Common Standards Monitoring Guidance

for

Bryophytes and Lichens

Version July 2005

JOINT NATURE CONSERVATION COMMITTEE

ISSN 1743-8160 (online)

1. Introduction

1.1 This chapter provides Common Standards Monitoring guidance for bryophytes and lichens (lichenised fungi) on designated sites, including SSSIs, ASSIs and SACs. It includes advice on the identification of interest features, attributes, targets and methods of assessment. It does not include guidance on monitoring either non-lichenised fungi or algae. Terminology for this group as a whole is confusing, and includes terms such as: 'lower plants', 'non-vascular plants' and 'cryptogams'. These terms should be avoided as they are imprecise and confusing. Any term using the word 'plant' should not be used to refer to fungi, which are in a separate kingdom. 'Cryptogams' include ferns, which are vascular plants; guidance for monitoring ferns was provided in the chapter on vascular plants.

1.2 The bryophytes comprise the mosses, liverworts and hornworts. There are about 1200 taxa known from the UK, although not all of these will be monitored. UK species range from those with a predominantly arctic distribution, which are concentrated in the mountains of Scotland, to those with a Mediterranean-Atlantic range, most of which are found in coastal districts of south-west England. Areas of high rainfall in the west support a particularly rich concentration of bryophytes, including some of quite exceptional interest. DA Ratcliffe said of Britain and Ireland that 'in its Atlantic bryophyte element, it is not only the richest part of the whole continent, but it is also one of the richest areas of the world' (Ratcliffe 1968). One of the difficulties in producing monitoring guidance for bryophytes, is that they are often plants of particular microhabitats which may recur in more than one major habitat type. This is in part due to the small size of bryophytes. For instance, *Lejeunea mandonii* can be found on shaded rocks and trees, which may be found in woodland, on block scree or on cliffs. The continued presence of such microhabitats within the broader habitat is fundamental for bryophyte conservation. Bryophytes not only reproduce sexually by spores, but also have a wide range of vegetative propagules. These include deciduous leaves and branchlets, bulbils in the leaf axils, gemmae on the stems and leaves, and small tubers on the rhizoids; in addition, many are able to regenerate from small fragments of stem and leaf if these become accidentally detached.

1.3 Lichens are composite organisms, part fungus and part alga or cyanobacterium. They are often referred to as 'lichenised fungi', and the scientific name is always that of the fungal partner. Generally speaking, the fungal component is incapable of living independently, whereas the algal component can often be found leading an independent existence as a species in its own right. Lichen taxonomy, like that for fungi more generally, has undergone a very large number of changes recently, and it may be difficult to provide a current name to lichens listed in citations or data sheets. The recent *Conservation Evaluation of British Lichens* considered a total of 1850 taxa. As for bryophytes, the lichen flora of the UK is of international importance because of its high proportion of oceanic species and endemics. Lichens also tend to be specific to microhabitats which can be difficult to assign to the broad habitat level. Lichens have a number of means for vegetative propagation, but only the fungal partner can reproduce sexually.

1.4 There are many similarities between bryophytes and lichens: small size, microhabitat specificity, important Atlantic communities. However, the habitat requirements of the two groups can differ, or indeed may be contradictory. Therefore it was agreed that

separate guidance should be produced for monitoring bryophyte and lichen interest features.

2 Bryophyte and lichen interest features

2.1 The guidance in this chapter deals only with bryophyte and lichen interest features which qualify as such according to the *Guidelines for selection of biological SSSIs: non-vascular plants* (Hodgetts, 1992), or according to guidelines used to select ASSIs, or which appear on the Habitats and Species Directive Annex II. Note that the SSSI guidelines are not those that appear in the *Guidelines for selection of biological SSSIs* (NCC, 1989), but the later revision to these.

2.2 There are just four bryophytes included in Annex II of the Habitats and Species Directive which constitute interest features on SACs, these species are listed in Appendix 1 of this chapter. No fungi, including lichenised fungi, are included in the Habitats and Species Directive. In domestic legislation, 37 bryophytes and 30 lichens are included in Schedule 8 of the Wildlife and Countryside Act. These taxa are also listed in Appendix 1. These taxa are all *individually qualifying interest features*, and may have been designated as such.

2.3 There are also some sites which have been designated on the basis of a single Red Data List taxon or a taxon threatened in Europe, as these can also constitute *individually qualifying interest features*. However, these sites are unusual, as the majority of bryophyte and lichen interest features are assemblages, which may include Red Data List taxa within them. When determining whether a site possesses an individually qualifying Red Data List taxon, the most up-to-date listings should be used. Lists are maintained on the JNCC website, and are published in: *British Red Data Books mosses and liverworts* (Church *et al.*, 2001, 2004), *A Conservation Evaluation of British Lichens* (Woods & Coppins, 2003). Those taxa listed as Critically Endangered (CR), Endangered (EN), or Vulnerable (VU), are Red Data List taxa. It should be noted that citations have not normally been altered to reflect new understanding of a species' status. Therefore, there may be instances in which designated interest features no longer qualify as such. In these cases advice should be sought from Country Agency designated sites advisors as to how to proceed.

2.4 The great majority of sites with bryophyte or lichen interest features are assemblages, mostly associated with a particular habitat or microhabitat on the site. A variety of scoring systems are described for assemblages in the selection guidelines; these are considerably more complex than those for vascular plants, and are not solely focussed on rare or scarce taxa. Included in the scores are Atlantic, sub-Atlantic and western bryophytes, woodland indicator bryophytes, and indicator lichens for sites rich in epiphytic lichens. These extra scoring systems are designed to select communities which are of international importance, but which are not necessarily threatened in the UK. Most (though not all) assemblages can be linked to a particular habitat or microhabitat on the site, for example the bryophyte assemblage on block scree at Titterstone Clee SSSI. Some designated assemblages will traverse two or more habitats.

2.5 There can be considerable difficulties in interpretation of citations, particularly older citations, when trying to decide whether there is a bryophyte or lichen interest feature on a site. Supporting documentation is likely to be required in many cases. The following points should be noted:

- Reference to 'important plants' may not mean vascular plants, but may refer to bryophytes, lichens, fungi, or algae
- Any citation that refers to important 'lower plants' or 'non-vascular plants' is likely to have a bryophyte or lichen interest feature
- Bryophyte assemblages and lichen assemblages are separate interest features (they qualify separately) and must be monitored and reported separately
- The lichens have undergone very extensive taxonomic review, and it may require specialist assistance to trace scientific names included in a citation; in these cases it is more important to identify that there is a lichen assemblage than to trace the taxa (although a large number of synonyms are available from the British Lichen Society at http://www.thebls.org.uk/synlist.htm)
- Not all citations which include named bryophytes or lichens necessarily include these as interest features; they may be used simply to describe the habitat, for instance *Rhytidiadelphus loreus* as a characteristic ground species of acidic Western woodlands or *Aspicilia calcarea* on hard calcareous rocks

2.6 In some cases it may be more appropriate to consider bryophytes or lichens as local distinctiveness attributes for the associated habitats. This is particularly likely when there are rare or notable taxa which do not appear to be notified in their own right, or form a part of a notified assemblage. In these cases it is suggested that extra attributes should be derived from the tables in the appendices of this chapter. Several of the guidance tables in the habitat chapters require that the presence of characteristic bryophyte and lichens are monitored. These are used as indicators for the condition of the habitat, but are not normally taxa which make up bryophyte or lichen interest features.

3. Monitoring bryophyte and lichen interest features

3.1 Whenever possible, both direct and indirect monitoring should be used to assess the condition of the feature. However, a lack of sufficient expertise in the UK will mean that the greater focus will be on indirect attributes. A problem with this approach is that bryophyte and lichen interest features are frequently very highly localised on a site *e.g.* epiphytic on one tree within a woodland, growing in one rock crevice in block scree, *etc.* This extreme localisation makes it inappropriate to apply indirect attributes to the entire site in many cases. It is vital to be able to target the monitoring of habitat attributes to the area of the site that contains the bryophyte or lichen interest, and hence it will be necessary to first produce a *site dossier*.

3.2 An example of a site dossier is included in Appendix 7. The most important aspect of the site dossier is that it needs to describe the features and their condition in simple terms and make an accurate record of their precise location in such a way that, using

the dossier, a stranger to the site could relocate the features and describe their condition on subsequent monitoring visits. The intention is that site dossiers will be sufficient to localise simple monitoring of habitat attributes, to assist in direct monitoring, and to provide a baseline for the feature, so that it can be monitored by CA staff, without the need for specialist identification skills. The necessary content is as follows:

- Record of the location and extent of the habitat/s supporting rare or scarce species on suitably large scale maps
- Annotated photographs of these habitats
- List of rare and scarce species found within the habitats and an indication of their extent within the habitat
- Detailed description of the habitat type
- More detailed notes for some selected populations of rare and scarce species (in particular very rare or threatened species and those which are likely to be easy and valuable to monitor in future)
    - GPS measurement
    - Annotated photographs
    - Population measures
    - Simple identification notes (in particular an assessment as to whether the photograph and location will be sufficient to identify the species)
- Record of environmental parameters that may threaten the interest feature either currently or in the future (*e.g.* scrub invasion)
- Recommendations for site management for the bryophyte or lichen interest
- An assessment by the specialist as to whether the feature as seen is favourable or unfavourable.

This should allow accurate localisation of habitat monitoring within the site, and should also allow some direct monitoring of the species whenever the localities, photographs and simple identification notes are sufficient to direct non-specialist staff.

3.3 The site dossier should be used in conjunction with the tables in this chapter to monitor the interest feature. Only those areas identified in the site dossier as being important for the maintenance of the interest feature should be monitored unless the table directs otherwise. Attributes should be derived from the tables in the appendices to this chapter, but extra attributes can be added if suggested in the site dossier, or targets can be modified in the light of descriptions in the site dossier.

3.4 Whenever possible, some direct attributes should be monitored for all interest features. Any site notified for the presence of Habitats and Species Directive or Schedule 8 taxa (Appendix 1), must have direct attributes monitored. This will normally involve ensuring the maintained presence of the taxon, although the site dossier may suggest other important measures such as extent. For other bryophyte and lichen interest features, direct measures should be derived from the site dossier; these might include monitoring the continued presence of a particular population for which a GPS measurement and photograph is given, or checking that particular

communities such as crustose communities are present. Measures should be simple and indicative of the condition of the interest feature. In some instances, it will be known that specialists have visited the site during the monitoring cycle. In these cases, their observations should be used to inform the condition of the feature. For instance, if a threatened taxon could not be found by the specialist, then this could trigger an unfavourable assessment, but at least should trigger a more detailed investigation before assigning a status. Details of specialist monitoring of threatened bryophytes is held on the Threatened Bryophyte Database, managed by the Biological Records Centre. It is also suggested that specialists should visit all sites periodically in order to ensure the continued presence of threatened taxa, however this is beyond the scope of Common Standards Monitoring.

4. Use of the tables to identify attributes and targets

4.1 Bryophyte interest features are mostly assemblage features associated with a particular habitat, but also include a number of individually notified species features, notably some SAC interest features. The taxa that make up assemblages include rare and scarce, Atlantic, sub-Atlantic and western, and woodland indicators. Tables in this chapter include the indirect attributes for important bryophyte habitats. Direct monitoring attributes should be derived from the site dossier.

4.1.1 Most of the rare and scarce bryophyte taxa in the UK are listed in Appendix 4. This table indicates which of the countries in the UK are currently believed to hold populations of each taxon, what its conservation status is, and further columns relating to the habitat(s). The columns relating to habitat attempt to place the various possible habitats for a taxon in order of importance. The numbered habitats refer to the list of special bryophyte habitats in Appendix 2. For instance, a taxon that has 15 in the first column, 14 in the second column, and 24 in the third, is principally to be found in sand dunes and slacks, has a secondary riparian habitat, and is sometimes found in quarries and pits. The final column refers to the habitat guidance chapters of Common Standards Monitoring.

4.1.2 There are a number of bryophyte taxa which can form part of notified assemblages which are not included in the Appendix 4 table. Many of these taxa will be associated with woodland, particularly western oceanic woodland. In these cases, it is necessary to identify the habitat or microhabitat on the site with which the assemblage is associated. These habitats should be selected from the list in Appendix 2 whenever appropriate, otherwise from the main habitat guidance chapters.

4.1.3 All bryophyte interest features must have an identified associated habitat for which the condition will be monitored. In some cases there will be more than one habitat on the site which is considered to be important for bryophytes, in which case multiple habitat types should be monitored in order to report on the condition of the feature. The associated habitat should be identified in one of three ways:

- From the notes included in the site dossier
- From the habitat columns in Appendix 4
- By selection from the list in Appendix 2

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For instance, if the citation clearly states that the assemblage is associated with a particular habitat, then this can be selected immediately from Appendix 2. The site dossier should be given the greatest weight when selecting the appropriate habitat. A case study is given in Appendix 8.

4.1.4 Tables of attributes and targets for the special habitats listed in Appendix 2, are given in Appendix 5. Attributes for other habitats, in particular lowland wetland habitats, should be taken from the appropriate habitat guidance chapters. In many cases, these other habitats will already be monitored as an additional notified feature on the site. The site dossier should also be used to ensure that targets are appropriately set for the feature. Direct monitoring attributes should be derived from the site dossier.

4.2 Lichen interest features are mostly assemblage features associated with a particular habitat, but also include a few individually notified species features. The taxa that make up assemblages include rare and scarce, and lichens in the Indices of Ecological Continuity. Tables in this chapter include targets for the indirect attributes of important lichen habitats. Direct monitoring attributes should be derived from the site dossier.

4.2.1 It was decided that it would be too complex to provide a table as in Appendix 4 for lichens. There are a number of reasons for this. Lichen taxonomy has changed markedly over the years, and it is a specialist task to trace the current names of lichens included in citations and supporting documentation. The current status assessment for lichens shows almost 1200 taxa that are rare or scarce. Very few sites are notified for individual taxa as opposed to an assemblage.

4.2.2 All lichen interest features must have an identified associated habitat for which the condition will be monitored. In a few cases there will be more than one habitat on the site which is considered to be important for lichens, in which case multiple habitat types should be monitored in order to report on the condition of the feature. The associated habitat should be identified in one of two ways:

- From the notes included in the site dossier
- By selection from the list in Appendix 3.

For instance, if the citation clearly states that the assemblage is associated with a particular habitat, then this can be selected immediately from Appendix 3. The site dossier should be given the greatest weight when selecting the appropriate habitat.

4.2.3 Tables of attributes and targets for the special habitats listed in Appendix 3, are given in Appendix 6. Attributes for other habitats, in particular heathland habitats, should be taken from the appropriate habitat guidance chapters. In many cases, these other habitats will already be monitored as an additional notified feature on the site. The site dossier should also be used to ensure that targets are appropriately set for the feature. Direct monitoring attributes should be derived from the site dossier.

4.2.4 A set of more detailed attribute and target tables are available on the JNCC website as additional information. These have been produced for a number of habitats within Scotland, where site dossier production is at an advanced stage. These tables should

be used in their appropriate habitats. They serve as excellent examples of the way in which indirect attributes can be modified and direct attributes added to a table, once a more detailed description of a site or habitat exists.

5. Assessing the condition

5.1 All assessments should be made with reference to the site dossier, which should set out a clear description of the feature and its condition at the time of dossier production. The parts of the site that are important for maintaining the feature should have their condition assessed. In some cases it is also appropriate to assess *potential* habitat for the interest feature – the habitats for which this approach is appropriate are noted in the tables.

5.2 It is not possible to give a usual assessment method for the habitats, since the extent that is important for the feature will be extremely variable. In some instances, only one tree or rock will need to be assessed; clearly in these cases it will be possible to have a complete assessment of the habitat condition. In other instances, the entirety of a large woodland might be of importance, in these cases a structured walk may be the most appropriate assessment method. Judgement should be exercised as to the most appropriate method given the extent of the interest feature.

5.3 Whenever possible, direct monitoring of the feature must be used in reaching the final condition assessment. Direct monitoring must invariably be used for SAC interest features, and individually notified Schedule 8 taxa. Direct measures may be derived from other surveys. It will not normally be the case that presence of all of the taxa making up an assemblage will be an obligatory target. Targets for direct monitoring should be derived from the site dossier and can include monitoring of clearly identified populations, or the presence of easily identified communities or indicator species. Note that collection of rare bryophytes and lichens from known populations is strongly discouraged, although voucher specimens for expert confirmation may be collected if a new locality is suspected.

5.4 If no site dossier exists, then the results of monitoring will have very low confidence. Changes to management should not normally be made until a site dossier has been produced. It should be realised that if only indirect monitoring is carried out on a site without a site dossier, then there is no information regarding the condition of the interest feature, only information regarding the suitability of the site to potentially support an interest feature.

5.5 The final assessment of the interest feature will be produced by combining the information from the direct and indirect attributes. The conclusion must be one of the following:

- Favourable maintained. All attributes, both direct and indirect, meet targets in current assessment, and previous assessment favourable.
- Favourable recovered. All attributes, both direct and indirect, meet targets in current assessment, and previous assessment unfavourable.
- Unfavourable recovering. At least one attribute does not meet target in current assessment. There should be evidence that failing attributes are

closer to meeting their targets than in the previous assessment, this may be because positive management is in place as long as the assessor is confident that the management will eventually produce favourable status.

- Unfavourable no change. At least one attribute does not meet target in current assessment. No clear evidence of recovery or decline.
- Unfavourable declining. At least one attribute does not meet target in current assessment. There should be evidence that attributes are becoming further from meeting their targets than in the previous assessment.
- Partially destroyed. This conclusion should be used if a part of the habitat supporting the interest feature has been destroyed.
- Destroyed. This conclusion should be used if the entirety of the habitat supporting the interest feature has been destroyed and the interest feature has been lost.

6. Materials required for monitoring

6.1 In addition to standard equipment, monitoring in the field will require:

- Site dossier
- Map or site for navigation and annotation
- GPS unit
- Tape measure
- Camera, preferably digital
- Plant labels for marking populations in photos
- Hand-lens
- CSM field recording forms.

Additional field materials are likely to be required by specialists producing site dossiers.

7. Further reading and bibliography

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8. Appendices

Appendix 1. Species listed in the Habitat and Species Directive Annex II and Schedule 8 of the Wildlife and Countryside Act.

Appendix 2. Habitats requiring special guidance for monitoring their bryophyte interest features.

Appendix 3. Habitats requiring special guidance for monitoring their lichen interest features.

Appendix 4. Red Data Book, rare and scarce bryophytes with suggested habitat linkages.

Appendix 5. Attributes and targets tables for indirect monitoring of habitats associated with bryophyte interest features.

Appendix 6. Attributes and targets tables for indirect monitoring of habitats associated with lichen interest features.

Appendix 7. Example of a site dossier.

Appendix 8. Case study.

Appendix 1. Species listed in the Habitat and Species Directive Annex II and Schedule 8 of the Wildlife and Countryside Act

Bryophytes included in the Habitat and Species Directive:

Buxbaumia viridis
Hamatocaulis vernicosus (Drepanocladus vernicosus)
Marsupella profunda
Petalophyllum ralfsii

There are no lichens included in the Habitat and Species Directive.

Bryophytes included on Schedule 8:

Acaulon triquetrum
Adelanthus lindenbergianus
Anomodon longifolius
Bartramia stricta
Bryum mamillatum
Bryum neodamense
Bryum schleicheri
Buxbaumia viridis
Cryphaea lamyana
Cyclodictyon laetevirens
Desmatodon cernuus
Didymodon cordatus (Barbula cordata)
Didymodon glaucus (Barbula glauca)
Ditrichum cornubicum
Geocalyx graveolens
Grimmia unicolor
Gymnomitrion apiculatum
Hamatocaulis vernicosus (Drepanocladus vernicosus)
Hygrohypnum polare
Hypnum vaucheri
Jamesoniella undulifolia
Lophozia rutheana (Leiocolea rutheana)
Marsupella profunda
Micromitrium tenerum
Mielichhoferia mielichhoferiana (M. mielichhoferi)
Orthotrichum obtusifolium
Petalophyllum ralfsii
Plagiothecium piliferum
Rhynchostegium rotundifolium

Riccia bifurca
Saelania glaucescens
Scorpidium turgescens
Southbya nigrella
Sphagnum balticum
Thamnobryum angustifolium
Zygodon forsteri
Zygodon gracilis

Lichens included on Schedule 8:

Alectoria ochroleuca
Bryoria furcellata
Buellia asterella
Caloplaca luteoalba
Caloplaca nivalis
Catapyrenium psoromoides
Catolechia wahlenbergii
Cladonia convoluta
Cladonia trassii (C. stricta)
Collema dichotomum
Enterographa elaborata
Fuscopannaria ignobilis (*Pannaria ignobilis*)
Gyalecta ulmi
Heterodermia leucomela (H. leucomelos)
Heterodermia propagulifera
Lecanactis hemisphaerica
Lecanora achariana
Lecidea inops
Megalaria laureri (Catillaria laureri)
Nephroma arcticum
Parmelinopsis minarum (Parmelia minarum)
Parmentaria chilensis
Peltigera lepidophora
Pertusaria bryontha
Physcia tribacioides
Pseudocyphellaria lacerata
Psora rubiformis
Solenopsora liparina

Squamarina lentigera
Teloschistes flavicans

Appendix 2. Habitats requiring special guidance for monitoring their bryophyte interest features

1. Western oceanic woodland
2. Rotten wood
3. Woodland rides
4. Ravines and ghylls
5. Hedgerows and wayside trees
6. Scrubby woodland
7. Disturbed open lowland calcareous grassland
8. Lowland heathland, bare ground, winter-wet, summer droughted with light disturbance
9. Snowbeds
10. Montane flushes
11. Montane hepatic mat
12. Montane heath
13. Reservoirs and ponds supporting ephemeral species
14. Riparian – rivers and other water bodies including flood-zone
15. Sand dunes and slacks
16. Coastal habitats including hard or soft cliffs, landslip, talus and maritime caves
17. Machair
18. Lowland calcareous rock
19. Lowland unshaded acid rock, including sarsen stones
20. Scree
21. Arable
22. Industrial – contaminated or toxic soils
23. Anthropogenic – man-made structures
24. Quarries and pits
25. Acid montane cliffs
26. Basic montane cliffs
27. Salt marsh

The condition of other habitats associated with bryophyte interest features, in particular woodlands (other than those listed above) and lowland wetlands, can be adequately assessed using the published habitat guidance.

Appendix 3. Habitats requiring special guidance for monitoring their lichen interest features

28. Woodland
29. Caledonian pinewoods
30. Woodpasture and parkland
31. Lowland rock
32. Metalliferous habitats
33. Maritime cliffs and slopes
34. Upland cliffs and block scree
35. Still-water lake margins in upland areas
36. Sand dunes and machair
37. Coastal shingle
38. Snowbeds

The condition of other habitats associated with lichen interest features, in particular lowland calcareous grassland, lowland heathland and montane heath, can be adequately assessed using the published habitat guidance.

Appendix 4. Red Data Book, rare and scarce bryophytes with suggested habitat linkages

Species name	Countries				Status	Main habitat	Second habitat	Third habitat	Other habitat guidance
Acaulon triquetrum	E				EN	7	16		
Acrobolbus wilsonii		S			NT	4			
Adelanthus lindbergianus		S			VU	12	16	20	
Aloina ambigua	E		W	NI	NS	24			
Aloina brevirostris	E				NS	24	22	7	
Aloina rigida	E	S	W	NI	NS	24	18	26	
Amblyodon dealbatus	E	S	W	NI	NS	15	10	17	
Amblystegium confervoides	E	S	W		NS	18			
Amblystegium humile	E	S	W	NI	NS				Lowland grassland
Amblystegium radicale	E		W		CR				Contact specialist
Amphidium lapponicum	E	S	W		NS	26	10		
Anastrophyllum donnianum		S			NS	11			
Anastrophyllum hellerianum	E	S	W	NI	NS	2			
Anastrophyllum joergensenii		S			NT	11			
Anastrophyllum saxicola		S			NT	20			
Andreaea alpestris		S			DD	9			
Andreaea blytii		S			NT	9			
Andreaea frigida	E	S			VU	25			
Andreaea megistospora	E*	S	W	NI	NS	25			
Andreaea mutabilis	E	S	W		NS	25	20		
Andreaea nivalis		S			NT	25			
Andreaea rothii rothii	E	S	W	NI	NS	25			
Andreaea sinuosa		S			NS	9			
Anomodon attenuatus		S			EN	4			
Anomodon longifolius	E	S	W*		VU	4			
Anthelia juratzkana		S	W		NS	9	26		
Anthoceros agrestis	E	S	W	NI	NS	21			
Anthoceros punctatus	E	S	W	NI	NS	21			
Aongstroemia longipes		S			NT	22	24		
Aplodon wormskjoldii	E	S			CR				Contact specialist
Arctoa fulvella	E	S	W		NS	9	20		
Athalamia hyalina		S			DD	26			
Atrichum angustatum	E			NI	EN	3			
Atrichum tenellum	E	S	W		NS	3	13		
Aulacomnium turgidum	E*	S			NS	26			
Barbilophozia atlantica	E	S	W		NS	1	20	19	
Barbilophozia kunzeana	E	S	W		NT	10	20		Lowland wetland / Upland
Barbilophozia lycopodioides	E	S			NS	26	10	9	
Barbilophozia quadriloba		S			NT	26	10		
Bartramia halleriana	E	S	W	NI	NS	4	26		

Species name	Countries				Status	Main habitat	Second habitat	Third habitat	Other habitat guidance
Bartramia stricta	E*	S	W		CR	18			
Bazzania pearsonii		S			NS	11			
Blindia caespiticia		S			EN	26			
Brachydontium trichodes	E	S	W	NI	NS	25	20	24	
Brachythecium appleyardiae	E				NT	18	23		
Brachythecium erythrorrhizon		S			DD	15			
Brachythecium glaciale		S			NS	9	20		
Brachythecium reflexum		S			NS	9	20		
Brachythecium salebrosum	E	S*	W		NS	2			
Brachythecium starkei		S			VU	26			
Brachythecium trachypodium		S			CR				Contact specialist
Bryoerythrophyllum caledonicum		S			NT	26			
Bryum archangelicum		S			DD	26			
Bryum arcticum		S			DD	26			
Bryum calophyllum	E	S	W		VU	15			
Bryum canariense	E		W		NS	16	7		
Bryum cyclophyllum	E*	S			EN	13			
Bryum elegans	E	S	W		NS	26	23	7	
Bryum gemmilucens	E		W		DD	21	3	8	
Bryum gemmiparum	E		W		EN	14			
Bryum knowltonii	E	S	W		VU	15	24	27	
Bryum mamillatum	E				CR	15			
Bryum marratii	E	S	W	NI	EN	15		27	
Bryum mildeanum	E	S	W		NS	14			
Bryum muehlenbeckii		S	W		NT	10			
Bryum neodamense	E	S	W	NI	EN	15			
Bryum pallescens	E	S	W	NI	NS	22	23		
Bryum riparium	E	S	W	NI	NS	14			
Bryum salinum	E*	S			VU			27	Contact specialist
Bryum schleicheri		S			CR	10			
Bryum stirtonii	E	S			VU	26			
Bryum tenuisetum	E	S	W		NS	8	13	21	
Bryum torquescens	E	S	W	NI	NS	7			
Bryum turbinatum	E*	S*	W*		EX	15	24		
Bryum uliginosum	E	S	W*	NI	CR	15			
Bryum warneum	E	S	W		VU	15	24	27	
Bryum weigelii	E	S	W		NS	10			
Buxbaumia aphylla	E	S	W		NS	24	22		
Buxbaumia viridis		S			EN				Contact specialist
Calliergon trifarium		S			NS	10			
Calypogeia integristipula	E	S	W	NI	NS	1			

Species name	Countries				Status	Main habitat	Second habitat	Third habitat	Other habitat guidance
Calypogeia suecica		S		NI	NS	2			
Campylophyllum calcareum	E	S	W	NI	NS	18			
Campylophyllum halleri		S			EN	26			
Campylopus gracilis (schwarzii)	E	S	W	NI	NS	10	25		
Campylopus pilifer	E	S	W		NS	19	16		
Campylopus schimperi		S			NS	9			
Campylopus setifolius	E	S	W	NI	NS	11	25	14	
Campylopus shawii		S			NS	10			
Campylostelium saxicola	E	S	W	NI	NS	4			
Catoscopium nigritum	E	S	W	NI	NS	15	10	17	
Cephalozia ambigua		S			DD	9	25		
Cephalozia catenulata	E	S	W	NI	NS	2	19		
Cephalozia loitlesbergeri	E	S	W		NS				Lowland wetland / Upland
Cephalozia macrostachya	E	S	W	NI	NS				Lowland wetland
Cephalozia pleniceps	E	S	W	NI	NS				Lowland wetland / Upland
Cephaloziella baumgartneri	E				EN	7			
Cephaloziella calyculata	E		W		VU	22	16		
Cephaloziella dentata	E				CR	8			
Cephaloziella elachista	E	S	W		NR				Lowland wetland
Cephaloziella integerrima	E				VU	8			
Cephaloziella massalongi	E		W		VU	22			
Cephaloziella nicholsonii	E		W*		VU	22			
Cephaloziella spinigera	E	S	W		NS				Lowland wetland
Cephaloziella stellulifera	E	S	W		NS	22	8	16	
Cephaloziella turneri	E	S	W		NT	16			
Ceratodon conicus	E		W		EN	23	24		Contact specialist
Cheilothela chloropus	E				NT	7			
Cinclidium stygium	E	S	W*	NI	NS				Lowland wetland
Cinclidotus riparius	E		W		VU	14			
Cirriphyllum cirrosum		S			NT	26			
Cladopodiella francisci	E	S	W	NI	NS				Lowland wetland / heath
Cololejeunea rossettiana	E	S	W	NI	NS	18	1		
Colura calyptrifolia	E	S	W	NI	NS	4			
Conostomum tetragonum	E	S	W*		NS	9			
Coscinodon cribrosus	E	S	W		NS	19			
Cryphaea lamyana	E		W		VU	14			
Cryptothallus mirabilis	E	S	W		NS				Contact specialist
Ctenidium procerrimum		S			VU	26			
Cyclodictyon laetevirens	E	S			EN	16			
Cynodontium fallax		S*			EX				

Species name	Countries				Status	Main habitat	Second habitat	Third habitat	Other habitat guidance
Cynodontium jenneri	E	S	W		NS	20	4		
Cynodontium polycarpon	E	S	W		DD	25	20		
Cynodontium strumiferum		S			NT	20			
Cynodontium tenellum		S			NT	20			
Daltonia splachnoides		S		NI	VU	4	14	2	
Dichodontium flavescens	E	S	W	NI	DD	14			
Dicranella crispa	E	S	W*	NI	NS				Contact specialist
Dicranella grevilleana		S			NT	26			
Dicranodontium asperulum	E	S	W	NI	NS	11	25	20	
Dicranodontium uncinatum	E	S			NS	11	25	1	
Dicranoweisia crispula	E	S	W		NS	25	20		
Dicranum bergeri	E	S	W		VU				Lowland wetland
Dicranum elongatum	E	S			CR	12			Contact specialist
Dicranum flagellare	E	S	W		NS	2			
Dicranum leioneuron	E	S	W		VU				Upland
Dicranum polysetum	E	S	W		NS				Woodland
Dicranum spurium	E	S	W*		VU	8	6		Contact specialist
Dicranum subporodictyon		S			NT	4			
Didymodon acutus	E	S	W	NI	NS	7	24		
Didymodon cordatus	E				VU	16			
Didymodon glaucus	E				CR	18			
Didymodon icmadophilus	E	S			NT	26			
Didymodon mamillosus		S			CR	26			
Didymodon nicholsonii	E	S	W	NI	NS	14	23		
Didymodon tomaculosus	E				NT	21			
Didymodon umbrosus	E		W		NS	23			
Diplophyllum taxifolium	E*	S	W*		NS	9	20		
Discelium nudum	E	S	W	NI	NS	13	14		
Distichium inclinatum	E	S	W	NI	NS	15	7	26	
Ditrichum cornubicum	E				EN	22			
Ditrichum flexicaule	E	S	W	NI	DD	26	7	17	
Ditrichum lineare	E	S	W	NI	NS	9	12	22	
Ditrichum plumbicola	E	S	W		NT	22			
Ditrichum pusillum	E	S	W	NI	NS	21	24		
Ditrichum subulatum	E				NT	16			
Ditrichum zonatum	E	S	W	NI	NS	9	20		
Drepanocladus lycopodioides	E	S	W	NI	NS	15	17		
Drepanocladus sendtneri	E	S	W	NI	NS				
Dumortiera hirsuta	E	S		NI	VU	14	1		
Encalypta alpina	E	S	W*		NS	26			
Encalypta brevicollis		S*			EX				
Encalypta ciliata	E	S	W	NI	NS	26			
Encalypta rhaptocarpa	E	S	W*	NI	NS	26	17		

Species name	Countries				Status	Main habitat	Second habitat	Third habitat	Other habitat guidance
Ephemerum cohaerens	E				CR	13			
Ephemerum recurvifolium	E		W		NS	7			
Ephemerum sessile	E		W	NI	NT	3	13		
Eremonotus myriocarpus	E	S	W	NI	NS	26	1		
Eurhynchium meridionale	E				VU	18			
Eurhynchium pulchellum	E	S		NI	EN	26			
Eurhynchium striatulum	E	S	W		NS	18	4		
Fissidens curvatus (algarvicus)	E		W		NT	1			
Fissidens limbatus	E	S	W		NS	5	3	23	
Fissidens monguillonii	E		W	NI	NT	14			
Fissidens polyphyllus	E	S	W		NS	14			
Fissidens rivularis	E	S	W		NS	14			
Fissidens rufulus	E	S	W	NI	NS	14			
Fissidens serrulatus	E		W		VU	14			
Fossombronia angulosa	E	S	W		NS	16			
Fossombronia caespitiformis	E		W		NS	21	3		
Fossombronia crozalsii	E*				EX	3			
Fossombronia fimbriata	E	S			NT	14	24		
Fossombronia husnotii	E		W		NS	16	3		
Fossombronia incurva	E	S	W	NI	NS	24	13		
Fossombronia maritima	E		W		NT	16	8		
Funaria muhlenbergii	E	S*	W		NS	7			
Funaria pulchella	E	S	W		NT	7			
Geocalyx graveolens		S		NI	VU	4			
Glyphomitrium daviesii	E	S	W*	NI	NS	20	16	26	
Gongylanthus ericetorum	E				NT	8	16		
Grimmia alpestris			W		DD	26			
Grimmia anodon	E*	S*			EX				
Grimmia arenaria	E		W		NT	19	23		
Grimmia atrata	E	S	W		NS	22			
Grimmia crinita	E*				DD	23			
Grimmia decipiens	E	S	W	NI	NS	19	18	23	
Grimmia elatior		S*			EX	25			
Grimmia elongata	E	S	W		NT	25			
Grimmia incurva	E	S	W		NS	25	20		
Grimmia laevigata	E	S	W	NI	NS	18	19	23	
Grimmia longirostris	E	S	W	NI	NS	26	25	20	
Grimmia montana	E	S	W		NS	26	25		
Grimmia orbicularis	E	S	W		NS	18	22		
Grimmia ovalis	E	S	W		VU	19	18	23	
Grimmia tergestina		S			VU	16	18		
Grimmia ungeri		S			VU	26			
Grimmia unicolor		S			VU	25	26		

Species name	Countries				Status	Main habitat	Second habitat	Third habitat	Other habitat guidance
Gymnocolea acutiloba		S	W		VU	20			
Gymnomitrion apiculatum		S			VU	9			
Gymnomitrion corallioides			W*		NT	26	9		
Gymnostomum calcareum	E	S	W	NI	NS	7	18		
Gymnostomum viridulum	E		W		NS	7	23		
Gyroweisia reflexa	E*				EX	24			
Habrodon perpusillus	E	S	W		EN	5	3		
Hamatocaulis vernicosus	E	S	W	NI	NS				Lowland wetland
Haplomitrium hookeri	E	S	W		NS	24	13	15	
Harpanthus flotovianus	E	S			NS	10	14		
Hedwigia ciliata	E	S	W		DD	20	19		
Hedwigia integrifolia	E	S	W	NI	NS	20	19		
Helodium blandowii	E*				EX				
Herbertus borealis		S			VU	12			
Herzogiella seligeri	E				NS	2			
Herzogiella striatella		S			NS	20	12		
Heterocladium dimorphum		S			VU	20	26		
Homomallium incurvatum	E	S			CR				Contact specialist
Hygrohypnum duriusculum	E	S	W		NS	10			
Hygrohypnum molle		S			VU	10	9		
Hygrohypnum polare		S			EN				Contact specialist
Hygrohypnum smithii		S			NT	10			
Hygrohypnum styriacum		S			CR	9	10		
Hylocomium pyrenaicum		S			NS	26	20		
Hymenostylium insigne		S			NT	26			
Hypnum bambergeri		S			NS	26			
Hypnum hamulosum	E	S	W		NS	26			
Hypnum imponens	E	S	W		NS				Lowland wetland / Upland
Hypnum revolutum		S			EN	26			
Hypnum vaucheri		S			VU	26			
Isopterygiopsis muelleriana		S	W		NS	20	26		
Jamesoniella autumnalis	E	S	W		NS	2	1		
Jamesoniella undulifolia	E	S			EN				Contact specialist
Jungermannia borealis		S	W		NS	26			
Jungermannia caespiticia	E		W		NT	10			
Jungermannia confertissima	E	S	W		NS	10	26		
Jungermannia leiantha	E	S			CR	1			
Jungermannia polaris		S			NT	26			
Jungermannia subelliptica	E	S	W	NI	NS	26			
Kiaeria blyttii	E	S	W	NI	NS	9	20		
Kiaeria falcata	E	S	W		NS	9	20		
Kiaeria glacialis		S			NS	9			
Kiaeria starkei	E	S			NS	9			

Species name	Countries				Status	Main habitat	Second habitat	Third habitat	Other habitat guidance
Leiocolea fitzgeraldiae		S	W	NI	NT	26	10		
Leiocolea gillmanii	E	S			NT	26	15		
Leiocolea heterocolpos	E	S	W	NI	NS	4	26		
Leiocolea rutheana	E	S			EN				Contact specialist
Lejeunea holtii		S			VU				Contact specialist
Lejeunea mandonii	E	S			EN				Contact specialist
Leptobarbula berica	E		W		NS	18	23		
Leptodontium gemmascens	E				VU				Contact specialist
Leptoscyphus cuneifolius	E	S	W		NS	1			
Lescuraea saxicola		S*			EX	26			
Leucobryum juniperoideum	E	S	W	NI	NS				Woodland
Lophozia capitata	E				VU	24			
Lophozia longidens	E	S	W		NS				Woodland
Lophozia longiflora		S			DD	2			
Lophozia opacifolia	E	S			NS	9	20		
Lophozia perssonii	E				NT	7			
Lophozia wenzelii	E	S			NT	9	10		
Marsupella adusta	E	S	W	NI	NS	9	20	25	
Marsupella alpina	E	S	W		NS	20			
Marsupella arctica		S			VU	9			
Marsupella boeckii		S			NT	20			
Marsupella brevissima		S			NS	9			
Marsupella condensata		S			NT	9			
Marsupella profunda	E				VU	22	24		
Marsupella sparsifolia		S			VU	9			
Marsupella sphacelata	E	S	W	NI	NS	9	20		
Marsupella stableri	E	S	W		NS	9	20	25	
Mastigophora woodsii		S			NS	11	20	26	
Meesia uliginosa	E	S	W		NS	10	15	17	
Microbryum floerkeanum	E		W*		NS	21	7		
Microbryum starckeanum	E	S	W	NI	NS	21	7	24	
Micromitrium tenerum	E		W		CR	13			
Mielichhoferia elongata	E	S			VU	22			
Mielichhoferia mielichhoferiana		S			VU	22			
Mnium ambiguum		S			NT	26			
Mnium spinosum		S			NT	26			
Mnium thomsonii	E	S	W	NI	NS	26			
Moerckia blyttii		S			NS	9	20		
Moerckia hibernica	E	S	W	NI	NS	15	10	24	
Myrinia pulvinata	E	S	W		NT	14			
Myurella julacea	E	S	W*	NI	NS	26			
Myurella tenerrima		S			EN	26			
Myurium hochstetteri		S			NS	16			

Species name	Countries				Status	Main habitat	Second habitat	Third habitat	Other habitat guidance
Nardia breidleri		S			NR	9			
Nardia geoscyphus	E	S	W		NS	8	14		
Nardia insecta	E				DD				Contact specialist
Neckera pennata		S*			EX				
Octodiceras fontanum	E		W		NS	14			
Odontoschisma elongatum		S			NS	10	14		
Odontoschisma macounii		S			NT	26			
Oedipodium griffithianum	E	S	W		NS	20			
Oncophorus virens	E	S			NS	10	26		
Oncophorus wahlenbergii		S			NT	10			
Orthodontium gracile	E	S	W*	NI	VU	1			
Orthothecium rufescens	E	S	W	NI	NS	26			
Orthotrichum consimile	E				DD				Contact specialist
Orthotrichum gymnostomum		S			NR	6			
Orthotrichum obtusifolium	E*	S			EN	6			
Orthotrichum pallens	E	S			EN	6	3		
Orthotrichum pumilum	E*	S			CR	6	3		
Orthotrichum speciosum	E	S			NT	6	3		
Orthotrichum sprucei	E	S	W	NI	NS	14			
Pallavicinia lyellii	E		W		NT				Lowland wetland
Paludella squarrosa	E*				EX				
Palustriella decipiens	E*	S			NT	10			
Paraleptodontium recurvifolium	E	S	W		NS	26	1		
Paraleucobryum longifolium		S			VU	20			
Pedinophyllum interruptum	E	S		NI	NS	18			
Petalophyllum ralfsii	E	S	W	NI	NS	15			
Phaeoceros carolinianus	E		W		EN	21			
Philonotis cernua		S	W*		CR	12	20		
Philonotis marchica	E				EN	16			
Philonotis rigida	E	S	W	NI	NS	16	24		
Philonotis seriata		S	W		NS	10			
Philonotis tomentella	E	S	W		NS	26			
Physcomitrium eurystomum	E				EN	13			
Physcomitrium sphaericum	E	S	W*	NI	NT	13			
Plagiobryum demissum		S			EN	26			
Plagiochila atlantica	E	S	W		NS	1			
Plagiochila carringtonii		S			NS	11	20	1	
Plagiochila norvegica	E				DD				Contact specialist
Plagiomnium medium		S			NT	10	26		
Plagiopus oederianus	E	S	W	NI	NS	26			
Plagiothecium cavifolium	E	S	W		NS	26			
Plagiothecium laetum	E	S	W	NI	NS	2			
Plagiothecium piliferum		S			CR	26			

Species name	Countries				Status	Main habitat	Second habitat	Third habitat	Other habitat guidance
Plagiothecium platyphyllum	E	S	W		NS	10			
Plagiothecium ruthei	E	S	W		NS	2	20	14	
Platydictya jungermannioides	E	S	W	NI	NS	1	26		
Platygyrium repens	E	S	W		NS	6	5		
Pleurochaete squarrosa	E		W		NS	16	15	7	
Pleurocladula albescens		S			NS	9			
Pohlia andalusica	E	S			NT	22	8		
Pohlia elongata polymorpha	E	S	W		NS	9			
Pohlia flexuosa	E	S	W	NI	NS	10			
Pohlia lescuriana	E	S	W		NS	14			
Pohlia ludwigii	E	S	W		NS	10			
Pohlia obtusifolia		S			EN	10	9		
Pohlia scotica		S			NT	14			
Polytrichum sexangulare		S			NS	9			
Porella obtusata	E	S	W	NI	NS	16			
Porella pinnata	E		W	NI	NS	14			
Pottiopsis caespitosa	E		W		NS	7			
Pseudobryum cinclidioides	E	S	W		NS	10	14		
Pseudoleskea incurvata		S			NT	26			
Pseudoleskea patens		S			NS	26	20	14	
Pseudoleskeella catenulata	E	S	W		NS	26			
Pseudoleskeella nervosa		S			VU	26			
Pseudoleskeella rupestris	E*	S			NT	26			
Pterigynandrum filiforme	E	S	W*	NI	NS	26			
Pterygoneurum lamellatum	E*	S*	W*	NI*	EX	23	7		
Pterygoneurum ovatum	E	S	W		NS	7			
Ptychodium plicatum		S			NT	26			
Pylaisia polyantha	E	S	W		NS	6			
Racomitrium affine	E	S	W	NI	NS	19			
Racomitrium canescens	E	S	W	NI	NS	8	7		
Racomitrium elongatum	E	S	W	NI	NS	7	18		
Racomitrium himalayanum		S			DD	20	26		
Racomitrium macounii		S	W		NT	10	25		
Racomitrium sudeticum	E	S	W	NI	NS	25	9		
Radula carringtonii		S			VU	4			
Radula voluta	E	S	W		NT	1	14		
Rhabdoweisia crenulata	E	S	W	NI	NS	25	20		
Rhizomnium magnifolium		S			NS	10	9		
Rhynchostegiella curviseta	E		W	NI	NS	14			
Rhynchostegium alopecuroides	E	S	W		NS	14			
Rhynchostegium rotundifolium	E				CR	5	4		

Species name	Countries				Status	Main habitat	Second habitat	Third habitat	Other habitat guidance
Rhytidiadelphus subpinnatus	E		W		EN	3			
Rhytidium rugosum	E	S	W	NI	NS	7	18	26	
Riccardia incurvata	E	S	W	NI	NS	15	14	24	
Riccia beyrichiana	E	S	W	NI	NS	24	16	15	
Riccia bifurca	E				VU	8			
Riccia canaliculata	E	S	W		VU	13			
Riccia cavernosa	E	S	W	NI	NS	13			
Riccia crozalsii	E		W		NS	16			
Riccia crystallina	E	S			NT	21			
Riccia huebeneriana	E	S	W		VU	13			
Riccia nigrella	E		W		VU	8			
Riccia subbifurca	E	S	W	NI	NS	21	14	27	
Ricciocarpos natans	E		W		NS	14			
Saelania glaucescens		S			VU	26			
Sanionia orthothecioides		S			NT				Contact specialist
Scapania aequiloba	E	S	W	NI	NS	26	17		
Scapania calcicola		S	W		NS	26	22		
Scapania cuspiduligera	E	S	W		NS	26	17		
Scapania degenii	E	S			NS	26	10		
Scapania gymnostomophila		S	W		NT	26			
Scapania lingulata	E	S	W		NS	4	26		
Scapania nimbosa		S	W*		NS	11			
Scapania ornithopodioides	E	S	W		NS	11			
Scapania paludicola	E		W		NT				Lowland wetland
Scapania paludosa		S	W		NR	10			
Scapania parviflora		S			DD	9			
Scapania praetervisa	E	S			VU	20			
Scapania uliginosa	E	S	W		NS	10	9		
Schistidium agassizii	E	S	W		NT	14			
Schistidium trichodon	E	S	W*		NS	26			
Scorpidium turgescens	E	S			VU	18	10		
Seligeria acutifolia	E	S	W	NI	NS	18			
Seligeria brevifolia	E	S	W		VU	26			
Seligeria calcarea	E		W	NI	NS	18	24		
Seligeria campylopoda	E		W		DD	18			
Seligeria carniolica	E	S*			CR	14			
Seligeria diversifolia	E	S			DD	26			
Seligeria donniana	E	S	W	NI	NS	26	18		
Seligeria pusilla	E	S	W	NI	NS	18	26		
Seligeria trifaria	E	S	W	NI	NS	26			
Sematophyllum demissum			W		EN	1			
Sematophyllum micans	E	S	W*		NS	1			
Southbya nigrella	E				VU	16			
Southbya tophacea	E		W		NT	15	16	22	

Species name	Countries				Status	Main habitat	Second habitat	Third habitat	Other habitat guidance
Sphaerocarpos michelii	E		W		NS	21	24		
Sphaerocarpos texanus	E		W		VU	21			
Sphagnum affine	E	S	W	NI	NS				Lowland wetland
Sphagnum angustifolium	E	S	W	NI	NS				Lowland wetland
Sphagnum austinii	E	S	W	NI	NS				Lowland wetland / Upland
Sphagnum balticum	E	S	W		EN				Contact specialist
Sphagnum flexuosum	E	S	W		NS				Lowland wetland
Sphagnum lindbergii		S			NT	10	9		
Sphagnum majus	E	S			VU				Contact specialist
Sphagnum obtusum	E*				EX				
Sphagnum platyphyllum	E*	S	W	NI*	NS				Upland
Sphagnum pulchrum	E	S	W	NI	NS				Lowland wetland
Sphagnum skyense		S			DD				Contact specialist
Sphagnum subsecundum	E	S	W		NS				Lowland wetland
Sphenolobopsis pearsonii	E	S	W	NI	NS	1	25		
Splachnum vasculosum	E	S			NT	10			
Stegonia latifolia		S			NT	26			
Syntrichia norvegica		S			VU	26			
Syntrichia princeps	E	S	W	NI	NS	26	4		
Syntrichia virescens	E	S	W		NS	5	23		
Targionia hypophylla	E	S	W	NI	NS	23	7	16	
Tayloria lingulata		S			EN	10			
Tayloria tenuis		S		NI*	CR				Contact specialist
Telaranea nematodes	E				VU	1			
Tetralophozia setiformis	E	S			NS	20			
Tetraplodon angustatus		S	W*		NS				Contact specialist
Tetrodontium repandum	E				CR	19			
Thamnobryum angustifolium	E				CR	14			
Thamnobryum cataractarum	E				VU	14			
Thuidium abietinum abietinum	E	S	W	NI	NS	7	15	24	
Thuidium abietinum hystricosum	E	S*		NI	NS	7			
Timmia austriaca		S			EN	26			
Timmia norvegica		S			NT	26			
Tomentypnum nitens	E	S	W	NI	NS				Lowland wetland / Upland
Tortella densa	E	S		NI	NS	18			
Tortella fragilis		S		NI	NT	15	17	26	
Tortella inflexa	E				NS	7			
Tortella limosella		S*			EX				
Tortula atrovirens	E	S	W	NI	NS	16	23		
Tortula canescens	E	S	W		NS	16	18		

Species name	Countries				Status	Main habitat	Second habitat	Third habitat	Other habitat guidance
Tortula cernua	E				EN	22			
Tortula cuneifolia	E		W	NI	VU	16	24		
Tortula freibergii	E				NT	23			
Tortula leucostoma		S			VU	26			
Tortula solmsii	E				NT	16			
Tortula vahliana	E		W*		NT	7	24		
Tortula viridifolia	E	S	W*	NI	NS	16	5		
Tortula wilsonii	E		W		EN	16	5		
Trematodon ambiguus		S*			EX				
Trichostomum hibernicum		S			NS	1	20	26	
Tritomaria exsecta	E				NS	2	1		
Tritomaria polita		S			NS	10	26		
Ulota calvescens		S	W	NI	NS	6			
Ulota coarctata	E	S	W		NS	6			
Weissia condensa	E	S*			VU	7	18		
Weissia levieri	E		W		EN	16			
Weissia mittenii	E*				EX	21	3		
Weissia multicapsularis	E		W		EN	21	16	3	
Weissia perssonii	E	S	W	NI	NS	16			
Weissia rostellata	E	S	W	NI	NT	13	21		
Weissia squarrosa	E	S*	W		EN	21	13	3	
Weissia sterilis	E		W		NT	7			
Zygodon forsteri	E		W*		EN				Contact specialist
Zygodon gracilis	E				EN	23			

Some species that are not considered to be priorities for monitoring have been removed from the table. The 'Countries' column is indicative, asterisked entries are those that are currently considered extinct.

Appendix 5. Attributes and targets tables for indirect monitoring of habitats associated with bryophyte interest features

UK GUIDANCE ON CONSERVATION OBJECTIVES FOR MONITORING DESIGNATED SITES

Interest feature: Bryophyte species of western oceanic woodland (Special habitat 1)

Many of the species, whilst rare, are perhaps better represented in the UK than elsewhere in Europe (or beyond). However, there are a larger range of species that are not regarded as Nationally Scarce but are relatively common in the UK, and attain greater luxuriance here (*e.g. Saccogyna viticulosa, Plagiochila spinulosa, Breutelia chrysocoma*) than on the continent. They are all particularly characteristic of oceanic woodland, predominately showing a western distribution in the UK with outliers in The Weald. Most occur in regions of the UK that experience 180 rain days per year or more. Whilst the 'Atlantics' occur with striking abundance in some western oak woods, such as at Borrowdale in the Lake District and Bovey Valley on Exmoor (comprising such species as *Bazzania trilobata, Plagiochila spinulosa, Saccogyna, Mylia taylorii* and *Dicranodontium denudatum*), other more widespread species also add to the general moss-dominated feature of these woodlands. Many of the species occur on wet dripping rocks such as *Jubula* and *Radula* spp., often in moderate shade, others on sloping damp rock such as *Sematophyllum* spp. and others on vertical rock exposures such as *Orthodontium gracile*. Threats include woodland clearance, coniferization, over grazing and pollution.

Assessment of attributes could be undertaken at any time. If any attribute fails, the feature is not in a favourable condition.

Attributes	Targets	Method of assessment	Comments
Niche availability	Sufficient area of suitable habitat to maintain population No net loss of area of suitable habitat	Mapping (area / aerial photographs)	Refer to the site dossier for baseline assessment and details of the area to be surveyed. Although obvious in terms of detriment to the feature of interest, loss of woodland through clear felling should be looked for.
Canopy structure	Woodland canopy should remain intact	Visual assessment	Individual felling of trees is likely to damage the surrounding area, but more insidiously may alter the microclimate of the site; most species require a high humidity and continuity of canopy. Any selective felling should be outside the areas of importance identified in the site dossier. Natural change is acceptable.
Hydrology	Water levels should be	Visual assessment	Manipulation of water catchments may affect supplies of

	maintained such that streams and cascades continue to flow		water, although woodland itself (including the large bryophyte biomass) acts as a sponge, releasing water slowly.
Bryophyte biomass	Bryophyte cover should dominate on wet ground, rocks, banks and trees (epiphytes)	Visual assessment, comparison with photographs	The sheer abundance of bryophytes in western oceanic woods is striking, and any reduction should be apparent. Compare with the photographs in the site dossier. Evidence of grazing, especially heavy grazing, in the form of dislodged bryophyte mats, churned up *Sphagnum*, should be looked for.
Negative indicators: pollution	No evidence of loss, discoloration or necrosis of epiphytic bryophyte species	Visual assessment, comparison with photographs	Pollution such as sulphur dioxide is less likely to be a problem now, but nitrogen deposition and other air borne pollutants may be on the increase. Necrosis should be apparent from a visual inspection, loss of epiphytic species can be monitored by comparison with photographs included in the site dossier.

UK GUIDANCE ON CONSERVATION OBJECTIVES FOR MONITORING DESIGNATED SITES

Interest feature: Bryophyte species of rotten wood (Special habitat 2)

All species in this group are strongly characteristic of rotten wood or decomposing tree trunks, mostly in shady, humid conditions in woodland. They are a dynamic group moving around an area as substrates become suitable, disappearing when substrates are unsuitable. More rarely they occur on peaty ground or rocks. *Calypogeia suecica* is almost restricted to moist decorticated coniferous logs, whereas the others are more characteristic of deciduous woodland. Some, such as *Anastrophyllum hellerianum* and *Jamesoniella autumnalis* may occasionally occur as epiphytes on living trees. Most have a north/west distribution in the UK, although *Brachythecium salebrosum* has a south-east range. In humid woodland, in particular, the retention of rotten wood and tree stumps is crucial for this group of species. Threats include loss of woodland or opening of canopy, thereby reducing humidity levels, and retaining too little rotten wood, or removal of rotten wood altogether.

Assessment of attributes could be undertaken at any time. If any attribute fails, the feature is not in a favourable condition.

Attributes	Targets	Method of assessment	Comments
Niche availability	No loss of woodland or other shady area supporting the feature of interest	Mapping (area / photographs)	Clear or partial felling of woodland should be looked for.
Canopy structure	Woodland canopy should remain intact	Visual assessment	Opening up of a canopy, reducing humidity and shade, is damaging to the interest feature. Any selective felling should be outside the areas of importance identified in the site dossier.
Presence of rotten wood	Rotten wood and tree stumps occasional to frequent throughout the shady/humid zones of the site	Visual assessment	The ideal amount of rotten wood/tree stumps in any one site is difficult to define, but should be encountered regularly during a search of an area. Preferably logs/stumps should be in various stages of decay to allow the species of interest to disperse around the site.

UK GUIDANCE ON CONSERVATION OBJECTIVES FOR MONITORING DESIGNATED SITES

Interest feature: Bryophyte species of woodland rides (Special habitat 3)

The small group of species associated with this habitat is characteristic of woodland rides, and apart from *Atrichum angustatum*, they behave as ephemerals, colonizing and remaining whilst conditions are suitable (open clayey bare ground, damp or ruts holding water in winter, not excessively shaded, and occasionally disturbed to bring spores to the surface). A typical niche is on the edge of wheel ruts, but not in the wettest parts. Rides can be moderately wide, 10m or more, or narrow, about 2m wide. Thus they can apparently disappear for a number of years, and reappear when conditions are again suitable. This makes them difficult to monitor directly. *Atrichum* however is a perennial, and is particularly characteristic of Wealden woodland. This plant favours edges of rides where competition from vascular plants is low, and shade not excessive. *Fossombronia crozalsii* has not been seen for many years despite searches and is probably extinct in the UK (but are spores waiting for suitable conditions to return somewhere?). *Ephemerum* spp. may also occur on reservoir margins. Threats include neglect (lack of disturbance, encroachment of trees/shrubs on to rides), heavy and regular recreational use and changes in hydrological regime.

Assessment of attributes should be undertaken in the autumn, winter, or early spring. If any attribute fails, the feature is not in a favourable condition.

Attributes	Targets	Method of assessment	Comments
Niche availability	Woodland rides supporting interest feature and other potential rides maintained	Mapping, photographs	The site dossier should indicate the most important rides for the interest feature, however, the dynamic nature of this group of species suggests that a network of rides should be present to allow population movement. Woodland rides need to be open with bare ground and occasionally disturbed. Damp clayey rides with wheel ruts are ideal.
Vegetation structure	More than 80% bare ground No excessive shading from encroaching scrub or tall herbs	Visual assessment	Difficult to be too prescriptive because these plants are very much dependent on microsite conditions, and light passing through an open canopy at intervals along the ride may be sufficient. However, colonization of the ride by perennial grasses or other perennial bryophytes is undesirable.
Hydrology	Water table in winter months to be at or near surface	Visual assessment	Rides ideally wet/damp in winter months, but not waterlogged to such an extent they become excessively churned up or are impassable.

UK GUIDANCE ON CONSERVATION OBJECTIVES FOR MONITORING DESIGNATED SITES

Interest feature: Bryophyte species of ravines and ghylls (Special habitat 4)

A rather heterogenous group of species, but all are typically found in shaded, humid ravines, exclusively in the north and west. They are typically sensitive to changes in the humidity regime. Some grow on shaded rock, typically base-rich/calcareous (*Anomodon* spp.), others grow on wet dripping rocks in deep shade, typically close to the sea (*Radula carringtonii*). *Daltonia splachnoides* requires good light, and is thus found on the upper edges of ravines (and scrubby burns). *Geocalyx graveolens* is inexplicably rare in the UK given the widespread occurrence of humid shady spots suitable for it. Threats include loss of ravine woodland through felling/timber extraction, water abstraction/diversion (hydroschemes), water pollution and direct competition from other plants.

Assessment of attributes could be undertaken at any time. If any attribute fails, the feature is not in a favourable condition.

Attributes	Targets	Method of assessment	Comments
Niche availability	No loss of woodland area	Mapping, photographs	Ravine woodland is normally safe from felling due to difficult terrain, but it is not unknown.
Hydrology	Streams and cascades with normal seasonal flow volumes	Visual assessment	Water maintains humidity in many ravine situations, or is essential directly in the case of *Radula carringtonii*. Diversion of water for hydroschemes, for example, would have a negative impact.
Water quality	Water clear with no evidence of obvious pollution	Visual assessment	Water should be flowing with no evidence of pollution (discoloration, foam, dead fish) which may indicate upstream contamination.
Canopy structure	No obvious changes to the canopy structure	Comparison with photographs	Fragmenting or opening up of the canopy can disturb finely balanced microsite conditions.

UK GUIDANCE ON CONSERVATION OBJECTIVES FOR MONITORING DESIGNATED SITES

Interest feature: Bryophyte species of hedgerows and wayside trees (Special habitat 5)

This small group of mosses is typically, but not exclusively, associated with trees and shrubs in the open, in hedgerows (*Leptodon smithii*) or trees along trackways (Sussex locality for *Rhynchostegium rotundifolium*). Mostly they occur as epiphytes, characteristically on base-rich barks, but occasionally are found on rock; *Syntrichia virescens* is found in a number of man-made habitats such as on asphalt paths. Removal of hedgerows and loss of wayside trees continue to be threats, and the decline in elm may also have had a negative impact. Pollution and eutrophication are also contributory factors in their decline.

Assessment of attributes could be undertaken at any time. If any attribute fails, the feature is not in a favourable condition.

Attributes	Targets	Method of assessment	Comments
Niche availability	No loss of area supporting the interest feature	Mapping, photographs	The site dossier should make it clear exactly which trees and sections of hedgerow are of importance. Photographs and text in the dossier should explain how the hedgerow should be managed (*e.g.* cutting regime) in order to maintain the interest.
Negative indicators: pollution	Algae should be no more than rare No dense growth of pleurocarpous mosses No other evidence of eutrophication or pollution	Visual assessment	Lower plants tolerant of pollution and/or eutrophication should be absent or rare. Proximity to intensive agricultural regime should be a warning to check for problems.

UK GUIDANCE ON CONSERVATION OBJECTIVES FOR MONITORING DESIGNATED SITES

Interest feature: Bryophyte species of scrubby woodland (Special habitat 6)

A group of epiphytic mosses that typically occur in scrubby woodland, on the shrub layer within open woodland, or more rarely on wind-pruned coastal scrub (*Ulota calvescens*). The host tree range is wide and includes hazel, elder, willow and juniper. More mature scattered trees, such as ash, aspen, rowan, sycamore and wych elm may also support these species. They typically require open conditions with good light, although not exposed and many thrive in high humidity situations. *Platygyrium* and *Pylaisia* can tolerate some degree of shading. Some species are highly characteristic of certain trees, such as *Orthotrichum obtusifolium* on aspen in Scotland, or *Pylaisia* on elder. *Orthotrichum* spp. and *Ulota* spp. are highly susceptible to pollution.

Assessment of attributes could be undertaken at any time. If any attribute fails, the feature is not in a favourable condition.

Attributes	Targets	Method of assessment	Comments
Niche availability	No loss of area of scrub supporting the interest feature	Mapping, photographs	The site dossier should make clear which areas of the site are important for their bryophytes. Areas of scrubby woodland are often regarded as of little economic value and thus are cleared/tidied, which would obviously damage the interest feature.
Vegetation structure	Open woodland structure with healthy regenerating shrub layer	Visual assessment	This varies according to the interest feature and site, the site dossier should include details. Elder is important for some species and should be freely regenerating. Aspen woods are typically open and there should also be evidence of regeneration.
Negative indicators: pollution	No evidence of pollution or eutrophication: algal growth, presence of pollution tolerant epiphytes, lack of epiphytes	Visual assessment	Most of the species associated with this habitat are intolerant of pollution (sulphur dioxide, industrial smokes, acidification, nitrogen deposition). Proximity to pollution sources, or being downwind of a source are warning signs.

UK GUIDANCE ON CONSERVATION OBJECTIVES FOR MONITORING DESIGNATED SITES

Interest feature: Bryophyte species of disturbed open lowland calcareous grassland (Special habitat 7)

Generally small bryophytes that are intolerant of competition and soon disappear if shaded by grasses and other vegetation, they require bare ground or open turf. Many in this group are characteristic of chalk, a few are more or less restricted to it, whereas some are found on other limestones. Paths and trackways often provide suitable niches where trampling suppresses vascular plant dominance. Disturbance (grazing) by sheep and rabbits, maintaining a short open turf, is ideal, although cattle also provide niches. Ancient earthworks and banks, where there is some soil slippage and sheltered overhangs and crevices, are often good for bryophytes. Threats include neglect (lack of grazing, scrub/coarse grass encroachment), improvement (fertilizer etc), eutrophication.

Assessment of attributes should ideally be between autumn and spring; in summer bare ground is less obvious and ephemeral species are not evident. If any attribute fails the feature is not in a favourable condition.

Attributes	Targets	Method of assessment	Comments
Niche availability	Sufficient area of suitable habitat to maintain population 10-25% sparsely vegetated / bare ground within defined areas	Mapping, visual assessment	The site dossier should be used to identify the areas important for the feature; these should be mapped and defined in the dossier. Turf is seldom uniform across a site; tracks, banks, *etc.* will typically support a short, more open turf. Rocky broken turf with thin droughty soils is a good niche where bryophytes can gain a hold.
Vegetation structure	Turf height less than 2 cm over at least 50% of the area supporting the interest feature.	Mapping, measurement	The site dossier must be used to define the areas where this attribute should be measured. Some species, such as *Thuidium abietinum*, can be maintained in a tight grazed fine-grass turf (coarse grass communities CG4 and CG5 are not generally favourable). Grazing would tend to create small pockets of bare ground within which bryophytes can establish.
Niche diversity	Anthills, soil slippage on steep slopes, terracing, S- and N-facing banks, *etc.* should be maintained where present	Comparison with photographs and sketch maps	A greater diversity of niches will support a greater diversity of bryophytes.

UK GUIDANCE ON CONSERVATION OBJECTIVES FOR MONITORING DESIGNATED SITES

Interest feature: Bryophyte species of lowland heathland with bare ground that is winter-wet, summer droughted with light disturbance (Special habitat 8)

All the threatened or scarce bryophytes on lowland heathland typically require open ground with bare nutrient-poor soil. The bare ground is often kept open by the harsh edaphic conditions including winter wet but droughted in summer. The open areas within lowland heath may be examples of acid grassland types (*e.g.* U1). In other circumstances bare open ground is maintained by regular but not excessive use of heathland paths and tracks. Some species can also be found in ruts. Low intensity grazing is ideal to maintain open areas (but may be detrimental to other cryptogam groups) and/or mowing. Threats include closing over of open ground by vascular plants, neglect, uncontrolled burning and inappropriate maintenance of tracks.

Assessment of attributes could be undertaken most times of the year. If any attribute fails, the feature is not in a favourable condition.

Attributes	Targets	Method of assessment	Comments
Niche availability	Sufficient area of suitable habitat to maintain population No loss of open heath (where *Calluna*/grass cover is less than 50%) Open heath areas to remain in same locations on site	Mapping, visual assessment	The site dossier should be used to identify the areas of open heath important for bryophytes. Scrub encroachment, development, and any other factor reducing the area of open heath is damaging. Some species may have a weak dispersal potential, therefore it is important to maintain existing areas of open ground, and not allow the open heath areas to move around the site.
Vegetation structure	At least 50% of site to consist in pioneer/degenerate *Calluna* OR At least 50% of site with vegetation height less than 15 cm	Visual assessment	Bryophytes can survive under an open canopy of *Calluna* in degenerate/pioneer stages, but not under a dense canopy. Aim should be to retain/create bare patches in heath mosaic.
Niche diversity	Area maintained where soils wet in winter / droughted in	Visual assessment based on mapping and aerial	Several species have specialist requirements of open bare ground (often with only other bryophytes and lichens as

	summer Features such as banks and paths retained	photographs	associates) that are wet in winter but dry out in summer. The regular use of paths or tracks is beneficial as long as there is not excessive erosion.
Species composition	Area of interest feature should appear approximately like the photograph in the site dossier	Conmparison with photographs	The area supporting the interest feature (*e.g.* a winter wet depression) should be photographed to convey the ideal state. This photograph will be in the site dossier. It may indicate a composition characterized by patches of bare ground with bryophyte and lichen associates and scattered tufts of fine grasses and small herbs.

UK GUIDANCE ON CONSERVATION OBJECTIVES FOR MONITORING DESIGNATED SITES

Interest feature: Bryophyte species of snowbeds (Special habitat 9)

A community characterized by small hepatics and mosses in areas where snow persists into the summer such as north facing corries and depressions. Found at high altitudes, the best examples are in Scotland. Threats include recreational development/pressure, atmospheric pollution, and global climate change poses an insidious threat.

Attributes	Targets	Method of assessment	Comments
Niche availability	No loss of area of snowbeds	Ideally satellite technology to monitor snow lie	Scotland in particular has a detailed inventory of snowbeds from which to monitor change.
Niche diversity	No observable loss of diversity from baseline	Comparison with photographs	The site dossier should include photographs illustrating the range of important niches on the site. Some species are terricolous on mineral soils, but others are indicative of runnels from snow melt, scree and crags in the vicinity of the snowbed.

UK GUIDANCE ON CONSERVATION OBJECTIVES FOR MONITORING DESIGNATED SITES

Interest feature: Bryophyte species of montane flushes (Special habitat 10)

A group of mosses characteristic of sites with a constant seepage of water, often over rock but sometimes detritus. The bryophytes associated with such habitats are often found in association with calcareous rocks, but not exclusively, some species being found on granite. Water is typically oligotrophic. Growth form varies between the bryophytes being components of turf on the edge of flowing water, to being components within sedge dominated flushes, to forming more or less single species tussocks. Sometimes associated with run-off from snow melt or late snow-lie. Water temperature is also a factor, and some flushes (*e.g.* a *Pohlietum glacialis* spring), consistently show temperatures below 4°C. Whilst this group of species is typical of 'montane flushes', some species are also characteristic of dune slacks. Favourable assessment requires maintenance of the seepage of water low in nutrient levels, of a pH consistent with the geology, and in quantities falling within a certain range consistent with historical levels. Flushes usually have a proportion of open ground (maintained perhaps by a combination of water movement, freeze-thaw, erosion and grazing/light poaching). Mechanisms to maintain these open conditions should continue to operate.

Assessment of attributes could be undertaken at any time, although the sites may be more accessible in the summer. If any attribute fails, the feature is not in a favourable condition.

Attributes	Targets	Method of assessment	Comments
Water quality	95% of montane flushes/springs running with cool, clear water	Visual assessment	The site dossier should indicate the flushes important for the bryophyte feature. Cloudy water, indicating nutrient enriched water, would be emerging evidence of a serious problem – possibly affecting a more extensive area than the site itself.
Water movement	All flushes and springs showing water movement	Visual assessment	May be difficult to establish if movement sub-surface. Lack of water movement could be caused by prolonged sub-zero temperatures or lack of precipitation resulting in drought. This attribute is not relevant to *Scorpidium turgescens* in England where it occurs in solution hollows in limestone pavement.
Vegetation structure	No encroachment by scrub	Visual assessment	Scrub encroachment may indicate drying out of flush, or may result in response to relaxation of grazing pressure.

	Some open areas present		Bryophytes are not able to survive under canopy, although scrub along margins may help to maintain cool humid microclimate. Open areas should be present to allow colonisation by vegetative propagules or spores.
Negative indicators: disturbance	All flushes or springs free from excessive trampling or poaching	Visual assessment	Poaching could provide a mechanism for keeping areas open otherwise likely to occlude, but trampling by either stock or humans would need to be assessed in terms of whether the site is sustaining pressure which needs to be addressed through grazing or through recreational management.

UK GUIDANCE ON CONSERVATION OBJECTIVES FOR MONITORING DESIGNATED SITES

Interest feature: Bryophyte species of the montane hepatic mat (Special habitat 11)

A group of attractive and robust species characteristic of humid but well-drained, shady slopes, on loose block scree and exposed boulder fields often in N- and E-facing corries, sometimes under dwarf-shrub heath, in acid grassland, or on acidic cliff ledges. Sometimes associated with late snow-lie. Typical of cool wet climates. Consists of several species that show very disjunct distributions for which the UK is of major importance.

Assessment of attributes should be undertaken in July or August. If any attribute fails, the feature is not in a favourable condition.

Attributes	Targets	Method of assessment	Comments
Niche availability	No loss of known area supporting feature of interest	Mapping, photographs	The site dossier should indicate the areas important for the bryophyte feature.
Vegetation structure	Ericaceous sub-shrub cover healthy and regenerating	Visual assessment	Shelter is important for this group of species, provided by the sub-shrub canopy and gaps between blocks in scree.
Negative indicators: fire	No evidence of burning	Visual assessment	Burning is particularly damaging to this group of species, and may arise as a result of out-of-control muir burns or vandalism.

UK GUIDANCE ON CONSERVATION OBJECTIVES FOR MONITORING DESIGNATED SITES

Interest feature: Bryophyte species of montane heath (Special habitat 12)

A group of species which occur either on open disturbed mineral soils (*Ditrichum lineare*, *Philonotis cernua*), in *Racomitrium* heath amongst rocks (*Herzogiella striatella*), or occur in the shaded and humid conditions provided by a dwarf-shrub canopy (*Adelanthus*). Mosaics of this kind, commonly found within the broad category 'montane heath' means these species may or may not occur as associates in any one area. *Adelanthus* is found only on Islay in the UK. Burning is thought to be damaging, and *Adelanthus* is particularly sensitive. However, *Philonotis cernua* is said to be associated with previously burnt areas. Over grazing is damaging to all features.

Assessment of attributes should be undertaken in July or August. If any attribute fails, the feature is not in a favourable condition.

Attributes	Targets	Method of assessment	Comments
Vegetation structure	Less than 20% bare ground Dwarf shrub canopy covering 60-100% of area, no more than 50 cm tall	Mapping, measurement	The site dossier should indicate the areas of the site that should be assessed. Some species in this group occur in disturbed ground, therefore evidence of some erosion is not necessarily a cause for concern. The dwarf shrub canopy of species such as *Calluna*, *Juniperus*, *Vaccinium myrtillus* provides humid conditions which suits some of the bryophytes in this group.
Negative indicators: fire	No evidence of burning	Visual assessment	Whilst fire in montane heath is not desirable, in that it can precipitate erosion, *etc.*, *Philonotis* appears to favour burnt peat, so if this species is a known feature of interest then some evidence of fire is acceptable (refer to site dossier).

UK GUIDANCE ON CONSERVATION OBJECTIVES FOR MONITORING DESIGNATED SITES

Interest feature: Ephemeral bryophyte species of reservoirs and ponds (Special habitat 13)

These mosses and liverworts are typically found on the draw-down zone of reservoirs and other standing water bodies. They tend to be ephemeral, appearing in early winter or spring following a lowering of water-levels which exposes bare mud. Maintenance of artificially high water table throughout the year (for recreational purposes) is thought to be a threat, and pollution events may also be damaging.

Assessment of attributes should be undertaken in late autumn. If any attribute fails, the feature is not in a favourable condition.

Attributes	Targets	Method of assessment	Comments
Water level	Water levels should fluctuate seasonally, exposing a margin of mud at least 10 metres wide in late summer/early autumn for a period of at least 12 weeks	Measurement	This refers to reservoirs; ponds can be expected to have narrower draw-down zones. The precise height of water tables will be affected by rainfall and should be taken into account. If the summer has been abnormally wet then draw-down may be reduced, but more than one year in any three may be of concern.
Water quality	No obvious signs of pollution evidenced by excessive algal growth or discoloration of water	Visual assessment, existing water quality monitoring systems	Without analytical testing, pollution can be difficult to detect. EA/SEPA should be consulted – monitoring is likely to be in place. Presence of the bryophyte species themselves (if these can be identified, see site dossier) is a good indicator that water quality is adequate.
Vegetation structure	Dominant vascular plant growth on draw-down zone less than 5%	Visual assessment, mapping	A thick cover of vascular plant growth will suppress bryophytes. Could be a build up of *Salix* scrub or an annual flush of *Polygonum* spp. (water peppers). This may indicate over-abstraction problems.

UK GUIDANCE ON CONSERVATION OBJECTIVES FOR MONITORING DESIGNATED SITES

Interest feature: Bryophyte species of riparian habitats – rivers and other water bodies including flood-zones (Special habitat 14)

A heterogeneous group, but all depend on presence of water, either running (headwaters or lowland), still or flood-zone. A number of species are very rare, known from just a single locality (and on a single rock), some are restricted to one water course, and others are more widespread. Many are submerged for most of the year, such as *Cinclidotus riparius*, although it may be exposed at particularly low flows. Both *Thamnobryum angustifolium* and *T. cataractarum* are normally completely submerged all year round and can only be directly monitored by sampling below water level. The position in a water course may vary; along banks, as in the case of *Porella pinnata*, either on rocks, soil or tree roots; or in the channel on rocks. *Ricciocarpos natans* occurs in still or slow flowing bodies, and *Dumortiera hirsuta* is characteristic of dripping rocks and steep banks in shaded glens, sometimes in wooded estuaries. *Grimmia lisae* is characteristic of rocks close to water, particularly lakes and lochs. A well defined group of species is characteristic of the flood zone of larger rivers, including *Cryphaea lamyana* and *Myrinia pulvinata*. *Orthotrichum sprucei* is characteristic of twigs and roots of trees which hang over the water. Threats come largely from alteration of the water course and its bankside vegetation, abstraction of water affecting flow, pollution and recreation.

Assessment of attributes could be undertaken at any time of year, although it may be desirable to time the visit so that high water flows can be seen. If any attribute fails, the feature is not in a favourable condition.

Attributes	Targets	Method of assessment	Comments
Niche availability	No loss of area of feature of interest	Mapping, photography	Refer to the site dossier for details of the relevant area to assess. The water course and associated habitat (*e.g.* bankside trees, rocks) should remain intact, such as a specific stretch of river or pond. Inappropriate management of water course/bankside vegetation is the cause of loss of species. Trees within flood-zones are particularly important to retain.
Water quality	No evidence of pollution in water course or associated habitats	Visual assessment	Pollution is not always evident, but discoloration of water, a film on the surface, foam or dying vegetation/animals are more obvious signs. Pollution in canals may be a threat to *Octodiceras fontanum*, although this can be found in dirty water, but probably not optimal.
Water flow	Water levels should be	Visual assessment,	This will depend on whether the feature is associated with

	commensurate with the type of water course	measurement	a small burn, a stream or larger river, and may vary within and between years.
Water level	Inundation of flood-zone should occur at regular intervals (to be determined from historic data)	Visual assessment	Periodic inundation is necessary for the specialized flood-zone community; can check by direct observation of high water, but also indirectly by signs of silt deposition on vegetation and on tree trunks.
Negative indicators: disturbance	No excessive disturbance to feature of interest	Visual assessment	Fishing/angling activities may cause local damage to sensitive communities. Boating traffic may also lead to erosion problems.

UK GUIDANCE ON CONSERVATION OBJECTIVES FOR MONITORING DESIGNATED SITES

Interest feature: Bryophyte species of sand dunes and slacks (Special habitat 15)

A group of species characteristic of sand dunes, slacks and periodically wet, typically oligotrophic, sandy ground. Most are typical of winter wet dune slacks, and may die back during the summer months, and therefore are not typical of loose, unstable sand (cf. psammophytes). Sites should remain damp all year round, at least just under the surface; under such conditions such species as *Petalophyllum ralfsii, Moerckia hibernica, Amblyodon dealbatus* and *Catoscopium nigritum* may occur. *Drepanocladus lycopodioides* may be locally abundant in some seasonally wet slacks. The *Bryum* group are highly characteristic of dune slack (but are taxonomically difficult), but may also occur on other damp sandy ground by the coast. They often disappear during the summer months, and mature sporophytes are needed for identification (late summer). Most species are poor competitors and are suppressed by excessive vascular plant growth; winter flooding checks vascular dominance normally, although grazing by rabbits or sheep may be important in some areas. The habitat is under threat throughout its range from coastal development, recreation, disturbance, eutrophication, change in water regime and neglect.

Water level should be checked in the winter, other attributes (particularly scrub encroachment) should be checked in the summer. If any attribute fails, the feature is not in a favourable condition.

Attributes	Targets	Method of assessment	Comments
Niche availability	Sufficient area of suitable habitat to maintain population No loss of area supporting the interest feature	Mapping, photography	The site dossier should contain maps and photographs showing the extent of ground supporting features of interest.
Water level	Water table at or above surface of slack for prolonged period during winter months	Visual assessment	Water table should be free to fluctuate with seasonal changes in rainfall; it is not possible to be prescriptive about the period inundated since this varies year on year.
Negative indicators: pollution	No evidence of excessive algal growth in dune slacks	Visual assessment	Run-off from nearby agricultural land may lead to algal blooms in spring; although temporally separated, it does nevertheless indicate potential nutrient enrichment problems.
Negative indicators: disturbance	No evidence of excessive disturbance to slack (or other sandy ground)	Visual assessment	Dunes and dune slacks are sensitive to excessive trampling which may result from being a popular spot for dog walkers, joggers, *etc.* Signs such as dog faeces should also be noted.
Negative indicators: scrub	Slacks and other sandy ground supporting the interest feature should be predominantly free from scrub	Visual assessment	Under certain conditions scrub can be a problem; brambles, bracken, pine, birch, sea buckthorn are typical invaders. Excessive creeping willow and thick grass cover is also undesirable.

UK GUIDANCE ON CONSERVATION OBJECTIVES FOR MONITORING DESIGNATED SITES

Interest feature: Bryophyte species of coastal habitats including hard or soft cliffs, landslip, talus and maritime caves (Special habitat 16)

Although the members of this group may occupy a wide range of niches, the common attribute is their coastal situation which exposes them to harsh conditions from drought to high salinity levels. There is some overlap with inland occurrences of cliffs, grasslands and rock exposures, but it is convenient to recognize a coastal element. Many species are terricolous, on cliff-top open grassland, or on banks close to the sea. A few species are saxicolous including *Grimmia tergestina* and *Cyclodictyon laetevirens*, the latter growing in dripping caves. Typically others occur on thin soil over coastal rock, including *Tortula canescens* and *Tortula cuneifolia*. Threats include coastal development, pollution (esp. oil), recreation, outfall pipe works, coastal protection schemes, and neglect/lack of grazing on cliff tops. Natural landslip may adversely affect some species (*e.g. Southbya nigrella*).

Assessment of attributes should be undertaken between the autumn and the spring. If any attribute fails, the feature is not in a favourable condition.

Attributes	Targets	Method of assessment	Comments
Niche availability	No loss in area supporting the feature	Mapping	The site dossier should be used to determine the area supporting the interest feature. Some habitats are dynamic, such as soft cliffs and landslip, and populations are known to fluctuate as a result of geomorphological changes. However, extensive landslip in an area where species are highly restricted (*e.g. Southbya nigrella*) is unfavourable, as are any sites so unstable as to preclude establishment of plants.
Vegetation structure	TERRICOLOUS SPECIES: Turf height no more than 2 cm (cliff top grassland) with little or no scrub SAXICOLOUS SPECIES:	Visual assessment, measurement	Use the site dossier to assess whether terricolous or saxicolous species constitute the interest feature, and where these occur. The feature should not be shaded by vegetation such as tall herbs at the base of cliffs or invasives such as *Carpobrotus*. Some species may occur in sheltered ravines (chines) where light levels are

	At least 10% of the substrate/rock surface available for colonization (*i.e.* unoccupied)		reduced: *Cyclodictyon laetevirens* occurs in dark sea caves.
Water presence and quality	No evidence of changes (*e.g.* no flow or reduced flow) in fresh water seepages or pollution/contamination	Visual assessment	Some species occur where fresh water percolates through or over the cliff face, therefore any drying out or change in quality is potentially damaging.
Negative indicators: disturbance	No evidence of coastal development or works that disrupt integrity of site	Visual assessment	Coastal defence works may change geomorphological processes, or effluent discharge works may affect cliffs (*e.g. Didymodon cordatus*).

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Interest feature: Bryophyte species of machair (Special habitat 17)

A group of strongly calcareous species associated with machair (this equates largely to NVC SD8 *Bellis-Ranunculus* and *Prunella* subcommunities; Corine C1A). Several of the species also occur within the montane suite. Some species grow in calcareous slacks which may flood in winter. *Catoscopium nigritum*, can form extensive carpets, others such as *Drepanocladus lycopodioides* grow as components of sedge rich communities. Favourable condition assessment requires evidence that the nutrient and water regime are compatible with the low level of nutrients and the damp/moist habitat required by these species is being maintained. Further, this group of species could become obliterated by vascular plants should grazing become too light or cease.

Assessment of attributes should be undertaken in the winter or spring, although sward height needs to be assessed in the summer. If any attribute fails, the feature is not in a favourable condition.

Attributes	Targets	Method of assessment	Comments
Vegetation structure	Sward height less than 20 cm in the summer Vascular cover less than 80%	Measurement	A tall vascular plant sward all year round would shade out smaller bryophytes. Grazing would reduce competition from vascular plants and create bare patches of ground; a hay crop with aftermath grazing is also acceptable.
Water level	Low lying areas clearly wet in winter months and damp in summer At least some indicator species present: creeping willow, horsetails, pennywort, corn mint, marsh helleborine, *Calliergonella cuspidata*, *Campylium stellatum*	Visual assessment, identification	Free draining shell sand typically occurs over peat within which water levels often show seasonal variation.
Nutrient status	High vascular plant diversity, with ratio of grasses to herbs about 30:70	Visual assessment	Application of artificial fertilizer would encourage grass growth at the expense of herbs and bryophytes. Seaweed application is acceptable at 'traditional' levels.
Negative indicators: scrub	Scrub such as brambles, birch and pine should be no more than rare on the site, and not expanding	Visual assessment, photography	If neglected (low or zero grazing) scrub can invade. This is detrimental to the flora, including bryophytes.

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Interest feature: Bryophyte species of lowland calcareous rock (Special habitat 18)

The species are all characterized by being more or less confined to calcareous rock outcrops, chalk or limestone, including ledges, stones and pavement, in the lowlands. The niche varies with a few species tolerating quite deep shade *(Brachythecium appleyardiae, Campylophyllum calcareum, Didymodon glaucus*) to those that require unobstructed light (*Bartramia stricta, Grimmia* spp.), although most occur in sheltered, lightly shaded situations. Some grow directly on rock (*Seligeria* spp., *Leptobarbula berica, Grimmia* spp.) whilst others extend to thin soils on rocky banks and ledges. In addition, a few are found on walls including *Brachythecium appleyardiae* in its Wiltshire station. A few members of this group are very restricted, known from single to a few sites. *Scorpidium turgescens* was recently discovered on limestone pavement in England. Threats include re-working of quarries/pits (although may also be beneficial), illegal dumping, maintenance of structures such a bridge/viaduct supports and walls, and eutrophication. Some species (*e.g. Seligeria calcarea*) grow on small stones in broken turf, especially in old quarries, and tall grass growth will result in loss.

Assessment of attributes should be undertaken from the autumn until the early summer. If any attribute fails, the feature is not in a favourable condition.

Attributes	Targets	Method of assessment	Comments
Niche availability	No loss in the area supporting the feature or in the area of potential substrate within the site	Mapping, photography	The site dossier should be used to identify the area supporting the feature and also potential habitat. A number of these species are found in old quarries and pits; late successional changes are often unfavourable, so may require management to maintain the pioneer stages; limited reworking may be beneficial. Unoccupied (*i.e.* potential habitat) is important to allow dynamic population movement within the site.
Vegetation structure	Vascular plant cover less than 20% within 50 cm range of the interest feature.	Visual assessment	The site dossier must be used to identify the area in which this attribute is assessed. Competition from vascular plants should be minimal. Some species *e.g. Seligeria campylopoda* grow on small stones in woodland, so a tree canopy is favourable in such situations. Vascular plant cover such as tree canopy may provide sheltered/humid conditions, and therefore there is a need to ass whether to clear the cover carefully.

UK GUIDANCE ON CONSERVATION OBJECTIVES FOR MONITORING DESIGNATED SITES

Interest feature: Bryophyte species of lowland, unshaded acid rock, including sarsen stones (Special habitat 19)

This group of species typically require unshaded acid rock, including coastal cliff faces, crags and quarry faces inland, stone walls and sarsen stones that have not been moved from their original positions. Rarely, *Grimmia ovalis* may occur on roofing slates. Some (*e.g. Campylopus pilifer* and *Coscinodon cribrosus*) are characteristic of dry rocks, whilst others (*e.g. Racomitrium affine*) prefer intermittent wetting. *Tetrodontium* has not been seen recently in the UK, and occurs on the underside of moist sandstone or gritstone rock. All are predominantly lowland but can extend to extreme north and are less common in southern England where acid outcrops are restricted. Threats include shading by trees, grasses *etc.*, recreational pressure (abseiling, rock climbing), lambs playing on sarsen stones, movement of sarsen stones to edges of fields, pollution. Management of sarsen sites should include grazing with sheep preferably, otherwise cattle or mixed at low stocking rates throughout the year to control rank potentially shading vegetation; but care is needed to avoid abrasion to the rocks and eutrophication of the rock surface (urea deposition).

Assessment of attributes could be undertaken at any time. If any attribute fails, the feature is not in a favourable condition.

Attributes	Targets	Method of assessment	Comments
Niche availability	No loss in the area supporting the interest feature OR No loss of individual sarsen stones	Mapping, photography	The site dossier should be used to identify the areas which support the interest feature. The integrity of the rock exposures should still be apparent; there should be no obstruction of cliff or quarry faces, and no unsympathetic maintenance of walls. There should be no signs of abrasion.
Vegetation structure	Surrounding vegetation should not shade rock surfaces	Visual assessment	Species are intolerant of shade. Herbs and grasses partially obscuring sarsen stones is unacceptable.
Integrity of rock	Sarsen stones should remain in original positions	Mapping	Sarsen stones are commonly moved to facilitate agricultural operations; this results in the bryophyte interest being lost (in contrast to lichens which can colonise moved stones).
Negative indicators: vascular plants	Invasive species such as *Buddleia* or *Urtica* no more than rare	Visual assessment, identification	Invasive species on cliff faces (*e.g. Carpobrotus*, *Buddleia*, ivy, brambles) are damaging. *Urtica dioica* may indicate eutrophication in grassland that supports sarsens.
Negative indicators: pollution	No signs of eutrophication in grassland supporting sarsens, or evidence of herbicide use	Visual assessment	Bryophytes on sarsen stones may be sensitive to eutrophication (dry or wet deposition, muck spreading) and herbicides (may be apparent in wilting 'weeds').

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Interest feature: Bryophyte species of scree (Special habitat 20)

Although the individual species are often found in sheltered and humid situations in block-scree, sometimes sheltered by a canopy of dwarf-shrubs, they constitute a rather heterogeneous grouping. Many of the species are very rare, known from just a single to a few sites. Most occur on siliceous sub-montane rocks in the oceanic north and west, often with the fern *Cryptogramma crispa*, and sometimes close to snow-beds where *Athyrium distentifolium* is a characteristic fern. Some species such as *Anastrophyllum saxicola* are characteristic of dry screes, whilst others such as the *Marsupella* are characteristic of wet screes where rocks are intermittently irrigated. Different species occupy different positions within the block scree, *Arctoa fulvella* on exposed tops, and *Brachythecium reflexum* between blocks where there is shelter. *Mastigophora woodsii* and *Plagiochila carringtonii* also occur in the sheltered interstices, often under a sub-shrub ericaceous canopy, but are perhaps better represented within the montane hepatic mat (Special habitat 11).

Assessment of attributes should be undertaken in July or August. If any attribute fails, the feature is not in a favourable condition.

Attributes	Targets	Method of assessment	Comments
Niche availability	No loss of area of block scree supporting feature of interest	Mapping, aerial photography	The site dossier should be used to identify the areas of block scree which are important for the bryophyte interest feature. Block scree, although an erosion feature, is generally stable, and unlikely to suffer loss or disturbance.
Negative indicators: fire	No evidence of burning	Visual assessment	Occurrence of fire in the sub-shrub canopy may lead to deleterious modification of the microclimate.
Negative indicators: disturbance	No disturbance observable in the form of abrasion or damage to the vegetation	Visual assessment	Recreational activities such as bouldering, scrambling, or access to a climbing route on cliffs above may be a threat.

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Interest feature: Bryophytes of arable habitats (Special habitat 21)

All species in this group require open conditions with regular disturbance (*i.e.* part of a cultivation regime), low or no competition and preferably little or no herbicide or fertilizer treatments. Stubbles are ideal but a range of other conditions are also suitable such as field margins and headlands. Threats include intensive cultivation regimes, early cultivation dates, vascular plant competition (long term setaside *etc.*).

Assessment of attributes should be undertaken between November and March. If any attribute fails, the feature is not in a favourable condition.

Attributes	Targets	Method of assessment	Comments
Niche availability	One or more margins/conservation headlands/uncropped strips in a field with obvious presence of mosses, or at least one stubble field and/or early rotational set aside on a farm.	Visual assessment	Occurrence of stubble *etc.* will depend on farming practices/agri-environment schemes in any particular geographical area. Soil type and characteristics will also affect presence/absence of bryophytes. Diaspore bank is also important. Margins/headlands should not be shaded by overhanging trees.
Vegetation structure	At least 20% bare ground (including moss cover) interspersed with low-moderate vascular cover (including crop) and organic debris (straw *etc.*)	Visual assessment	Vascular plants including the crop should not be so dominant as to suppress bryophytes which are generally poor competitors.
Disturbance	Stubbles left until mid-March (unless autumn cultivation in October)	Visual assessment	Some species (*Anthoceros* spp.) are summer annuals and require stubble fields (spores disturbed during spring cultivation and sporophyte form late summer or early winter).
Negative indicators: vascular plants	Nettles, cleavers, chickweed and vigorous grasses no more than rare.	Visual assessment, identification	Higher nutrient status not necessarily damaging to bryophytes directly, but they are intolerant of competition.

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Interest feature: Bryophyte species of industrial habitats with contaminated or toxic soils (Special habitat 22)

Some bryophytes are renowned indicators of metal-bearing rocks (*e.g.* 'copper mosses'). Industrial processes often leave behind waste products such as mine spoil, bings (coal spoil), highly alkaline spoil and china clay waste. Typically the bryophytes require open, bare ground with some disturbance. The substrates are often toxic to vascular plants, but a number of bryophytes tolerate and thrive under these low-competition conditions. Grazing (sheep) may be desirable, but eutrophication from dunging may be a problem. *Bryum pallescens* sometimes occurs on thatch that has a cover of galvanized (zinc) wire (toxic to other thatch mosses though), or on soil under wire fences or under pylons. To maintain a plagiosere, disturbance may be required or herbicides may be used to keep down competitors (*e.g.* in management for *Marsupella profunda*). Threats include landscaping, development, neglect.

Assessment of attributes should be undertaken between late autumn and spring. If any attribute fails, the feature is not in a favourable condition.

Attributes	Targets	Method of assessment	Comments
Niche availability	No loss in total niche area	Mapping	Any loss of potentially suitable (*i.e.* could support the feature of interest) ground within a defined site will reduce the capacity of meta-populations to colonise unoccupied niches. There should no evidence of recent dumping, excavation or redistribution of materials (boulders *etc.*).
Bare ground	At least 80% bare ground	Visual assessment	Bare ground is either soil/spoil or moss/lichen cover. As toxicity of soils ameliorates, vascular plants will establish. The bryophytes are intolerant of any competition. Clearance of gorse *etc.* may be necessary. However, if there is no replenishment of toxic substrate maintaining suitable conditions, the site may not be viable in the long term. Regular disturbance may be necessary to recreate suitable conditions.
Hydrology	Any streams or water courses flowing through the metalliferous site should be	Visual assessment	Cessation or reduction of flow may lead to loss/decline of *Cephaloziella massalong* and possibly *C. nicholsonii*. Water quality should remain high and pass through

	maintained		metal-rich beds/ground and not be diverted.
Negative indicators: eutrophication	No signs of concentrated dunging from stock or latrine formation (to the extent that it is physically smothering) in areas identified as supporting the interest feature	Visual assessment	The site dossier should be used to identify the most important areas to assess. The species may not only be physically obliterated by dung, but this will also encourage colonization by vascular plants through the elevated nutrient levels.

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Interest feature: Bryophyte species of anthropogenic habitats – man-made structures (Special habitat 23)

A group of mosses that currently have their main locus in the UK on man-made structures such as walls, on mortar, mud capped walls, bridge supports and concrete. One species which used to grow on mud-capped walls in southern England (*Pterygoneurum lamellatum*) may be extinct in the UK, and *Ceratodon conicus*, often an associate, is now very rare but may still occur on compacted ground overlying the Oolite. *Zygodon gracilis* occurs on drystone walls in the Craven district, and only very rarely has it been recorded on natural outcrops. *Grimmia crinita* is possibly casual; it was once known on a concrete bridge revetment in Warwickshire but has been lost, however it was found recently on concrete in Cornwall. *Tortula freibergii* occurs on sandstone walls and rocks, and in the Manchester area on sandstone canal edging. *Didymodon umbrosus* occurs on mortar at the base of walls but is considered to be an introduction. Two additional mosses could be mentioned (links to other special habitats) *Brachythecium appleyardiae* which grows on a wall in Wiltshire (but has more records on natural rock outcrops) and *Rhynchostegium rotundifolium*, which occurs on a roadside wall in Gloucestershire, and on trees in a hedgerow in Sussex. Most species are under substantial threat, mostly from unsympathetic maintenance or even destruction of structures, and from eutrophication.

Assessment of attributes could be undertaken at any time. If any attribute fails, the feature is not in a favourable condition.

Attributes	Targets	Method of assessment	Comments
Niche availability	Structure supporting interest feature intact and not damaged	Mapping, photography	Maintenance of walls and other structures often proceed in ignorance of interest. Even when interest is flagged up to authorities, damage is possible. Notify owners/managers and monitor regularly.
Bryophyte layer	Bryophyte growth evident on structure supporting interest feature	Photographs, sketch maps	Ideally, the actual species of interest should be monitored, using the photographs and location details in the site dossier. Some authorities are zealous cleaners of bridges *etc.* and remove moss and other plant growth with sprays or by physical means.

UK GUIDANCE ON CONSERVATION OBJECTIVES FOR MONITORING DESIGNATED SITES

Interest feature: Bryophyte species of quarries and pits (Special habitat 24)

This small group of species is highly characteristic of disused quarries and pits in early successional stages before vascular plant growth dominates. They are, however, not restricted to quarries, and may occasionally occur on compacted soil elsewhere, particularly on banks, footpaths or bare ground within grassland or heathland. *Lophozia capitata* is a calcifuge, typically found in sand-pits where water table is high or at the surface in winter months; *Aloina* spp. are calcicoles, typically in chalk pits or limestone quarries, but *A. rigida* may also occasionally occur in sand and gravel pits, and formerly on mud capped walls (see Special habitat 23). *Gyroweisia* was known at a single site, but it is now thought to be extinct. Threats include neglect (leading to natural succession), development, recreational pressures and unsuitable use of disused quarries and pits, such as rubbish dumps.

Assessment of attributes should be undertaken between the late autumn and spring. If any attribute fails, the feature is not in a favourable condition.

Attributes	Targets	Method of assessment	Comments
Niche availability	Sufficient area of suitable habitat to maintain population No loss of area supporting interest feature	Mapping, photography	The site dossier should be used to identify the areas to assess. Loss of area due to development, dumping of material *etc.* can potentially eliminate the interest feature or reduce the area available to it.
Vegetation structure	Predominantly open with at least 80% bare ground in areas supporting interest feature	Visual assessment	The site dossier should be used to identify the areas to assess. Encroaching scrub, tall herb communities/coarse grass development is unfavourable for low competitive bryophytes that require open ground.
Water level	Evidence of high water table at surface for period in winter	Visual assessment	This is applicable to *Lophozia capitata*, which favours seasonally wet sites. If hydrology/drainage changes and site becomes dry succession, interest feature may be lost.
Negative indicators: disturbance	No evidence of inappropriate levels of recreational activities	Visual assessment	Activities may be varied from climbing to motorbike scrambling. The level is a matter of judgement; low levels of disturbance are in fact frequently desirable.

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Interest feature: Bryophyte species of acid montane cliffs (Special habitat 25)

A heterogeneous group, but all are characteristic of sub-montane to montane rocky outcrops including crags, cliff faces, corries, cliff ledges and isolated boulders. May be on north facing aspects such as both *Dicranodontium* species or exposed to full light, typically all *Grimmia*. Most grow directly on rock, a few are found on thin lithosols. A few species are very rare, known from single localities such as *Grimmia unicolor*. Most are strictly montane, and rarely descend to sea level, and *Brachydontium trichoides* is found in the lowlands. Threats are few, but include recreational pressures and grazing animals accessing cliff ledges.

Assessment of attributes should be undertaken in July or August. If any attribute fails, the feature is not in a favourable condition.

Attributes	Targets	Method of assessment	Comments
Niche availability	No loss of area of rock outcrop	Mapping, photography	The site dossier should be used to identify the areas which need to be assessed. The rock outcrop is unlikely to suffer loss of area directly, although growth of scrub or trees at the base of cliffs would lead to a loss.
Negative indicators: disturbance	No evidence of grazing No obvious evidence of abrasion	Visual assessment	Cliff ledge flora is very sensitive to grazing. Rock climbing and scrambling may be a problem.

UK GUIDANCE ON CONSERVATION OBJECTIVES FOR MONITORING DESIGNATED SITES

Interest feature: Bryophyte species of basic montane cliffs (Special habitat 26)

This is a heterogeneous group but contains species of considerable conservation and phytogeographical interest. Many are rare, known from single or a few sites. All are montane, although a few are found in the lowland zone such as *Seligeria pusilla, S. donniana* and *Aloina rigida* and *Tortella fragilis* occurs at sea level (on machair). Some grow directly on rock (*Grimmia* species) but most occur on lithosols or humic soils, often on species-rich ledge communities. Some prefer dry rock, others where there is some periodic flushing. Most are calcicoles, but a few such as *Grimmia unicolor* have a requirement for base other than calcium. Threats include grazing pressures damaging rock ledge communities, recreational activities such as climbing.

Assessment of attributes should be undertaken in July or August. If any attribute fails, the feature is not in a favourable condition.

Attributes	Targets	Method of assessment	Comments
Niche availability	No loss in area of rock outcrop	Mapping, photography	The site dossier should be used to identify the areas to assess. Cliffs, rock faces, crags and similar should remain intact.
Negative indicators: disturbance	No evidence of grazing No obvious evidence of abrasion	Visual assessment	Stock scrambling on fragile ledges and rock faces causes considerable damage to these communities. Signs should be looked for of climbing aids or erosion/abrasion suggesting climbing pressure. Some rock faces may be able to accommodate recreational activity if sited away from the interest feature, check in the site dossier.

UK GUIDANCE ON CONSERVATION OBJECTIVES FOR MONITORING DESIGNATED SITES

Interest feature: Bryophyte species of salt marsh (Special habitat 27)

Salt marshes are normally regarded as dull for bryophytes, but there are exceptions. The genus *Bryum* can sometimes be found in upper salt marsh on bare ground, particularly on the ecotone between dune and marsh where the soils are sandy. The four *Bryum* in the group are very rare and local, but possibly under-recorded owing to difficulties in identification (mature sporophytes are needed). All occur in dune slacks and other damp open places but typically by the coast. Threats are largely through loss of habitat, development or inappropriate management.

Assessment of attributes could be undertaken at any time, although late summer would be necessary if *Bryum* identification was to be attempted. If any attribute fails, the feature is not in a favourable condition.

Attributes	Targets	Method of assessment	Comments
Niche availability	Sufficient area of suitable habitat to maintain population No loss of area known to support the interest feature	Mapping, photography	The site dossier should be used to identify the areas that are important for supporting the interest feature. Upper salt marsh is very prone to being agriculturally improved.
Water level	Area supporting interest feature wet in winter and damp in summer	Visual assessment	Reprofiling of land by upper salt marsh and drainage alters the hydrology resulting in soils drying out, which is not favourable for *Bryum*.
Water quality	No significant influence of nutrient rich run-off from adjoining farmland	Visual assessment	Eutrophication of upper salt marsh is often a problem.
Vegetation structure	5-20% bare ground in area supporting interest feature	Visual assessment	The site dossier must be used to identify the areas where this should be assessed. *Bryum* spp. are poor competitors and require open patches of ground. Thick vascular vegetation is unfavourable.

Appendix 6. Attributes and targets tables for indirect monitoring of habitats associated with lichen interest features

UK GUIDANCE ON CONSERVATION OBJECTIVES FOR MONITORING DESIGNATED SITES

Interest feature: Woodland lichens (Special habitat 28)

There are a large range of woodland types which have subtle but significant differences in the conditions required for lichens. Most of the targets below should be interpreted locally, including information from the site dossier and expert opinion.

Woodlands and areas of scrub which are rich in lichens tend to be oceanic oak woodlands, willow carr, gorge woodlands, Atlantic hazel woodlands in Scotland, scrub woodlands on coastal cliffs and lastly those with old growth stands which are often former woodpasture. Classic coppice with standards woodland is generally of less importance. Old growth stands (veteran trees) provide a substrate for the more slow growing species which are often indicators of continuity, but in optimum conditions as in the west of Scotland relatively young growths can be colonised.

Air quality needs to be good with low levels of SO_2 and nitrogen compounds, such as might originate from livestock units, or nearby applications of fertiliser and slurry, as well as from long distance transport. Generally there should be a good age range of trees to provide continuity of substrate.

Assessment of attributes could be undertaken at any time. If any attribute fails, the feature is not in a favourable condition.

Attributes	Targets	Method of assessment	Comments
Niche availability	No loss of area of woodland	Mapping, aerial photographs	Loss can come about through felling of trees.
Stand structure	Percentage canopy cover appropriate for the wood, as an absolute minimum to be greater than 20% Age-range present amongst trees and shrubs	Visual assessment	**The canopy cover target needs to represent the type of wood, in many cases a target of at least 50-60% will be more appropriate.** Examples of appropriate targets are included in Appendix 8. An age-range target is appropriate for natural woodland, plantations may also be important for lichens. For plantations, the future management needs to be considered. Mature trees tend to be particularly important for lichens

	Dead wood present		
Stand composition	Baseline range of tree/shrub species maintained to ensure continuation of habitat and niches for the species-rich lichen flora in mixed native woodlands	Visual assessment	Different tree/shrub species have varying bark properties/niches, which support a range of lichen communities.
Lichen communities	Targets for communities of lichens should be derived from the site dossier	Visual assessment	There are significant regional differences in the communities that should be present. A site dossier is necessary to determine the targets.
Negative indicators: non-native species	No rhododendron in area of feature Any regeneration of non-native trees should not be at the expense of native trees, unless this is likely to reduce the overall diversity of the woodland (*i.e.* avoiding a formerly mixed wood becoming dominated by birch regeneration)	Visual assessment	Occasionally, 19th century planting of beech and conifer as 'landscape' features has occurred within or at the edges of native woodlands. These plantings may be of historic interest, especially where these trees are now mature specimens, and may also be useful lichen host trees. Regeneration of exotics should be carefully monitored, and kept under control.
Negative indicators: shade	A balance between no grazing and over-grazing. A mosaic of open glades and closed tree canopy to be maintained, retaining diversity of light/shade, humid and well-ventilated conditions around trees and rocks. No more than 10% ivy and/or bramble present. Hazel stools not	Visual assessment; look for evidence of ivy being browsed, glades kept open; bramble not choking glades or covering boulders or rock outcrops; look for evidence of regeneration of trees and shrubs, including any 'phoenix' trees; does hazel exhibit the classic 'tree' form, indicating heavy overgrazing;	Both ivy and bramble can be important additional components of the overall biodiversity of the habitat. It is impossible to define 'light grazing' in terms of numbers of sheep, cattle and/or deer per site or seasonal period. However, periodic assessment should clearly indicate whether grazing is adequate, excessive or insufficient.

	restricted to one or two stems only	is there evidence of thicket regeneration developing	
Negative indicators: pollution	Where the woodland abuts on to agricultural land; trunks, branches and twigs at the periphery should not be seen to carry 20% cover of green, algal 'gunge' deposits No evidence of air pollution damage No evidence of acid rain damage	Visual assessment	Intensive agricultural practices (with dense animal stocking or regular spreading of slurry) result in a build-up of algal deposits on surrounding trees and shrubs. This excessive nutrient input leads to the demise of lichens with a low tolerance of high nutrient-status conditions. Other targets should be set according to the site dossier. They may be targets regarding lichen communities, or they may draw on more general environmental monitoring.

UK GUIDANCE ON CONSERVATION OBJECTIVES FOR MONITORING DESIGNATED SITES

Interest feature: Lichens of Caledonian pinewoods (Special habitat 29)

Primarily of ancient-origin native pine, the tree and vegetation composition of native pinewoods varies across Scotland. On living pine trees, the best development of lichens occurs on older pines, especially open-grown 'granny' trees in sheltered situations. Typically, living pines which support a significant lichen flora often occur as a few individuals within a stand of several hundred trees. Dead wood (especially decorticate pine) is of prime importance as a lichen habitat in native pinewoods. The most species-rich pine lignum habitats also tends to be restricted to a few standing or fallen 'bones' in well-lit, sheltered conditions, and it is believed that these 'bones' can persist for several centuries. Fallen decorticate trunks which are partly lifted from the ground by root plates and upper canopy branches, allowing air to circulate freely, provide the most suitable lignum habitat. 'Snags', or attached, dead decorticate branches are also valuable lignum habitats, and stumps and tree bases that are not overgrown with bryophytes, although partial shading by *Calluna* or *Vaccinium* can provide additional shaded and humid niches. Old, knotty pine roots that have been exposed for a long time (such as on eroded banks or slopes), also provide an additional habitat niche that is not often encountered in more Western pinewoods, where these features are covered in thick bryophyte mats and cushions. Favourable condition for lichens in native pinewoods is ensuring that the 'status quo' of young, mature, old and dead trees (pine and broad-leaved) are continuously present, as many of the specialized lichens associated with the pinewoods are niche-specific if not host-specific. As most of the specialized lichens associated with ancient pinewoods are very small and require microscopic identification, monitoring is not dependent on re-finding characteristic species, but on ensuring a continuity of suitable habitats and niches.

Assessment of attributes could be undertaken at any time. If any attribute fails, the feature is not in a favourable condition.

Attributes	Targets	Method of assessment	Comments
Niche availability	No loss of area of woodland	Mapping, aerial photographs	Loss can come about through felling of trees
Stand structure	At least 30% canopy cover overall Old living pine trees present, together with old birch and rowan (at least) and old aspen and juniper if known to be present at the site Continual presence of dead wood (especially pine 'bones', standing or fallen decorticate	Visual assessment	Trees in glades (especially in sheltered, humid situations) tend to support the greatest lichen diversity. Look out for open glades amongst the stand, and also to some extent in valleys and ravines. Old trees tend to be niche-rich habitats. A continual presence of old trees provides opportunity to retain niches required by specialized lichen assemblages. Pine 'bones' (standing or fallen) are a prime habitat for the more specialized pinewood lichens. 'Snags' (dead, decorticate, but still attached pine branches) are also important,

	pine trunks)		together with old stumps. The ideal ratio of dead wood ('bones') to living pines has never been attempted.
Stand composition	Continued presence of native trees other than pine, shrubs and sub-shrubs known to be present in the stand, or in associated valleys	Look for birch and rowan, but (if known from the site) also aspen, holly, alder, willow, oak, juniper, *etc.* Some may be confined to valleys or ravines.	In native pinewoods diversity of tree species within (or at the edge of) the woods adds to the overall niche-availability for lichen communities.
Vegetation composition	Presence of mossy hummocks with exposed *Calluna* or *Vaccinium* roots (Western native pinewoods only)	Visual assessment	Formed from decaying root plates of fallen trees, exposed 'suspended' roots form an additional niche.
Lichen communities	Evidence of *Caliciales* seen on suitable areas of lignum, particularly pine More than one species of *Bryoria* present Central and western pinewoods should have *Alectoria sarmentosa* subsp. *sarmentosa* present, if previously known from the site Central and western pinewoods should have *Lobarion* communities present (if known from the site) In western pinewoods at least 60% lichen cover, and at least some *Usnea* species present on branches and twigs, especially on birch in well-lit and sheltered situations	Visual assessment, photographs	These targets can only be assessed from a site dossier. The 'pin-head' lichens (*Caliciales*) are one of the key features of the pinewood habitat. Diversity of habitat within pinewoods should support more than one species of *Bryoria*. *A. sarmentosa* subsp. *sarmentosa* is a key species of some Western and Central Native Pinewoods. The oceanic deciduous woodlands support internationally important *Lobarion* communities. In central pinewoods they are often a rare component, usually restricted to rowan, *Salix* or hazel. *Parmelietum laevigatae*, associated with more sheltered conditions on the acid bark of birch, can be locally abundant and species-rich.

Negative indicators: non-native species	No rhododendron in area of feature No regeneration of exotic species	Visual assessment	Occasionally, 19th century planting of exotics (beech, conifer) as 'landscape' features has occurred within or at the edges of native woodlands. These plantings may be of historic interest, especially where these trees are now mature specimens, but any regeneration of exotics should be rigorously curbed.
Negative indicators: disturbance	Grazing evidence minimal, restricted to low-intensity deer grazing	Visual assessment	'Natural' herbivore interaction within the pinewood habitat is seen as contributing to the overall habitat functioning, but must be at a level that allows some natural regeneration to occur.
Negative indicators: pollution	Where the woodland abuts onto agricultural land, trunk, branches and twigs at the periphery should have less than 10% cover of green, algal 'gunge' deposits No loss of *Lobarion* lichens, or decline of species diversity of *Parmelietum laevigatae*	Visual assessment	These targets should be assessed in conjunction with the site dossier. Intensive agricultural practices (with dense animal stocking or regular spreading of slurry) result in a build-up of algal deposits on surrounding trees and shrubs. This excessive nutrient input leads to the demise of lichens with a low tolerance of high nutrient-status conditions. Acid rain is not a phenomenon currently associated with Scotland, but is something that should be considered if there is an inexplicable noted decline in lichen diversity.

UK GUIDANCE ON CONSERVATION OBJECTIVES FOR MONITORING DESIGNATED SITES

Interest feature: Lichen assemblages in woodpasture & parkland (Special habitat 30)

Parkland and pasture woodland of lichenological interest is in favourable condition when there are stands of old growth trees (veteran trees) with large dead standing and fallen timber together with younger trees for long term continuity of the communities. Lichens are often conspicuous on the trunks, (often as coloured or white crusts) and on branches where they may be shrubby and sometimes pendulous. The lichen interest is usually though not exclusively associated with mature or over-mature old growths. The land use around the trees is grazing with moderate or low stock levels and there are no slurry, fertiliser or herbicide inputs (other than spot treatment of herbicides or mechanical control). The trunks of the trees are not heavily shaded through young growth of shrubs or climbers *e.g.* holly or ivy. Air quality should be good. Additional habitats, for example worked wood in old fences, barns *etc.* may also be important, particularly in parks.

Assessment of attributes could be undertaken at any time. If any attribute fails, the feature is not in a favourable condition.

Attributes	Targets	Method of assessment	Comments
Niche availability	No loss of wooded area of parkland or wood pasture No more than 5% loss of old growth ancient trees and large deadwood	Visual assessment, tagging the trees may help in this	It is inevitable that there will be some loss of trees over a period through storm, disease, *etc.* It is important to ensure continuity and no loss through felling or poor management *e.g.* incorrect pollarding.
Stand composition	Maintain dominance of native trees within parkland (especially oak and ash, but also beech and holly) Young, mature and over-mature native trees present	Visual assessment noting approximate ratios Record any young, mature or over-mature trees present, giving approx. numbers or percentage within the habitat, and say whether you consider this is adequate to ensure the	With the possible exception of walnut, sycamore or Norway maple, native trees tend to support a more species rich and luxuriant parkland lichen flora than do non-native species. Young and mature trees within the overall parkland habitat are essential to perpetuate the habitat and provide future host trees for lichens.

		viability of the habitat	
Vegetation composition	No observable change in abundance of ivy on trunks of trees	Visual assessment	
Land use	Low intensity agricultural usage or no evidence of increase in stocking and agrichemical usage	Visual assessment	Changing land use to arable is likely to damage lichen interest unless cultivation stops short of tree drip line and fertilizer usage avoids trees. Increased grazing levels may lead to eutrophication of trees.
Lichen communities	Maintain a range of notable lichen assemblages on different host trees, and different aged trees and parts of trees (trunks including continued presence of niches such as base-rich streaks, crevices, sheltered from direct rainfall *etc.*; branches and twigs), as well as on dead wood No diminution of the aspects occupied by lichens on trunks	Record lichens from a range of trees (age and species) and dead wood, noting carefully host tree species so as to assess the most important phorophytes (trunks, branches & twigs), and the role of dead wood	Different trees species (and age of trees) will support different lichen assemblages. This target should be set once a site dossier is available. Atmospheric pollutants often first affect the lichens on one aspect of a tree trunk, the side away from the pollution source being sheltered from it. A check should be made for any change in this directional effect.
Negative indicators: shade	No observable increase in dense shrub or climber growth particularly of evergreens *e.g.* rhododendron, ivy and holly around tree trunks	Visual assessment	Dense growth, particularly of evergreens is likely to damage the lichen interest through shading.
Negative indicators:	No inappropriate application of organic (e.g. slurry) &	Visual assessment	Both concentrated organic fertiliser *e.g.* slurry and inorganic fertiliser are likely to damage lichen

pollution	inorganic fertiliser & herbicides on the site, as evidenced by changes in ground flora and in colour of sward or deposition of slurry on trunks or loss of lichen cover and increase in algae on trees		communities especially those on acid bark. There should be signs of algae overgrowing lichens.
	SO_2 levels should not exceed 30µg / m^3. Annual averages and peak loads of NOX and ammonia should not be increasing in average or peak conditions	Evidence of loss of lichen cover or changes in composition of lichens in twig communities and on trunks. National and local trends in air pollution data	Lichens generally do not tolerate high SO_2 levels. Nitrogen compounds in various forms are an increasing problem. Any evidence of air pollution needs following up. A visual check of local land use changes *e.g.* construction of intensive poultry or pig units, slurry lagoons *etc.* in immediate vicinity (*c.* 100m) of site may provide alert to potential problems.

UK GUIDANCE ON CONSERVATION OBJECTIVES FOR MONITORING DESIGNATED SITES

Interest feature: Lichen communities on lowland rocks (limestone, sandrock & other acid rock outcrops, including sarsen stones in lowland situations) (Special habitat 31)

Generally should be in pasture with moderate stocking rates or grazed by rabbits or in situations on steep slopes where land use intensity is low. Interest is both on the rock, or with limestone exposures particularly in pockets of soil in crevices and where rock occurs just below the turf, stressing the higher plants and allowing lichens to compete. Acid and calcareous substrates will differ in their key and characteristic species and therefore communities.

The land use around the rocks or stones is grazing with moderate or low stock levels and there are no slurry, fertiliser or herbicide inputs (other than spot treatment of herbicides or mechanical control). Shading by shrubs and the growth of ivy is likely to be detrimental. Sarsen stones should remain *in situ*.

Assessment of attributes could be undertaken at any time. If any attribute fails, the feature is not in a favourable condition.

Attributes	Targets	Method of assessment	Comments
Niche availability	No loss of area of rocks (or numbers of rocks)	Visual assessment	Loss can occur through, *e.g.* removal of stones/rocks, creation of new paths, steps, quarrying or building work.
Land use	No input of inorganic fertilisers or slurry or other concentrated organic fertilisers on land adjacent to the rock outcrops/stones or significant change in type or numbers of grazing stock	Visual assessment	These communities thrive in areas of low intensity land use. Application of fertilisers, herbicides or high stocking rates are likely to lead to increased nutrient inputs which will change the communities. Conversion of grassland to arable is likely to be damaging.
Lichen communities	No visible change in extent of open rock habitat dominated by lichens	Visual assessment	The lichens are dependent on the presence of usually well-lit rock outcrop/stone. Growth of ivy, brambles, tall herbs, alien plants *e.g.* cotoneaster and mosses over the rocks reduce available niches for lichens. Need to establish baseline through photographs *etc.*

Negative indicatiors: shade	No measurable change in quantity of open ground and exposed rock faces and no increase in cover of climbers or shaded area from adjacent trees or scrub, *e.g.* ivy	Visual assessment	Some scrub and climbing plants are important in providing additional substrates but increases in area will result in the loss of those light-demanding lichens growing on the rocks and soil. Light grazing is often beneficial in controlling competing vegetation.
Negative indicators: pollution	No atmospheric pollution effects No evidence of hypertrophication, in particular no evidence of increasing algal dominance and never more than 5% - 10% algal cover on rock surfaces	Check on national and where available local air pollution records Visual assessment of algal cover, suggesting application of slurry or fertilisers. Inappropriate grazing levels resulting in excessive animal dung can also cause hypertrophication	N0x, NH_3 $S0_2$ all may damage sensitive species. Low level nutrient enrichment is a requirement of some lowland rock communities but excessive nutrient pollution is harmful.
Negative indicators: burning	No evidence of fires in the vicinity of rocks	Visual assessment	Burning around rock outcrops is detrimental to the lichen interest
Negative indicators: disturbance	No widespread damage from recreational activities (localised tracks and paths, or regularly used sites for rock climbing are acceptable)	Visual – trampling, dislodging vegetation mats and cushions, scraping bryophyte mats, ferns, lichens off rocks; dislodging boulders; litter, camping, camp fires, rock climbing, graffiti, *etc.*	These communities thrive on long established rock surfaces. Damage of the rock surface through climbing, graffiti *etc.* may result in loss of lichen interest. Excessive trampling and scrambling over rocks may cause loss of lichen interest. This may be an issue in areas with high recreational pressure.

UK GUIDANCE ON CONSERVATION OBJECTIVES FOR MONITORING DESIGNATED SITES

Interest feature: Lichen communities on metalliferous sites (Special habitat 32)

This habitat is in a favourable condition when it continues to provide a range of specialised niches rich in heavy metals and sufficiently undisturbed to permit the establishment and growth of a significant range of obligate and facultative metallophyte lower plants. Favoured habitats include old buildings and walls especially with lime mortar, entrances to adits, outcrops, spoil tips, track edges and old timber. Many sites are grazed along with adjacent semi-natural areas of vegetation. Provided trampling and dunging is not extensive, grazing is beneficial in keeping sites free of undesirable shading woody growth. Nutrient inputs from atmospheric pollutants should be controlled to levels which preclude the spread of nutrient-loving species.

Assessment of attributes could be undertaken at any time. If any attribute fails, the feature is not in a favourable condition.

Attributes	Targets	Method of assessment	Comments
Niche availability	No loss of area of habitat	Mapping, aerial photos	Loss can come about through mismanagement, redevelopment & landscaping activities.
Niche diversity	Terricolous habitats about metalliferous spoil heaps, tracks, paths and in and around old buildings present Retention of metal-rich saxicolous habitats (stonework of old buildings, water-wheel pits and retaining walls *etc.*, rock outcrops around entrances to adits and shafts and open works, rocky rubble, boulders and small stones on tips)	Visual assessment with reference to previous photographs of the site	Terricolous metalliferous lichen species require open but relatively stable heavy-metal contaminated soils, often best developed when receiving lime rich dry and seasonal wet flushing from *e.g.* old mortared walls and are often associated with cushion forming mosses. Heavy-metal bearing rocks & rubble, plus contaminated stonework of built structures, provide essential habitat for saxicolous lichens requiring these conditions.
Lichen communities	Terricolous lichen communities present with at least some heavy-metal indicator species Saxicolous lichen communities present with at least some heavy-metal indicator species	Visual assessment	These targets should be set once a site dossier has been prepared.

Negative indicators: disturbance	No damage from recreational activities or land reclamation or the removal of materials, particularly rocks from tips No burial of lichen communities by tipping of materials No modern re-working of the mine site	Visual assessment – look for wheel-tracks or scuffing and breaking up of consolidated soil crusts, indicating regular disturbance of terricolous habitats. Check photographic record for signs of removal of materials from the site or new areas of fly-tipping.	Regular disturbance is damaging to this habitat. Some small scale intermittent disturbance may be acceptable if it creates new habitat available for colonization by lichens. Hard core has been traditionally and often illegally removed from many of these sites. Signs of recent digging or an increase in the area of bare lichen free rock surfaces indicates removal of material. Picking over tips for mineralogical specimens can cause unacceptable levels of disturbance. Metal mine sites have suffered from fly-tipping. Compare photographic records for signs of new areas of tipping. Four-wheel drive vehicles, trial and mountain bikes can cause unacceptably large areas of disturbance.
Negative indicators: shade	No measurable increase in area shaded by woody species	Visual assessment	Most metallophytes are harmed by increased shading and leaf fall from woody species. Heavy metal levels may prevent woody growth, but many important areas for metallophytes are maintained by regular grazing. Reduction or loss of grazing by, for example, the provision of public safety fencing or the increase in seed rain from adjacent wooded areas can all lead to the sudden spread of woody species on a previously open site.
Negative indicators: pollution	No evidence of land reclamation	Visual assessment; look for evidence of top-soil being brought in to covert heavy-metal contaminated soils; re-seeding; application of slurry or fertilisers	Over-laying of contaminated soils will lead to loss of habitat for terricolous lichens associated with heavy-metal sites, mainly through being out-competed by vascular plants. Lichens in this habitat also generally sensitive to any form of nutrient pollution.

UK GUIDANCE ON CONSERVATION OBJECTIVES FOR MONITORING DESIGNATED SITES

Interest feature: Lichens on maritime cliffs and slopes (Special habitat 33)

Lichen communities on rocky shores extend from the littoral through the mesic-supralittoral to the terrestrial zone. The littoral zone tends to be dominated by black crustose lichens mostly *Verrucaria* species (note that these can frequently be mistaken for oil pollution on rocks around high tide mark!), the mesic-supralittoral by species predominantly orange in colour particularly *Caloplaca* species. The terrestrial zone tends to split into communities which have some salt tolerance and those which are generally intolerant, these latter communities tend to occur in sheltered situations *e.g.* Scottish lochs or some distance from the sea. In many cases these coastal cliff merge into maritime heath as on the Lizard.

The habitat is characterised by its wide range of niches generally created by rock type, extent of rock outcrop, exposure, intensity of grazing and extent of scrub. Lichen communities are often best developed on headlands and islands where there is usually the greatest development of niches. Rock outcrops with rough, exposed upper surfaces, sloping faces, ledges, cracks and crevices (which remain damp), hollows and solution pockets, crumbling edges and rock-turf interfaces all provide a diversity of niches available to be colonized by rock dwelling (saxicolous) lichens, turf and soil-inhabiting (terricolous) lichens, and lichens colonizing over bryophytes (muscicolous or bryophilous lichens).

The main threats likely to affect favourable condition are oil pollution mostly on the lower zones, nutrient run-off from fields, extensive growth of scrub, fires, changes in grazing and recreational pressures.

Assessment of attributes could be undertaken at any time. If any attribute fails, the feature is not in a favourable condition.

Attributes	Targets	Method of assessment	Comments
Niche availability	No loss of area	Visual assessment	Loss can occur through developments, *e.g.* creation of new paths, steps, quarrying or building work.
Lichen communities	Range of lichen communities present in this niche-rich habitat, including crustose, leprose, foliose, fruticose and squamulose spp.	Visual assessment – photographic recording of typical assemblages from different niches; sample lists from a range of niches	A wide range of saxicolous, terricolous and epiphytic lichens can be present depending on environmental and habitat factors. The target should be set according to the site dossier.
Negative indicators: pollution	No oil spill incidents	Visual assessment	Oil pollution and more particularly artificial cleaning methods are very damaging especially of the intertidal lichen communities and those in the splash zone. If spills

	No atmospheric pollution effects Where agricultural land abuts onto agricultural land, rocks should not be seen to carry increasing areas of algal 'gunge' deposits	Check on national and where available local air pollution records	occur it is advisable to not to use detergent to 'clean up' the damage but to allow the oil to gradually break down over time. N0x, NH_3 $S0_2$ all may damage sensitive species *e.g. Teloschistes, Lobaria*. Significant increases in grazing pressure by farm stock or applications of farm slurry may cause excessive nutrient run off on to coastal rocks resulting in a growth of algal colonies at the expense of lichens. This excessive nutrient input leads to a demise of lichens with a low tolerance of high nutrient-status conditions.
Negative indicators: shade	No measurable change in quantity of open ground and exposed rock faces and no increase in cover of climbers *e.g.* ivy	Visual assessment	Some scrub and climbing plants are important in providing additional substrate but increases in area will result in the loss of those lichens growing on the rocks and soil. Light grazing is often beneficial.
Negative indicators: disturbance	No evidence of recreational disturbance	Visual – trampling, dislodging vegetation mats and cushions, scraping bryophyte mats, ferns, lichens off rocks; dislodging boulders; litter, camping, camp fires, rock climbing, graffiti, *etc.*	Excessive trampling and scrambling over rocks may cause loss of lichen interest. This may be an issue in areas with high recreational pressure.
Negative indicators: burning	No burning of vegetation in associated habitats	Visual assessment	Heath, grass & scrub fires damage adjacent lichen habitats on rock.

UK GUIDANCE ON CONSERVATION OBJECTIVES FOR MONITORING DESIGNATED SITES

Interest feature: Lichen species of upland cliffs and block scree (Special habitat 34)

Upland cliffs and block screes are in a favourable condition for their lichen interest when lichens are able to grow and complete their life cycle unaffected by anthropogenically engendered factors *e.g.* disturbance and damage caused by quarrying, moorland fires, intensive rock climbing, recreation, atmospheric pollution or changes in land management. Adverse land management changes by afforestation of light demanding communities, dense stocking of low-nutrient demanding communities or reduction in stocking levels allowing the growth of competing higher plants such as ivy should be avoided. Atmospheric pollution from long range as well as local sources can be significant in determining the health of lichen populations. Moorland fires can particularly damage lichens on small boulders and low cliffs.

Assessment of attributes could be undertaken at any time. If any attribute fails, the feature is not in a favourable condition.

Attributes	Targets	Method of assessment	Comments
Niche availability	No loss of extent of habitat	Mapping, aerial photographs	Loss can occur through quarrying or redevelopment.
Lichen communities	Target to be set according to site dossier	Visual assessment	Look at the range of niches available from open exposed crags to sheltered underhangs and gullies. Also degrees of nutrient enrichment from occasional water seepage, dust from mineral soil, fragments of animal faeces or bird perch rocks.
Negative indicators: pollution	No visual damage by bleaching, colour change or visible death of significant areas of lichen. No increase in monitored levels of SO_2, NO_x and NH_3	Visual assessment and check on national and local air pollution records	Changes may be more subtle and only be detected by specialist survey. A change in measured pollution levels would indicate need for specialist survey.
	No evidence of hypertrophication (no increase in and no more than 5% - 10% algal cover on rock surfaces)	Visual assessment for algal cover, suggesting application of slurry or fertilisers. Inappropriate grazing levels resulting in excessive animal dung can also cause	Low level nutrient enrichment is a requirement of some upland rock communities but excessive nutrient pollution is harmful.

		hypertrophication	
Negative indicators: shade	No spread of woody species or climbing plants likely to significantly alter light levels of the site	Visual assessment	Changes in light regime will have impacts on lichen communities.
Negative indicators: disturbance	No widespread damage from recreational activities (localised tracks and paths, or regularly used sites for rock climbing are acceptable)	Visual assessment – look for scuffing and erosion of rock surfaces spreading out from regularly used paths or rock-climbing stances	Uncontrolled and excessive trampling and erosion will depauperate the lichen interest on rock faces.
Negative indicators: burning	No evidence of fires in the vicinity of cliffs and scree	Visual assessment	Burning around rock outcrops and scree is detrimental to the lichen interest.

UK GUIDANCE ON CONSERVATION OBJECTIVES FOR MONITORING DESIGNATED SITES

Interest feature: Lichen communities of still water: lake margins in upland areas (Special habitat 35)

Upland lakes fringed by boulders and/or small rocks which are partly or completely submerged by water. These provide a range of niches for this specialised habitat. Water levels will fluctuate but this should be within the limits of natural change. Most of these lakes are oligotrophic or mesotrophic. There should be no sudden or permanent raising or lowering of levels.

Assessment of attributes could be undertaken at any time. If any attribute fails, the feature is not in a favourable condition.

Attributes	Targets	Method of assessment	Comments
Niche availability	No loss of boulders through removal or increase in overhanging trees	Visual assessment	
Hydrology	Fluctuations within historical limits. No change to outflow or signs of new abstractions or input to lake or catchment	Visual assessment	Different lakes will have different water level regimes, however any departure through *e.g.* destruction of dam, deepening of an outflow *etc.* or major land use change of catchments is likely to be damaging.
Water quality	No significant change in pH or existing nutrient levels	Visual assessment	Some aquatic lichens are pH sensitive. Any change in water quality *e.g.* by coniferous planting of acid-sensitive catchments may be undesirable. Increased nutrients leading to algal blooms are likely to result in loss of vigour and perhaps total loss through shading and perhaps direct damage. There should be no increase in nutrients caused by the release of waterfowl resulting in increased dunging on boulders in splash zone.
Negative indicators: disturbance	No physical damage to boulders/rocks	Visual assessment	Intensive recreational pressure with people trampling rocks, moving rocks *etc.* may result in the loss of lichens from the rocks.

UK GUIDANCE ON CONSERVATION OBJECTIVES FOR MONITORING DESIGNATED SITES

Interest feature: Lichen communities on sand dunes & machair (Special habitat 36)

The lichen interest in sand dune & machair systems is generally confined to niches where the competitiveness of the vascular plants is reduced, for example where sand covers low-lying rocky outcrops of rock, lies thinly over shingle, or in places where there is light trampling by humans and/or animals. Rock outcrops with rough, exposed upper surfaces, sloping faces, ledges, cracks and crevices (which remain damp), hollows and solution pockets, crumbling edges and rock-turf interfaces all provide a diversity of niches available to be colonized by rock dwelling (saxicolous) lichens, turf and soil-inhabiting (terricolous) lichens, and lichens colonizing over bryophytes (muscicolous or bryophilous lichens). Dunes with a low pH may support *Cladonia* communities whilst those with a high pH will tend to have a suite of species including *Collema* and *Leptogium* species. Provided trampling and dunging is not extensive, grazing is beneficial in keeping sites free of undesirable shading woody growth. Nutrient inputs from atmospheric pollutants should be controlled to prevent vascular plants gaining a competitive advantage over lichens in these low nutrient habitats.

Assessment of attributes could be undertaken at any time. If any attribute fails, the feature is not in a favourable condition.

Attributes	Targets	Method of assessment	Comments
Niche availability	No loss of area of habitat	Mapping, aerial photographs	Loss can occur through developments *e.g.* caravan sites or through under-grazing or over-grazing.
Lichen communities	Target to be set from site dossier	Visual assessment	
Negative indicators: burning	No evidence of burning	Visual assessment	These communities are intolerant of burning.
Negative indicators: disturbance	No evidence of damage from trampling or as a result of recreational pressures or significant change in grazing pressure	Visual assessment; also note incidences of animal dung (cattle, ponies, sheep, rabbits). Visual increase in pathways, vehicle tracks	Some terricolous communities are dependent on grazing, particularly by rabbits. It is impossible to define 'appropriate grazing' in terms of numbers of animals per site or seasonal period. However periodic assessment should clearly indicate whether grazing is adequate, excessive or insufficient. Dune systems are often in areas of high recreational pressure. Whilst light to moderate trampling can be

			beneficial, heavy trampling breaks up the sward.
Negative indicators: shading	No scrub or climbers in the lichen-rich areas, particularly rhododendron, sea buckthorn, bramble or *Clematis vitalba* No evidence of rank vegetation developing	Look for signs of under grazing with vascular plants becoming more robust	The lichen communities on dunes tend to be in the marginal niches where rock or shingle are near the surface and scrub invasion is less likely to be a problem. However, excessive shading could be damaging to lichen communities.
Negative indicators: pollution	No atmospheric pollution effects	A marked reduction of diversity in the lichen assemblages	Many lichen species are intolerant of atmospheric pollution. Ammonia and ammonium deposition may also cause indirect effects through altering the competitive balance between lichens and vascular plants.

UK GUIDANCE ON CONSERVATION OBJECTIVES FOR MONITORING DESIGNATED SITES

Interest feature: Lichen communities on coastal shingle (not forested) (Special habitat 37)

Lichen interest is best developed on long established and stable shingle systems where vascular plants remain uncompetitive. The substrate may range from small pebbles 1 cm in diameter to cobbles up to >10 cm across. Lichens colonise both the pebbles and the matrix of stable soil and mosses with dwarf scrub such as *Calluna* and *Prunus spinosa,* sometimes supporting additional lichen interest. Lichen-rich habitats on shingle tend to occur on well established spit or ness systems or on old raised beaches notably in Scotland. Loss through natural processes on these dynamic systems is not an attribute for unfavourable condition. The habitat is likely to become unfavourable for lichens through disturbance by vehicles and gravel extraction.

Assessment of attributes could be undertaken at any time. If any attribute fails, the feature is not in a favourable condition.

Attributes	Targets	Method of assessment	Comments
Niche availability	No loss of area of habitat	Mapping, aerial photographs	Loss can come about through over-grazing or under-grazing.
Lichen communities	Lichen-dominated communities present	Visual assessment	Lichen communities may be developed directly on the pebbles or cobbles and/or on the intervening sand and silt giving rise to lichen heath. In places where *Calluna* and other vascular plants are present, lichen communities may be developed on their stems.
Negative indicators: disturbance	No loss of shingle through removal or movement by man No damage from the use of vehicles	Visual assessment (evidence of shingle removal, recent bulldozing *etc.*) Evidence of wheel tracks or scuffing indicating regular use by vehicles	Lichen communities on shingle are normally developed on stable systems. Beach recharge, bulldozing, removal of shingle for aggregate are all damaging to lichen communities. Lichens require stable conditions in the shingle habitat, regular disturbance by vehicles for recreational or military purposes is likely to be damaging.
Negative indicators: pollution	No atmospheric pollution effects Where a site abuts agricultural land there should	A marked reduction in the lichen assemblages by visual assessment, look also for algal 'gunge', and vascular plants out-competing lichens	Many lichen species are intolerant of atmospheric pollution. Natural eutrophication occurs in this habitat where silt from adjacent saltmarshes becomes incorporated into the

	be no evidence of hypertrophication from drift of fertiliser or slurry applications resulting in deposits of algal 'gunge' or apparent excessive growth of vascular plant vegetation (other than ericaceous shrubs *e.g. Calluna*) No oil spill incidents		shingle and also through seaweed and other material washed onto the strandline. However excessive nutrient run off from heavily stocked fields or slurry application is likely to be damaging. Oil pollution, and more particularly artificial cleaning methods, are very damaging, especially of the intertidal lichen communities and those in the splash zone. If spills occur it is advisable to not to use detergent to 'clean up' the damage but to allow the oil to gradually break down over time.

UK GUIDANCE ON CONSERVATION OBJECTIVES FOR MONITORING DESIGNATED SITES

Interest feature: Lichen communities associated with semi-permanent snowbeds (Special habitat 38)

A community characterized by mainly crustose lichens growing on the soil, pebbles, small and large rocks in areas where snow persists into the summer such as north facing corries and depressions. Found at high altitudes, the best examples are in Scotland. Threats include recreational development/pressure and atmospheric pollution especially through acid deposition in the snow, whilst global climate change poses an insidious threat.

Assessment of attributes should be undertaken in the summer. If any attribute fails, the feature is not in a favourable condition.

Attributes	Targets	Method of assessment	Comments
Niche availability	No loss of area of snowbeds	Visual assessment (better still satellite or aerial photography)	There is a detailed inventory of snowbeds to monitor change.
Lichen communities	No loss of diversity or cover	Visual assessment	Lichens occur in a variety of niches in this habitat including terricolous on nearly bare soil, boulders, smaller rocks, meltwater streams and amongst grasses and other vascular plants.
Negative indicators: pollution	No increase in acid rain/precipitation	Measurements of snow pH	Lichen communities may be affected by acid rain accumulated in the snow deposits.
Negative indicators: disturbance	No damage due to recreational activities *e.g.* snowboarding, skiing, camping, trampling	Visual assessment	The limited size and high interest makes this habitat vulnerable to relatively small impacts from recreation.

Appendix 7. Example of a site dossier

Site Dossier: Den of Airlie

Site name: Den of Airlie SSSI

SNH Area: Tayside and Clackmannanshire

Site description: The Den of Airlie is the lower part of a deep, wooded ravine cut through Old Red Sandstone by the River Isla which extends from the falls at Reekie Linn at Craigisla to the north to the flat strath of Strathmore near Airlie to the south. The orientation of the ravine is broadly NW to SE but it is sinuous in places giving a variety of aspects. The ravine also extends up a short section of the Melgam Water, a tributary entering the main river from the NE by Airlie Castle. The Old Red Sandstone is moderately calcareous over much of the ravine, though noticeably less so on the true right bank, i.e. when looking downstream. Much of the site is wooded but there are large exposures of rock, notably in the area near the Castle and locally downstream of this and again upstream, below the falls at the Slug of Auchrannie, the northern limit of the site. **In terms of the bryophyte populations, these rocky outcrops are the most important part of the site**.

Bryophyte communities: The site has a long list of bryophyte and the communities in which they occur can be roughly divided into three types; woodland floor and epiphytes, rock outcrops and the riparian bryoflora.

The woodland floor has a luxuriant bryophyte layer in most areas where the vascular plants are not too dominant. This consists of large common pleurocarpous mosses like *Eurhynchium striatum, Rhytidiadelphus triquetrus Eurhynchium praelongum, Brachythecium rutabulum* and, where the ground is more disturbed, large stands of *Atrichum undulatum* and the smaller *Fissidens bryoides*. Epiphytes are common on most trees; trees with more acid bark like oak and birch have *Hypnum cupressiforme, Hypnum andoi, Dicranum scoparium, Dicranum fuscescens* and *Frullania tamarisci*. Trees with more basic bark like ash and willow have a more diverse flora including *Orthotrichum lyellii, Orthotrichum stramineum, Ulota bruchii, Radula complanata, Frullania dilatata, Frullania tamarisci, Metzgeria fruticulosa, Zygodon rupestris* and larger mosses like *Neckera complanata, Homalothecium sericeum* and *Isothecium alopecuroides*.

The rock outcrops are often rather broken and easy-angled so that large woodland floor species dominate here also. The more calcareous facies of the sandstone are also quite soft and easily eroded and so the steeper faces are often devoid of bryophytes except where kept damp. Common species on the rocks include *Isothecium alopecuroides, Neckera complanata, Homalothecium sericeum, Eurhynchium crassinervium, Anomodon viticulosus, Didymodon insulanus* and, in humid places, *Thamnobryum alopecurum*, particularly near the river where it is often spectacularly abundant. More locally there are stands of *Neckera crispa, Fissidens dubius, Leiocolea badensis, Gyroweisia tenuis, Porella cordeana, Porella platyphylla, Apometzgeria pubescens, Ditrichum gracile* and *Seligeria donniana*.

The site has an extensive riparian flora on boulders in the river, crags flushed by the river and, at the southern end of the site, rock terraces by the river. Species that occur here with varying degrees of dominance include *Amblystegium fluviatile, Schistidium rivulare, Cinclidotus fontinaloides, Hygrohypnum luridum, Rhynchostegium riparioides* and *Fontinalis*

antipyretica. More limited are stands of *Racomitrium aciculare*, *Scapania undulata*, and more interestingly *Fissidens rufulus*, *Fontinalis squamosa*, and *Amblystegium tenax*. *Thamnobryum alopecurum* is abundant on rocks above the normal river level and *Climacium dendroides* often occurs on silty ground flushed by the river at high levels and *Homalia trichomanoides* is locally abundant in this zone also.

Bryophyte features of interest: The SSSI citation mentions "an exceptionally high number of woodland vascular plants, mosses and liverworts, many of which are rare".

The basis for this statement is presumably the records listed in the Bryophyte Flora of Angus (Duncan, 1966) and a report by Royal Botanic Garden Edinburgh (David Chamberlain) held in the site scientific file. In these lists the species of interest are:

Scapania cuspiduligera – nationally scarce
Pylaisia polyantha – nationally scarce
Fissidens rufulus – nationally scarce and very rare in Scotland
Timmia austriaca – RDB, rated as Endangered
Pseudoleskeella catenulata – nationally scarce
Pseudoleskea incurvata RDB, rated as Lower Risk – near threatened.
Anomodon longifolius – WCA Schedule 8; RDB, rated as Vulnerable
Anomodon attenuatus – RDB, rated as Endangered

Of these, only *Pylaisia polyantha*, *Fissidens rufulus* and *Anomodon longifolius* have been seen since the 19th century. Apart from the epiphyte *Pylaisia polyantha*, all of these species are limited to at least moderately calcareous rocks and all but the riparian *Fissidens rufulus* normally occur on rather open, dry crags.

Given that most of these species of interest have not been seen on the SSSI for over 100 years the statement in the SSSI citation regarding the rare species is perhaps difficult to justify. Most of the bryophytes on the site are relatively common species and warrant little attention. The most important bryophyte features of the site are **1) the communities on the more open calcareous rock faces** and **2) the riparian flora on large boulders or bedrock**. The former community used to contain most of the rarities listed above and probably still holds a small population of *Anomodon longifolius* as well as other relatively uncommon species like *Seligeria donniana*, *Eurhynchium crassinervium*, *Apometzgeria pubescens* and *Rhychostegiella teneriffae*. The riparian community represents a northern outpost of a community more common on the calcareous sandstones of northern England and distinguished by the presence of *Fissidens rufulus*, a very rare species in Scotland.

Distribution of features of interest:
1) Bryophytes of open calcareous rocks. Historically the most important area for this community was the area near Airlie Castle where there are extensive outcrops of sandstone. These extend for some distance downstream on the true left bank, almost as far as the road bridge which forms the southern boundary of the site. The outcrops are more broken to the north of the castle and the best development is where the ravine narrows again towards the Slug of Auchrannie. The crags are less extensive on the true right bank and here the largest, some 500m south of the castle, is rather acid. There are also quite large crags by the Melgam Water but most of these are very wet. All of the larger areas of crag are difficult to explore either because of steepness, looseness or difficult access.

2) Bryophytes of large boulders and bedrock in the river. Elements of this community are common in the river along the whole of the site but it is best developed on the extensive terraces of sandstone upstream of the bridge which marks the S boundary of the site. Another good area, just downstream of the Castle, has a large jumble of boulders on the edge of the river. Further upstream, much of the bed of the river is more mobile until the ravine narrows close to the Slug of Auchrannie, and good stands of most of the species occur here as well.

Monitoring: 1) Bryophytes of open calcareous rocks. Most stands have a number of the typical species and probably the best means of monitoring the whole community is by noting the occurrence of a number of indicator species:

Anomodon viticulosus
Porella cordaeana
Eurhynchium crassinervium
Apometzgeria pubescens
Leiocolea badensis

Seligeria donniana
Rhynchostegiella teneriffae
Mnium marginatum
Scapania aspera
Cololejeunea calcarea

The first five species can be readily found at the moment; the remaining five are much more local. A short search in the vicinity of the castle should produce all of the first group and most of the second and give a rapid check on the health of this community. See monitoring sites 1 and 2 below.

2) Bryophytes of large boulders and bedrock in the river. The most important species in this community is *Fissidens rufulus* which occurs on rocks that are normally inundated and so it is useful to have low water to give access to the target rocks. Other species in this community are more widespread on the rocks with *Amblystegium fluviatile, Hygrohypnum luridum, Rhynchostegium riparioides* and *Schistidium rivulare* almost ubiquitous on stable rocks along the length of the site. A checklist showing the presence of these indicator species plus *Fontinalis squamosa* and *Amblystegium tenax* would demonstrate the continued health of the site. See monitoring site 3 below.

Site condition:
1) Bryophytes of open calcareous rocks. **Unfavourable – no change.**
Relatively common calcicole species still present in abundance and less common species like *Seligeria donniana*, *Apometzgeria pubescens*, Leiocolea badensis and Rhynchostegiella teneriffae are still readily found. The probable loss of the stand of *Anomodon longifolius* could be seen as part of the process of loss of rare species over the past 100 years. The changes that have caused this loss are not easily identified as we have no idea how the condition of the site has altered over the years. The most likely cause would seem to be the competition from more robust species and vascular plants; many crags are now very overgrown and possess few niches for species which prefer open conditions. In the section of the site above the Castle on the true left bank and for most of the right bank, there is evidence of **eutrophication** where water drains off the fields, mostly in the form of large banks of nettles (*Urtica dioica*). Though this may have no direct effect on the drier crags, it may have some input into the general luxuriance of the more common species.

2) Bryophytes of large boulders and bedrock in the river. **Favourable – maintained**.
This community is well-developed over much of the site but particularly so in the southern part below the Castle. Most of the species are still common on stable rocks and the rarest of them, *Fissidens rufulus*, is locally frequent in the lower part of the site.

Management: Apart from some tree planting on the true left bank in the section above the Castle and work in the policy woodland below the Castle itself, there is little apparent management for conservation (???Need to check this with the Airlie Office). The riparian community would appear to be in good condition and contains similar species to those mentioned in the Bryophyte Flora of Angus and in the Royal Botanic Gardens paper. There must be some long-term concern about the effect of run-off from the arable fields above, but much of the catchment is free of this problem.

With little knowledge of the condition of the calcareous crags in the past and thus no knowledge of the changes that have taken place and of their effect on bryophyte populations, it is difficult to offer any management advice. It would be of interest to know of any monitoring of vascular plants over the years and whether this has highlighted any changes. The failure to re-find *Anomodon longifolius* was disappointing but, given the good stands a few kilometres upstream at Reekie Linn, it seems likely that a proper search for this species

and perhaps Anomodon attenuatus in the Den of Airlie would produce further stands, albeit small. Given the status of these two species this **further survey** should be a management objective.

Monitoring site 1. *Seligeria donniana* and *Eurhynchium crassinervium* occur together with *Anomodon viticulosus*.

Grid reference: NO2931.5238

Location: A path leads N from the bridge over the Melgam Water along a ledge between the river and crags. As the crags ease back the path divides with one path angling down towards the river and the other heading diagonally upwards across the slope. The site is on broken sandstone crags just above the upper path.

Photo 1.1. Location of stands of *Anomodon viticulosus*, *Eurhynchium crassinervium* and *Seligeria donniana* on Site 1.

Photo 1.2. Detail of stands of *Anomodon viticulosus*, *Eurhynchium crassinervium* and *Seligeria donniana* on Site 1. *Seligeria donniana* is too small to be visible but occurs in tiny patches in the area indicated.

Monitoring site 2. Location from which *Anomodon longifolius* was recorded in 1996.

Grid reference: NO2853.5287.

Location: The River Isla emerges from a very narrow section into a large pool on a right-angled bend from E to S. On the true left bank of the pool there is a line of crags running S-N which runs into the pool at a rocky rib. The stand occurred on the rocky rib.

Photo 2.1. The location where *Anomodon longifolius* was seen in 1996.

The small stand occurred at the bottom edge of a large patch of *Anomodon viticulosus*, which is still abundant on the line of crags. Though not seen in 2002, a visit to the site and a further search for *Anomodon longifolius* would be a worthwhile exercise.

Monitoring Site 3. The riparian community on sandstone terraces close to the River Isla.

Grid reference: NO2960.5066

Location: From the road bridge at the S end of the site the sandstone terraces at the side of the river are obvious looking upstream. Access is easy on the R side of the bridge; the site is at the first really narrow section (see photo 3.1)

Photo 3.1. Location of monitoring site 3 from the road bridge looking N.

Photo 3.2. Closer location shot of Site 3 from downstream looking N.

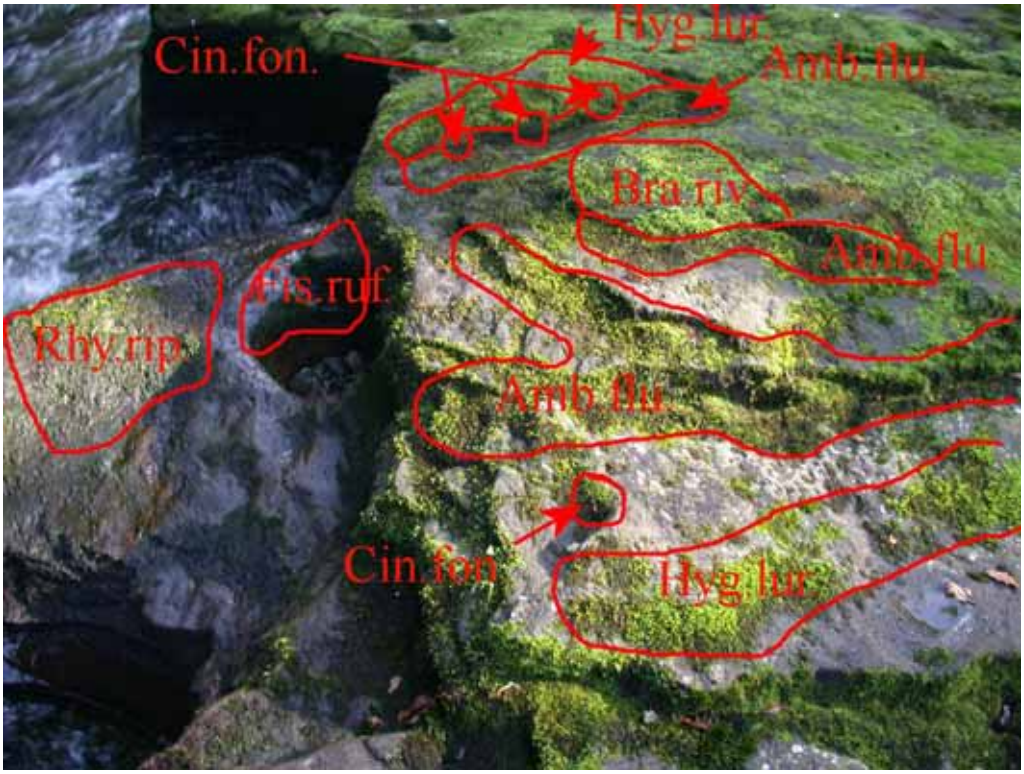

Photo 3.3. Detail of monitoring site looking upstream. Only relatively pure stands of the constituent species of the community are outlined.
Key: Rhy.rip. = *Rhynchostegium riparioides*, Fis.ruf. = *Fissidens rufulus*, Cin.fon. = *Cinclidotus fontinaloides*, Amb.flu. = *Amblystegium fluviatile*, Hyg.lur. = *Hygrohypnum luridum*, Bra.riv. = *Brachythecium rivulare*.

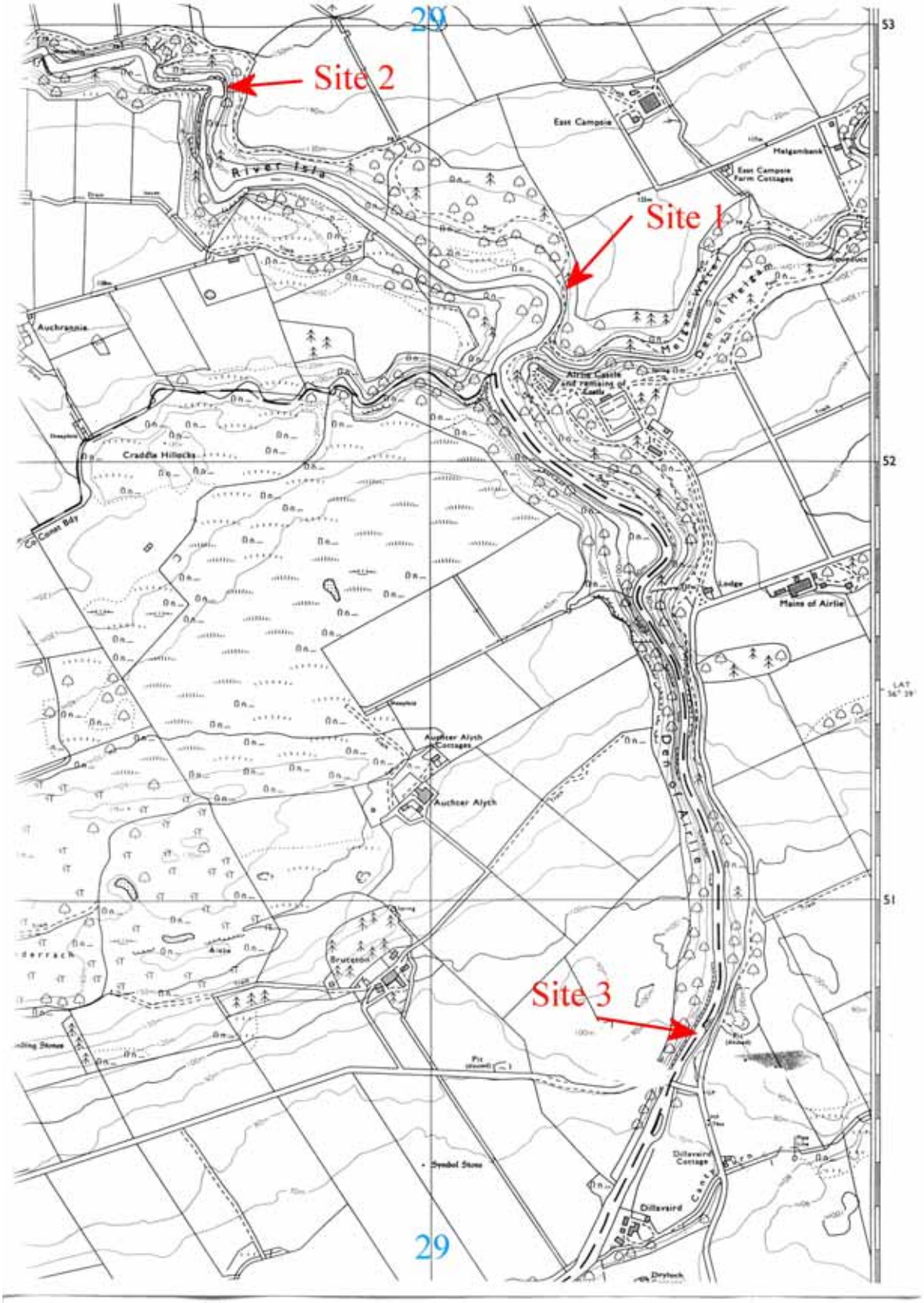

Fig.1. Map of the Den of Airlie showing the monitoring sites.

Annex 1 **Bryophyte species list for the Den of Airlie NNR**
Recorded on 16/17 September 2002.

Mosses

Amblystegium serpens
Amblystegium fluviatile
Amblystegium tenax
Anomodon viticulosus
Atrichum undulatum
Didymodon insulanus
Bryoerythrophyllum recurvirostrum
Didymodon rigidulus
Blindia acuta
Brachythecium rivulare
Brachythecium plumosum
Brachythecium rutabulum
Bryum capillare
Bryum pseudotriquetrum
Bryum pallens
Calliergonella cuspidata
Cinclidotus fontinaloides
Eurhynchium crassinervium
Cirriphyllum piliferum
Climacium dendroides
Cratoneuron filicinum
Palustriella commutata var commutata
Ctenidium molluscum
Dichodontium pellucidum
Dicranella heteromalla
Dicranella varia
Dicranum fuscescens
Dicranum majus
Dicranum scoparium
Ditrichum gracile
Sanionia uncinata
Encalypta streptocarpa
Eurhynchium praelongum
Eurhynchium striatum
Eurhynchium hians
Fissidens bryoides
Fissidens dubius
Fissidens rufulus
Fontinalis antipyretica
Fontinalis squamosa
Gymnostomum recurvirostrum
Gyroweisia tenuis
Heterocladium heteropterum
Homalia trichomanoides
Homalothecium sericeum
Hygrohypnum luridum
Hypnum cupressiforme
Hypnum andoi
Pseudotaxiphyllum elegans
Isothecium myosuroides
Isothecium alopecuroides
Mnium hornum
Mnium marginatum
Mnium stellare
Neckera complanata
Neckera crispa
Orthotrichum affine
Orthotrichum lyellii
Orthotrichum stramineum
Plagiomnium undulatum
Plagiomnium rostratum
Plagiothecium succulentum
Polytrichum formosum
Scleropodium purum
Racomitrium aciculare
Rhizomnium punctatum
Rhynchostegium riparioides
Rhynchostegiella teneriffae
Rhytidiadelphus squarrosus
Rhytidiadelphus triquetrus
Thamnobryum alopecurum
Thuidium tamariscinum
Tortella tortuosa
Anoectangium aestivum
Trichostomum crispulum
Ulota bruchii
Schistidium rivulare
Schistidium apocarpum
Seligeria donniana
Fissidens pusillus
Zygodon rupestris
Zygodon viridissimus var viridissimus

Liverworts

Aneura pinguis
Apometzgeria pubescens
Cephalozia bicuspidata
Cephaloziella divaricata
Chiloscyphus polyanthos
Cololejeunea calcarea
Conocephalum conicum
Frullania dilatata
Frullania tamarisci
Jungermannia atrovirens
Jungermannia pumila
Leiocolea badensis
Lejeunea cavifolia
Lepidozia reptans
Lophocolea bidentata
Marchantia polymorpha ssp polymorpha
Metzgeria fruticulosa
Metzgeria furcata
Nowellia curvifolia
Pellia endiviifolia
Pellia epiphylla
Plagiochila asplenioides
Plagiochila porelloides
Porella cordaeana
Porella platyphylla
Radula complanata
Riccardia palmata
Scapania aspera
Scapania undulata
Tritomaria quinquedentata

Annex 2. **Older records of interest**

1) Species of interest recorded from the Den of Airlie in the Bryophyte Flora of Angus

The dates are the last record of the species; no date means the species has been seen recently.

Liverworts
Scapania cuspiduligera, 1877.

Mosses
Fissidens rufulus
Timmia austriaca 1823, near Airlie Castle; 1855, above Airlie Castle.
Pseudoleskeella catenulata, (19th century)
Pseudoleskea incurvata, 1848, below Airlie Castle.
Anomodon longifolius
Anomodon attenuatus, 1871.

2) Species of interest recorded by Chamberlain (c. 1980)

Mosses
Fissidens rufulus
Pylaisia polyantha - not seen on the 2002 survey.

Appendix 8 Case study

Morrone Birkwood SSSI

The citation reads simply 'The flora is thus unusually diverse, and a total of nearly 1000 plant species are recorded, including 280 vascular plants and 187 bryophytes.' Although such a citation would not necessarily imply that the bryophytes are a notified feature, further investigation of the associated scientific files reveals an impressive list of RDB and nationally scarce species, and a Site Dossier has been produced by SNH.

The list of species, together with their status and the tables suggested for their monitoring is shown below:

Species	**Status**	**Habitat**	**1ary habitat**	**2ary habitat**	**3ary habitat**
Amblyodon dealbatus	NS		15	**10**	17
Barbilophozia quadriloba	RDB		**26**	**10**	
Cinclidium stygium	NS	Lowland wetland			
Encalypta rhaptocarpa	NS		**26**	17	
Grimmia incurva	NS		25	**20**	
Harpanthus flotovianus	NS		**10**	14	
Jungermannia polaris	RDB		**26**		
Jungermannia subelliptica	NS		**26**		
Leiocolea gillmanii	RDB		**26**	15	
Leiocolea heterocolpos	NS		4	**26**	
Odontoschisma elongatum	NS		**10**	14	
Racomitrium canescens	NS		8	7	
Scapania cuspiduligera	NS		**26**	17	
Scapania gymnostomophila	RDB		**26**		
Schistidium trichodon	NS		**26**		
Sphagnum platyphyllum	NS	Upland			
Stegonia latifolia	RDB		**26**		
Tayloria lingulata	RDB		**10**		
Tritomaria polita	NS		**10**	**26**	

Habitat numbers shown in bold represent those that are appropriate for this site.

In most cases the selection of the appropriate habitat for the species is obvious, being either the only possible habitat, or the primary habitat. In a few instances the primary habitat is not appropriate:

Amblyodon dealbatus '15 Sand dunes and slacks' not present on site, use '10 Montane flushes'

Grimmia incurva '25 Acid montane cliffs' not present on site, use '20 Scree'. (This is the only species in this habitat, but the selection is confirmed in the Site Dossier: 'In the higher scree there are some interesting species like *Tetralophozia setiformis* and *Grimmia incurva*'.)

Leiocolea heterocolpos '4 Ravines' not present on site, use '26 Basic montane cliffs'

Therefore, the indirect assessments which are required on this site for the assessment of the bryophyte interest are:

Mire habitat *Sphagnum platyphyllum, Cinclidium stygium*

Suite 10 *Amblyodon dealbatus, Barbilophozia quadriloba, Harpanthus flotovianus, Odontoschisma elongatum, Tayloria lingulata, Tritomaria polita*

Suite 20 *Grimmia incurva*

Suite 26 *Barbilophozia quadriloba*, *Encalypta rhaptocarpa*, *Jungermannia polaris*, *Jungermannia subelliptica*, *Leiocolea gillmanii*, *Leiocolea heterocolpos*, *Scapania cuspiduligera*, *Scapania gymnostomophila*, *Schistidium trichodon*, *Stegonia latifolia*, *Tritomaria polita*

This analysis of the habitats that require monitoring agrees well with the assessment made in the Site Dossier, which states that the bryophyte interest is located in 'the flushed mires' (Mire habitat), 'the calcareous stony flushes' (10) and 'the calcareous crags' (26).

Habitat 10 covers species occurring in 'montane flushes'. A series of these flushes extends across the site from east to west, essentially occurring below the line of calcareous rocks which outcrop on the steeper lower slopes. Some of these flushes occur in an exclosure area in the east of the SSSI.

The site dossier notes that it is only the western flushes that are of interest for their bryophytes, and this is the area of the site that should be monitored. If the flushes in the exclosure were to be monitored using bryophyte guidance, these would be found to be suffering from an increase in shading as the woodland regenerates in this area, and hence these would be Unfavourable for bryophyte interest. However, this would clearly be an erroneous conclusion for the actual bryophyte interest feature in the western flushes.

Therefore, the assessment of the flushes for their bryological interest should only be made at the western end of the site, having consulted the Site Dossier. Assessment of flushes across the entire site could lead to an erroneous conclusion, and to inappropriate management action being initiated.