link these areas with subsequent light thinning work. The frequency of this will depend on factors such as aspect, exposure, species, age, susceptibility to windthrow, conifer regeneration etc. If the aim is to convert conifer plantation to native woodland, the intensity of thinning might need to increase further down the line to get sufficient light to initiate broadleaf regeneration and recruitment into the canopy. This is a process that can easily take 30 years or more!

Issue 9:
Invasive native/near native species

The issue:

Shading caused by colonisation and/or spread of native or 'near-native'[12] species e.g. holly, ivy, beech, which is often exacerbated by a reduction or removal of grazing.

The impact is not necessarily entirely negative; sycamore is well adapted to the climate in South West England and can be an important substrate for lichens and bryophytes requiring more basic bark (especially given ash dieback). However, problems arise with excessive, uncontrolled growth.

The issues associated with each species are addressed below.

Sycamore & Norway maple

Problem:

Heavy shading from dense unconstrained regeneration.

Solutions:

- Grazing/browsing: within well managed pasture woodlands dense regeneration is constrained by grazing/browsing. The trees that survive to maturity are more likely to be beneficial rather than damaging in such situations.
- Other intervention may be required e.g. ahead of, or in the absence of grazing. In such circumstances remove regenerating seedlings e.g. by hand pulling and saplings e.g. by hand winch or cutting (and chemical treatment of stumps in the absence of grazing).

Key considerations:

They can be important for epiphytes e.g. *Lobarion* lichens and have potential as replacement for ash (sycamore) and elm (Norway maple), especially as veteran trees. Managers should not seek to eradicate these species from Atlantic woodland, but instead manage them as a component of the woodland. For example, in north Wales, woodland managers and Natural Resources Wales (in respect of designated sites) will tolerate 10-20% sycamore in the canopy of some sites acknowledging its importance as a component of our Atlantic woodland. This should be achievable through appropriate grazing management.

[12] Species that are native to continental Europe, and may or may not be considered native in parts of the UK e.g. beech, sycamore, Norway maple

Beech

Beech is native to Britain, but generally regarded as non-native in the South West. Although there is some evidence it may have arrived naturally in the region, planting since the 18th century has greatly increased its presence.

Beech can become very lichen rich with age (Fritz *et al*, 2008) e.g. beech-oak-holly woods in the New Forest are some of the richest woods for lichens in western lowland Europe and lichen-rich beech stands have developed at Clovelly, Devon and in Cornwall at Ethy, Lanhydrock and Boconnoc. However, beech takes much longer than oak to become good for lichens (100's of years) and if not constrained by grazing or thinning it will change the character of an oak woodland; regenerating quite happily in shade it will displace oak over time, turning them into beech-oak woods and producing densely shaded species-poor stands. Within areas where beech is native this is just as problematic (Vera 2000 & Sanderson 2010).

Problems:

- Loss of lichen and bryophyte interest as a result of shading and accumulation of leaf litter, especially in oak woodland.
- A change in the structure of Atlantic woodlands e.g. to beech-oak woods, as beech will out-compete and displace oak over time, creating densely shaded species-poor.

Solutions:

- Beech requires management, not non-intervention.
- Grazing/browsing: moderate levels of browsing are required to constrain regeneration to maintain an open structure and allow oak to survive within pasture woodlands stands.
- Other intervention is also likely to be required especially ahead of, or in the absence of, grazing. In such circumstances regenerating beech seedlings can be removed using a number of methods: hand-pulling saplings, hand-winch, cutting (and chemical treatment of stumps in the absence of grazing). More mature trees could be felled or ring-barked (but be aware of health and safety implications if opting for the latter).
- Assess the overall conservation and landscape contributions of old beech trees, and potential impacts of regeneration derived from their seed-fall, and institute a programme of gradual control of problem trees by felling and/or ring-barking (by chainsaw).
- In woods where there is little beech, maintaining the past natural woodland composition will be an acceptable aim, but in those heavily invaded with beech it will be very difficult to eradicate, and arguably this should not be an aim of management. In these woods beech will need to be managed as described above with retention of old trees and small "beech tolerance areas".

Holly

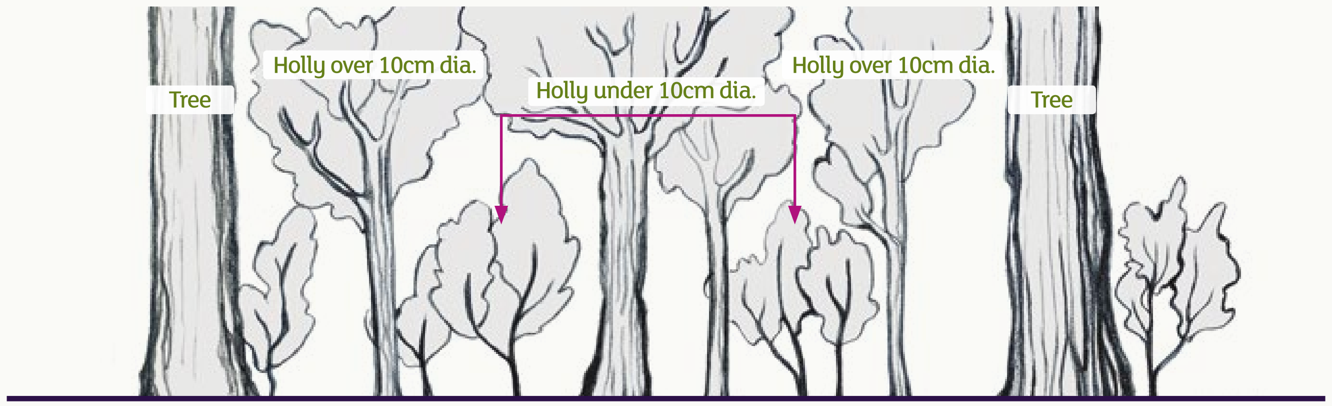
South-West Atlantic woods were probably naturally oak–holly woods but intensive oak management and winter sheep grazing hugely reduced its cover historically[13], and old hollies are now rare. Where they do occur they can be very rich in smooth bark lichen assemblages e.g. Ethy and Millook in Cornwall.

Problem:

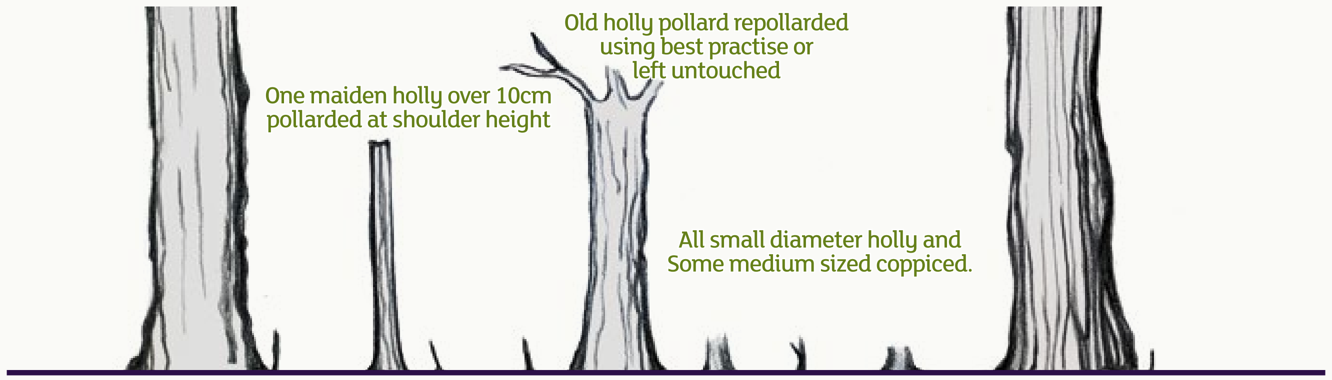
With a reduction or cessation in management, particularly grazing, holly rapidly reinvades woods where it can seriously reduce lichen and bryophyte diversity through shading; the impact of an uncontrolled holly invasion differs little from that of *Rhododendron*.

Figure 23: A diagram showing before and after in a treated stand of Holly in lichen rich pasture woodland the New Forest (from Sanderson, 1997).

Before Cutting



After Cutting



Solutions:

- Holly can only really be contained by ensuring sufficient grazing/browsing to keep it under control.
- Existing holly invasions will need to be cleared, especially in species-rich areas.
- Where holly is cut regrowth can be suppressed by grazing/browsing.

Conceivably the stumps could be treated but this seems unsuitable for a native species of value in its own right. Browsed holly thickets can also protect the regeneration of other species.

- Leave a scatter of uncut stems or pollarded stems to mature into old bushes (Sanderson, 2010).

Ivy

Two native species - common ivy *Hedera helix* and Irish or Atlantic ivy *Hedera atlantica* - are present in the South West. Ivy control can be controversial as it is often regarded as of general benefit to wildlife, although it can be a major threat to lichen and bryophyte diversity (Sanderson & Wolseley, 2001).

Problem:

Unconstrained it can smother woods, greatly reducing lichen and bryophyte diversity.

Solutions:

- Grazing/browsing: It is used as a major winter source of food by large grazing animals, including deer and domestic stock if they are present in woods. Indeed it is likely to have been greatly reduced by this in the past, and in the New Forest it is greatly reduced, but not eliminated, by grazing.
- Where important woods are being overrun by ivy, younger invasions should be cut from the trees. Retain some older crown ivy for its biodiversity value.

Key considerations:

- Ivy does have some associated invertebrate interest as well as providing cover for birds and bats.
- Sanderson (2001) recorded 4 – 12% of canopy trees in two ancient grazed pasture woodlands as having crown ivy. Even on the trees with ivy, the lowest 2m of trunk, the richest area for lichens, were kept clear of ivy by browsing. This gives an indication of acceptable levels of ivy in woods rich in lichens and bryophytes.
- In the past, grazing and ivy cutting could leave woods totally without epiphytic ivy; this is as equally unacceptable as woods overrun by ivy.

Issue 10:
Lack of deadwood

In Atlantic woodland, the lichen and bryophyte interest is generally associated with standing dead wood (including tree stumps and large bits of fallen trunk propped off the ground by branches), wood exposed on live veteran trees, and for bryophytes in particular, large diameter deadwood on the woodland floor. Often dead wood with good interest will be in reasonably well-lit but sheltered locations. Small diameter dead wood e.g. fallen branches does not tend to support species of interest, nor does shaded, damp dead wood.

Problem:

Past thinning has reduced the amount of standing dead wood, depleting many Atlantic woods completely of this resource. It is noteworthy that former coppices that have been long abandoned often have comparatively more standing dead wood as a result of self-thinning

Solutions:

- As a priority, allow natural dead wood to develop within more open, well-lit grazed woods.
- Retain standing or partly fallen dead wood in situ if at all possible.
- If standing dead trees need to be felled or moved for H&S reasons, aim to leave larger sections propped off the ground in sheltered, well-lit situations rather than leaving small cut up sections in full contact with the ground and in deep shade.
- Consider creating deadwood habitats e.g. through ring-barking or chemical injection to create standing deadwood.

Key considerations:

- Large diameter dead wood is more valuable than small diameter wood.
- If desirable, an inventory of deadwood can be carried out and the quantities present estimated (m3/ha) to get an idea of the quantities present against recommended levels - usually at least 40-100 m3/ha (Forest Enterprise 2002).

Issue 11: Climate change

Woodland is highlighted as one of the habitat types more resilient to climate change (Hossell *et al.* 2000), with a likely change in species composition rather than the loss of woodland altogether (Mitchell *et al.* 2007). However, there will certainly be a direct impact on lichen and bryophytes in Atlantic woodland.

Potential impacts:

Loss of oceanic lichens and bryophytes (Ray *et al.* 2010; Ellis 2012):

While there will be winners and losers, species with narrow ecological niches and those at the edge of their climatic range are likely to suffer.

Changes in tree species composition:

Though a gradual change, research predicts under a high emissions scenario that upland oakwoods will severely contract across Britain. English oak is likely to replace sessile oak. Beech could also increase, with further implications for oakwoods (Forestry Commission 2010).

Increased storm frequency:

This is likely to have a significant but mixed impact – rare species that prefer undisturbed woods are likely to suffer. To some extent some Atlantic woodlands are 'adapted' by constant exposure to high winds (and oak is relatively resilient to wind damage). The consequences of increased wind throw should be monitored to assess if positive benefits arise e.g. creation of new glades versus negative impacts e.g. increased shading from pioneer birch (Ray 2008).

Changes in woodland structure:

We will see increased shading as a result of enhanced growth rates of trees and longer growth seasons (with earlier canopy closure). This will have knock-on effects on shrub and herb layers, which may also play a role in determining the outcome for lower plants.

Increase in pests and diseases and invasive species:

We are likely to see an increase in the arrival and spread of plant pests and diseases. A warmer climate is likely to aid the spread of invasives. There will also be heightened risks of other disturbances e.g. fires.

Effects on veteran trees:

Increased frequency of storms, summer droughts and impacts on soil mycorrhizal associations will increase vulnerability of veteran trees (particularly in more open situations).

Building resilience:

The ability of species to 'keep up' with a changing climate and find their new climate space and/or a resilient refuge will ultimately determine their survival. However there are many steps that can be taken to increase species chances in this regard and to build a more resilient, 'strong and connected natural environment (Lawton 2010). To do this we need to:

1. Better protect and manage existing sites; woodland habitat and lichens and bryophytes that are already under pressure will be less resilient; minimising other threats and getting sites in optimal condition should be a key aim.
2. Establish a better connected landscape through habitat restoration and creation; the extent and connectivity of Atlantic woodland will be key to facilitating adaptation for lichens and bryophytes.

Key actions are likely to be:

- Maximising structural diversity across woodland types at a landscape scale to promote microhabitat diversity and provide refugia (Ellis 2012). See issue 1 and 3.
- Creation of buffering habitat, e.g. allowing scrub to develop along woodland edges, to alleviate humidity losses.
- Identifying potential refugia where the direct impacts of climate change may be less severe than in the surrounding area is informative for woodland plans e.g. in drought prone areas, stands with consistent water supplies, such as wooded ravines and spring lines, should be protected and managed as refugia. This is likely to be particularly important for bryophytes (Edwards 1986). North-facing or sheltered slopes may also give sanctuary to some species.

Monitoring

Regular species and habitat monitoring is a key recommendation and should be seen as an intrinsic part of adaptation. A well-designed monitoring programme is fundamental to inform site-level decisions, especially in the light of climate change. Although multiple factors interact with climate, the methodology and analysis should take into account wider environmental trends so that the results can be interpreted and the relative importance of the causes of site changes ascertained. Lower plants are renowned environmental indicators; their monitoring should help shape management responses to climate change – i.e. adaptive management[14].

[14] 'Adaptive management' refers to an iterative process of trialling new management techniques and refining them; it is therefore dependent on effective monitoring.

Issue 11:
Tree diseases and pests

Tree pests and diseases have the potential to drastically alter our woodland habitats and cause the loss of key trees for epiphytic lichens and bryophytes. Their occurrence is expected to increase, bringing significant impacts on our woodland biodiversity. Ash dieback is one of the most significant current threats to British woodlands with the potential to alter woodland composition on a scale similar to that of the loss of elm. Cases of acute oak decline, causing rapid declines in oak tree health, could also be increasing.

General advice:

- Keep vigilant, see **http://www.forestry.gov.uk/pestsanddiseases** for details of current threats and symptoms.
- Keep abreast of developments.
- Favour natural regeneration over planting.
- If planting is deemed necessary then use genuine local provenance stock i.e. grown locally, and consider transplanting local saplings and young trees.
- Adopt biosecurity and hygiene measures where possible.

Dutch Elm Disease

The potential impact on *epiphytic* lichen and bryophyte communities is well illustrated by the case of Dutch Elm Disease which has decimated our elm trees, altering woodland composition and leading to a drastic decline in dependent epiphytic lichens and bryophytes e.g. the epiphytic S41 lesser squirrel-tail moss Habrodon perpusillus is thought to have lost 70% of its sites (Bosanquet 2013) and many 'elm-specialist' lichen species are now listed on S41 due to their drastic declines and threatened status.

Conservation measures have included the planting of disease-resistant elm, although in recent years wych elm appears to be recovering naturally in some areas e.g. the Cotswolds and North Wales, although the suspected arrival of the pathogen Elms Yellows may dash any hopes of a recovery.

Ash dieback

Problem:

Habitat loss: Over 25% of the lichen species found in Britain have been recorded growing on ash, of which the majority are nationally rare or scarce, or have a conservation status of near-threatened or above (http://www.britishlichensociety.org.uk/about-lichens/habitats-conservation/ash-chalara-dieback-and-lichens). 58 species of moss and liverwort are associated with ash in the UK, and six of these are only found on ash (Mitchell *et al.* 2014). A list of 26 mosses and four liverworts have been highlighted as most strongly associated with ash (BBS 2012). Whilst many of these species also occur on other tree species the impact of ash dieback is predicted to have a significant impact on ash woods across the south-west.

Potential solutions:

A long term strategy to mitigate the impacts of ash dieback could be:

- Manage the existing woodland to create and maintain optimum conditions for lichens and bryophytes.
- Retain mature and veteran ash trees in and around areas of existing interest where possible, even if infected, to provide more time for epiphytic species to disperse and colonise new habitat. Evidence suggests that old ash trees that are infected die more slowly than younger ones.
- Select the next generation to replace veteran ash if need be, and manage around them to create conditions that will favour the colonisation of lichens and bryophytes. Sycamore, Norway maple, aspen and field maple all have with similar bark chemistry to ash as do willow/sallow species and hazel.
- Encourage the development of hazel and willow/sallow adjacent to existing areas with ash interest. Being fast growing, and seemingly becoming suitable for lichen colonisation relatively quickly, these species will provide a stop-gap before slower growing species e.g. sycamore, field maple, become potentially suitable. However be mindful of creating suitable conditions for colonising lichens to survive e.g. areas may need to be thinned once colonisation is underway (see case study pages 35-36).
- Favour natural regeneration and consider planting alternative tree species only as a last resort (trees planted now are unlikely to be old enough to support key epiphytes before ash dieback has had its full impact).
- Translocation of epiphytic leafy lichens has worked for some species but is not without risk and expert advice should be sought.
- For current advice on dealing with ash dieback refer to **http://www.forestry.gov.uk/pestsanddiseases.**

Issue 12:
Air pollution

Acid rain – long range pollutants (sulphur dioxide and nitrogen oxide):

The single largest cause of historic decline in the *Lobarion* community. Whilst improved regulatory measures since the 1990s have reduced the impacts, sensitive species are still recovering and not yet occupying their former range. Sources of acidifying pollution have a long-range impact, and are mainly from traffic (including marine traffic) and industry.

Nitrogen deposition - short range pollutants from ammonia (NH3):

Atmospheric nitrogen deposition is above the critical load over large areas of the UK e.g. 70% of Special Areas of Conservation (SACs) exceed or partly exceed these damage thresholds (**http://jncc.defra.gov.uk/pdf/4Page_booklet_1_nitrogenDep.pdf**). Over 80% of these emissions come from agriculture e.g. fertilisers, poultry farms and pig farms.

Woodlands provide a 'rough surface' and tend to intercept larger amounts of nitrogen (N) than 'less rough surfaces', e.g. grasslands. This is particularly the case for woodland edges, which experience the highest N deposition, especially where there is a local source of gaseous N e.g. from roads. One European study detected impacts on lichens and bryophytes about 50m from the wood edge (Moen & Jonsson 2003) whilst British research has shown elevated nitrogen levels up to 100m from arable boundaries (Willi *et al.* 2005).

Anecdotal evidence suggests even the accumulation of dung from livestock resting below trees or adjacent to boulders can have an impact on sensitive lichen species, something that is perhaps more of an issue in parkland situations than in woodland.

Communities most at risk are those rich in bryophytes, and those with lichens which contain blue-green algae as a photosynthetic partner e.g. *Peltigera horizontalis*, *Sticta limbata* and many of the other species that make up the *Lobarion* community.

Figure 24: *Xanthoria parietina* an indicator of nitrogen deposition.

© Jenny Seawright

Solutions:

- Identify the extent to which air pollution is a problem, by using lichen indicators (see **http://www.apis.ac.uk/nitrogen-lichen-field-manual** for details)
  - A lack of SO2 sensitive species such as *Usnea* species in the canopy, or those containing blue-green algae e.g. *Lobaria, Nephroma, Parmeliella* and *Sticta* species on trunks, could indicate impact of acid rain, although note that there are many other factors that can influence their abundance.
  - An abundance of *Xanthoria* and *Physcia* species will indicate that nitrogen deposition is high. Note however, that these species are often abundant on the edges of woodland, but less so within the wood.
- In more open situations e.g. parkland where grassland is managed more intensively by grazing or as silage (i.e. with high levels of inputs) consider reversion of this to a less intensive regime e.g. hay meadow, extensive grazing.
- Tree belts surrounding conservation sites can be effective at buffering N impacts at smaller sites (Dragosits *et al.* 2006), whereas the margins of larger tracts of woodland act as buffers themselves. Further information on establishing appropriate tree belts can be found here: **http://ec.europa.eu/environment/integration/research/newsalert/pdf/47na2_en.pdf**

Key considerations:

Even the best woodlands are likely to show some impact, especially on their margins. It is probably only worth considering active management where there is either a clear impact extending into the woodland, or where there is a known source of pollution nearby e.g. a poultry unit, intensive grassland management, major road.

Issue 13:
Small-scale Hydroelectric Power (HEP) Schemes

Small hydroelectric power (HEP) schemes are currently being encouraged regionally and nationally. These schemes remove water from a river or stream by constructing a weir (generally above a steeper section of the watercourse) and running it through a pipeline to a turbine before being put back in to the watercourse. The section of the watercourse which is by-passed by the pipeline will experience altered flows. Whilst commendable in terms of producing relatively clean energy these schemes have the potential to be quite damaging to lichen and bryophyte populations through direct construction impacts and by altering humidity regimes.

In Western Britain these schemes tend to be developed in steep-sided wooded gullies and ravines and there are already a large number operating in Scotland, Wales and North West England. Whilst some sites have been developed sympathetically, others have caused substantial damage and have the potential to impact on nationally or internationally lichen and bryophyte populations.

Solutions:

Ensure potential development sites are fully surveyed by a professional bryologist in the first instance.

If sites are found, or known, to support species of national or international importance the precautionary principle should be adopted until such time as more conclusive evidence is available to inform decisions.

Refer to, and adopt, the guidance published by Scottish Natural Heritage in terms of the suitability of sites for HEP development: Averis, A.B.G., Genney, D.R., Hodgetts, N.G., Rothero, G.P. & Bainbridge, I.P.(2012). Bryological assessment for hydroelectric schemes in the West Highlands –2nd edition. Scottish Natural Heritage Commissioned Report No.449b **http://www.snh.gov.uk/publications-data-and-research/publications/search-the-catalogue/publication-detail/?id=1953**

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Appendix 1: Bryophytes associated with specific micro-habitats

Micro-habitats	Mosses	Liverworts
General epiphytes	*Dicranoweisia cirrata, Dicranum scoparium, Hypnum cupressiforme, Isothecium myosuroides, Neckera complanata, Ulota crispa, Ulota phyllantha*	*Frullania tamarisci, Metzgeria furcata, Microlejeunea ulicina, Radula complanata*
Rotting stumps and logs	*Dicranodontium denudatum* (very rare), *Dicranum scoparium, Mnium hornum, Hypnum cupressiforme, Orthodontium lineare, Tetraphis pellucida*	*Jamesoniella autumnalis* (very rare), *Lepidozia cupressina* (rare), *Lepidozia reptans, Nowellia curvifolia, Riccardia palmata, Scapania umbros*
Woodland floor	*Dicranum majus, Hylocomium splendens, Hypnum jutlandicum, Kindbergia praelonga, Loeskeobryum brevirostre, Polytrichum formosum, Rhytidiadelphus loreus, Sphagnum quinquefarium, Thuidium tamariscinum*	
Rocks	*Anomodon viticulosus, Neckera crispa, Tortella tortuosa*	*Bazzania trilobata, Lepidozia cupressina* (rare), *Marchesinia mackaii, Plagiochila punctata, Plagiochila spinulosa, Saccogyna viticulosa, Scapania gracilis*
Riparian habitats – ravines, rivers, watercourses	*Dichodontium palustre, Fontinalis squamosa, Heterocladium wulfsbergii, Hygrohypnum ochraceum, Racomitrium aquaticum, Rhynchostegium alopecuroides, Sciuro-hypnum plumosum*	*Drepanolejeunea hamatifolia, Jubula hutchinsiae, Marsupella emarginata, Metzgeria conjuga, Nardia compressa, Porella pinnata, Scapania undulata*

Appendix 2: SW England Atlantic Woodland lichens and bryophytes that are listed on Section 41 of the NERC ACT 2006.

S41 Oceanic woodland lichens		Habitat (Smith *et al.* 2009)	Community or niche	Rarity in the region
Arthonia anglica	A comma lichen	Smooth bark of beech and holly in ancient woodlands	Smooth bark	Very rare
Arthonia invadens	A comma lichen	Grows on *Schismatomma quercicola* in ancient woodland	Acid bark	Rare but widespread
Bacidia circumspecta	A dot lichen	Trunks of mature oak, beech and elm in old woodlands	Base-rich bark	Very rare
Bacidia incompta	A dot lichen	Mainly found on the bark or lignum of wounded trunks of trees with basic bark e.g. ash, beech, sycamore etc	Wound-tracks / seepages & base-rich bark	Rare
Bacidia subturgidula	A dot lichen	On wood inside hollows on old holly.	Dead wood and dry lignum	Very rare
Bryoria smithii	A horsehair lichen	On ancient oak trees, and occasionally boulders, in sheltered, well-lit locations	Acid bark	Very rare
Caloplaca lucifuga	A firedot lichen	In crevices of rough-barked old trees (especially oak) in wood pasture	Ancient dry bark	Very rare
Collema fragrans	Dwarf jelly-lichen	Bark, especially elm, in old parkland	Base-rich bark & wound-tracks/seepages	Rare
Enterographa elaborata		Shaded bases and trunks of mature or ancient trees	Ancient dry bark & smooth bark	Very rare
Enterographa sorediata		Dry side of oak trunks in old growth woodland	Ancient dry bark	Rare
Fuscopannaria sampaiana	Brown shingle-lichen	Smooth or mossy bark of mature trees e.g. Ash, elm in humid old woodland	Base-rich bark	Very rare
Graphina pauciloculata	A script lichen	Smooth bark of e.g. birch, hazel, oak in moist woodland. Often occurs on *Graphina ruiziana*	Smooth bark	Rare but widespread
Lecania chlorotiza	A rim lichen	Very shaded base-rich bark, and inside hollow trees, especially ash, elm, willow and very old oak in sheltered woodland sites.	Base-rich / ancient dry bark	Rare but widespread
Lecanographa amylacea		On dry bark of ancient oak, usually low down and not directly wetted by rain.	Ancient dry bark	Rare but widespread
Lecanora quercicola	A rim lichen	Dry rough bark of ancient deciduous trees, especially oak, in open woodland and parkland	Base-rich / ancient dry bark	Rare
Lecidea erythrophaea	A tile lichen	Smooth bark of deciduous trees e.g. young ash, hazel and poplar in sheltered woodlands	Smooth bark	Rare
Leptogium cochleatum	A jelly skin lichen	Sheltered trunks of old deciduous trees e.g. ash, hazel (also mossy rocks) especially near streams	Base-rich bark	Very rare
Megalospora tuberculosa		Broad-leaved trees e.g. ash, beech, oak in sheltered humid ancient woodlands	Base-rich bark	Rare but widespread
Melaspilea lentiginosa		Found on the dark-spored script lichen *Phaeographis dendritica* in ancient woodland	Smooth bark	Rare but widespread
Opegrapha prosodea	A scribble lichen	Dry shaded rough bark of mature and ancient trees e.g. Oak. Old woodland and parkland indicator	Ancient dry bark	Rare but widespread
Parmeliella testacea	A shingle lichen	Mossy broad-leaved trees, rarely rocks, in moist sheltered woodlands	Base-rich bark	Very rare
Pertusaria velata	Rimmed wart lichen	Rough bark on sheltered well-lit trunks of mature trees e.g. ash, beech, oak in ancient woodland and parkland	Base-rich / shaded mesic bark	Rare
Physcia tribacioides	Southern grey physcia	Well-lit wayside and parkland trees e.g. ash, oak, sycamore and formerly elm	Base-rich bark	Rare but widespread
Porina effilata		Sheltered bases of mossy base-rich bark e.g. oak, in old woodland	Base-rich bark	Very rare

Porina hibernica	A pimple lichen	Dry base-rich bark of mature oak in ancient woodland and parkland	Base-rich bark	Rare
Ramonia chrysophaea		Spongy bark of mature or old trees e.g. ash, elm, oak in shaded old woodland and wood inside hollow holly	Base-rich bark & dry lignum	Rare
Ramonia dictyospora		Bark of ash, beech, elm, oak, sycamore and wood inside hollow holly	Base-rich bark & dry lignum	Very rare
Ramonia nigra		Wood inside hollow trunks of old ash, beech and holly and spongy bark of oak in old woodlands	Dry lignum	Very rare
Rinodina isidioides	A pepper-spore lichen	Bark , or mosses, on mature oak in ancient woodland	Old oaks	Rare but widespread
Schismatomma graphidioides		Trunks of deciduous trees e.g. ash, beech, oak in parkland or well-lit woodland	Ancient dry bark	Rare but widespread
Teloschistes flavicans	Golden hair lichen	Rocks, soil, twigs and bark in well-lit and wind-mist exposed sites especially on or near the coast	Twigs and bark inc *Usneion* community	Uncommon but widespread
Tylophoron hibernicum		Dry sheltered bark at bases of old oak and holly in ancient woodland. Initially grows on other lichens e.g. *Enterographa crassa*, *Schismatomma* species, *Lecanactis* species etc	Ancient dry bark	Rare but widespread
Usnea articulata	String of sausage lichen	Well lit, dry situations e.g. Inclined branches in crowns of trees.	*Usneion*	Uncommon but widespread
Usnea florida	Witches whiskers	Twigs and branches in the canopy of broad-leaved trees, rarely on trunks, shrubs, fence posts etc	*Usneion*	Uncommon but widespread
Wadeana dendrographa		Rough bark of mature trees e.g. ash, elm, oak in little disturbed old woodland	Ancient dry bark	Rare

S41 Oceanic woodland bryophytes		Habitat (Blockeel *et al.* 2014)	Community or niche	Rarity in the region
Dendrocryphaea lamyana	Multi-fruited cryphaea	Rocks and trees e.g. alder, ash, sycamore by the side of large rivers, occurring above normal water level, but in a zone which is regularly flooded		Rare
Dumortiera hirsuta	Dumortier's liverwort	Shady humid places by wooded streams and waterfalls in wooded ravines		Rare
Fissidens serrulatus	A pocket moss	On sand, gravel, rocks, tree roots and soil by streams and in overhangs, caves and ravines.		Rare
Lejeunea mandonii	A pouncewort	Shaded, dry or periodically irrigated N or E facing rocks or cliffs in wooded ravines, sea caves or on coasts.		Very rare
Orthodontium gracile	A thread-moss	Shaded rocks in lowland woods		Very rare
Telaranea europaea	Irish threadwort	Moist peaty banks, peat on rocks in deeply shaded humid sites.		Very rare

Appendix 3: Simple survey of habitats to assess potential lichen and bryophyte interest

Lichen and bryophytes on trees/rocks	None	1	Occasional and limited range of species	2	Frequent-abundant, but a limited range of species apparent	3	Abundant, and a good range of species apparent	4
Connectivity	Isolated from other woodland cover	1	Some connectivity with other woodlands/ wooded landscape	2	Part of a small-medium (50-100 ha) network of woodland/wooded landscape	3	Part of extensive network (>100 ha) of woodland/wooded landscape	4
Presence of rocks and boulders	None	1	Occasional; scattered small boulders or crags on even slope	2	Frequent; larger boulders and crags on uneven slope	3	Abundant; large blocky boulders and crags; hard to walk across	4
Ravines	None	1	Minor watercourses with gradually shelving sides	2	Deep gulley, but no waterfall or crags	3	Deep ravine with waterfalls and crags	4
Veteran trees	None	1	Rare	2	Occasional	3	Frequent, and a range of species	4
Canopy cover	Low canopy cover, small or young trees & shrubs	1	High canopy cover (70-90%) with small or young trees & shrubs	2	High canopy cover (70-90%) with older trees & shrubs	3	Low canopy cover, with veteran trees or shrubs; or old woodland / hazel scrub with frequent glades	4
Tree species composition	Dominated by fast growing acid bark species e.g. birch, alder	1	Dominated by fast growing acid bark species e.g. birch, alder, but including some others e.g. oak, ash	2	Limited tree species, but including more species with potential for base-rich bark e.g. oak, ash	3	Varied tree species composition e.g. oak with areas of ash, hazel, sallow, elm, mature birch and alder	4
Age structure	Small/young i.e. recently established trees	1	Some old/big trees with fissured bark, and a mixed age structure present	2	Many old/big trees with fissured bark, and a mixed age structure present	3	Old/big trees with fissured bark	4
Presence of glades of c30m diameter	None	1	Rare	2	Occasional	3	Frequent	4
Regeneration	Abundant, dense regeneration throughout	1	Frequent areas of dense regeneration	2	Occasional; some patches of dense regeneration, but generally scattered	3	Rare; regeneration present but at low levels, or isolated patches, not causing excessive shading of mature trees	4
Presence of invasive non-native species	Abundant	1	Frequent	2	Occasional, scattered	3	Isolated and scattered or absent	4
Presence of invasive native species	Abundant	1	Frequent	2	Occasional, scattered	3	Occasional, scattered	4
Conifers	Dominant i.e. conifer plantation w/ isolated native broad-leaved trees	1	Abundant i.e. plantation with patches of native	2	Rare i.e. the odd isolated individual	3	None	4
Dead wood - standing or fallen	Rare, and/or limited to small diameter standing or fallen deadwood	1	Some standing and/ or fallen deadwood including larger diameter	2	Frequent standing and fallen deadwood from a range of species and sizes	3	Abundant standing and fallen deadwood from a range of species and of a range of sizes	4

Scores mostly 1's and 2's = LOW CURRENT/POTENTIAL INTEREST; Scores mostly 3's = MEDIUM CURRENT/POTENTIAL INTEREST; Scores mostly 4's = HIGH CURRENT/POTENTIAL INTEREST

Appendix 4: Simple survey to assess presence and abundance of key lichen and bryophyte species

Bryophytes						
Plagiochila spinulosa / P. punctata	Not present	**1**	Low abundance and restricted to unusual features	**2**	High abundance over wide range of features	**3**
Scapania gracilis	Not present	**1**	Low abundance and restricted to unusual features	**2**	High abundance over wide range of features	**3**
Hymenophyllum species (honorary bryophyte in this context)	Not present	**1**	Low abundance and restricted to unusual features	**2**	High abundance over wide range of features	**3**
Lichens						
Lobarion species (Plantlife Guide 1) on ash, hazel, willow, rowan and old oak	Not present	**1**	Low abundance and restricted to few features	**2**	High abundance over wide range of features	**3**
Parmelion species (Plantlife Guide 2) on birch, alder, oak	Dominated by common species e.g. *Parmelia saxitilis, Platismatia glauca, Evernia prunastri*	**1**	Any of the following species in low abundance and restricted to few features, *Cetrelia olivetorum, Hypotrachyna laevigata, H. taylorensis, Parmotrema crinitum, Usnea articulata, U. florida*	**2**	Frequent presence of any of the following on trees and rocks: *Cetrelia olivetorum, Hypotrachyna laevigata, H. taylorensis, Parmotrema crinitum, Usnea articulata, U. florida* and/or presence of *Menegazzia terebrata, Bunodophoron melanocarpon*	**3**
Crustose species on smooth bark of hazel, rowan and holly	Not present - hazel often covered in common mosses	**1**	Moderate abundance on younger smaller stems with only a few species	**2**	Frequent crustose lichens on hazel and other species (e.g. rowan and holly) with a good variety of species	**3**

Appendix 5: A non-exhaustive list of legislation relevant to management works:

- Felling licences see http://www.forestry.gov.uk/england-fellinglicences
- Sites of Special Scientific Interest (SSSIs) see **http://www.forestry.gov.uk/forestry/INFD-92QE5W**
- Scheduled Ancient Monuments (SAMs)
- Wildlife and Countryside Act e.g. disturbance to breeding birds see **http://www.forestry.gov.uk/forestry/INFD-92QE5W**
- European Protected Species (EPS) e.g. bats, dormice, otters see **http://www.forestry.gov.uk/forestry/INFD-92QE5W**
- Owners/occupier public liability
- Health and safety e.g. operational work, contractors, general public
- Tree Preservation Orders (TPOs) see **http://planningguidance.communities.gov.uk/blog/guidance/tree-preservation-orders/**
- Protection of Badgers Act see **http://www.forestry.gov.uk/forestry/INFD-92QE5W**

If you'd like to discuss management of Atlantic woodlands for lichens and bryophytes please contact Dave Lamacraft (IPA Lower Plants Champion for England & Wales) at **dave.lamacraft@plantlife.org.uk**

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