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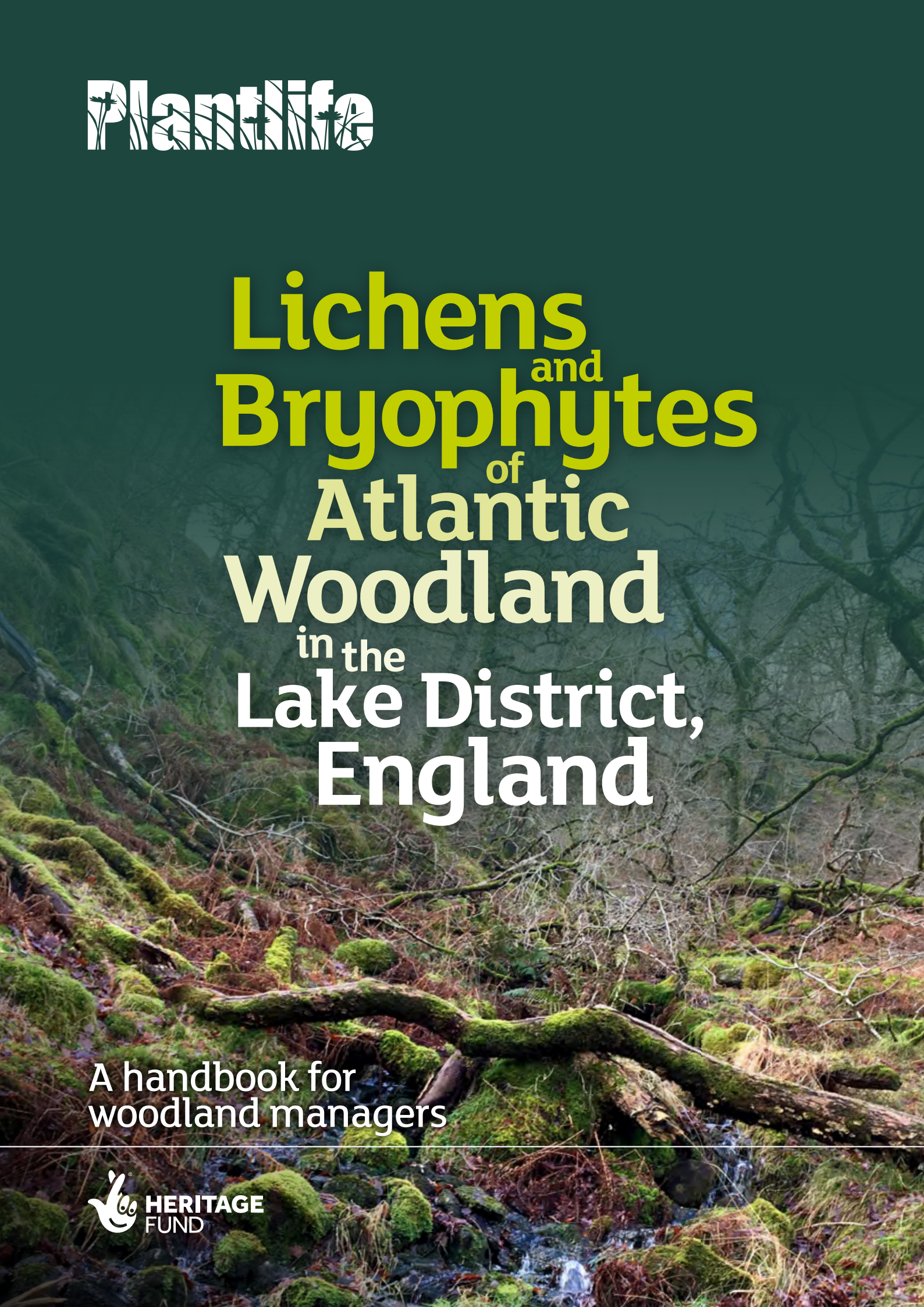
Lichens and Bryophytes of Atlantic Woodland in the Lake District, England



A handbook for woodland managers

HERITAGE FUND

Contents

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Scope

The Atlantic woodlands of the Lake District are part of the Celtic Rainforest of western Britain and are internationally important for their rich lichen and bryophyte communities.

Due to their global conservation significance, many sites are recognised as Important Plant Areas (IPAs) and designated as Sites of Special Scientific Interest (SSSIs) or Special Areas of Conservation (SACs), supporting a number of red listed and Section 41 species.

Despite their international importance, our 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 a changing climate, atmospheric pollution and tree disease. To ensure a secure future for this habitat, favourable long-term management is essential.

Written for woodland owners and managers, this publication will help in understanding the key conservation issues affecting woodland lichens and bryophytes, while providing a framework and guidance to manage Atlantic woodlands in the Lake District for lichens and bryophytes.

Atlantic birchwood with oceanic lichen and bryophyte communities. Stanley Ghyll, Eskdale

Front cover: A rich Atlantic woodland habitat of Seatoller (Borrowdale), with rocky streams supporting populations of oceanic bryophyte *Radula voluta*. This species is known from three sites in England, all found within the Borrowdale Woodland Complex. The population found within Seatoller Wood is considered the largest in the UK (A. McLay, pers comm).

Global distribution of the temperate rainforest biome

Britain's Atlantic woodland: Our Celtic Rainforest

Atlantic woodlands are part of the temperate rainforest biome, a type of habitat with a globally restricted distribution. Atlantic woodlands are characterised by:

- Rainfall; high annual average with little variation through the year and total number of wet days
- Temperature; little annual temperature variation

Atlantic woodlands in the Lake District

In the Lake District, Atlantic woodlands are generally 'oceanic'[1] in character, but some areas have either 'hyper-oceanic'[2] (e.g. Seathwaite, Borrowdale) or 'sub-oceanic'[3] elements (e.g. Rydal, Ambleside) and these harbour globally rare and threatened species of lichens and bryophytes. As well as 'typical' Atlantic woodland, the Lake District is also home to important ancient wood pasture and parkland habitat, where the significant lichen interest is associated with veteran trees.

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Veteran wych elm at Gowbarrow Park, Ullswater (above)

Borrowdale Atlantic woodland, Ashness Woods

Important Plant Areas in the Lake District

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

For more information on Important Plant Areas (IPAs) in the Lake District and across the UK, see **www.plantlifeipa.org**

[1] Relatively little difference in rainfall and temperature through the year (relatively equable climate).
[2] Very little difference in rainfall and temperature through the year (very equable climate).
[3] Slightly drier and sunnier than in more typically oceanic areas.

Lichen and bryophyte interest in the Atlantic woodlands of the Lake District

© April Windle

Oak with base-rich bark supporting the *Lobarion* community. Rydal Park, Lake District

Lichens

Different species of lichen can have preferences for similar environmental conditions, forming distinct communities. Key factors in determining which lichens grow where, and hence where communities of lichens are found, is the chemistry and texture of the substrate ie. tree, rock, soil.

Table 1 shows typical bark chemistry for common tree species. It is worth noting that substrate chemistry can be influenced by factors such as atmospheric pollution, and that bark chemistry of some species changes over time (e.g. oak, which becomes less acidic with age).

Table 1: **Typical bark chemistry for common tree species**

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

*Old beech and oak become less acidic and more base-rich with age and can support *Lobarion* species.

Important lichen communities and their ecological requirements:

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

This includes the large leafy *Lobaria* and *Sticta* species. See Plantlife's 'Lichens of Atlantic Woodlands in the Lake District – Guide 1, *Lobarion*'.

This community requires well-lit, less acidic substrates, such as ash, elm, hazel, willow and old oak trees alongside base-rich rocks.

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Lobarion community on base-rich bark

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

This includes the large leafy 'loop lichens' (*Hypotrachyna* species) and grey 'cudbear lichens' (*Ochrolechia* species). See Plantlife's 'Lichens of Atlantic Woodlands in the Lake District – Guide 2, *Parmelion*'.

This community requires well-lit, acidic substrates, such as birch, alder and young oak trees, alongside acidic rocks.

© April Windle

Parmelion community on stunted oak

Smooth bark community (the *Graphidion* – 'dots and squiggles')

Although often dominated by common species, such as the script lichen *Graphis scripta*, in the Lake District this includes globally rare species such as the 'blackberries in custard' *Pyrenula hibernica*.

This community requires smooth, young bark, typically of undisturbed (i.e. un-coppiced) hazel stands.

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Smooth bark *Graphidion* community on hazel

Mesic bark community (the *Pertusarietum* – specialist crustose species)

A largely southern community in the UK, but with a very important stronghold in the Lake District, where this community includes the largest fertile population of the rare geranium firedot lichen *Caloplaca herbidella* in England.

This community requires well-lit mature trees with less acidic bark e.g. in parkland.

© April Windle

Pertusarietum community with S41 *Caloplaca herbidella*

Veteran tree communities (specialist crustose species)

Communities found on veteran trees, with features such as craggy bark, exposed lignum, wound tracks and dry bark. This includes many rare species such as the orange-fruited elm lichen *Caloplaca luteoalba* and the sap-groove lichen *Bacidia incompta*.

These communities require well-lit veteran trees, generally with less acidic bark i.e. old oak, ash and wych elm.

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Veteran tree community on craggy bark

All of these lichen communities require long-standing habitat continuity, medium to high light levels, and low or no atmospheric pollution. Some of these communities – *Lobarion*, *Parmelion* and *Graphidion* in particular – also require high humidity.

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Bryophytes

One of the best indicators of an important Atlantic woodland bryophyte flora are rocks and trees with greater whipwort *Bazzania trilobata* and cushions of prickly featherwort *Plagiochila spinulosa*. Other good indicators are the spotty featherwort *Plagiochila punctata*, western earwort *Scapania gracilis* and the small fern, Wilson's filmy-fern *Hymenophyllum wilsonii*. Although bryophytes are not classified into defined communities in the same way as lichens, the following associations are key in Atlantic woodland habitats.

Oceanic species Wilson's filmy-fern, *Hymenophyllum wilsonii* (above)

Oceanic species greater whipwort, *Bazzania trilobata* (left)

Important bryophyte communities and their ecological requirements:

Deadwood community

A community that grows on deadwood, particularly on dead tree stumps and large limbs lying on the woodland floor. This includes common species, such as rustwort *Nowellia curvifolia*, along with some rare species such as Autumn flapwort *Jamesoniella autumnalis* and rock fingerwort *Lepidozia cupressina*.

This community requires large-diameter deadwood left on the woodland floor.

© April Windle

Nowellia curvifolia, a deadwood specialist staining the substrate red

Rocky watercourse community

A community of species that have a very low tolerance for desiccation and only occur in close proximity to wooded water courses, such as ravines and rocky woodland streams. These are species such as Hutchins' hollywort *Jubula hutchinsiae* and pale scalewort *Radula voluta*.

This community requires clean, free-flowing water courses beneath a woodland canopy. They are often associated with ravines, especially where the flow of water over falls creates a 'mist-zone'.

© April Windle

Radula voluta in rocky woodland stream. Seathwaite, Borrowdale

Woodland floor community

A community that occupies the woodland floor, such as boulder clitter, earth banks and around the bases of trees. These species are easily outcompeted by the growth of vascular plants e.g. bramble.

The woodland floor tends to be occupied by wefts of common species, such as the little shaggy moss *Rhytidiadelphus loreus*, common tamarisk-moss *Thuidium tamariscinum* and mouse-tail moss *Isothecium myosuroides*.

© April Windle

Rhytidiadelphus loreus carpeting the woodland floor

Rocky community

A community that inhabits large boulders, rocky outcrops and craggy structures. These natural rock faces support common mosses, alongside rare species such as the sparkling signal moss *Hageniella micans*, where new habitat opens up from sloughing vegetation.

A variety of rocky substrates will support a richer bryophyte flora, for example acid rocks can support large cushions of rare rock fingerwort *Lepidozia cupressina*, whereas base-rich crags can support large patches of MacKay's pouncewort *Marchesinia mackaii*.

© April Windle

Lepidozia cupressina, a species found on acid rocks in woodlands

These bryophyte communities require continuity in woodland cover, low light levels with shaded conditions and low or no atmospheric pollution. In general, bryophytes have a preference for damper conditions, with some communities requiring high humidity, such as those inhabiting rocky substrata or near/along watercourses.

Ideal conditions for lichens and bryophytes

There are many factors that influence the abundance and distribution of lichens and bryophytes. These operate at different levels: at the woodland level and at the substrate level i.e. the features of the individual tree, rock face or boulder on which they are growing.

At the woodland level

Diverse structure:

A diverse structure including areas of closed canopy, dappled shade, glades, a patchy understorey, with standing and fallen deadwood is favourable. A variety of different tree species and ages, while retaining veteran trees will establish a diversity in composition, structure and age profile.

An even age woodland profile with a lack of tree age diversity limits available niches for lichens and bryophytes. A uniform structure with similar canopy density and lack of open spaces will result in unvaried light and humidity regimes.

© April Windle

Birchwood on the upper slopes of Naddle Forest, Haweswater (RSPB)

Diverse topography:

A range of woodland habitats with a diversity of light and humidity regimes will ensure optimum conditions for a range of lichens and bryophytes, promoting a diverse flora. Important topographical features include river valleys, ravines, rocky outcrops, flushes and scree.

In terms of aspect, north-facing slopes tend to provide more shaded and damper conditions, which are favoured by bryophytes. In contrast, the well-lit south-facing slopes tend to support more light-demanding lichens.

© April Windle

Vertical rock face and boulder field with rich lichen and bryophyte communities. Scales Wood, Buttermere

At the substrate level

Rocky outcrops and boulders:

Provide an important habitat for both lichens and bryophytes. Steep, rocky terrain is often less intensively managed, with the exposed geology always being the oldest component of the wood with the least disturbance. This rocky habitat can also act as a refuge when tree habitats are lost e.g. to tree pests and diseases or acidification by atmospheric pollution.

The cycle of accumulation of plants on a rock face and subsequent sloughing off is particularly important as it provides a steady supply of new, open habitat for rarer, less competitive species to colonise.

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North-facing rock face supporting oceanic communities. Stanley Ghyll, Eskdale

Diverse tree and shrub communities:

A diversity of shrub and tree species, alongside a variety of age classes is important for providing a range of habitats for lichens and bryophytes. This also ensures the continuity of the woodland going forward.

Woods with a high proportion of veteran/ancient trees are much more likely to support important epiphytic communities. Relict trees, such as those in old, open-grown ancient pastures and woodland boundaries, are often significant for the more light-demanding species.

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Diverse tree and shrub community comprised of ash, sessile oak and hazel understorey, Borrowdale

Frequently asked questions

1. What is the 'right' management? Apart from the removal of *Rhododendron* and securing an appropriate grazing regime, few management options are universally viewed as the 'right thing to do'; there are many ways to crack a nut. Managers need to be able to make a case for their chosen management interventions (or lack of them) based on the characteristics of their sites.

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. 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 change and 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 timeframes 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, although perhaps more 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 there is now a greater acceptance of well-thought-out management where benefits are proven e.g. controlled grazing and thinning of Atlantic oakwoods as 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. Any urgent issues should be dealt with as a priority 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 long timeframe. Taking this approach will allow future management to be informed by developing lichen or bryophyte interest and other emerging issues.

Planning management of Atlantic woodlands for lichens and bryophytes

Rapid Woodland Assessment

The Rapid Woodland Assessment is a tool developed by Plantlife to help assess the condition of woodlands across the Lake District, while understanding the sites' potential to support important lichens and bryophytes. The information generated can be used to inform conservation management decisions and provide a framework for woodland management plans for lichens and bryophytes. The Rapid Woodland Assessment can be downloaded from the LOST project's website **www.plantlife.org.uk/LOST**.

Lake District Rapid Woodland Assessment and Handbook for Woodland Managers

Key steps in planning management

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

Desk-based study. Search for existing data, with options including the National Biodiversity Network (NBN) Atlas and Cumbria Biodiversity Data Centre (CBDC). Some sites will have lichen and bryophyte survey reports available (note that pre-2000 surveys will likely need updating).

Self-led survey. Simple habitat assessment using Plantlife's Rapid Woodland Assessment and species survey to note presence/abundance of lichens and bryophytes. For ID of key species, use the 'Lichens (*Lobarion* & *Parmelion*) & Bryophytes of Atlantic Woodlands in the Lake District' guides.

Expert-led survey. Contracting a professional lichenologist or bryologist to conduct a species survey. Baseline assessments will ensure a good overview of the lichen and bryophyte interest of the site and allow future changes to be detected.

Step 2: **Determine priority species, communities and habitats.**

Create a list of priority species, communities and habitats across the woodland and map where these occur on the site. If there is no apparent interest within the woodland, note areas with the highest potential and consider management to enhance and extend these features.

Step 3: **Assess the current condition of woodlands for lichens/bryophytes and identify any issues.**

Use the Rapid Woodland Assessment and the section on 'Making Sites Better: Site Management' (page 14) to assess woodland composition and structure, locate important habitat features, alongside identifying any threats and woodland management issues.

Step 4: **Identify and prioritise management actions.**

Priority 1. Manage to address the issues that are affecting the most important species or best areas of the woodland.

Priority 2. Manage to address the issues that are on the cusp of becoming more significant i.e. it is much easier and cheaper to deal with a small amount of young regeneration or invasive species than it is to deal with it in 20 years' time.

Priority 3. Manage to enhance the condition of the remaining woodland for lichens and bryophytes where it is appropriate.

It is important to consider the legal requirement of your planned management works.

Step 5: **Integrate with other management objectives.**

Management for lichens and bryophytes should fit well with the management of Atlantic woodlands for a broad range of conservation outcomes and objectives. However, the management actions identified above will need to be integrated with other management objectives.

The main potential conflicts are likely to be:

- Between lichens and bryophytes (see FAQs on page 11), 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 of value 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 found.
- 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

Step 6: **Monitoring of management.**

The effects of management operations should be monitored against their objectives or planned outcomes. Possible approaches include:

Simple field observations. Visit the sites of operation before, during and (periodically) after they take place and keep an informal diary of observations, backed up by photographs.

Fixed point photography. This can be used for important sites, to assess changes in lichen and bryophyte composition and abundance over time.

Periodic surveys of managed areas. Use quadrats or transects to assess habitat condition, measuring factors such as light levels or changes in ground flora/epiphytic composition.

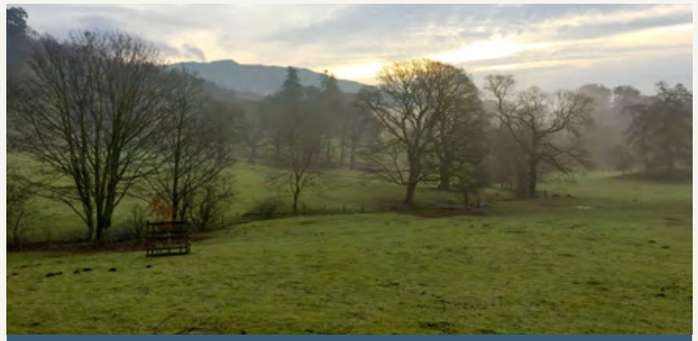
Grid mapping. A method to document the distribution and abundance of important bryophyte species, developed by Des Callaghan (Callaghan, 2013), using 10m or 100m grid squares.

Grazing and browsing

Issue 1:
Managing grazing and browsing

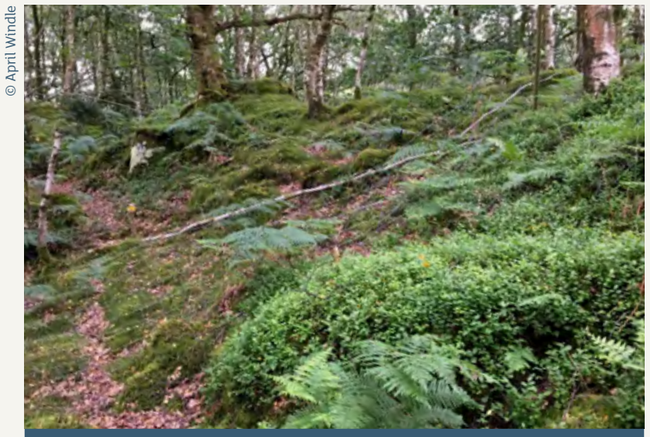
Grazing and browsing is the key long-term management tool for Atlantic woodlands and its reduction or cessation is at the root of many other problems that develop. Studies have shown that the removal of grazing markedly reduces ground flora and bryophyte diversity and sees a general shift from specialist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

Research 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 (Cannell 2005 & Smout et al 2005). Here, 92% of woodland lichens of conservation interest are found within pasture woodlands (Sanderson 2008), where the continuity of this management over centuries has been fundamental to the development of species richness.



© April Windle

Parkland habitat with a long history of grazing supporting lichen species and communities of conservation interest. Rydal Park, Lake District



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Sheep fence showing community changes inside and outside an exclosure. Coniston Woods, Lake District

Extensive grazing is the only practical method of maintaining important lichen and bryophyte-rich woodlands in the long term. Rather than just maintaining conditions around a few especially rich trees, which can be done with mechanical intervention, woodland management requires the maintenance of good conditions around dozens or hundreds of trees, both veteran and maturing, and this is only feasible with grazing.

A key aim for management of Atlantic woodland for lichens and bryophytes is to have controlled grazing and browsing regimes. This will in turn address many of the other issues highlighted here, such as dense regeneration, invasive species and maintenance of open space.

Key considerations:

- While a certain amount of regeneration is important, it is worth remembering the timescales involved e.g: with oak, generation gaps of 100 years are possible without compromising the woodland structure or habitat continuity, although for some other species shorter gaps are better; 100-year-old oaks are a more important resource than newly regenerated oaks for replacing existing 300-year-old trees.

Solutions:

- While every wood is different, and the grazing and browsing issues should be assessed for each, Table 2 will give a guide (after Sanderson 2015).

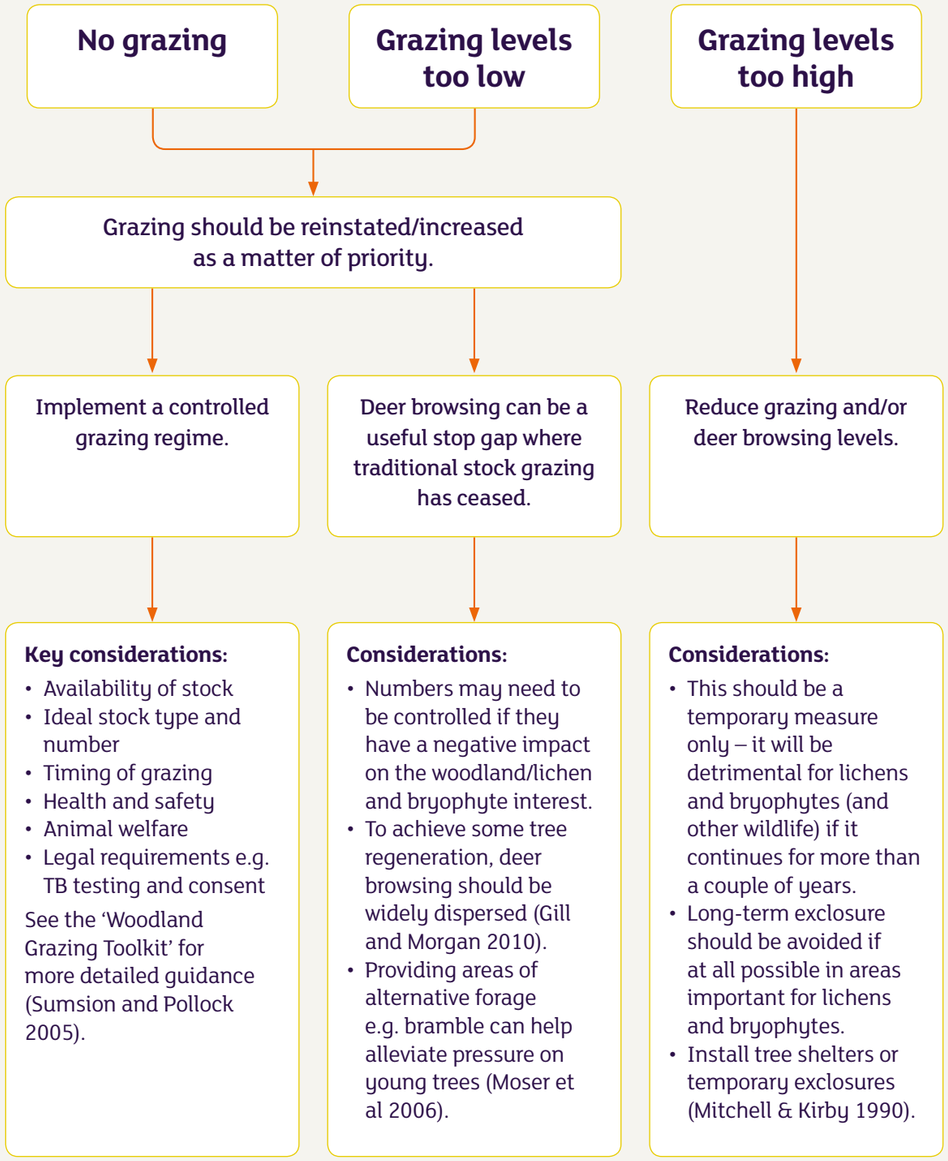
© Dave Lamacraft

Cattle grazing at Dolmelynllyn, Gwynedd, Wales

Table 2: **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 colonised by grasses, with early succession communities absent.

Chart 1: **Implement well-planned grazing scheme.**



Diverse woodland structure and composition

Issue 2:
Lack of tree age diversity

Former oak plantations and coppice, such as those found in parts of the Lake District, tend to have an even age structure. This limits available habitats for lichens and bryophytes.

Solutions:

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


© April Windle

Even-aged Atlantic oakwood, Eskdale

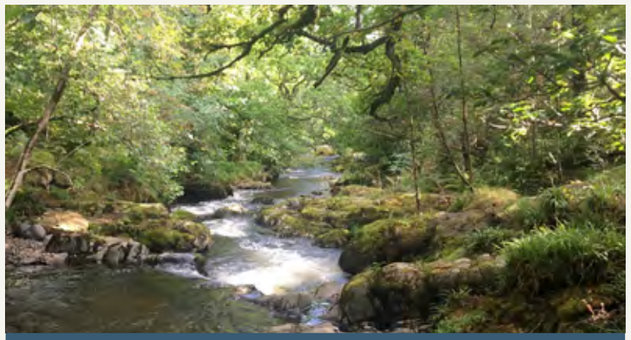

© April Windle

Post-mature oak with rich lichen community. Aira Force woodland, Ullswater

Key considerations:

- Avoid standard silvicultural thinning i.e. thinning that favours straight 'perfect' tree specimens. The 'wonky' trees are often the ones that support the greatest lichen and bryophyte interest.
- An alternative to thinning is to allow the stand to eventually fall apart as it ages. This will contribute to tree age diversity and promote veteran tree features, important for specialist species and communities. However, a decision needs to be made on whether these natural processes are adequate or whether active management is required.
- 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.

- Retain canopy cover in areas important for bryophytes, or potentially important bryophyte areas, such as ravines, watercourses, rocky woodland floors and small crags.
- Ensure management works are sensitive to avoid damage to rocks and boulders during operations, alongside considering impacts when felling to waste on top of rocks, crags and boulders.

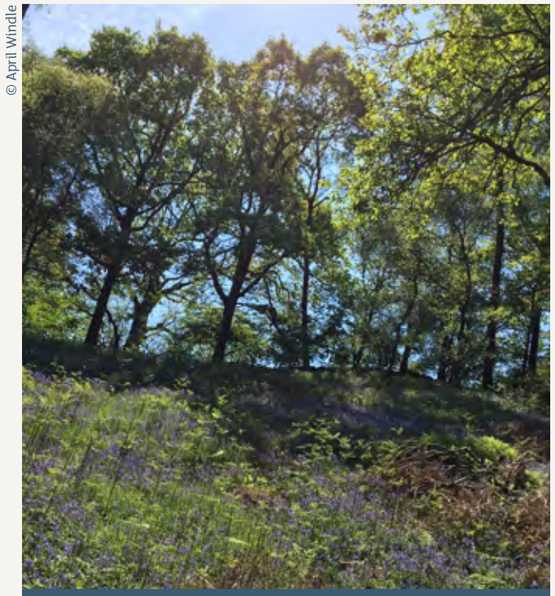


© April Windle

Canopy cover over Aira Beck, Ullswater

Issue 3:
Lack of structural diversity

Bryophytes and lichens thrive in woodlands containing a mosaic of canopy cover and open space in the form of glades and rides. There is the danger of these mosaics being lost due to issues such as excessive regeneration and a lack of grazing.



© April Windle

Glade with boundary trees supporting light-demanding *Hypotrachyna laevigata*. Skelwith Woods, near Ambleside

Solutions:

- Identify areas where glades are likely to be important, based on the species and habitat assessments recommended in Step 1 (p12). Consider what management needs to be implemented to create and perpetuate open space.
- Grazing and/or browsing will be essential to maintain glades in the long term and goes hand-in-hand with any restructuring works. Restoring controlled grazing before or shortly after any opening up, haloing, or glade and 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 for old woodland lichens, at least 30% of the wood should be made up of well-lit glades (of about 30m 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 4:
Excessive regeneration that cannot be addressed with grazing

Natural regeneration is essential for the replacement of trees and the future of the woodland. However, excessive regeneration is problematic as dense shade is casted on the woodland floor and tree trunks. When regeneration is beyond the stage at which it can be controlled by grazing alone, other management interventions maybe required.

Solutions:

- Undertake mechanical management i.e. 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 within the woodland.

© Jimmy Carter

Dense oak regeneration in woodland

Key considerations:

- Manual clearance should not be seen as a surrogate for grazing unless repeated regularly, as 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.

Issue 5:
Lack of tree species diversity

A lack of tree species diversity limits the availability of substrates and niches for lichens and bryophytes.

Solutions:

- Identify areas which would have naturally supported species that may now be missing e.g. as a result of past management; ash may have been removed and replaced with oak. Ash and wych elm are suited to areas with more base-rich soils, birch and alder more acidic and oak either.
- Diversify tree canopy species to reflect site conditions through selective thinning.
- Where natural seed sources are being inhibited by grazing or browsing, consider adjusting the grazing regime.
- Protect seedlings through tree guards.
- If natural seed sources are lacking, consider planting or transplanting seedlings of local provenance and origin in appropriate locations. This ensures the stock is well adapted to local growing conditions.
- Encourage development of hazel and sallow if they are under-represented, ideally through natural regeneration, but resorting to small-scale planting if necessary. These are likely to be important species in mitigating the impacts of ash dieback on lichens.

Key considerations:

- Note that a dense understorey of shrubs will probably not favour lichens and bryophytes.
- Keep in mind how tree species diversity within Atlantic woodlands might change under different climate change scenarios. These can be through changes in tree species distribution as a direct response to climate or indirectly through the spread of tree pests and disease.

Current and future veteran trees

Issue 6:
Declining conditions of existing veteran trees

Many veteran trees, and the lichens that grow on them, are threatened by issues such as shading from dense regeneration and 'hemming in' by adjacent mature trees.

Solutions:

- Keep existing veterans living as long as possible to maximise overlap in life spans of these and future veterans. This enables dispersal and colonisation of lower plants onto neighbouring trunks.
- Halo-thin dense regeneration around veteran trees to stop shading of lichen interest and remove pressures on the veteran trees themselves e.g. competition for light. Veteran trees need space to be able to 'retrench' as they age.

Key considerations:

- Appropriate grazing levels are the most viable long-term mechanism to control regeneration (see page 14).
- Sensitive tree surgery may be required to prolong the life of a veteran tree.

Issue 7:
Recruitment of future ancient trees

A loss of veteran trees (and associated veteran features) across the Lake District landscape is an issue, as a specialist group of lichens are associated with the old, dry, craggy bark of veteran trees. Lichen diversity increases when the tree reaches 150 years old and some lichen species are limited to 400-year-old oaks.

Solutions:

- To recruit future veterans, select existing middle-aged trees to replace current veterans; 100-year-old oaks are a more important resource than newly regenerated oaks for replacing existing 300-year-old trees.
- Use opportunities such as thinning work, clearing regeneration or creating canopy gaps to select and retain veteran trees of the future.
- Select trees with important features such as deadwood in the canopy, decay holes, fused stems, forks, knot/rot holes, healing wounds and burs. See Read (2000) Chapter 8 and Thompson (2005).

Veteran ash with rich *Lobarion* community. Yew Crag, Ullswater

Ancient dry bark community

- If creating or allowing new woodland to develop, plan for a component of open-grown trees to become future open-grown veteran trees. This should be at a spacing of 10m or more (Read, 2000).
- In woodlands lacking veteran trees, consider creating veteran features on younger trees. For further guidance, see chapter 8 in 'Veteran Trees: a guide to good management' (Natural England, 2000).
- Avoid coppicing hazel in Atlantic woodlands to recruit ancient stands, with any harvesting limited to taking selected individual stems. Avoid under-planting pure hazel stands with other species that will eventually overtop and shade them out.
- To the left, a veteran oak with a dry bark lichen community visible as white patches on the lower trunk. This community occupies areas sheltered from direct rainfall and the flow of water down the trunk.

The Lake District's Atlantic hazel

The Lake District supports the richest known Atlantic hazelwood in England (Seathwaite, Borrowdale), supporting rare hyper-oceanic hazelwood specialists such as *Pyrenula hibernica* and *Thelotrema petractoides* (Sanderson, 2018).

When left, veteran hazel stands are a key habitat for lichens, and with the spread of tree pests and diseases, this species is an important surrogate for ash and elm.

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Hyper-oceanic hazelwood at Seathwaite Bridge, Borrowdale

© April Windle

Split ash pollard exhibiting a suite of microhabitats. Seathwaite, Borrowdale

The Lake District's ancient pollards

In the Lake District, there is a long history of pollarding for boundary trees, wood materials and livestock fodder. This practice is commonly seen on ash and these trees are known as the 'cropping ashes'.

Pollarding increases the longevity of the tree and contributes to an interesting architecture. This provides continuity of habitat for lichens and bryophytes, and the development of important niches e.g. craggy bark.

Retention of deadwood

Issue 8:
Lack of standing and lying deadwood

In Atlantic woodlands, deadwood is a key habitat feature and contributes to the lichen and bryophyte interest of the site. Historic management and land use has reduced the amount of deadwood habitats, depleting many Atlantic woodlands of this resource. It is noteworthy that former coppices that have been long abandoned have comparatively more deadwood as a result of self-thinning.

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A natural development of deadwood within a woodland. Low Stile Wood, Borrowdale

Solutions:

- As a priority, allow deadwood to naturally develop and accumulate within the woodland, especially in more open, well-lit grazed woods. If possible, retain standing and partly fallen deadwood in-situ.
- Aim for a range of deadwood types, including standing, fallen (large-diameter) tree stumps, fallen trunk propped by branches, in the canopy and wood exposed on live veteran trees.
- If standing dead trees need to be felled e.g. for health and safety reasons, aim to leave larger sections propped off the ground in well-lit sheltered situations, rather than small sections cut up in full contact with the ground in shaded areas.
- Consider creating deadwood habitats through ring barking, chemical injection, breaking branches, bark removal or mimicking natural fracture cuts.

Key considerations:

- Deadwood with specialist lichen interest is usually found standing in relatively open, well-lit, grazed areas.
- Large-diameter deadwood is more valuable than small-diameter wood. Often the deadwood with good interest will be in reasonably well-lit, but sheltered locations.
- An inventory of deadwood can be carried out with estimating quantities (m^3/ha) that can be compared against recommended levels, usually at least 40-100m^3/ha (Forest Enterprise, 2002).

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Deadwood supporting a rich community of bryophyte species

Management of native/non-native species

Issue 9:
Invasive species; both native and non-native

Many species of tree and shrub, both native and non-native can be considered 'invasive' in Lake District woodlands. The impacts of these vary with the species, but generally relate to increasing shade, which proves a problem for lichens and bryophytes as they require light in order to photosynthesise and survive.

The presence of dense growth of shade-casting species e.g. holly, ivy, beech, *Rhododendron*, cherry laurel can result in prolonged or permanent periods of shading, which can decimate lower plant populations.

Dense holly regeneration in deer-fenced woodland, Lake District

While eradication should be an aim for invasive non-native species such as *Rhododendron*, native or near-native species such as holly, ivy, beech and sycamore are an important component of woodlands in the UK and may require a more subtle approach, especially as some e.g. sycamore can be an important tree for threatened lichens.

Invasive Non-Native Species (INNS) e.g. *Rhododendron*, cherry laurel

Solutions:

- Map the location, extent and density of INNS, especially in relation to important lichen and bryophyte communities.
- Refer to the management guidance on the Non-Native Species Secretariat website: **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 eventually total eradication.
- On sites with priority bryophytes and lichens still present, consider using stem treatment (Edwards 2007) if the bushes are mature (to avoid exposing lichens and bryophytes to a sudden change in environmental conditions).
- Control should be part of a strategic landscape-scale management plan to prevent re-invasion from adjacent sites.

Rhododendron threatening *Menegazzia subsimilis*, with this tree supporting the only known population in England. Stanley Ghyll, Eskdale

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).

Native or near-native species e.g. holly, ivy, sycamore, beech and Norway maple

Solutions:

- Grazing and browsing: within well-managed pasture woodlands, dense regeneration of e.g. sycamore, beech, holly and ivy growth is constrained by grazing and browsing. Trees that then survive to maturity are more likely to be beneficial rather than damaging in such situations.
- Other interventions may be required, ahead of or in the absence of grazing. In such circumstances, consider hand pulling seedlings, hand wynching or cutting saplings and the chemical treatment of stumps. More mature trees could be felled or ring-barked (but be aware of health and safety implications).
- Assess the overall conservation and landscape contributions of e.g. old beech trees.
- In woods that are 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'.

Key considerations:

Holly English Atlantic woodlands were probably naturally oak-holly woods, but historic intensive oak management and grazing has reduced holly cover. Holly trees have smooth bark which can support rich *Graphidion* (smooth bark) communities, alongside specialists such as *Stenocybe septata* (a bark fungus). When clearing dense holly stands, leave some older ones to mature.

Sycamore and Norway maple that survive until maturity can be important for epiphytes, and may serve a role in replacing ash and elm, mitigating against tree pests and diseases such as ash dieback.

In many cases, woodland managers should not seek to eradicate these species from Atlantic woodland, but aim to manage them as a valuable component of the wood. Natural Resources Wales (in respect of designated sites) will tolerate 10-20% sycamore in the canopy, acknowledging its importance as a component of Atlantic woodlands. This should be achievable through appropriate grazing management.

Beech can become very lichen rich with age, with beech-oak-holly woods in the New Forest being some of the richest in lowland England. Beech takes longer to become good for lichens (hundreds of years). However, if uncontrolled, it can displace oak over time as regenerates well in shaded environments (Sanderson, 2010).

Manual clearance should not be seen as a surrogate for grazing. Unless repeated regularly, this results in regeneration of denser thickets. By clearing an area, light levels will increase and encourage a dense regeneration or ivy/bramble growth as a response.

Ivy As an evergreen, young invading ivy which smothers trunks is particularly damaging. Through browsing, the lowest 2m of the trunk can be kept clear, with the tree still supporting crown ivy for other biodiversity interest; 4-12% trees with crown ivy is an indication of acceptable levels of ivy in lichen-rich woods (Sanderson, 2001).

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Old holly stand with S41 *Schismatomma graphidioides*. Glencoyne, Ullswater

© April Windle

Sycamore supporting population of *Lobaria virens*. Rydal Park, Lake District

© Dave Lamacraft

Beech pollard with large population of S41 *Pyrenula nitida*. Burnham Beeches

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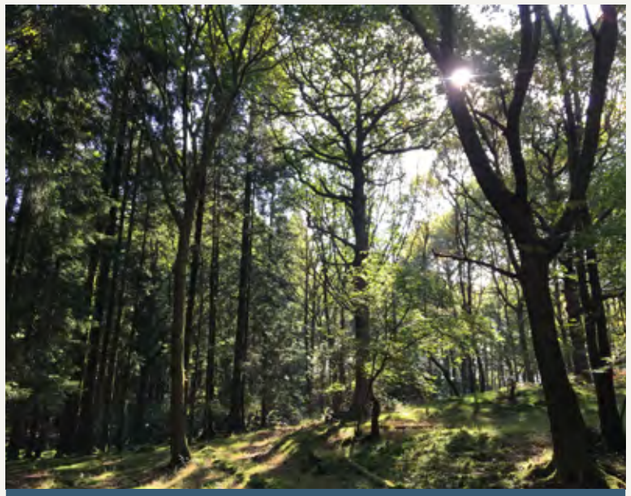
Nephroma laevigatum getting smothered in ivy

Issue 10:
Restoring conifer plantation to native woodland

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 relic ancient woodland or have isolated/boundary broad-leaved trees, which may have significant lichen and bryophyte interest, but are now hemmed in by conifers.

Solutions:

- Convert conifers to native woodland applying a gradual approach that maintains woodland cover.
- Halo-thin the surviving broad-leaved trees and other areas of potential, such as rocky areas and stream-sides initially, then expand 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 wind-throw, conifer regeneration.
- If the aim is to convert conifer plantation entirely to native woodland, the intensity of thinning might need to increase further down the line, allowing sufficient light to initiate broadleaf regeneration and recruitment into the canopy. This is a process that can easily take 30 years or more.



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Coniferous plantation managed as part of a broadleaved woodland. Quaker Wood, Ruslands

Making sites bigger and better connected: site management

Resilient woodlands

Issue 11:
Habitat fragmentation

Habitat fragmentation across the landscape is an issue for Atlantic woodlands. In the Lake District, woodland connectivity is considered an issue, despite Borrowdale containing the most extensive block of old sessile oakwoods in northern England. Small populations in small habitat patches are more vulnerable and less resilient than those in larger, better connected patches.

Solutions:

- Aim to expand and connect existing areas of Atlantic woodland, along with old boundary trees and more isolated wood and scrub patches in adjacent meadows. Ideally, patches of woodland should be greater than 100 hectares.
- Expansion should be achieved primarily through natural regeneration and should be feasible 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, and Thompson 2005.

Key considerations:

- Suitability of the 'donor land' must be considered carefully, avoiding damage to important wildlife sites i.e. open ground with flowering plant and fungi interest.
- If undertaking planting, ensure stock is from local provenance and grown locally. This ensures the stock is well adapted to local growing conditions and limits potential for introducing tree pests and diseases. Consider the translocation of saplings within the site.
- When planting or expanding woodlands, keep in mind the desired future woodland structure and composition, alongside the management required to achieve this. For lichens and bryophytes, aim for a varied but generally open structure, and a variety of tree species.

Tree planting and natural regeneration connecting Great Wood and Ashness Woods, Falcon Crag, Borrowdale

Issue 12:
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 also expected to increase, bringing significant impacts to 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.

Solutions:

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

Ash dieback

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 (BLS 2014). Twenty-six species of moss and four liverworts are strongly associated with ash (BBS 2012). The loss of ash trees is likely to have a significant impact on lichens, mosses and liverworts, alongside wider woodland habitats across the UK.

The *Lobarion* community is an association of species, for which the UK has an International Responsibility (i.e. the UK supports over 10% of the global population). In the Lake District, this community is mainly found on ash; the loss of ash will have a devastating impact on this community.

The Lake District is renowned for its ancient ash pollards known as the 'cropping ash'. As well as being important for the *Lobarion* community, some rare and specialist species are found on their old craggy bark e.g., the dot lichen *Bacidia subincompta*.

Ash tree supporting rich *Lobarion* community. Gowbarrow Park, Ullswater

Making sites bigger and better connected: site management

Dutch elm disease

The potential impact on epiphytic lichen and bryophyte communities is well illustrated by the case of Dutch elm disease. This disease has decimated elm trees across the UK, which has altered woodland composition and resulted in drastic declines of lichens and bryophytes that are dependent on this habitat.

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 e.g. *Anaptychia ciliaris, Bacidia incompta*, *Caloplaca luteoalba, Collema fragrans* and *Cryptolechia carneolutea*.

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.

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Collema fragrans on wych elm. Gowbarrow Park, Ullswater

Species distribution map – *Bacidia incompta* (■ +2000, □ 1960+, ■ 1960-).
© British Lichen Society

Solutions:

A long-term strategy to mitigate the impacts of ash dieback should:

- 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 for as long as possible, even if infected (taking account of health and safety implications). This will provide more time for epiphytic species to disperse and colonise new habitats. Evidence suggests that infected old ash trees die more slowly than younger ones.
- If work is required for health and safety purposes, consider crown reduction or cutting the trunk at height (polllarding in effect) as the lichen interest is often greater on the lower trunk.
- Select the next generation to replace veteran ash if need be, and manage around them to create optimum conditions that will favour the colonisation of lichens and bryophytes.
- Encourage the growth of surrogate species with similar bark chemistry to ash; these include sycamore, Norway maple (slow-growing), alongside hazel and willow (fast-growing).
- Encourage the development of hazel and willow adjacent to existing areas with ash interest. As these are fast-growing species, they become suitable for lichen colonisation relatively quickly, providing a stop-gap before slower growing species e.g. sycamore become potentially suitable.
- Be mindful of creating suitable conditions for colonising lichens to survive, areas may need to be thinned once colonisation is underway.
- 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 lichens has varying levels of success, but should be seen as a last resort. Leave the material on the tree for as long as possible, to increase opportunities for dispersal. Appropriate habitat management and mitigation going forward should take precedence. If translocation is the only viable option, expert advice should be sought.
- For current advice on dealing with ash dieback, refer to **www.forestry.gov.uk/pestsanddiseases**
- For more information and advice on ash dieback, see **www.cumbriawoodlands.co.uk/woodland-management/ash-dieback.aspx**

Issue 13:

Climate change

Woodland is highlighted as one of the habitat types likely to be more resilient to climate change (Hossell et al 2000), with a likely shift in species composition rather than the loss of woodland altogether (Mitchell et al 2007).

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Rich oceanic bryophyte community

There are likely to be both direct and indirect impacts on lichens and bryophytes in Atlantic woodland:

Loss of oceanic lichens and bryophytes. While there will be winners and losers, species with narrow ecological niches or those at the edge of their climatic range are likely to suffer in response to a changing climate (Ray et al 2010; Ellis 2012).

Changes in woodland structure. Increased shading as a result of enhanced growth rates of trees and longer growth seasons resulting in earlier canopy closure. This will have knock-on effects on shrub and herb layers, which may also have a role in determining outcomes for lichens and bryophytes.

Changes in species composition. Research predicts that under a 'high-emissions scenario', upland oakwoods will gradually contract in range across Britain. Changes in composition are also expected, with English oak likely to replace sessile oak and beech could also increase, with further implications for oak woodlands (Forestry Commission, 2010).

Making sites bigger and better connected: site management

Increased storm frequency. This is likely to have a significant but mixed impact, with rare species that prefer undisturbed woods likely to suffer. To some extent, Atlantic woodlands are subject to constant exposure by high winds, with oak relatively resilient to wind damage. The consequences of increased wind-throw should be monitored to assess if positive benefits arise (i.e. glade creation) versus negative impacts (i.e. increased shading from pioneer birch (Ray, 2008).

Increase in pests and diseases, alongside invasive species. There is likely to be an increase in the spread and arrival of plant pests and diseases. In addition to this, a warmer climate is likely to aid the spread of Invasive Non-Native Species.

Effects on veteran trees. Veteran trees are likely to be increasingly vulnerable to extreme weather e.g. an increased frequency of summer droughts will impact on soil mycorrhizal associations and the health of the tree.

Potential solutions:

- The ability of species to respond to a changing climate will ultimately determine their survival. Species distribution may change as a response, but others may align with their new climatic envelope, or 'find' a resilient rufugia where conditions are still favourable. However, there are many steps that can be taken to increase species chances and to build more resilient, 'strong and connected natural environment' (Lawton 2010). To do this we need to:

  Better protect and manage existing sites. Woodland habitats and their associated lichens and bryophytes will be less resilient if they are already under pressure. Therefore, getting sites in optimal condition and minimising other threats should be a key aim.

  Establish a better connected landscape through habitat restoration and creation. Lichens and bryophytes in Atlantic woodlands have an increased chance of responding and 'adapting' to environmental changes in more extensive and better connected woodlands.
- Take a landscape scale approach to maximise structural diversity across woodland types, promoting microhabitat diversity and providing refugia (Ellis, 2012).
- Creation of 'buffering habitat', by allowing scrub to develop along woodland edges to alleviate humidity losses.
- Identify potential areas of refugia within the woodland, where conditions may still remain favourable and direct impacts of climate change are not as eminent. In drought-prone areas, features such as wooded ravines, spring lines, rivers and streams should be protected and actively managed as refugia, this is particularly important for bryophytes (Edwards 1986). North-facing sheltered slopes may also give sanctuary to some species. These refuge sites should be incorporated into woodland management plans.

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Steep-sided ravine at Aira Force, Ullswater

Monitoring

- Regular species and habitat monitoring is a key recommendation, essential for the conservation of species and habitats going forward. 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. Interpretation of the results will allow site managers to ascertain the causes of site changes and the relative importance of this. Lichens and bryophytes are renowned environmental indicators and their monitoring should help shape management responses to climate change i.e. adaptive management.

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Monitoring of species and habitat changes using fixed point photography

Issue 14: Air pollution

Air pollution and its associated impacts at the habitat and species level is a complicated subject. With the international significance of the Lake District for its lichens and bryophytes – alongside pressures including increased road traffic and intensification of farming – concerns are raised on multiple levels.

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Lobaria scrobiculata, a sensitive species to air pollution, now deemed as locally extinct in the Lake District

Lichens and bryophytes absorb many substances from their immediate environment, ranging from necessities such as water and gases for photosynthesis, to pollutants and toxins which rapidly accumulate and become toxic to the individual.

Different species have a range of adaptations, resulting in varying toleration levels. Therefore, some species will survive in areas with higher levels of pollution, whereas others will diminish. This makes lichens and bryophytes particularly efficient environmental indicators, allowing inferences to be made about the quality of the surrounding environment based on the presence or absence of certain species.

Making sites bigger and better connected: site management

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

Acid deposition is the single largest cause of historic decline in the *Lobarion* community. While improved regulatory measures since the 1950s have reduced the impacts, sensitive species are still recovering and not yet occupying their former range. Sources of acidifying pollution have both a long- and short-range impact, and are mainly from traffic (including marine traffic) and industry.

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Lobaria scrobiculata specimen (Tullie House Museum), collected June 1913 from Seathwaite, Borrowdale. Species now lost from all known Lakeland localities, most likely due to acidifying pollution

Nitrogen deposition – short range pollutants (ammonia, NH_3):

Atmospheric nitrogen deposition is above the critical load over large areas of the UK (DEFRA, 2002). 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', such as grasslands. This is particularly the case for woodland edges, which experience the highest amounts of nitrogen deposition, especially where a local source is present.

One European study detected impacts on lichens and bryophytes about 50m from the woodland edge (Moen & Jonsson 2003), while British research has shown elevated nitrogen levels up to 100m from arable boundaries (Willi et al. 2005). Communities most at risk are those rich in bryophytes, and those with lichens containing cyanobacteria as a photosynthetic partner (*Lobarion* community).

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.

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Oak containing evidence of slurry residue and a flora dominated by *Physconia enteroxantha*, a species of nutrient-enriched bark. Lake District

Solutions:

- Identify the extent to which air pollution is a problem, by using lichen indicators (see **www.apis.ac.uk/nitrogen-lichen-field-manual** and **www.opalexplorenature.org/airsurvey**).
- A lack of SO2 sensitive species such as *Usnea* species in the canopy, or those containing cyanobacteria could indicate impact of acid rain, although there are other factors that can influence their abundance (see Plantlife 'Lichens in Atlantic Woodlands of the Lake District (*Lobarion* & *Parmelion*)'.
- An abundance of *Xanthoria* and *Physcia* species, especially on oak, 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 (see **www.opalexplorenature.org/airsurvey**).
- In more open situations such as parklands, where the grassland is managed more intensively by grazing or as silage (i.e. with high level input), consider reversion of this to a less intensive regime, such as hay meadow or extensive grazing.
- Tree belts surrounding conservation sites can be effective at buffering nitrogen 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**

© Jenny Seawright

Xanthoria parietina, an indicator of nitrogen deposition

Key considerations:

- Even the best woodlands are likely to show some impact of pollution, 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.
- For further info see **http://ec.europa.eu/environment/integration/research/newsalert/pdf/47na2_en.pdf**

Issue 15:
Small-scale Hydroelectric Power (HEP) schemes

Small hydroelectric power (HEP) schemes have been encouraged regionally and nationally as a form of renewable energy. These schemes divert water from a river or stream, through a pipeline and turbine, before being returned to the watercourse.

Such schemes have the potential to be quite damaging to lichen and bryophyte populations through direct construction impacts, and altered flows and humidity regimes.

In Western Britain, these schemes tend to be constructed in steep-sided wooded gullies and ravines. While some sites have been developed sympathetically, others have caused substantial damage, with the potential to negatively impact on important lichen and bryophyte populations.

Hydroelectric power (HEP) scheme. Snowdonia National Park, Wales

Solutions:

- Ensure potential development sites are fully surveyed by competent, impartial, professional lichenologists and bryologists in the first instance.
- If sites are known to support species of national or international importance, the precautionary principle should be adopted until 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. and Bainbridge, I.P.(2012). Bryological assessment for hydroelectric schemes in the West Highlands – 2nd edition. Scottish Natural Heritage Commissioned Report No.449b

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