British Red Data Books

mosses and liverworts

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Foreword

As one who has delighted in bryophytes for as long as he cares to remember, and who has many long and treasured friendships with bryologists – amateur and professional alike – preparation of the Foreword to this, the first British Red Data Book to cover mosses and liverworts, has given me particular joy. From the deep cloughs and bleak moors of my Lancashire childhood to the alpine ledges and woodlands of Wales, the Lake District and Scotland and the heathlands and grasslands of southern England, the infinite hues of mosses and liverworts add an exquisite extra dimension to the landscape. The individual plants may be small but, because of their intrinsic beauty, remarkable diversity and ecological dominance in particular communities, where they form the only natural habitats for many other plants and animals, bryophytes greatly enrich our natural heritage.

The extremely rich bryophyte flora of Britain, consequent on fortuitous and unique combinations of climate, geology and quaternary vegetational history, is widely recognised as a biological attribute of major international importance. The British bryophyte flora is also one of the most intensely studied and best known anywhere in the world, a situation attributable to a long tradition of highly skilled and mainly amateur bryologists. This is all the more remarkable since competence in bryophyte taxonomy requires untold hours of microscopic study. Within the corpus of expertise of British bryologists has been, and still is, an intimate knowledge of the localities and habitats of every rare, vulnerable and endangered species. At one time a small number of individuals always knew, or know, the exact whereabouts of each species, this key information passing from generation to generation almost exclusively by word of mouth. The publication of the Red Data Book heralds the translation of what might best be described as bryological folklore into hard, definitive data.

Following the completion of the three-volume *Atlas of bryophytes of Britain and Ireland*, the appearance of the Red Data Book could not have been more timely. With lower plants (cryptogams) now being afforded their rightful equal status alongside animals and vascular plants in virtually all properly executed environmental assessments and conservation programmes, an authoritative account of the general ecology and importance of bryophytes, together with precise and detailed information on all threatened species, is absolutely vital. This volume therefore represents a massive contribution to increasing awareness of these plants.

On reading this Red Data Book, aside from the immense pleasure at seeing a job so well done, my overwhelming feelings were those of alarm tempered with relief and respect. On the one hand, the survival of a worryingly high number of bryophytes is seriously threatened by a veritable plethora of factors, on the other very few British species have become extinct either unwittingly by man's thoughtless activities or from over-zealous collecting. The pages of the bryophyte Red Data Book stand as a fine tribute to generations of highly responsible, conservation-minded bryologists.

Thus, all those concerned about the preservation of biodiversity, be they field bryologists who love the plants first hand, conservation officers, environmental planners or government ministers, will find this book indispensable. The authors have done our natural heritage a great service.

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Thanks are also extended to everyone else who gave help and contributed information, especially: Andy Amphlett (RSPB), Ben Averis, John Blackburn, John Bratton (CCW), Pelham Conduit (South London Botanical Institute), the late Alan Crundwell, Len Ellis (Natural History Museum, London), Lynne Farrell (SNH), Paul Hackney (Ulster Museum), Alan Hale (CCW), Mark Hill (Centre for Ecology & Hydrology), Andy Jackson (Royal Botanic Gardens, Kew), Stefa Kaznowska (JNCC), Chris Leon (Royal Botanic Gardens, Kew), Neil Lockhart (National Parks and Wildlife Service, Ireland), David Long (Royal Botanic Gardens, Edinburgh), Howard Matcham, Ian McLean (JNCC), David Morgan (formerly JNCC), Angela Newton (the Natural History Museum), Alan Orange (National Museum of Wales), Margaret Palmer (formerly JNCC), Jean Paton, Sandy Payne (SNH), Roy Perry (formerly National Museum of Wales), Peter Pitkin (SNH), Ron Porley (EN), Francis Rose, Tony Smith (University of Wales, Bangor), Gavin Stark (formerly JNCC), Rod Stern, Rosemary Stewart, Donal Synnott (National Botanic Gardens, Glasnevin), the late Peter Wanstall, Richard Weyl (Environment and Heritage Service, Northern Ireland), Stephen Wharton, the late Harold Whitehouse and Dan Wrench (Sefton LIFE Project).

The British Bryological Society, and in particular its Conservation Committee, provided advice and guidance throughout the project. We thank the Biological Records Centre (Centre for Ecology & Hydrology) for access to its database, and the Glasnevin Botanic Gardens, Dublin, the Natural History Museum, London, the National Museum of Wales, Cardiff, the Royal Botanic Gardens, Edinburgh and the Ulster Museum, Belfast for access to their herbarium collections. County Wildlife Trusts, the Countryside Council for Wales (CCW), English Nature (EN), Scottish Natural Heritage (SNH) and the National Trust gave us information about sites, and the Natural History Museum provided accommodation and facilities. We also thank the European Committee for the Conservation of Bryophytes, the South London Botanical Institute and the Threatened Plants Unit of the World Conservation Monitoring Centre for help during the course of the project.

1 Introduction

The bryophytes (mosses, liverworts and hornworts) are particularly well represented in Britain. Over 1,000 species have been recorded, some 60% of the total European flora. By comparison, we have 45% of the European ferns, 35% of the European lichens and less than 20% of the European flowering plants. The British 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 (Hill and Preston 1998). Areas of high rainfall in western Britain support a particularly rich concentration of bryophytes, including some of quite exceptional interest. D A 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).

Since the 17th century professional and amateur bryologists have studied the British bryophyte flora. The British Bryological Society (BBS) has co-ordinated the collection of data on the distribution of species in both Britain and Ireland since its foundation (as the Moss Exchange Club) in 1896 (Preston 1991). Interest in bryophytes has been particularly strong in the period since 1945. Modern identification guides to both mosses (Smith 1978; Daniels and Eddy 1985) and liverworts (Smith 1990; Paton 1999) are available, and the distribution of the species has been mapped at a 10 km² (hectad) scale (Hill et al. 1991, 1992, 1994). In view of the richness of the bryophyte flora and the long history of study, the potential contribution of our islands to the conservation of bryophytes at an international level is very great.

Although Britain is rich in bryophytes, many species have declined (while some have increased) because of changes in the environment. Bates and Farmer (1992) drew together much useful information relating the response of bryophytes to changes in the environment. This Red Data Book brings together the latest knowledge about our threatened bryophyte species. Each species is allocated to a category in a system devised by the International Union for the Conservation of Nature (IUCN), which summarises the degree of the threat to the British populations. The appearance, habitat and British and European distribution of each species is summarised and the threats to the species discussed. Note that the single British hornwort on the British Red List, *Phaeoceros carolinianus*, is treated as an 'honorary liverwort' for the purposes of this book, in order to avoid over-cumbersome column headings in tables, etc. It is, of course, acknowledged that hornworts are *not* liverworts and that most recent phylogenetic work shows them to be distinct from either mosses or liverworts.

This book results from the co-operation of several statutory and voluntary organisations. The collection of information for Red Data Books covering Britain's bryophytes, lichens and stoneworts began in 1988, and was initially funded by the Nature Conservancy Council (NCC). The Conservation Association of Botanical Societies (CABS) — a voluntary conservation organisation set up by the main botanical societies in Britain and Ireland — carried out the work. In 1990 CABS amalgamated with Plantlife, another voluntary organisation, which inherited the project. In 1991 the NCC was disbanded and a new statutory agency, the Joint Nature Conservation Committee (JNCC), took over the management of the project. Also in 1991, a similar project to collate information on rare and threatened bryophytes, lichens and stoneworts was set up in Ireland by the Republic's Office of Public Works and the Department of the Environment for Northern Ireland. As a result of these initiatives Red Data Books covering British and Irish stoneworts (Stewart and Church 1992) and British lichens (Church et al. 1996) have already been published, and the bryophytes of Britain are covered in this volume. These join other recent Red Data Books for birds (Batten et al. 1990), insects (Shirt 1987), other invertebrates (Bratton 1991) and, most recently, vascular plants (Wigginton 1999).

It must be recognised that our level of knowledge about the status of species is constantly changing, and that any Red Data Book is likely to be out of date within a few years, or even as soon as it is published. However, this book provides a benchmark for future research and survey. The Red Lists themselves will be kept up to date regularly on the JNCC website (http://www.jncc.gov.uk) and through the JNCC *Species Status* series.

2 Preparation of the Red Data Book

Area covered

This Red Data Book covers Great Britain (i.e. England, Scotland and Wales) and the Isle of Man but not Ireland (i.e. Republic of Ireland and Northern Ireland) or the Channel Islands. The original intention of the project leading to this book was to cover Ireland as well, but a number of factors conspired to make this aim unachievable. It is anticipated that a separate volume covering Ireland will be published in due course.

Taxonomy and nomenclature

The nomenclature used in this book follows *A checklist and census catalogue of British and Irish bryophytes* (Blockeel and Long 1998), except where non-British taxa are mentioned. The names used in this checklist differ in a number of respects from the previously generally accepted names which tended to follow the most recent floras (Smith 1978, 1990), the old vice-county checklist (Corley and Hill 1981) or the European checklists (Corley et al. 1981; Corley and Crundwell 1991; Grolle 1983). Where these differences occur, the name most commonly used in Britain is given as a synonym.

Initial selection of species

Records for all species of British bryophytes are currently held at the Biological Records Centre at the Centre for Ecology & Hydrology, Monks Wood. These records were used as the basis for the initial selection of species considered for the Red Data Book.

Native species were selected for consideration if they fulfilled at least one of the following criteria:

- well-recorded species found in Britain in 15 or fewer hectads (10 km² squares) since 1950
- species occurring in slightly more than 15 hectads, but with populations which were known to be small at all or nearly all sites
- species occurring in more than 15 hectads, but which have shown a marked decline
- species that are probably still under-recorded, but which are known to be sufficiently habitat-confined that they are likely to fit the above criteria, even when better recorded

Non-native species, introductions, varieties and hybrids (including those between native species), and dubious taxa are excluded.

Table 1 shows taxa that might have been included in the Red List on the basis of their frequency but were excluded because they were considered to be introductions.

Table 1. Introduced bryophytes rare in Britain

Liverworts	*Native distribution*
Lophocolea bispinosa	Australasia
Lophocolea semiteres	S America, S Africa, Australasia
Lophozia herzogiana	New Zealand
Riccia rhenana	Central Europe and SW Asia
Telaranea longii	Australasia?
Telaranea murphyae	Australasia?
Mosses	
Atrichum crispum	N America
Calyptrochaeta apiculata (*Eriopus apiculatus*)	Southern Hemisphere (widespread)
Chenia leptophylla	N & S America, Africa, Asia, Australasia, Oceania
Scopelophila cataractae	America, Asia
Tortula amplexa	N America

It is perhaps worth noting that this list merely reflects current opinion. There are plants listed here that may in fact be native. *Lophozia herzogiana*, for example, is a very rare plant in New Zealand (Crundwell and Smith 1989) and it is just possible that, rather than being native there and introduced in Britain, the truth is the opposite! *Telaranea longii* and *T. murphyae* have not yet been found anywhere else in the world, and their status as introduced plants is inferred on the basis of their occurrence only in and near botanical gardens (Paton 1965, 1992). Some bryologists consider it likely that *Scopelophila cataractae* is a native plant. Conversely, there are some plants in the Red List currently generally considered native that may actually be introduced. It should also be noted that, although *Lophocolea semiteres* is listed here as 'rare', it appears to be spreading rapidly and will therefore probably become much more common.

A number of species have been recorded erroneously from Britain in the past. These too have been excluded from consideration for the Red List (Table 2).

Table 2. Erroneously recorded species

Liverworts
Metzgeria simplex
Pleurocladula islandica
Riccia warnstorfii
Mosses
Andreaea crassinervia
Bryum purpurascens
Cynodontium gracilescens
Didymodon asperifolius
Didymodon reedii
Orthotrichum urnigerum
Racomitrium microcarpon
Schistidium boreale
Sphagnum subfulvum

No species of *Schistidium* in the *S. apocarpum* complex, recently revised by Blom (1996), are included in the Red List. This is because their distribution and status in Britain have yet to be established.

Collation of records

For each of the species selected for consideration, the following information was collected and compiled on a computer database: English names, recently-used synonyms, site records, distribution, state of populations, international distribution, ecology, threats, conservation needs, notes on identification, existing site protection, existing legal protection, experts with knowledge of the species, and references.

The following sources were used during the compilation of this information:

- Records were collected by BBS members for the *Atlas of bryophytes*.
- The records for bryophytes held at the Biological Records Centre formed the basis for the distribution information. The information available for each record includes details of locality, grid reference, date of record, recorder and the source of the record.
- Herbaria

  Information was collected from specimens in the main herbaria for Britain, Northern Ireland and the Republic of Ireland. These included the herbaria of the Royal Botanic Gardens, Edinburgh (E), the National Botanic Gardens, Glasnevin (DBN), the National Museum of Wales (NMW), the Natural History Museum, London (BM) and the Ulster Museum, Belfast (BEL). Specimens of each of the species under consideration were examined and the details of habitat and locality were noted.
- Literature sources

  A number of sources were searched for information on the localities, habitats and ecological requirements of individual species, including publications such as *Journal of Bryology*, *Transactions of the British Bryological Society* and various floras. See individual species accounts for further references.
- Expert knowledge

  Experts with field knowledge of the species were an invaluable source of information and were consulted throughout the project. Towards the end of the project, a number of members of the British Bryological Society provided additional information for updating the species accounts.
- Other organisations

  Additional information on site protection and possible threats to sites was provided where necessary by the regional officers of English Nature, Scottish Natural Heritage, the Countryside Council for Wales, Wildlife Trusts and the National Trust.

Allocation of species to threat categories

After the records for each species had been collated, the species were allocated to threat categories according to the revised system proposed by the IUCN in 1994 (World Conservation Union 1994). These categories replace those previously approved by the IUCN and used in Red Data Books published before 1994. Wigginton (1999) gives further details of the history and rationale behind the development of the new system of threat categories. A brief outline of the interpretation of the revised IUCN categories and criteria, and their application to bryophytes in Britain is given below. It is, however, important that users of the new system refer to the published document (World Conservation Union 1994), which fully explains the categories and contains many qualifying remarks. The official IUCN definitions of the categories are given in Table 3 and the hierarchical relationship of the categories in Figure 1.

Newly established categories are *Extinct in the wild* (EW), and *Critically Endangered* (CR). Whilst the terms *Endangered* (EN) and *Vulnerable* (VU) have been maintained, they are now defined differently, and species in one of these threat categories in the old system will not necessarily be in the same category in the new. Most species deemed to be *'Rare'* in the old system have been assigned to the *Lower Risk* (*near threatened*) (LR(nt)) category in the new system though, on the basis of the new criteria, some are now regarded as *Vulnerable*. The *Lower Risk* (*least concern*) (lc) subdivision of the *Lower Risk* category represents all other species including the most widespread and ubiquitous. Note that, in a forthcoming IUCN review of the criteria, the system will be simplified by removing *Lower Risk* (*conservation dependent*) altogether and making *near threatened* and *least concern* categories in their own right rather than sub-categories of *Lower Risk*. This will have very little effect on the bryophyte Red List, as LR(cd) has not been used and the other changes are merely nomenclatural. The category *Extinct in the wild* (EW) has also not been used, as there are no bryophytes in Britain to which it applies.

Table 3. Definitions of IUCN threat categories (World Conservation Union 1994) [a]

IUCN threat category	*Definition of taxon*
Extinct (EX)	A taxon is *Extinct* when there is no reasonable doubt that the last individual has died.
Extinct in the Wild (EW)	A taxon is *Extinct in the Wild* when it is known to survive only in cultivation, in captivity or as a naturalised population (or populations) well outside the past range. A taxon is presumed *Extinct in the Wild* when exhaustive surveys in known and/or expected habitat, at appropriate times (diurnal, seasonal, annual) throughout its range have failed to record an individual. Surveys should be over a time frame appropriate to the taxon's life cycle and life form.
Critically Endangered (CR)	A taxon is *Critically Endangered* when it is facing an extremely high risk of extinction in the wild in the immediate future, as detailed by any of the criteria A– E. [a]
Endangered (EN)	A taxon is *Endangered* when it is not *Critically Endangered* but is facing a very high risk of extinction in the wild in the near future, as defined by any of the criteria A–E. [a]
Vulnerable (VU)	A taxon is *Vulnerable* when it is not *Critically Endangered* or *Endangered* but is facing a high risk of extinction in the wild in the medium-term future, as defined by any of the criteria A–D. [a]
Lower Risk (LR)	A taxon is *Lower Risk* when it has been evaluated but does not satisfy the criteria for any of the categories *Critically Endangered, Endangered* or *Vulnerable*. Taxa included in the *Lower Risk* category can be separated into three sub-categories: • *Conservation Dependent* (cd): Taxa which are the focus of a continuing taxon-specific or habitat-specific conservation programme targeted towards the taxon in question, the cessation of which would result in the taxon qualifying for one of the threatened categories above within a period of five years. • *Near Threatened* (nt): Taxa which do not qualify for *Lower Risk* (*conservation dependent*), but which are close to qualifying for *Vulnerable*. • *Least Concern* (lc): Taxa which do not qualify for *Lower Risk* (*conservation dependent*) or *Lower Risk* (*near threatened*).
Data Deficient (DD)	A taxon is *Data Deficient* when there is inadequate information to make a direct or indirect assessment of its risk of extinction based on its distribution and/or population status. A taxon in this category may be well studied, and its biology well known, but appropriate data on abundance and/or distribution are lacking. *Data Deficient* is therefore not a category of threat or *Lower Risk*. Listing of taxa in this category indicates that more information is required and acknowledges the possibility that future research will show that a threatened category is appropriate.
Not Evaluated (NE)	A taxon is *Not Evaluated* when it has not been assessed against the criteria.

[a] For full details of criteria see Appendix 1

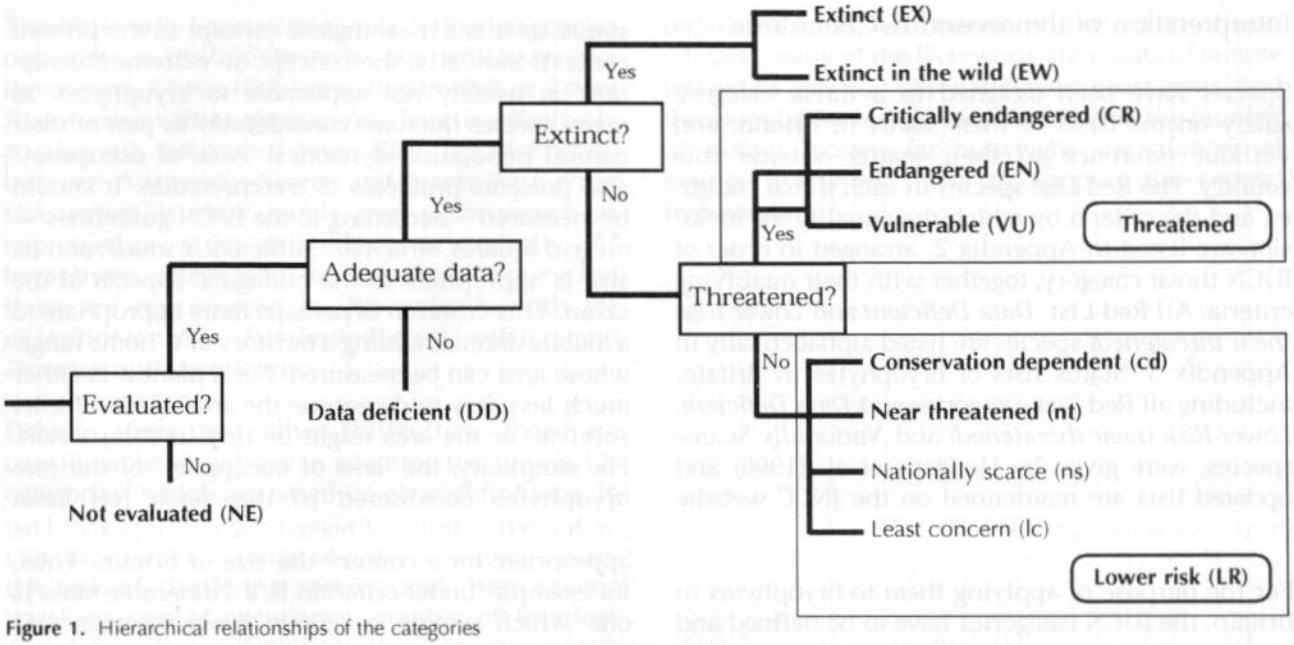


Figure 1. Hierarchical relationships of the categories
Figure adapted from World Conservation Union (1994) *Red List Categories*.

The Red List (i.e. the list of threatened or extinct species) consists of species in the categories *Extinct*, *Extinct in the Wild*, *Critically Endangered*, *Endangered* and *Vulnerable*. For each of the main threat categories (*Critically Endangered*, *Endangered* and *Vulnerable*) there is a set of five main criteria A–E (an additional sub-criterion for the *Vulnerable* category), any one of which qualifies a taxon for listing at that level of threat. The qualifying thresholds within the criteria A–E differ between threat categories. They are summarised in Table 4, and given in full in Appendix 1.

Table 4. Summary of the thresholds of the IUCN criteria

	Main thresholds		
Criterion	*Critically Endangered*	*Endangered*	*Vulnerable*
A rapid decline	>80% over 10 yrs or 3 generations in past or future	>50% over 10 yrs or 3 generations in past or future	>20% over 10 yrs or 3 generations in past or future
B small range — fragmented, declining or fluctuating	extent of occurrence <100 km^2 or area of occupancy <10 km^2 + single locality, decline or fluctuation	extent of occurrence <5,000 km^2 or area of occupancy <500 km^2 + 2–5 localities, decline or fluctuation	extent of occurrence 20,000 km^2 or area of occupancy <2,000 km^2 + 6–10 localities, decline or fluctuation
C small population and declining	<250 mature individuals, population declining	<2,500 mature individuals, population declining	<10,000 mature individuals population declining
D1 very small population	<50 mature individuals	<250 mature individuals	<1,000 mature individuals
D2 very small range			<100 km^2 or < 5 locations
E probability of extinction	>50% within 5 years	>20% within 20 years	>10% within 100 years

Interpretation of the revised IUCN criteria

Species have been assigned to a threat category solely on the basis of their status in Britain, and without reference to their status outside this country. The Red List species in each threat category, and the criteria by which they qualify for inclusion are listed in Appendix 2, arranged in order of IUCN threat category, together with their qualifying criteria. All Red List, *Data Deficient* and *Lower Risk* (*near threatened*) species are listed alphabetically in Appendix 5. Status lists of bryophytes in Britain, including all Red List categories and *Data Deficient*, *Lower Risk* (*near threatened*) and *Nationally Scarce* species, were given by Hodgetts et al. (1996) and updated lists are maintained on the JNCC website (http://www.jncc.gov.uk).

For the purpose of applying them to bryophytes in Britain, the IUCN categories have to be defined and interpreted appropriately. Only 'recent' (post-1970) records were used to determine area of occupancy and number of locations. *Extinct* has been interpreted as not having been seen for the last 50 years or, if seen more recently, confined to sites which have been thoroughly surveyed without success in recent years, or where all suitable habitat has disappeared. *Extinct in the Wild* has not been used for bryophytes.

Criterion E was not used at all, as there have been no population viability analyses of bryophytes in Britain. The allocation of species to the categories A–D is not always straightforward. For example, deciding what constitutes a 'mature individual' is often difficult and, even if an individual can be defined, estimates of the size of bryophyte populations are rarely available. Measuring the rate of decline of a species from available data is also difficult, as records have often been made at different times in different areas, and there has been little systematic monitoring of bryophyte populations. The use of generation time for bryophytes — a useful concept enabling decline over a longer time period than 10 years to be used — has been explained by Hallingbäck et al. (1998). They advise using a *maximum* of 25 years for one generation (for species that are not known to reproduce sexually), with a 'sliding scale' of 11–25 years for species that reproduce sexually only infrequently, down to 1–5 years for short-lived ephemeral colonists that reproduce frequently with small, highly mobile spores. In other words, a system of life strategies, such as that devised by During (1992), needs to be adopted in order to obtain a broad estimate of generation time.

'Extent of occurrence' (IUCN definition in Appendix 1) has not been used in assessing species status, as it is a meaningless concept in the present context. Similarly, the concept of 'extreme fluctuation' is usually not applicable to bryophytes, as many species fluctuate considerably as part of their natural population dynamics. 'Area of occupancy' also presents problems of interpretation. It should be measured —according to the IUCN guidelines — on grid squares '*which are sufficiently small*', and its size is appropriate to the biological aspects of the taxon. This criterion is perhaps more appropriate to a mobile animal holding a territory or a 'home range' whose area can be measured. For a plant it is either much less easy to determine the area needed for its survival, or the area might be tiny in comparison. For simplicity, the 'area of occupancy' of the rare bryophytes considered in this book has been interpreted in terms of hectads, which appears to be appropriate for a country the size of Britain. Thus, for example, under criterion B, a *Vulnerable* moss is one which occurs in 20 or fewer hectads and satisfies two of the three sub-criteria.

It was particularly difficult to assign threat categories to a group of species comprising *Bryum uliginosum*, *Cephaloziella dentata*, *Dicranum elongatum*, *Ephemerum cohaerens*, *Philonotis cernua*, *Plagiothecium piliferum*, *Pohlia crudoides* and *Tetrodontium repandum*. All of these species were last seen in the 1950s or (mostly) the 1960s (i.e. not since the 1970 threshold). However, because they are either very inconspicuous or unpredictable in occurrence, or grow in very remote places that have not been visited in recent years, it was decided to retain them in the *Critically Endangered* category rather than 'demote' them to *Data Deficient*, although deficient in data they certainly are. This decision may be questionable, but it seems the most appropriate use of the criteria for these species.

At the national level, countries are permitted to refine the definitions for the *Lower Risk* categories and to define additional ones of their own. JNCC has established one extra category and two definitions as a national standard. The *Lower Risk* (*near threatened*) category, which includes 'species which are close to qualifying for *Vulnerable*', is defined as species occurring in 15 or fewer hectads, but which are not threatened (i.e. not qualifying as *Critically Endangered*, *Endangered* or *Vulnerable*). As applied in Britain, this sub-category includes species which occur in 15 or fewer hectads, but which do not qualify as *Critically Endangered*, *Endangered* or *Vulnerable*. Many arctic–alpine species that are very rare but not considered to be particularly threatened are included in this sub-category. *Lower Risk* (*near threatened*) species are listed in Appendix 2.

The *Nationally Scarce* category is defined as species occurring in 16–100 hectads, but which are not threatened, *Lower Risk* (*near threatened*) or *Lower Risk* (*conservation dependent*). This is effectively another sub-category of *Lower Risk*. The distinction between *Nationally Scarce* and *Lower Risk* (*near threatened*) is thus purely one of frequency as expressed on a dot-map. There are currently 267 bryophytes categorised as *Nationally Scarce* but these are not covered in this volume, with the exceptions of *Petalophyllum ralfsii* and *Hamatocaulis vernicosus*.

Despite these and other difficulties, there are considerable advantages in adopting the 1994 IUCN categories, which are based on clear definitions, in preference to the earlier, more subjective classification. The range of criteria available eases the task of classifying species, and those criteria invoking area of occupancy, number of locations and inferred population decline are those most frequently used for the bryophytes. For a detailed discussion of the application of the 1994 IUCN criteria to the British flora, see Palmer et al. (1997). Hallingbäck et al. (1996, 1998) have provided guidelines for the application of the revised IUCN criteria to bryophytes (including discussion of difficulties and how they may be addressed), which have now been adopted officially by the IUCN as a standard for bryophytes and followed, as far as possible, in this book.

Number of species in threat categories

The number of species in each threat category is summarised in Table 5.

Table 5. The number of threatened bryophyte species in Britain

	EX	*CR*	*EN*	*VU*	*Total*
Liverworts	1	2	5	25	33
Mosses	17	22	37	41	117
Total	*18*	*24*	*42*	*66*	*150*

In addition there are 24 *Data Deficient* species and 76 *Lower Risk* (*near threatened*) species (see Appendix 2). It is interesting to note that there are disproportionately low numbers of liverworts in the categories EX, CR and EN, with a disproportionately high number in the VU category. There could be a number of reasons for this. Firstly, it could be an artefact of the system, whereby we have been more reluctant to assign rough population estimates for liverworts than for mosses, because of their tendency to grow in amorphous swards rather than in discrete tufts, unlike many mosses. Secondly, it could reflect that threatened liverworts are less threatened than threatened mosses. Many of the threatened mosses are lowland plants of highly populated areas, and therefore under more threat, whereas many of the liverworts are plants of remote upland or sparsely populated west coast areas, and therefore under less threat. The fact that the number of extinct mosses far outweighs the number of extinct liverworts tends to support the second hypothesis.

3 Habitats of the Red List bryophytes and their conservation

In regions with a temperate climate, such as Britain, most habitats are dominated by vascular plants. Bryophytes have little chance of directly outcompeting these usually much larger organisms, and persist by exploiting a range of restricted niches in which vascular plants are at a disadvantage. These may include sites where there is little or no soil (as on rock outcrops or stones and boulders), where the soil is low in nutrients or contaminated by toxic heavy metals (as on mine spoil), or where the growth of vascular plants is restricted by climatic extremes such as summer drought (as on rocky, south-facing slopes) or winter cold (as on mountain tops). Rapidly growing bryophytes may colonise disturbed ground and complete their life cycle in the brief interval before vascular plants assume dominance, or may exploit transient habitats such as mud at the edge of lakes and rivers which is exposed for a few months in especially dry summers. In structurally complex vegetation types such as woodland, bryophytes may even grow as epiphytes on the vascular plants themselves, colonising the trunk, branches or twigs of trees and shrubs, or they may occupy the deeply shaded woodland floor.

One feature of bryophytes that distinguishes them from flowering plants is the range of reproductive structures. Mosses and liverworts 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.

The major habitats for the Red List bryophytes are discussed below and summarised in Table 6. It is not always easy to allocate species to habitats such as 'woodland' or 'sea cliffs', partly because the small size of bryophytes means that they are often plants of particular microhabitats which may recur in more than one major habitat type. A species such as *Lejeunea mandonii*, for example, grows on shaded rocks and trees, and may be found in woodland, in block scree or on north-facing cliffs. The classification of some species is therefore somewhat arbitrary, but in the text that follows the species are listed under the habitat(s) with which they are most closely associated, together with an appropriate

Table 6. The number of threatened bryophytes[(a)] in different habitats

Habitat	*EX*	*CR*	*EN*	*VU*	*Total*
Ruderal	4.5	2	7	5.5	*19*
Trees & hedgerows	2	2	4.5	1	*9.5*
Woods	0.5	0	4.5	3	*8*
Grassland	0	0	2	2.5	*4.5*
Sand dunes	1	1	2	4	*8*
Sea cliffs	0	0	3	4	*7*
Lowland waters	0	5	3	7	*15*
Upland waters	0	1	2	3	*6*
Fens and bogs	3	1	3	3.5	*10.5*
Heathland and moorland	0	4	0	5	*9*
Lowland, base-rich rocks	3	3	3.5	6	*15.5*
Lowland, acidic rocks	1	1	0.5	1.5	*4*
Upland, base-rich rocks	2	3	7	14.5	*26.5*
Upland, acidic rocks	1	0	0	2.5	*3.5*
Snow patches	0	1	0	3	*4*
Total	*18*	*24*	*42*	*66*	*150*

(a) Species occurring in two habitats are scored as 0.5 in each

abbreviation to indicate whether they are *Extinct* (EX), *Critically Endangered* (CR), *Endangered* (EN), *Vulnerable* (VU) or *Data Deficient* (DD). *L. mandonii*, for example, is labelled EN, to indicate that it is *Endangered*. The species accounts should be consulted for a more precise description of the habitat of particular taxa. *Hamatocaulis vernicosus* and *Petalophyllum ralfsii*, now both categorised as *Nationally Scarce* (NS), are also included here because of their listing in national and international legislation.

A list of the habitats of our threatened bryophytes is rather different from a list of all our bryophyte habitats. Some habitats with rich assemblages which are important even in an international context — such as western woodland and blanket bog — have few threatened species and therefore do not appear very prominently in the list below, and other habitats which may be very important in particular areas (such as churchyards) do not appear at all. More comprehensive accounts of bryophyte habitats in particular areas are available in the introductory sections of regional floras (e.g. Bates 1995; Gardiner 1981; Hill 1988).

Ruderal habitats

Many bryophytes colonise disturbed ground, and rapidly produce spores to complete their life cycle before they are destroyed by renewed disturbance or out-competed by vascular plants. Even arable fields may be colonised by species that grow in the autumn and winter months, after the crop has been harvested. These species include the threatened liverworts *Phaeoceros carolinianus* (EN) and *Sphaerocarpos texanus* (VU). Species of *Ephemerum*, *Fossombronia* and *Weissia* often grow on disturbed soil which is damp during the winter months, and tend to occur in sites such as paths and rutted woodland rides, as well as in fallow fields: these include *E. stellatum* (EN), *F. crozalsii* (EX), *W. mittenii* (EX), *W. multicapsularis* (EN) and *W. squarrosa* (EN). Many of these species have relatively large spores and capsules which do not dehisce. They are 'shuttle species' (During 1979), which depend on recurring disturbance in the same localities for their survival, rather than dispersal to newly available sites. *Cephaloziella dentata* (CR) is virtually confined to winter-flooded depressions on tracks across heathland, *Lophozia capitata* (VU) grows in wet places in disused sand or clay pits, and the sole British record of *Trematodon ambiguus* (EX) was from disturbed soil by a moorland track. Two mosses not seen for many years, *Bryum turbinatum* (EX) and *B. uliginosum* (CR) seem to have been generalists of damp ground, and it is not clear why they have declined so severely.

Mosses requiring disturbed, calcareous ground formerly found ideal conditions on 'mud-capped walls'. Jones (1952) gave the best description of this habitat when he described how walls made of the 'brashy or fissile' Jurassic Limestone in the Oxford area were capped from time to time by earth taken from the roadside. Many ephemeral mosses colonised these wall tops, some appearing later than others in a successional sequence. Jones noted in 1952 that

> it is sad to record the rapid deterioration of these walls; even thirty years ago the custom of renewing the earth capping had lapsed and many of the characteristic species were consequently becoming rarer, but at the present time the majority of these walls have either been capped with cement or are tumbling down; others in the villages are beautified with aubretias, and 'good' spots are now rare and of small extent. (Jones 1952)

The habitat has now disappeared completely and the species that were most dependent upon it, which included *Ceratodon conicus* (EN) and *Pterygoneurum lamellatum* (EX), are themselves extinct or survive precariously on disturbed, calcareous soil in other habitats.

Another important ruderal habitat is the spoil left by mining operations. *Cephaloziella calyculata* (VU), *C. massalongi* (VU), *C. nicholsonii* (VU) and *Ditrichum cornubicum* (EN) are found around disused copper mines, *Marsupella profunda* (VU) is confined to the vicinity of china clay quarries, and *Tortula cernua* (*Desmatodon cernuus*) (EN) is most frequent in old Magnesian Limestone quarries.

The conservation of bryophytes of ruderal habitats poses many problems. Colonists that rarely persist for long at a single site are especially difficult to deal with: it is difficult to be sure of the current distribution of the species and pointless protecting the known sites if the species may be here today and gone tomorrow. The species of mine spoil are restricted to defined sites, but the conservation of these sites is difficult. When active mining ceases, non-toxic spoil such as china clay waste and limestone rubble becomes overgrown, and may need disturbance to maintain suitable open habitats. Land contaminated by heavy metals is less readily colonized, but habitats may be destroyed if old mines are subjected to 'landscaping', or if it becomes profitable to rework the spoil heaps for the metal ores they still contain. In recent years the bryophyte communities of arable fields have been adversely affected by agricultural intensification and, in particular, by the ploughing of fields

immediately after harvest followed by the sowing of a new crop.

Trees and hedgerows

Epiphytic bryophytes grow on the trunks, branches and twigs of trees and shrubs. Most species fruit freely or reproduce vegetatively by gemmae, which are produced in abundance; even the species that fruit freely will often produce gemmae in addition. Very few epiphytic bryophytes are restricted to a particular host species, although many prefer a certain type of bark, and will therefore tend to occur preferentially on a restricted range of hosts. *Habrodon perpusillus* (EN), *Orthotrichum obtusifolium* (EN) and *O. pallens* (EN) are plants of well-illuminated, basic bark and therefore tend to grow on trees such as ash *Fraxinus excelsior*, elm *Ulmus* and sycamore *Acer pseudoplatanus* in pastures, parks or hedgerows. *Zygodon forsteri* (EN) is more restricted in its host range, being more or less confined to beech *Fagus sylvatica* on acid soils in ancient woodlands. Two epiphytes on the Red List, *Orthotrichum gymnostomum* (EX) and *Neckera pennata* (EX), have been found only once (in Scotland); it is difficult to know whether these species were ever present as established populations or whether they were merely casual colonists.

Many epiphytic species of moss (and lichen) have declined in historic times because of air pollution. There is particularly strong evidence that sulphur dioxide (SO_2) pollution was responsible for the decline of many species in the 19th and early 20th centuries, and these may have included *Orthotrichum obtusifolium* (EN), *O. pallens* (EN) and *O. pumilum* (CR). Since 1965 levels of atmospheric SO_2 have fallen markedly, and many commoner epiphytes are now recolonising areas from which they were eliminated many years ago (Adams and Preston 1992; Bates et al. 1997). Levels of other pollutants such as ozone (O_3 and nitrogen oxides (NO_x) have increased, and the effect of these pollutants on bryophytes is little understood, although the nitrogen oxides are urban pollutants which are therefore unlikely to affect many bryophyte species. 'Acid rain' may also affect epiphytic bryophytes by acidification of bark or by the fertilising effect of the nitrate it contains (Farmer et al. 1992).

In addition to air pollution, epiphytes growing on well-illuminated trees may be affected by the drift of agricultural herbicides and fertilisers applied to nearby fields (Brown 1992) and by the felling of host trees. The recent outbreak of Dutch elm disease has removed many epiphyte hosts, and the consequences of this for populations of *Orthotrichum obtusifolium* (EN) — which usually grows on elm in Scotland — are not yet clear.

A few threatened bryophytes may be found on hedgebanks. *Tortula cuneifolia* (VU) and *Tortula wilsonii* (EN) grow on hedgebanks and treeless Cornish 'hedges', and *Rhynchostegium rotundifolium* (CR) is unique amongst British bryophytes in being restricted to hedgerows, where it grows on tree bases and exposed tree roots as well as limestone rocks.

Woods

Although woods are the richest and most important habitats for bryophytes in many areas, there are few threatened woodland species. The only example of such a species in southern England is the Wealden moss *Atrichum angustatum* (EN). However a number of plants of disturbed soil, notably *Fossombronia crozalsii* (EX), are found on woodland rides.

Buxbaumia viridis (EN) is restricted in Britain to long dead, soft, decaying trunks of Scots pine *Pinus sylvestris*. Its original habitat was probably in the Caledonian pinewoods of eastern Scotland, but most recent records have been in secondary woodland or plantations. *Anomodon attenuatus* (EN) is also confined to eastern Scotland, on tree trunks and sandstone rocks in woods and wooded ravines.

Oakwoods and hazelwoods on the western seaboard are an exceptionally important bryophyte habitat. Hodgetts (1993) points out that the Atlantic woodlands of Britain have a bryophyte diversity comparable to that of some tropical forests. Averis (1991) has given a thorough account of bryophytes in Atlantic woodland in the Scottish Highlands. The richest sites are those where the substrate and topography is varied, and wooded ravines are often especially rich. They include a wide range of microhabitats including living and dead wood, dry or moist rocks and boulders, flushes and streams. Many of the characteristic species of these woods are frequent in the most oceanic parts of Britain, and extreme rarities are few. Threatened species include *Daltonia splachnoides* (VU), *Radula carringtonii* (VU), *Sematophyllum demissum* (EN) and *Telaranea nematodes* (VU). Although not an Atlantic species, *Rhytidiadelphus subpinnatus* (EN) is a plant of damp grassy banks in acid woodland on the west side of the country.

The characteristic species of Atlantic woodlands differ in their precise ecological requirements, but almost all require sheltered and humid conditions. Ratcliffe (1968) suggested that they were concentrated in sites which not only have a continuous history as *woodland*, but have never

been coppiced or clear-felled and therefore also have a continuity of *tree cover*. The extent to which this is true is debatable: some oceanic bryophytes can be found on old coppice stools, and an investigation of the history of four species-rich woods in Snowdonia showed that their history included episodes of coppicing or even clear-felling (Edwards 1986; Edwards and Birks 1986). During these phases the more exacting bryophytes presumably survived in crevices between boulders and in rock outcrops, which continued to offer shade and shelter. Nevertheless, the conservation of the Atlantic woodland bryophytes is best served by ensuring the continuity of tree cover. This requires not only protection from felling, but also from over-grazing by deer, sheep or cattle which prevents tree regeneration, opens up the vegetation beneath the canopy and (in the case of cattle grazing in particular) destroys small flushes which support many bryophyte species (Hodgetts 1993).

A further threat to the Atlantic woodlands is the spread of the introduced shrub *Rhododendron ponticum*, which thrives in oceanic climates and has colonised many western woodlands. The very dense shade cast by this evergreen excludes many bryophytes, although it does provide conditions that are suitable for the shade-tolerant *Telaranea nematodes* (VU).

Grassland

The single most important factor influencing the bryophyte flora of grassland is the vigour of the flowering plant sward. Few habitats are as devoid of bryophytes as dense grassland, whether this is a traditionally managed hay meadow or an improved agricultural sward. The combination of competition from flowering plants, and the lack of structural diversity in the vegetation, provides virtually no opportunity for bryophyte colonisation. Grazed grassland over less nutrient-rich soils supports a more diverse flora, especially if the turf is disturbed by grazing animals or broken by rocks, molehills and anthills. In grazed, acidic grassland common bryophytes may constitute a significant proportion of the vegetation (Hill 1988), but there are few rare species. However, decaying vegetation in acidic grassland is apparently the natural habitat for *Leptodontium gemmascens* (VU), although this species is better known for its occurrence on old thatch.

Calcareous grassland is an important bryophyte habitat, and supports some threatened species. *Acaulon triquetrum* (EN), *Eurhynchium meridionale* (VU) and *Weissia levieri* (EN) are all species with Mediterranean–Atlantic distributions which in Britain are confined to open turf, rocky grassland or short turf on coastal chalk and limestone. *Weissia condensa* (VU) is also found in short, open calcareous turf.

Much calcareous grassland has been converted to arable or ploughed, reseeded and fertilised to produce a dense agricultural sward. In many inland areas unimproved grassland survives only as small patches on earthworks, steep valley sides and roadside verges. These sites are often ungrazed and lose their characteristic bryophytes as the vegetation changes to a tall sward or eventually to scrub. Coastal sites with their more rugged topography are less vulnerable to agricultural improvement. Exposure to salt-laden winds and summer drought often helps to maintain open conditions on the rocky, south-facing coastal slopes favoured by many species with a southerly distribution.

Sand dunes and salt marshes

Many species occurring in calcareous grassland over chalk and limestone also grow in short turf over calcareous dune sand. *Tortella limosella* (EX) was known only from a sandy sea shore in Scotland.

Dune slacks support a particularly rich bryophyte flora, including a suite of threatened species. These include: *Bryum calophyllum* (VU), *B. knowltonii* (VU), *B. mamillatum* (CR), *B. marratii* (EN), *B. neodamense* (EN), *B. warneum* (VU) and *Petalophyllum ralfsii* (NS). Several of the *Bryum* species have declined markedly in recent decades and are now amongst the most threatened British bryophytes.

The decline of many dune slack bryophytes is a result of a complex sequence of changes (Houston 1997). Sand dune systems are naturally dynamic. Dunes grow as sand accretes at the seaward end of the system and they are initially unstable. Slacks start as hollows which develop in mobile dune systems. They initially become colonised by bryophytes and small vascular plants, but succession in the slack may eventually lead to the replacement of these communities by scrub; alternatively, the slacks may be filled by blown sand. In the natural state the loss of some slacks would be balanced by the development of others, but many dunes are now stabilised by coastal protection works or by deliberate planting of the dune system with sand-binding species. The gradual loss of the pioneer communities in dune slacks has often been accelerated by the fact that many dunes are no longer grazed by domestic stock, and rabbit grazing is less intense than it was before the introduction of myxomatosis. Turf stripping can be used to provide open ground suitable for colonisation by pioneer species, and Dutch conservationists have

experimented with 'managed destabilisation' of fixed dunes.

Some of the threatened dune slack *Bryum* species, including *B. knowltonii* (VU), *B. marratii* (EN), *B. salinum* (VU) and *B. warneum* (VU), have been recorded at the edge of salt marshes, but otherwise this habitat supports only a very restricted range of bryophytes (Adam 1976).

Sea cliffs

The threatened species of chalk and limestone grassland on sea cliffs have already been discussed. Several other threatened species with southerly or Mediterranean–Atlantic distributions in Europe are found in open habitats on sea cliffs. *Didymodon cordatus* (VU) is found on soft and crumbling sandstone cliffs, and *Philonotis marchica* (EN) grows on wet rocks and soil on unstable sandstone cliffs. *Tortula wilsonii* (EN) and *Cephaloziella calyculata* (VU) grow on thin soils on sea cliffs. Depressions on cliff slopes and cliff tops, which are damp in winter but dry out in summer, support *Riccia bifurca* (VU) and *R. nigrella* (VU).

Three oceanic bryophytes of Macaronesian and tropical affinities are found in the sheltered environment of sea caves in Britain, where they reach the northern limit of their world distribution. They are *Cyclodictyon laetevirens* (EN), *Lejeunea holtii* (VU) and *L. mandonii* (EN).

Lowland rivers, streams and standing waters

Wet rocks and banks by sheltered streams provide an environment which, like that of sea caves, is buffered from extremes of temperature and drought. This is the habitat of *Dumortiera hirsuta* (VU), a predominantly tropical liverwort, the Mediterranean–Atlantic *Fissidens serrulatus* (VU), as well as the more widespread *Jungermannia leiantha* (CR). The endemic *Thamnobryum cataractarum* (VU) is also found on streamside rocks, where it normally grows below the water level. The other endemic British *Thamnobryum* species, *T. angustifolium* (CR), grows on a limestone rock face by a calcareous spring, and wet limestone rocks and tufa by streams are the habitat of *Seligeria carniolica* (CR).

The western European moss *Cryphaea lamyana* (VU) grows on rocks and silt-covered tree trunks by larger streams and rivers, and *Cinclidotus riparius* (VU) is confined to flood-zone rocks on a single West Midlands river. *Bryum gemmiparum* (EN) grows on wet ground and silt by rivers.

Damp mud exposed at the edge of lakes, reservoirs and ponds when water levels fall in dry summers can support a rich community of ephemeral bryophytes, including many 'shuttle species' that persist through the flooded periods as dormant spores. *Ephemerum cohaerens* (CR), *Micromitrium tenerum* (CR), *Physcomitrium eurystomum* (EN), *Riccia canaliculata* (VU) and *R. huebeneriana* (VU) all fruit freely in this habitat, whereas *Bryum cyclophyllum* (EN) reproduces by gemmae.

There are few threats to the western streams and rivers that support the rarest bryophytes. Establishing threats to the species of exposed mud is less easy. Because they appear for only a few months towards the end of dry summers it is difficult to assess their current distribution, let alone to comment on any threats. Smaller water bodies appear to be more threatened than larger lakes and reservoirs, as artificial stabilisation of the water level for fishing restricts the habitat available to ephemeral bryophytes.

Upland flushes, streams and lakes

A number of threatened bryophytes grow in upland flushes, including *Bryum schleicheri* (CR), *Scorpidium turgescens* (VU) and *Tayloria lingulata* (EN). Flushes are vulnerable habitats as they are small in area and can be damaged through trampling by people or cattle. Flushes at moderate but not high altitudes are also likely to be destroyed by drainage or afforestation. The semi-aquatic bryophytes that grow by streams and lakes at very high altitude are less threatened. They include *Andreaea frigida* (VU) and two threatened species of *Hygrohypnum*, *H. molle* (VU) and *H. polare* (EN).

Fens and bogs

British botanists traditionally distinguish calcareous 'fens' from acidic 'bogs'. Both habitats have suffered a long history of destruction and degradation throughout the European lowlands. According to the *Red Data Book of European bryophytes* (European Committee for the Conservation of Bryophytes 1995), 'fens are one of the most threatened habitats in lowland Europe', and 'bogs are one of the most threatened habitats in Europe'. The British experience supports this: several of the characteristic bryophytes of these habitats have already become extinct and others are threatened.

The draining of the fens to provide land for agricultural use has been a major objective for many centuries (Darby 1940) and, despite many setbacks, it has largely been accomplished. In lowland Britain only small and much-modified fragments of fenland remain. The remaining areas of fen are vulnerable to

many different pressures, including falling regional water tables, eutrophication of the water which feeds them, and the loss of traditional management, such as grazing. All these changes can result in the replacement of bryophyte-rich plant communities — which are typically low swards of small sedges — by taller fen vegetation dominated by tall sedges and reeds (which exclude most bryophytes) or shrubs.

Helodium blandowii (EX) and *Paludella squarrosa* (EX) have been lost from all their British sites, although the latter was recently newly discovered in Ireland (Lockhart 1999). The drainage of the few sites where these species persisted into the historical period delivered the *coup de grace* to plants which had already undergone a long period of decline (Dickson 1973). Fossil evidence indicates that both species have relict distributions in our area. The surviving populations of the liverwort *Leiocolea rutheana* (EN), a species with a boreo–arctic distribution, are also threatened.

Two threatened species grow on decaying vegetation in swamps and fen carr: *Amblystegium radicale* (*A. saxatile*) (CR) and *Pallavicinia lyellii* (VU).

The oceanic climate of Britain provides ideal conditions for the development of bogs, which are dominated by species of *Sphagnum*, and there is a great diversity of different bog types in our area. However, many lowland bogs have been destroyed by drainage, usually to provide land for agriculture or forestry, or damaged by peat extraction, which may take place on an industrial scale. Large areas in uplands adjacent to industrial centres — notably in the South Pennines — have also been degraded by the effects of air pollution on the dominant *Sphagnum* species (Press et al. 1983). Not surprisingly, there is a suite of extinct or threatened bog species, comprising *Dicranum bergeri* (VU), *D. leioneuron* (VU), *Jamesoniella undulifolia* (EN), *Sphagnum balticum* (EN), *S. majus* (VU) and *S. obtusum* (EX). The protected species *Hamatocaulis vernicosus* (NS) grows in mires that are mineral-rich but not strongly calcareous.

Heathland and moorland

Upland heath in the extremely oceanic climate of western Britain may support an exceptionally interesting assemblage of bryophytes. At the richest sites the normal carpet of mosses that grows beneath *Calluna vulgaris* and other ericaceous shrubs is replaced by a community of liverworts which Ratcliffe (1968) called the 'mixed hepatic mat'. This community 'reaches its finest development on steep, rocky slopes facing between north-west and east, especially in deep and dark, sheltered corries' (Ratcliffe 1968), and is normally found at middling altitudes (300–600 m). The same species may also occur in rocky grassland and block scree. The importance of this community lies in the restricted distribution of its component species. Within Europe many species are confined to Britain and Ireland, or are much more frequent here than elsewhere, and they tend to have very disjunct world distributions. They are dioecious species which neither reproduce sexually nor have specialised vegetative propagules. All these facts suggest that they must once have been more widespread but now have highly relict distributions (Crundwell 1992). The threatened liverworts, *Adelanthus lindenbergianus* (VU) and *Herbertus borealis* (VU), are members of this remarkable group of bryophytes. D G Long (in Hill et al. 1991) has suggested that the original habitat of these species in Scotland might have been scrub and heath at or near the natural tree line, but that this has now been obscured by woodland clearance.

The oceanic liverworts of the mixed hepatic mat community are much less widespread than one would expect on the basis of their climatic requirements, and it has been suggested that they may have been eliminated from many areas by burning (Averis 1992; Hobbs 1988). Burning remains one of the major threats to these communities today.

A number of other threatened species are found on peaty soil in western moorlands, including *Geocalyx graveolens* (VU) and *Philonotis cernua* (CR). Like the oceanic liverworts of the mixed hepatic mat, *P. cernua* is restricted within Europe to Britain and Ireland and has a disjunct world range. However, it differs greatly in its reproductive biology, as it is a monoecious species which fruits freely and tends to be most abundant on sites that have been burnt. Another group of threatened species is found in moorland at high altitudes, mainly in eastern Scotland: *Aplodon wormskjoldii* (CR), *Dicranum elongatum* (CR) and *Tayloria tenuis* (CR). Lowland heathland outside areas of highly oceanic climate is not an especially rich habitat for bryophytes, and there are only two threatened species that are normally associated with this habitat, the liverwort *Cephaloziella integerrima* (VU) and the moss *Dicranum spurium* (VU).

Rocks and cliffs

A large number of the threatened bryophytes grow on rocks or on very thin soil over rocks and cliffs. In the following account this habitat is subdivided by altitude and substrate chemistry, with lowland and middle altitude species (i.e. those which usually

occur below 500 m) separated from upland species, and plants of calcareous and other base-rich rocks separated from those of acidic substrates.

Lowland, base-rich rocks

The threatened species of lowland, base-rich rocks fall into two ecological groups. Some grow on limestone, basalt or other base-rich rocks or on thin soil overlying such rocks, in situations where they are usually exposed to full sunlight. They include *Bartramia stricta* (CR), *Eurhynchium meridionale* (VU), *E. pulchellum* (EN), *Grimmia anodon* (EX), *G. ovalis* (VU), *G. tergestina* (VU), *Riccia nigrella* (VU), *Southbya nigrella* (VU) and *Zygodon gracilis* (EN). Some of these species have colonised quarry faces, walls and bridges. The second group comprises species that grow on shaded rocks, often in sheltered situations. Many of these species are found on softer, base-rich rocks such as chalk and sandstone. *Anomodon longifolius* (VU), *Cephaloziella baumgartneri* (EN), *Didymodon glaucus* (CR), *Encalypta brevicollis* (EX), *Gyroweisia reflexa* (EX), *Homomallium incurvatum* (CR), *Lejeunea mandonii* (EN) and *Scapania praetervisa* (VU) are the members of this group.

Several epilithic *Grimmia* species, including *G. ovalis* (VU), have undergone a marked decline in Britain. The most plausible explanation for this decline is that they are susceptible to atmospheric pollution, but this hypothesis has not been tested by experimental studies (Adams and Preston 1992). Otherwise the bryophytes of lowland, base-rich rocks are not an especially threatened group. Individual sites may be threatened by quarrying, and individual species by vegetation changes (whether the result of natural succession or deliberate management) which deprives them of their particular requirements for light or shade.

Lowland, acidic rocks

The list of threatened bryophytes of lowland acidic rocks is smaller than the corresponding group of basicolous species, and there are no bryophytes of exposed rocks of this type in the Red List. *Cynodontium fallax* (EX), *Orthodontium gracile* (VU), *Pallavicinia lyellii* (VU), *Sematophyllum demissum* (EN) and *Tetrodontium repandum* (CR) are plants of shaded rock outcrops. The main threats to these species are activities that disrupt their preferred microclimate. *O. gracile* is more seriously threatened by competition from the widespread alien species *O. lineare*.

Upland, base-rich rocks

More threatened bryophytes grow on upland, base-rich rocks than in any other habitat, and mountains such as Ben Lawers, which have large exposures of such rock at high altitude, have long attracted the attention of bryologists. The species included in this category are normally found at altitudes above 500 m, but some may descend to lower altitudes in the north and west of Scotland. Many of these species are likely to be 'glacial relicts' which were widespread at the end of the last glacial period in open plant communities on disturbed, calcareous soils. However, following the improvement of the climate and the growth of peat in many upland areas, they retreated to a few refugia where base-rich rocks outcrop at high altitude. Rupestral species are less likely to be preserved as subfossils than plants which grow in fens or bogs, but there is fossil evidence that *Hypnum revolutum* (EN) and *H. vaucheri* (VU) were formerly more widespread. Many of the other threatened species listed below are included by Dickson (1973) in a list of possible glacial relicts. Many of these species are not always strictly rupestral also, or even principally, growing in associated rock crevices or turf.

Blindia caespiticia (EN)
Brachythecium starkei (VU)
Brachythecium trachypodium (CR)
Bryum lawersianum (EX)
Bryum stirtonii (VU)
Campylophyllum halleri (*Campylium halleri*) (EN)
Ctenidium procerrimum (VU)
Didymodon mamillosus (CR)
Grimmia ungeri (VU)
Grimmia unicolor (VU)
Heterocladium dimorphum (VU)
Hypnum revolutum (EN)
Hypnum vaucheri (VU)
Lescuraea saxicola (EX)
Mielichhoferia elongata (VU)
Mielichhoferia mielichhoferiana (VU)
Myurella tenerrima (EN)
Paraleucobryum longifolium (VU)
Plagiobryum demissum (EN)
Plagiothecium piliferum (CR)
Pohlia obtusifolia (EN)
Pseudoleskeella nervosa (VU)
Saelania glaucescens (VU)
Seligeria brevifolia (VU)
Syntrichia norvegica (*Tortula norvegica*) (VU)
Timmia austriaca (EN)
Tortula leucostoma (*Desmatodon leucostoma*) (VU)

Individual species differ in their precise ecological requirements. Some may extend onto base-poor rocks which are irrigated by base-rich water. A few species (notably *Mielichhoferia elongata* and *M. mielichhoferiana*) are found on rocks rich in copper or other heavy metals.

The habitat of these species is generally relatively free from threats, and for this reason most species are classified as *Vulnerable* rather than *Endangered*. Even the species currently regarded as extinct might yet be rediscovered. However, it should be noted that the largest group of extinct species in North Wales is that of montane plants. Hill (1988) suggests that these losses demonstrate the continuing decline, from natural causes, of species which have been in retreat since the last ice age.

Upland, acidic rocks

Whereas there are few exposures of base-rich rocks at high altitude, acidic rocks make up extensive areas of the British uplands. This may explain why there are few Red List species in this habitat. Included are *Grimmia elatior* (EX), *Gymnocolea acutiloba* (VU), *Paraleucobryum longifolium* (VU) and *Pohlia crudoides* (VU). Although rapid climate change, overgrazing and afforestation in the uplands are all current factors affecting the upland bryophyte flora in general, most of these rocky upland habitats are not threatened.

Snow patches

A distinctive bryophyte flora characterises areas in mountains where snow persists into the summer, such as north-facing corries and sheltered depressions. This includes the Red List species *Gymnomitrion apiculatum* (VU), *Hygrohypnum styriacum* (CR), *Marsupella arctica* (VU) and *M. sparsifolia* (VU). The main threats to these species arise from the increase in recreational activities in the mountains, with the consequent risk of erosion of these damp and rather fragile habitats. Global climate change poses a longer term and more intractable threat. Rothero (1990, 1991) has recently surveyed snow-patch communities in Scotland in detail and these reports provide a baseline against which future change can be monitored.

4 Conservation action and legislation

Ratcliffe (1977) recognised both the importance of bryophytes in general in British biotopes, and the significance of rare and threatened species, listing many in the accounts of the major habitats and sites identified. Since then, bryophytes, along with other 'lower plants', have steadily gained credibility among conservationists.

Because knowledge about individual species is often incomplete, it is sometimes difficult to recommend positive and effective conservation measures for Red List bryophytes. However, with the increasing emphasis on the conservation of biodiversity, and the recognition that Britain's bryophyte flora is of international importance, more action is now being taken which will benefit bryophytes. For example, since 1992 — when selection guidelines for Sites of Special Scientific Interest (SSSIs) for lower plants were published (Hodgetts 1992) — it has been possible to designate SSSIs purely for their bryophyte interest. Several SSSIs now exist where the primary interest is the bryophyte flora.

In most circumstances, despite the often slow growth rate of bryophytes, neither collecting for commercial purposes nor botanical collecting is a significant threat to Red List species. In the past, collecting by botanists has been more of a problem: the Victorian collecting mania — which lasted well into the 20th century — demanded that copious specimens, particularly of rare species, should be taken for the herbarium and for exchange with fellow botanists. Although close examination is sometimes necessary for identification purposes, modern bryologists are normally sufficiently aware to collect responsibly, or to record rare species photographically. However, in a few cases, where populations are tiny (e.g. *Hygrohypnum styriacum*), collecting could seriously damage a colony.

Commercial or private collecting of *Sphagnum*, and swards of some of the larger pleurocarpous mosses (e.g. *Hylocomium splendens*, *Scleropodium purum*), for use in hanging baskets or other horticultural items takes place in some areas. When moss-gathering is controlled and takes place in areas such as forestry plantations, there are few grounds for concern. Only common species are taken, and the trade can be regarded as sustainable, but in some circumstances there may be concern that rarer species are unwittingly gathered up at the same time. There is also a problem when moss-gathering takes place as an unauthorised activity on a protected site, because extensive habitat destruction can occur and rare species may be taken.

To counteract some of these threats, Britain has legislation relating to wildlife protection and nature conservation. There are two aspects to this legislation, covering sites and species. The law requires the designation of areas of wildlife importance — Sites of Special Scientific Interest (SSSIs) and National Nature Reserves (NNRs). As mentioned above, the presence of rare species and outstanding assemblages of bryophytes can be used as a justification for giving a site SSSI status (Hodgetts 1992). The Wildlife and Countryside Act (1981) protects all plants against unauthorised removal from the wild. The Act also gives special protection to certain rare species, which covers damage to, removal and sale of plants. As highlighted in a recent report (Plantlife 1999), there have been a number of successful prosecutions under the Wildlife and Countryside Act for illegal moss gathering. The 37 species of bryophyte on the schedule of protected plants (Schedule 8) in Great Britain (i.e. excluding Northern Ireland) are listed in Appendix 3. The Theft Act (1968) can also be used to combat illegal removal of plants from the wild.

Other legislation of relevance to plants covers controls on the release to the wild of alien species, pollution control, and the requirement for environmental impact assessments to be drawn up for major developments. *Sphagnum* is now afforded additional protection by its generic inclusion on Annex Vb of the EC Habitats & Species Directive (see below).

Bryophytes are included in several current conservation programmes. Survey underpins these activities, and monitoring is essential to indicate the success or otherwise of any recovery programme. Under the Scottish Cryptogamic Conservation Project — a partnership between Scottish Natural Heritage and the Royal Botanic Garden, Edinburgh — known sites of selected threatened species have been surveyed and conservation recommendations drawn up, many of which are now being acted upon. Proposals have been made for the conservation of the Scottish bryophytes listed on Schedule 8 of the Wildlife and Countryside Act 1981, and it is intended that other Red List species should be covered in the future. An example of recent action under this programme is for *Bryum schleicheri*.

English Nature's Species Recovery Programme is a programme of action for bringing threatened species back from the brink of extinction. Several species, including *Petalophyllum ralfsii*, have benefitted from this programme. The Countryside Council for Wales also has its own programme for species conservation. However, most targeted action for species conservation now takes place under the aegis of the UK Biodiversity Action Plan (UKBAP).

Seventy-five habitats of conservation importance are listed in *Biodiversity: the UK steering group report. Volume 2* (HMSO 1995b), a document produced by the UK Government in response to the United Nations Convention on Biological Diversity, which the UK ratified in 1994. Habitats mentioned in this document which are of particular importance for bryophytes include: broadleaved and yew woodland, native pine woodland, lowland wood pastures and parkland, calcareous grassland, lowland heathland, rivers and streams, montane habitats, upland heathland, maritime cliff and slope, shingle above high tide mark, boulders and rock above the high tide, machair, sand dunes and limestone pavements.

At about the same time, a consortium of non-government organisations (NGOs) produced *Biodiversity Challenge: an agenda for conservation in the UK* (Wynne et al. 1993, 1995). Both governmental and non-governmental documents contained a series of targets and summary Action Plans for a range of species which were considered priorities for action. *Biodiversity: the UK Action Plan* (HMSO 1994) included a set of 59 steps to be implemented by Government and its agencies, which encompassed a range of activities, from the need to continue with the programme of European site designations required by EC Directives to education and awareness programmes. One of these steps (Step 33) reads:

> Prepare Action Plans for threatened species in the following order of priority: globally threatened; threatened endemics; other threatened species listed in the relevant schedules or annexes to UK and EC legislation and international agreements to which the UK is a party; *Endangered* and *Vulnerable* species listed in Red Data Books ... with an aim to complete and put into implementation Action Plans for at least 90% of the currently known globally threatened and threatened endemics within the next 10 years.

The Government then established a Steering Group to take forward the work of the *UK Biodiversity Action Plan*, consisting of representatives of Government, statutory conservation agencies and NGOs. This work culminated in the publication of *Biodiversity: the steering group report* (*volumes 1 and 2*) in 1995 (HMSO 1995a, b), the recommendations of which were broadly accepted by the Government in 1996, and became the basis for much of the work that has developed since. The report contained costed Action Plans for 14 habitats, including lowland heathland, upland oak *Quercus* woodland, native pinewood and limestone pavement, and also Action Plans for the conservation of six species of moss and five species of liverwort (see Table 7). As an example of the sort of very general recommendations contained in the Action Plans, the plan for *Weissia multicapsularis* included recommendations to 'encourage positive management for this species on all sites, especially periodic disturbance to maintain open soils'. Clearly, this is more easily said than done, and of limited use without more detailed information about the ecology of the species, and expert specialist input from bryologists. However, the Action Plans are leading to much valuable new research, and an increase in our understanding of the ecology, distribution and needs of some of these threatened species. Specific conservation actions and monitoring programmes will be the ultimate result for most of them.

Bryophytes were also taken into account in several of the habitat Action Plans. For example, the Action Plan for upland oakwoods emphasises the importance of this habitat for epiphytes (including bryophytes), and recommends a number of conservation measures, including strengthening planning legislation to include a presumption against building roads within upland oakwoods.

More recently, a second tranche of bryophyte Action Plans was compiled (UK Biodiversity Group 1999a), including plans for a further 27 species of moss and six species of liverwort, and plans for another two mosses were included in Volume 6 of the series (UK Biodiversity Group 1999b). All bryophytes

currently having Action Plans are listed in Table 7. Note that not all the Action Plan species are Red List species: some are not considered threatened in Britain, but have been included in the UKBAP list of 'Species of Conservation Concern' because of international obligations for their conservation (see below). Each species for which an Action Plan has been written has been allocated a 'lead partner' — an organisation with the responsibility for taking forward conservation action for that species. At present, the plant conservation charity Plantlife is lead partner for many of the species, but other organisations have also taken on responsibility for some species.

Action for most species initially concentrates on detailed survey work, but the emphasis will shift to monitoring and management as time goes on. Shorter 'species statements' — essentially pared-down Action Plans — have also been appended to the published Action Plans for two liverworts, *Fossombronia crozalsii* and *Marsupella stableri*, and 16 mosses, *Atrichum angustatum*, *Bryum calophyllum*, *B. turbinatum*, *B. uliginosum*,

Table 7. Bryophytes covered by Biodiversity Action Plans

Liverworts	*Date Action Plan published*	*Contact point*	*Lead partner*	*Status in Britain*
Acrobolbus wilsonii	1999	SNH	FC	LR(nt)
Adelanthus lindenbergianus	1999	SNH	SNH	VU
Cephaloziella nicholsonii	1999	EN	EN/NHM	VU
Herbertus borealis	1999	SNH	SNH	VU
Jamesoniella undulifolia	1995	SNH	SNH	EN
Leiocolea rutheana	1995	EN	Wildlife Trusts	EN
Lejeunea mandonii	1995	EN	Plantlife	EN
Marsupella profunda	1995	EN	EN	VU
Pallavicinia lyellii	1999	EN/CCW	RBGK/Plantlife	VU
Petalophyllum ralfsii	1995	CCW	Plantlife	NS
Riccia huebeneriana	1999	EA	Plantlife	VU
Mosses				
Acaulon triquetrum	1999	EN	EN	EN
Andreaea frigida	1999	SNH	Cairngorm Partnership/RSPB	VU
Bartramia stricta	1999	CCW	CCW	CR
Brachythecium appleyardiae	1999	EN	EN	LR(nt)
Bryoerythrophyllum caledonicum	1999	SNH	NTS	LR(nt)
Bryum mamillatum	1999	EN	Plantlife	CR
Bryum neodamense	1999	EN	Plantlife	EN
Bryum warneum	1999	EN	Plantlife	VU
Buxbaumia viridis	1995	SNH	SNH	EN
Cryphaea lamyana	1999	EA	Plantlife	VU
Didymodon glaucus	1995	EN	EN	CR
Didymodon mamillosus	1999	SNH	SNH	CR
Didymodon tomaculosus	1999	MAFF	Plantlife	LR(nt)
Ditrichum cornubicum	1995	EN	EN/NHM	EN
Ditrichum plumbicola	1999	EN	EN/NHM	LR(nt)
Ephemerum stellatum	1999	MAFF	Plantlife	EN
Fissidens exiguus	1999	EA	Plantlife	LR(nt)
Hamatocaulis vernicosus	1995	CCW	CCW	NS
Leptodontium gemmascens	1999	EN	EN	VU
Orthodontium gracile	1999	EN	EN	VU
Orthotrichum obtusifolium	1999	SNH	Plantlife	EN
Orthotrichum pallens	1999	SNH	Plantlife	EN
Pohlia scotica	1999	SNH	SNH	LR(nt)
Rhynchostegium rotundifolium	1999	EN	EN	CR
Seligeria carniolica	1999	EA	Plantlife	CR
Sematophyllum demissum	1999	CCW	CCW	EN
Sphagnum balticum	1999	EN	Plantlife	EN
Thamnobryum angustifolium	1995	EN	EN	CR
Thamnobryum cataractarum	1999	EN	EN	VU
Tortula cernua (Desmatodon cernuus)	1999	EN	Plantlife	EN
Tortula freibergii	1999	EN	NHM	LR(nt)
Weissia multicapsularis	1995	EN	EN	EN
Weissia rostellata	1999	EA	to be determined	LR(nt)
Zygodon forsteri	1999	EN	EN	EN
Zygodon gracilis	1999	EN	EN	EN

Abbreviations: EA — Environment Agency; FC — Forestry Commission; NHM — The Natural History Museum; NTS — National Trust for Scotland; RBGK — Royal Botanic Gardens, Kew

Campylopus setifolius, *Ephemerum cohaerens*, *Micromitrium tenerum*, *Orthotrichum gymnostomum*, *O. sprucei*, *Pictus scoticus*, *Plagiothecium piliferum*, *Seligeria calycina*, *Sphagnum skyense*, *Tetrodontium repandum*, *Weissia squarrosa* and *W. sterilis* (UK Biodiversity Group 1999b).

Ex-situ conservation of bryophytes has until recently received little attention. The few people with experience of growing mosses and liverworts have usually done it for reasons other than conservation. A few scientists have cultivated bryophytes in laboratories for research purposes, and bryophytes are occasionally grown horticulturally (e.g. in Japanese moss gardens). Fletcher (1991) described some techniques for growing bryophytes in greenhouse conditions. Recently, a joint project has been initiated between the statutory conservation agencies — led by English Nature and the Royal Botanic Gardens, Kew — to look into the possibility of *ex-situ* conservation for bryophytes. A workshop meeting in February 1999 brought together experts on the subject from around the world, and it is intended to use *ex-situ* techniques in the conservation of some of our most threatened species. The emphasis, however, will always be on complementing *in-situ* conservation, not providing an alternative to it.

5 The international context

International conventions, legislation and organisations

There are several international treaties and laws that are relevant to the conservation of bryophytes.

The Convention on Wetlands of International Importance especially as Waterfowl Habitat (Ramsar Convention) places an obligation on signatory countries to protect wetland areas of international importance. This convention came into force in 1975, but so far most of the sites have been chosen because of their bird populations. Redgrave and Lopham fens (Norfolk and Suffolk) are among a smaller number of sites selected under criteria covering other species and general wetland habitat features.

The Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention) is primarily concerned with the protection and conservation of selected threatened species. The plant list was substantially revised in January 1991 and now includes 26 species of bryophyte on Appendix 1, including the following British species: western rustwort — *Marsupella profunda*; petalwort — *Petalophyllum ralfsii*; green shield-moss — *Buxbaumia viridis*; slender green feather-moss — *Hamatocaulis* (*Drepanocladus*) *vernicosus*. These were the first 'lower plants' to be listed under any international convention. A panel of experts has been set up to review this list periodically.

The European Community *Directive on the Conservation of Natural Habitats and of Wild Fauna and Flora* (the 'Habitats and Species Directive'), that came into force in 1992, has several important aspects. Firstly, it seeks to ensure the protection of important sites for threatened species, as well as protection for the species themselves. There are no bryophytes in the latter category but, as far as British bryophytes are concerned, the same four species listed on the Bern Convention require Special Areas of Conservation (SACs) to be designated for their protection (Annex IIb). The Directive also seeks to ensure the protection of internationally important habitats. A considerable number of the habitats listed on the Directive are of importance for bryophytes, including active bogs and dune systems. Another article in the Directive deals with the taking from the wild and exploitation of certain species (Annex Vb). This means that the status of all *Sphagnum* species and *Leucobryum glaucum* should be monitored by member states and, if they consider it necessary, governments should take measures to protect these species. This Directive has the strength of European law and is enforced through domestic legislation. EC funds are available for certain conservation measures relevant to the Directive.

There are also several other European Community directives of some benefit to plant conservation, including those relating to air and water pollution, and to the requirement for environmental impact assessments for large developments.

Following its inauguration in 1990, the European Committee for the Conservation of Bryophytes (ECCB) has produced a Red Data Book for bryophytes in Europe (ECCB 1995). British species included in this publication are listed in Appendix 4. The ECCB has now grown to include representatives from almost all European states in its network, and is currently working on a revision of the Red Data Book using the revised IUCN threat categories. It has also identified the areas of Europe requiring more survey work to improve significantly the level of bryological information available. Although it has virtually no resources of its own, the ECCB has made an impact on bryophyte conservation by mobilising and bringing together a network of specialists. It holds a conference on bryophyte conservation every four years, with workshop meetings and Board meetings in-between. It also maintains contacts with other important organisations, including Planta Europa, the European Union and IUCN (as a regional subcommittee of the IUCN/

Species Survival Commission Bryophyte Specialist Group).

The IUCN/Species Survival Commission Bryophyte Specialist Group is one of the network of specialist groups constituted under the umbrella of the Species Survival Commission (SSC). It also acts as the Endangered Species Committee of the International Association of Bryologists. Like all SSC specialist groups, one of its prime tasks is to produce Action Plans, on a world basis, for the group covered, in order to encourage and inform conservation work. The first of these has just been produced (Hallingbäck and Hodgetts 2000), and updated versions will appear in the future. The Action Plan includes a list of 92 of the world's most threatened bryophytes, including the British species *Herbertus borealis*, *Jamesoniella undulifolia*, *Marsupella profunda*, *Ditrichum cornubicum* and *Thamnobryum angustifolium*.

It is therefore clear that bryophytes are now firmly on the conservation agenda and that their protection is likely to be addressed with increasing effectiveness as our knowledge about them increases.

International importance: endemism and disjunction

The bryophyte flora of Britain is of international importance because of its high proportion of oceanic species. A large number of species have their European 'headquarters' on the western seaboard, of which the west coast of Britain forms a substantial part. Many of the very rich species assemblages found in the west are not known anywhere else in the world, or are known elsewhere only in an impoverished state. The deep, humid ravines of western Scotland and Wales are particularly important for their bryophytes. Montane bryophyte communities, principally in Scotland, are much more oceanic than their equivalents elsewhere in Europe, and so show a distinctively British species composition.

Very few species of bryophytes are endemic to Britain (Table 8), and it is not unlikely that at least a proportion will be found elsewhere eventually. Bryophytes tend to have lower levels of endemism than vascular plants because of their often efficient dispersal mechanisms and ability to colonise microhabitats (Gradstein 1992; Schofield 1992). Furthermore, temperate regions have a lower level of endemism than tropical regions. Several species which until recently were thought to be endemic have now been found outside Britain (e.g. *Ditrichum plumbicola*, *Plagiochila britannica*).

Table 8. Bryophyte species endemic to Britain

Liverwort	*Status in Britain*
Cephaloziella nicholsonii	VU
Mosses	
Brachythecium appleyardiae	LR(nt)
Bryoerythrophyllum caledonicum	LR(nt)
Bryum dixonii	LR(nt)
Bryum lawersianum	EX
Ditrichum cornubicum	EN
Pictus scoticus	DD
Pohlia scotica	LR(nt)
Sphagnum skyense	DD
Thamnobryum angustifolium	CR
Thamnobryum cataractarum	VU
Tortella limosella	EX
Weissia mittenii	EX

Although there are few British endemics, quite a large number of British bryophytes — nearly all strongly oceanic species, some of them relatively frequent in Britain and Ireland — are endemic to western Europe (Table 9). Britain therefore contains a high proportion of the world population of these species, which are listed below so that they may be taken into account in assessing conservation priorities. Western Europe has been interpreted here to include Britain, Ireland, Iceland, the Faeroe Is., Norway, Holland, Belgium (including Luxembourg), France, Spain, Portugal and Macaronesia (Azores, Madeira and the Canary Is.). However, because some species have slight eastward range extensions into Italy, Germany, Sweden and Switzerland, these countries have also been included. *Plagiochila killarniensis* was originally included in this list but has recently been synonymised with the neotropical *P. bifaria* (Sw.) Lindenb. (Heinrichs et al. 1998).

The British bryophyte flora also includes a number of species that exhibit extreme worldwide disjunctions. Taking account of these patterns of distribution is as important for bryophyte conservation as consideration of endemic species is for the conservation of vascular plants. The most striking and important examples of this common bryological phenomenon are listed in Table 10. All are strongly oceanic species confined, worldwide, to cool regions with a high rainfall, and many are members of the 'mixed hepatic mat' community (Ratcliffe 1968).

Table 9. British bryophytes endemic to western Europe and Macaronesia

Liverworts	*Status in Britain*	*Occurrence elsewhere*
Acrobolbus wilsonii	LR(nt)	Ireland, Faeroe Is., Macaronesia
Fossombronia fimbriata	LR(nt)	Ireland
Frullania microphylla	LR(lc)	Ireland, Germany, France, Spain, Portugal, Macaronesia
Frullania teneriffae	LR(lc)	Ireland, Faeroe Is., France, Spain, Portugal, Macaronesia
Gymnomitrion crenulatum	LR(lc)	Ireland, Norway, France, Spain, Portugal
Herbertus aduncus ssp. *hutchinsiae*	LR(lc)	Ireland, Faeroe Is., Norway
Herbertus borealis	VU	Norway
Jubula hutchinsiae	NS	Ireland, France, Spain, Macaronesia
Jungermannia paroica	LR(lc)	Ireland, Faeroe Is., Belgium, Germany, France
Lejeunea mandonii	EN	Ireland, Spain, Portugal, Macaronesia
Marsupella profunda	VU	Portugal, Macaronesia
Plagiochila atlantica	NS	Ireland, France
Plagiochila britannica	LR(lc)	Ireland, Switzerland, Spain
Plagiochila carringtonii ssp. *carringtonii*	NS	Ireland, Faeroe Is.
Plagiochila norvegica	DD	Norway, Sweden
Plagiochila punctata	LR(lc)	Ireland, Norway, Belgium, Germany, France, Italy, Spain, Portugal, Macaronesia
Plagiochila spinulosa	LR(lc)	Ireland, Faeroe Is., Norway, Belgium, France, Macaronesia
Radula aquilegia	LR(lc)	Ireland, Faeroe Is., Norway, Spain, Macaronesia
Radula carringtonii	VU	Ireland, Spain, Macaronesia
Saccogyna viticulosa	LR(lc)	Ireland, Faeroe Is., Norway, France (incl. Corsica), Italy, Macaronesia
Mosses		
Campylopus brevipilus	LR(lc)	Ireland, Norway, Belgium, Holland, Denmark, Germany, France (incl. Corsica), Switzerland, Italy (incl. Sardinia), Spain, Portugal, Macaronesia
Campylopus setifolius	NS	Ireland, Spain
Didymodon tomaculosus	LR(nt)	Ireland
Fissidens celticus	LR(lc)	Ireland, Switzerland
Glyphomitrium daviesii	NS	Ireland, Faeroe Is., Iceland, Norway, Macaronesia
Grimmia retracta	NS	Ireland, Spain, Portugal
Isothecium holtii	LR(lc)	Ireland, Norway, Belgium, Germany, France, Spain
Myurium hochstetteri	NS	Ireland, Macaronesia
Orthotrichum sprucei	NS	Ireland, Belgium, Holland, France
Rhynchostegium alopecuroides (*R. lusitanicum*)	NS	Ireland, Norway, Germany, France, Spain, Portugal
Seligeria calycina (*S. paucifolia*)	LR(lc)	Ireland, Belgium, France
Tortula freibergii	LR(nt)	France, Italy, Spain, Portugal
Trichostomum hibernicum	NS	Ireland, France
Ulota calvescens	NS	Ireland, France, Spain, Portugal, Macaronesia
Weissia multicapsularis	EN	France
Weissia sterilis	LR(nt)	France

Table 10. British bryophytes with widely disjunct world distributions

Liverworts	*Status in Britain*	*Occurrence elsewhere*
Adelanthus lindenbergianus	VU	Ireland, Africa (mountains), C & S America, Antarctica
Anastrepta orcadensis	LR(lc)	Ireland, Himalayas, W China, Taiwan, Japan, Aleutian Is., North America, Hawaii
	NW	
Anastrophyllum donnianum	NS	Faeroe Is., SW Norway, Himalayas, Alaska, W Canada
Anastrophyllum joergensenii	LR(nt)	SW Norway, Himalayas
Bazzania pearsonii	NS	Ireland, E & SE Asia, NW North America
Colura calyptrifolia	NS	Ireland, France, Azores, Africa (mountains), South America
Herbertus stramineus	LR(lc)	Faeroe Is., W Norway, Iceland, NW North America
Mastigophora woodsii	NS	Ireland, Faeroe Is., C & E Asia, NW North America
Pleurozia purpurea	LR(lc)	Ireland, Faeroe Is., SW Norway, Svalbard, Himalayas, Alaska, Guadeloupe
Scapania nimbosa	NS	Ireland, SW Norway, Himalayas, W China
Scapania ornithopodioides	NS	Ireland, Faeroe Is., Norway, Himalayas, W China, Taiwan, Philippines, Hawaii
Sphenolobopsis pearsonii	NS	Ireland, Norway, Malawi, Himalayas, Taiwan, N America (British Columbia, Appalachian Mts.) Macaronesia
Mosses		
Andreaea sinuosa	NS	Aleutian Is., NW North America (British Columbia)
Campylopus shawii	NS	Ireland, Azores, Caribbean
Grimmia austro-funalis (*G. britannica*)	NS	Ireland, Australasia
Hymenostylium insigne	LR(nt)	Ireland, Spain, NW North America (British Columbia)
Molendoa warburgii (*Anoectangium warburgii*)	LR(lc)	Ireland, Faeroe Is., Norway, Nepal
Paraleptodontium recurvifolium	NS	Ireland, NW North America (British Columbia, Alaska)

6 Species accounts

Plan of the species accounts

The species accounts appear in alphabetical order of the accepted scientific name (Blockeel and Long 1998), for liverworts (including hornworts) and mosses separately. English names are also provided if they are specified in Schedule 8 of the Wildlife and Countryside Act 1981. The heading also specifies the status which qualifies the species for inclusion on the Red List, and gives its status in Europe, which here is taken to include Macaronesia (European Committee for the Conservation of Bryophytes 1995). All species on the Red List (*Extinct, Critically Endangered, Endangered* and *Vulnerable*) and all *Data Deficient* species have full species accounts. *Hamatocaulis vernicosus* and *Petalophyllum ralfsii*, now both categorised as *Nationally Scarce*, also have species accounts because of their listing in national and international legislation. *Lower Risk* (*near threatened*) species do not have species accounts but are listed in Appendix 2. Other *Nationally Scarce* species are not listed here, but are included on the JNCC website (http://www.jncc.gov.uk).

The text of the species accounts provides a brief 'pen portrait' of the species, and describes its habitat and distribution in Britain. In describing the distribution, 'recent' refers to the period from 1970 onwards, and the 'counties' usually refer to Watsonian vice-counties (Dandy 1969). Names of vice-counties have sometimes been amended slightly where they are thought to be obscure (e.g. 'Skye' is cited rather than 'North Ebudes'). Wherever possible, the number of localities in which the species has been seen from 1970 onwards which are scheduled as Sites of Special Scientific Interest (SSSIs) are estimated. Reasons for any decline of the species are discussed and current threats outlined. The wider distribution of the species is also described.

Distribution maps have been provided for a small number of species in cases where their known distribution differs significantly from that published in the Atlas (Hill et al. 1991, 1992, 1994). Finally, the number of hectads in which the species has been recorded is given, together with the corresponding figure for the period from 1970 onwards. It should be noted that many areas have not been surveyed for bryophytes since 1970, so the latter figure is probably an unduly pessimistic estimate of the current distribution of many species.

Liverworts

Adelanthus lindenbergianus (Lehm.) Mitt.

Lindenberg's leafy liverwort
Status in Britain: *VULNERABLE*. WCA Schedule 8
Status in Europe: *Vulnerable*

This is a dark brown to blackish, cushion-forming leafy liverwort with erect, sparsely branched shoots up to 10 cm long. It resembles *Anastrophyllum donnianum* and *Anastrepta orcadensis*, but differs from both in having broadly oval, toothed leaves all pointing in one direction, with the margin of one side of the leaf incurved. In Britain, this species is known from a single site on a quartzite hill on Islay in western Scotland, where it was discovered in 1990. A healthy population still exists, growing as a constituent of the northern Atlantic mixed hepatic mat community (Ratcliffe 1968). The community here is less diverse than it sometimes is on the mainland, the only other mixed hepatic mat species growing in close association being *Herbertus aduncus* ssp. *hutchinsiae* and *Pleurozia purpurea*, both common plants in the western Highlands. However, *Anastrepta orcadensis* and *Bazzania tricrenata* both grow nearby. Other close associates include *Calluna vulgaris*, *Vaccinium myrtillus*, *Erica cinerea*, *Festuca* sp., *Sphagnum capillifolium* and *Hypnum jutlandicum*. The stands of *Adelanthus lindenbergianus* grow at the boundary between unvegetated scree and *Calluna*-dominated vegetation, often on 'steps' in the uneven surface or at the edge of the ridge (Long and Rothero 1995–96).

Although there is at present no statutory protection for the site, SNH is aware of its importance. The most serious potential threats are muirburn and overgrazing: in Ireland, recent history has shown that the mixed hepatic mat can quickly be damaged, or even eradicated, by uncontrolled burning and an increase in stocking levels. On Islay, the thin peaty soil over scree on which *Adelanthus* occurs would be very vulnerable to damage by fire. Although listed on Schedule 8 of the Wildlife and Countryside Act, illegal collecting by botanists could be a threat to this plant on Islay. It is to be hoped not only that the remoteness of the site will afford it some protection, but also that modern bryologists are sufficiently responsible not to collect such a rare plant at its only British locality. The population was surveyed recently as part of the Scottish Cryptogamic Conservation Project 1993–1995 and is the subject of a Biodiversity Action Plan (UK Biodiversity Group 1999a).

The only other sites for *A. lindenbergianus* in Europe are in Ireland, where it was discovered new to Europe in 1903 and still occurs at scattered sites on the west coast. It is a predominantly Southern Hemisphere species, occurring in the East African mountains, Madagascar, central and southern America and Antarctica.

Total no. of hectads: 1 1970 onwards: 1

Athalamia hyalina (Sommerf.) S.Hatt.

Status in Britain: *DATA DEFICIENT*
Status in Europe: *Not threatened*

This plant is a thalloid liverwort which forms distinctive grey–green patches *c.* 4–7 cm in diameter. The rather small and delicate (not leathery) thallus has very conspicuous pores on the upper surface, and is often tinged purple at the margins. The hyaline appendages of the ventral scales often protrude from beneath the thallus, forming a fringe. As growth progresses, the older parts become blackish and the upper surface readily disintegrates. Discovered in Britain too late to be included in *The liverwort flora of the British Isles* (Paton 1999), there are good descriptions of *Athalamia hyalina* in a number of other texts (e.g. Schuster 1992). *A. hyalina* grows on open soil on ledges of limestone crags of varying aspect at about 500 m and seems to avoid sites with prolonged insolation. Vegetation on the ledges is often very sparse but a constant associate is the rare moss *Stegonia latifolia*. Other associates can include *Didymodon ferrugineus*, *Encalypta rhaptocarpa*, *Syntrichia ruralis*, *Tortella tortuosa*, *Preissia quadrata* and *Scapania gymnostomophila*. The plant is dioecious; vegetative growth takes place in winter and early spring and female plants produce receptacles in April. Spores ripen in May.

A. hyalina is currently known from just one site in Britain, an SSSI near Braemar where it was discovered in January 1999 (Long and Rothero, in prep.). The crags where the plant grows are often exceedingly loose, and the site has a general problem with erosion caused by grazing, primarily by rabbits. However, many of the stands seem physically stable and the population is quite large and able to withstand some perturbation, and the plant is in any case a colonist of bare soil. *A. hyalina* is widespread in the montane areas of Europe and locally common on limestone in parts of Sweden. It is also known from North America and Greenland.

Total no. of hectads: 1 1970 onwards: 1

Cephalozia ambigua C.Massal.

Status in Britain: *DATA DEFICIENT*
Status in Europe: *Not threatened*

Cephalozia ambigua is very similar to small forms of the very common species *C. bicuspidata*, which unfortunately are common in the areas of late snow-lie which are the habitat of *C. ambigua*. *C. ambigua* has small cells which differ from those of small *C. bicuspidata* in being both narrower and thinner-walled. This is the only reliable character separating the two, although in the field the plant has a less stiff habit than *C. bicuspidata*. In Britain *C. ambigua* is markedly chionophilous with all confirmed localities being in areas where snow lies late into the summer. Within these areas it occurs on the finer sands and gravels, often where there is periodic irrigation by snow-melt.

The distribution of *C. ambigua* is not clear, as many old records are incorrect. Most confirmed records are centred on the Cairngorms with outlying sites on the Breadalbane mountains and Sgurr na Lapaich giving a total of some eight localities. Of these sites, all lie within SSSIs and six are also within NNRs. Population size is difficult to determine as plants are so difficult to distinguish in the field but it is probable that, where the plant grows on sites with large areas of suitable habitat, reasonable stands do occur. The threats to this species are the same as those for snow-beds in general, those of gradual diminution through global warming, pollution loading through preferential deposition and concentration of pollutants in the snow pack, and local threats of disturbance by trampling. Any management to conserve the vegetation of areas of late snow-lie will presumably benefit this species. *C. ambigua* is an arctic–alpine species, apparently frequent in the Arctic with scattered localities in the higher mountains farther south.

Total no. of hectads: 8 1970 onwards: 3

Cephaloziella baumgartneri Schiffn.

Status in Britain: *ENDANGERED*
Status in Europe: *Not threatened*

The genus *Cephaloziella* consists of minute leafy liverworts with two-lobed leaves borne on relatively thick and opaque stems. *C. baumgartneri* is distinguished from other species by its obliquely inserted leaves with entire rather than toothed lobes and large basal cells, coupled with the absence of underleaves and an invariably autoecious inflorescence. It is also the only calcicolous member of the genus in Britain. Both sporophytes and gemmae are frequent.

C. baumgartneri has been seen recently at about 15 sites on limestone or skeletal soil over limestone on coastal cliffs and quarry floors on the Isle of Portland (Dorset), where it grows with *Gymnostomum viridulum*, *Rhynchostegiella tenella* and *Southbya nigrella*, and at one other site near Arundel in West Sussex, on a small chalk cliff by a lake. There are further, older records from the coastal chalk cliffs of East Sussex and east Kent and one from calcareous greensand on the south coast of the Isle of Wight. There is also a single record from the chalk of Box Hill, Surrey, but the species has not been seen there since 1955. The plant may still be extant at some of these sites. Most sites are within SSSIs, and the three sites on Portland outside the Isle of Portland SSSI are within Dorset County Wildlife Sites. No immediate threats are known to *C. baumgartneri* on Portland, but when it was last seen at the Arundel site (1985), it was observed that the colony, formerly substantial, had been reduced to tiny scraps, apparently by the spread of ivy. Elsewhere it may be at risk from stabilisation and subsequent colonisation of its habitat by taller vegetation. It therefore seems likely that active management may be required to maintain open skeletal soils and rock surfaces at sites which are becoming overgrown. *C. baumgartneri* is a Mediterranean–Atlantic species widespread in the Mediterranean region, and occurring along the Atlantic seaboard from Macaronesia north to England and Belgium.

Total no. of hectads: 11 1970 onwards: 4

Cephaloziella calyculata (Durieu & Mont.) *Müll.Frib.*

Status in Britain: *VULNERABLE*
Status in Europe: *Not threatened*

Although minute, like other members of the genus, this green or brownish-green leafy liverwort is distinguished by the relatively large female inflorescence, which has an unlobed sheath around the perianth. *Cephaloziella calyculata* grows on thin, open soils on slopes and sea cliffs overlying serpentine or limestone, on rocks and spoil associated with copper mines and on old walls. Rilstone (1948) comments, 'This small plant, at all times very difficult to find, appears to be never very long in one place, and may disappear entirely from a locality where it was relatively frequent'. *C. calyculata* is a strongly south-western species, with most of the British population in West Cornwall, where it has been found at twelve sites. It also occurs at one site in East Cornwall and another in the Mendips (Somerset). It was also recorded at a further site, on the Gower Peninsula (Glamorgan), in 1963. It may be susceptible to competition from other vegetation and, where it grows on old walls, renovation may potentially threaten the plant. Old mine sites are vulnerable to landscaping initiatives, and these need to take this plant into account. Most sites are unprotected although at least two sites are proposed SSSIs. *C. calyculata* has a Mediterranean–Atlantic distribution, extending from Britain to Portugal and Macaronesia, and eastwards to Yugoslavia. It also occurs in north Africa.

Total no. of hectads: 12 1970 onwards: 6

Cephaloziella dentata (Raddi) Mig.

Status in Britain: *CRITICALLY ENDANGERED*
Status in Europe: *Not threatened*

The rather strongly toothed leaves on the sterile stems of *Cephaloziella dentata* distinguish it from all the other British *Cephaloziella* species, except *C. turneri* (which lacks underleaves on the sterile stems), *C. massalongi* and *C. nicholsonii* (which have smaller leaf cells and smooth, not papillose, gemmae). In Britain this species is (or was) confined to shallow, winter-flooded depressions and old tracks on serpentine heath on the Lizard Peninsula in West Cornwall (Paton 1969). Only female plants are known here, and the plant is therefore presumably able to spread only by gemmae.

This species has not been seen recently at its two post-1950 sites, both on Goonhilly Downs, within an SSSI: the most recent record was made in 1968, when it was described as 'rare', and there are older records (the most recent being 1934) from the Kynance Cove area. Other British records have proved to be incorrect. In addition to *C. dentata*, several rare or scarce vascular plants (notably *Cicendia filiformis*, *Juncus capitatus*, *J. pygmaeus*, *Pilularia globulifera*, *Radiola linoides* and *Ranunculus tripartitus*) and the rare stonewort *Chara fragifera* are found on the remaining ancient trackways. The pattern of use of tracks on the Lizard Peninsula is changing: only a small number of tracks remain in use, providing suitable habitat, while other tracks are abandoned (Byfield 1991) and grown over with coarse perennial vegetation such as *Agrostis canina*, *Glyceria declinata*, *Juncus bulbosus* and *Scirpus fluitans*, with scrub eventually taking over (Wigginton 1999). In the past, some ruts and winter-flooded depressions in the tracks have been filled with hard-core as a path management measure, clearly a procedure that is likely to lead to a permanent loss of habitat. Although recent work has failed to refind *C. dentata*, it is premature to say that it has disappeared, as gemmae might survive in the soil. This species has a Mediterranean–Atlantic distribution, occurring along the Atlantic seaboard from Madeira and Portugal to Sweden, and at scattered sites in the Mediterranean east to Yugoslavia. It has also been reported from Asia and North America.

Total no. of hectads: 1 1970 onwards: 0

Cephaloziella integerrima (Lindb.) Warnst.

Status in Britain: *VULNERABLE*
Status in Europe: *Not threatened*

The prostrate, irregularly branched shoots of this minute leafy liverwort turn up at their tips. *Cephaloziella integerrima* is characterised by its combination of angular gemmae, untoothed leaves attached more-or-less at right angles to the stem, thin-walled leaf cells, leaves bilobed to half way on the sterile stems, no underleaves and a shallowly lobed sheath around the perianth. Older records for this liverwort are from bare, rabbit-grazed, often damp, sandy soils in heathland or on wayside banks; for example growing with *C. rubella* in *Calluna* heath on the edge of Frilford Bog in Berkshire (Jones 1952). However, all recent records are from old mining ground in East and West Cornwall, mainly from copper-rich substrates supporting sparse, low vegetation. Sporophytes have been recorded in Britain and gemmae are usually present.

As its distribution map demonstrates (Hill et al. 1991), *C. integerrima* has declined markedly in Britain. It was seen during the 1960s at two sites in Cornwall and found during 1996–98 at seven others. There are older records from single localities in East Sussex, Berkshire and Wiltshire, and from several sites in West Sussex. Few of the post-1950 sites have any designated site protection, although one Cornish site is an SSSI. The reasons for the decline of this species are not fully understood, but they might include the general deterioration of heathlands and the reduction in rabbit-grazing following the myxomatosis epidemic. At a site in Ireland, *C. integerrima* benefited from the creation of open habitats by the widening of a road in the 1960s, and periodic disturbance may be necessary to maintain suitable habitat. Sites with both recent and old records need to be surveyed to ascertain whether the species is still present. This species has a northern distribution in Europe, extending north to the high Arctic, east to the former USSR and south to Italy and Hungary. This northerly distribution contrasts with the southern distribution of the species in Britain. *C. integerrima* has also been recorded from North America.

Total no. of hectads: 11 1970 onwards: 3

Cephaloziella massalongi (Spruce) Müll.Frib.

Status in Britain: *VULNERABLE*
Status in Europe: *Rare*

Although this leafy liverwort is minute, it can form quite large patches. It has irregularly branched, prostrate or ascending shoots, which are yellowish-green, dark reddish-brown or blackish in colour and bear toothed leaves. *Cephaloziella massalongi* is similar to *C. nicholsonii*, from which it can be separated only by the narrower leaf cells and stem cortex cells. This species grows mainly on damp acidic soil, mine-spoil, walls, rocks and stones around copper mines. It is particularly luxuriant at one site on the banks of a stream, where copper-rich silt has been washed down from old mine-workings. There is a single record from a wall where there was no apparent copper enrichment. It grows in similar habitats to, and often with, *C. nicholsonii*, but is possibly less drought-tolerant, although there is much overlap. Sporophytes have not been found in Britain and reproduction is by gemmae, which are produced frequently.

In Britain *C. massalongi* is restricted to south-west England and north Wales. It has been found in at least 20 sites in East and West Cornwall and western South Devon, at a few of which it is locally abundant. It was also recorded regularly in the late 19th and early 20th centuries from about 10 sites in Anglesey and Gwynedd (Caernarvonshire and Merioneth) (Hill 1988). However, it has been seen at only three of these during the last 40 years, and the only recent records are from two sites in Gwynedd in 1996. One Cornish site and one Welsh site are within SSSIs, but most sites have no statutory site protection. Threats to this species may include 'tidying up' derelict land and land reclamation schemes. A survey of the sites in north Wales is needed. Site protection is being considered for those sites with the best populations. This liverwort is widely scattered in north-western Europe, extending south to Iberia, Corsica and Italy and east to Slovakia and Bulgaria. It also occurs in the southern Appalachians (USA).

Total no. of hectads: 19 1970 onwards: 12

Cephaloziella nicholsonii Douin & Schiffn.

Status in Britain: *VULNERABLE*. Endemic
Status in Europe: *Rare*. Endemic

Very similar to the closely related *Cephaloziella massalongi*, *C. nicholsonii* is often larger and has wider cells in the leaves and stem cortex. Ecologically similar to *C. massalongi* (q.v.), with which it frequently occurs, *C. nicholsonii* grows mainly, if not exclusively, on copper-enriched acid soils on banks, walls and spoil around disused copper mines. Other associates include *Cephalozia bicuspidata*, *Cephaloziella divaricata*, *C. stellulifera*, *Diplophyllum albicans*, *Gymnocolea inflata*, *Jungermannia gracillima*, *Lophozia ventricosa*, *Pohlia* spp., *Pogonatum aloides* and *Trichostomum brachydontium* (Paton 1984). Recent records are concentrated in the four vice-counties of Devon and Cornwall, especially Cornwall, where it occurs at about 22 sites. At one site, in East Cornwall, it is locally abundant along the banks of a stream where copper-rich silt has been washed down from old mine workings. It previously occurred at one site in Gwynedd (Merioneth), where it has not been seen for over 60 years. It has also been recorded recently (1998) from sandy ground in a disused copper mine at Alderley Edge in Cheshire, a significant northerly extension of its range.

Significant threats to *C. nicholsonii* may include encroachment of scrub and other vegetation at old mines, where there has been little working for over half a century, and landscaping or other 'tidying up' schemes and development for recreation, to which disused mine areas are particularly prone. The conservation needs of this and other mine-waste specialist bryophytes should be fully integrated with any such schemes. Where it occurs on walls, restoration of these could be damaging to this plant. Exploratory digging to relocate old mineshafts is a threat to populations at several sites: local authorities anxious to replace unsafe timber cappings on old shafts usually carry out this activity. Two *C. nicholsonii* sites in Cornwall are within SSSIs. Recent (1995–1998) surveys of old mine sites in Cornwall, commissioned by EN, have elucidated the distribution of this plant in the area. As a threatened species endemic to Britain, it is the subject of a Biodiversity Action Plan, which recommends the completion of surveys of mine sites in south-west England, and management measures such as scrub clearance and a certain amount of ground disturbance.

Total no. of hectads: 17 1970 onwards: 14

Dumortiera hirsuta (Sw.) Nees

Status in Britain: *VULNERABLE*
Status in Europe: *Rare*

This liverwort grows in dark green mats composed of thalli up to 10 cm long. It differs from some of the other large thalloid liverworts in Britain and Ireland (such as *Conocephalum conicum*, with which it sometimes grows) in lacking small pores on the upper surface of the thallus, and from the superficially similar *Pellia* species, in having shorter dorsal epidermal cells near the margin and sparse marginal hairs. This is a species of moist, well-shaded habitats, such as wooded ravines and shaded streambanks or riverbanks at low altitudes in high rainfall areas. It grows on damp slopes and dripping rocks in recesses by waterfalls, where there is a constant supply of ground water, and seems to favour mildly basic conditions.

Dumortiera hirsuta is recorded from about a dozen sites along the west coast from West Cornwall to Islay and Jura in the Inner Hebrides. It also occurs at a single site on rocks in a stream, just below a waterfall, in East Sussex. It is the only Red List species in the Isle of Man, where it is known from Groudle Glen. Four of the nine sites from which the species has been recorded recently are within SSSIs. It is more frequent in Ireland, where it has been recorded from approximately 30 sites. *D. hirsuta* is potentially at risk from reduction in humidity and shade as a result of felling activities that open up the canopy. In most cases disturbance of the canopy in the neighbourhood of colonies should be discouraged, but *Rhododendron ponticum* should be controlled and removed where possible if it is a threat at any site. Pollution of ground water may be a threat, particularly at the East Sussex site, which is subject to nutrient-rich run-off from a nearby farm. This species is widespread throughout the tropics. In Europe it is mainly an Atlantic species, occurring from Macaronesia northwards to Scotland, where it reaches the northern edge of its world range. There are one or two records from the Mediterranean region.

Total no. of hectads: 14 1970 onwards: 9

Fossombronia crozalsii Corb.

Status in Britain: *EXTINCT*
Status in Europe: *Rare*

This small, pale green liverwort has shoots 3–7 mm long and resembles most other British *Fossombronia* species in having broad, blunt, wavy-edged or lobed, rather crowded leaves and purple rhizoids. The species can be identified only by microscopic examination of the spores, which are produced in August and September (Jones and Harrington 1983; Paton 1973). *Fossombronia crozalsii* is a plant of sheltered open ground which is moist in winter, and has been recorded from two sites in Britain, in Berkshire and Wiltshire. At the Wiltshire site, it was found on moist sandy loam in a wide, rutted, grassy ride within a conifer wood, associated with other *Fossombronia* species, *Riccia* species and other liverworts. The extent of the population is unknown because of the presence of other *Fossombronia* species, indistinguishable in the field. The wood has no designated site protection, and the track where it was originally recorded has been re-laid with gravel. It was not refound during searches of the locality in 1991 and 1998, and it seems reasonable to suppose that *F. crozalsii* has disappeared. *F. crozalsii* is also apparently extinct in Berkshire, where it grew on sandy soil on a ride in a larch plantation (Jones 1952). It was last seen there in 1938, despite frequent searches.

The reasons for the apparent disappearance of *F. crozalsii* are not well understood but, as well as the gravelling of the track in Wiltshire, they may include the effects of excessive shading as the conifer plantations have matured and lack of soil disturbance. It is just possible that a spore bank survives at one or both sites, and positive management to create the right conditions for the plant to reappear would be highly desirable. This might include reducing the shade locally and scraping the soil surface. *F. crozalsii* is otherwise known only from southern France, the Canary Islands and north Africa. However, it is possible that it may be conspecific with a common west African species, *F. occidento-africana*.

Total no. of hectads: 2 1970 onwards: 1

Geocalyx graveolens (Schrad.) Nees

Turpswort

Status in Britain: *VULNERABLE*. WCA Schedule 8

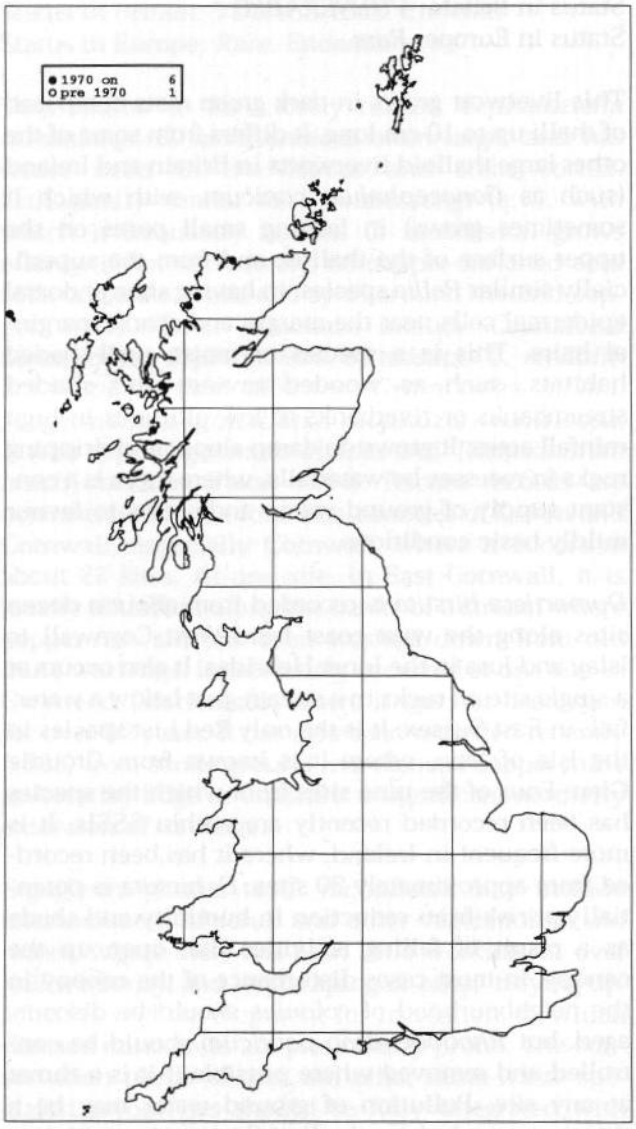
Status in Europe: *Not threatened*

This pale yellowish-green leafy liverwort grows in patches which become dark purplish-green when exposed to sunlight. The creeping shoots are up to 2 cm long, and the leaves are bilobed, much as in *Lophozia* and *Lophocolea* and *Acrobolbus wilsonii*. *Geocalyx graveolens* differs from all of these in having underleaves divided almost to the base into two long, narrow, pointed, untoothed lobes. This liverwort grows on damp, shaded peat or humus on steep north-facing banks, in sheltered areas near the sea where the microclimate is constantly humid, often under trees or heather *Calluna* or among rocks, and occurs in mixed communities with other small liverworts. This habitat is widespread along the west coast of Scotland, and the reasons for the rarity of *G. graveolens* are not understood. Unusually, *G. graveolens* also grows in a wet hollow on an exposed cliff top on Hirta, St Kilda (Long and Ratcliffe 1996). Sporophytes are produced occasionally.

In Britain *G. graveolens* is restricted to the west coast of Scotland, where it has been found at seven scattered sites (Birks and Birks 1974; Long and Rothero 1995–96; Milne-Redhead 1955). All the populations are small, the largest being on the Plock of Kyle and nearby associated islets, where there are at least seven small colonies. One of the mainland sites is within an NNR, one within an SSSI, whilst the remainder have no designated site protection. *G. graveolens* is apparently not in decline, nor under any known threat, although collection by botanists might be a threat at some sites. A stand on Skye is known to have been over-collected by bryologists in the 1960s, and the humus bank on which it was growing was drying out and breaking up by the early 1990s, so this population may have disappeared. The populations of *G. graveolens* were surveyed recently as part of the Scottish Cryptogamic Conservation Project 1993–1995. The strongly oceanic distribution of *G. graveolens* in Britain is not reflected in its distribution elsewhere. It is widely distributed throughout Europe, north to Fennoscandia and extending eastwards to Siberia, as well as southwards to the Azores and Madeira. It is abundant in North America.

Total no. of hectads: 7 1970 onwards: 6

Geocalyx graveolens



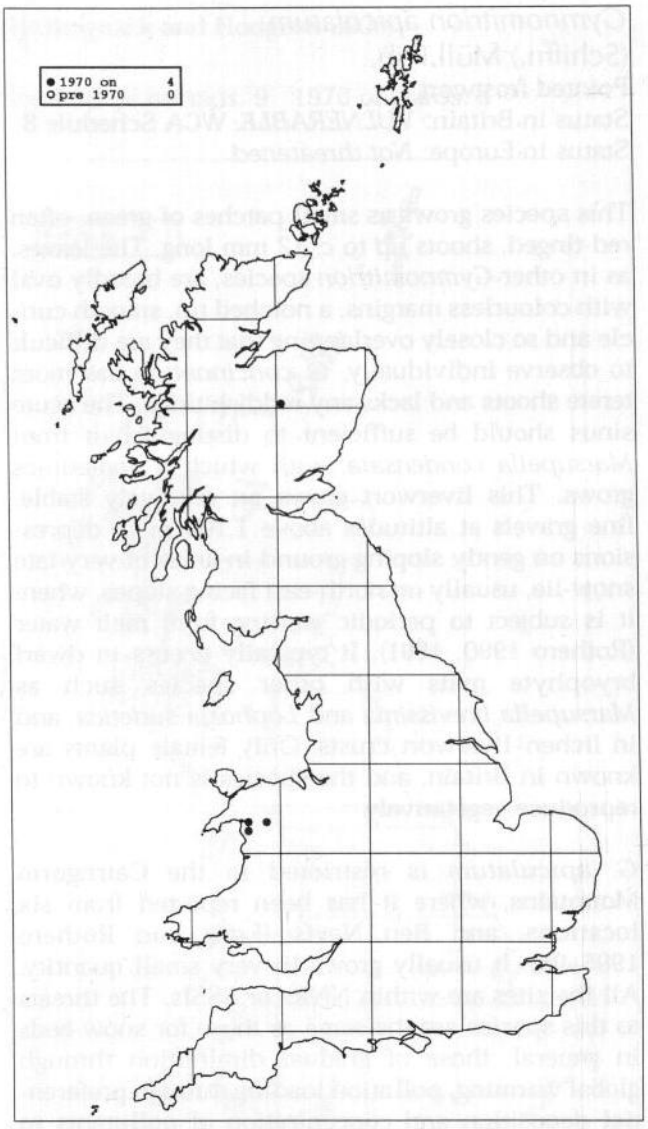
Gymnocolea acutiloba (Schiffn.) Müll.Frib.

Status in Britain: *VULNERABLE*
Status in Europe: *Not threatened*

This species resembles the very common *Gymnocolea inflata*, differing primarily in having more sharply pointed leaf lobes. *G. acutiloba* grows on dry acidic rocks and boulders in boulder scree at altitudes between 395 and 600 m. Its main associates are *Diplophyllum albicans, Gymnomitrion crenulatum, G. obtusum, Mylia taylori, Andreaea rothii, Campylopus flexuosus, Pseudotaxiphyllum elegans* (*Isopterygium elegans*), *Racomitrium lanuginosum* and lichens such as branched *Cladonia* species. Additional associates at the Scottish site include *Anastrepta orcadensis* and *Bazzania tricrenata*. It is dioecious and only female plants are known in Britain. Like *G. inflata*, it reproduces vegetatively from perianths which become detached from the female plant, but these are rarely produced by the plant in Britain.

In Britain, populations of *G. acutiloba* were, until 1997, thought to be restricted to a single mountain massif (the Rhinogs) in Gwynedd (Merioneth), within an SSSI and partly within an NNR, where it occurs in several sub-populations up to 1 km apart. However, it was then found at Arenig Fawr, in the same county, also within an SSSI (Blackstock and Newton 1999), and has very recently been detected in Scotland, in the Cairngorms (Rothero 2000). No immediate threats to this species have been identified, but it should be checked occasionally to ensure its continued survival and freedom from threat. Damage to the rocky heathland habitat from fires may be a potential threat. *G. acutiloba* is an uncommon arctic–alpine plant which occurs in north-west Russia, Fennoscandia, Svalbard and the central European mountains east to Romania and Turkey. It also occurs in Greenland and in Maine (USA).

Total no. of hectads: 4 1970 onwards: 4



Gymnomitrion apiculatum (Schiffn.) Müll.Frib.

Pointed frostwort
Status in Britain: *VULNERABLE*. WCA Schedule 8
Status in Europe: *Not threatened*

This species grows as small patches of green, often red-tinged, shoots up to *c.* 12 mm long. The leaves, as in other *Gymnomitrion* species, are broadly oval with colourless margins, a notched tip, smooth cuticle and so closely overlapping that they are difficult to observe individually. *G. concinnatum* has more terete shoots and lacks any reddish tinge. The acute sinus should be sufficient to distinguish it from *Marsupella condensata*, with which it sometimes grows. This liverwort grows on relatively stable, fine gravels at altitudes above 1,100 m in depressions on gently sloping ground in areas of very late snow-lie, usually on north-east facing slopes, where it is subject to periodic wetting from melt water (Rothero 1990, 1991). It typically occurs in dwarf bryophyte mats with other species such as *Marsupella brevissima* and *Lophozia sudetica*, and in lichen–liverwort crusts. Only female plants are known in Britain, and the species is not known to reproduce vegetatively.

G. apiculatum is restricted to the Cairngorm Mountains, where it has been reported from six locations, and Ben Nevis (Long and Rothero 1995–96). It usually grows in very small quantity. All the sites are within NNRs or SSSIs. The threats to this species are the same as those for snow-beds in general, those of gradual diminution through global warming, pollution loading through preferential deposition and concentration of pollutants in the snow pack, and local threats of disturbance by trampling. Any management to conserve the vegetation of areas of late snow-lie will presumably benefit this species. The populations of this species were surveyed recently as part of the Scottish Cryptogamic Conservation Project 1993–1995. This is an arctic-montane species which occurs throughout arctic Europe and in the central European mountains. It is also reported from Greenland, Alaska and Japan.

Total no. of hectads: 4 1970 onwards: 3

Herbertus borealis Crundw.

Status in Britain: *VULNERABLE*
Status in Europe: *Vulnerable*. Endemic

This is a large yellowish to orange-brown leafy liverwort forming patches up to 20 cm tall. It has asymmetrical leaves deeply divided into two narrow lobes, with underleaves similar to the lateral leaves but distinctly smaller. Like other species of *Herbertus*, it looks superficially more like a species of *Dicranum* than a liverwort. It was collected at its single British site, on Beinn Eighe in West Ross, several times between the first recorded collection in 1868 and being described as a new species (Crundwell 1970). *H. borealis* grows in pure patches or mixed with other bryophytes on peaty soils on an exposed north-east-facing quartzite slope dominated by *Calluna vulgaris*, dwarf *Juniperus communis* and *Arctostaphylos uva-ursi*, at altitudes between 380 and 550 m (McVean and Ratcliffe 1962). At this site it is a component of the Northern Atlantic mixed hepatic mat community, and the other hepatic mat species *H. aduncus* ssp. *hutchinsiae*, *Pleurozia purpurea* and *Plagiochila carringtonii* are close associates. It also occurs in smaller quantity in nearby ravines, a much more sheltered habitat which more closely resembles its sites in Norway. *H. borealis* is sterile in Britain, although male plants have been recorded in Norway.

At its single site, which is within an NNR and an SSSI, *H. borealis* is abundant over an area of several square metres in one place, with individual patches sometimes exceeding 1 m^2 in extent, and also occurs in smaller colonies nearby. The dwarf juniper scrub in which *H. borealis* grows is vulnerable to fire, and a single fire could have a catastrophic effect on the population; excessive grazing would also be a threat. The populations in sheltered gullies are probably less threatened. A Biodiversity Action Plan has been written for this species, and it is included on a list of the world's most threatened bryophytes (Hallingbäck and Hodgetts 2000). *H. borealis* is otherwise known from only three localities in south-western Norway, but at none of these is it as abundant as at its Scottish site. The genus *Herbertus* is apparently very ancient and has a fragmented distribution. Many species occur as relicts in montane areas, and the nearest relatives of *H. borealis* are found in the Himalayas.

Total no. of hectads: 2 1970 onwards: 2

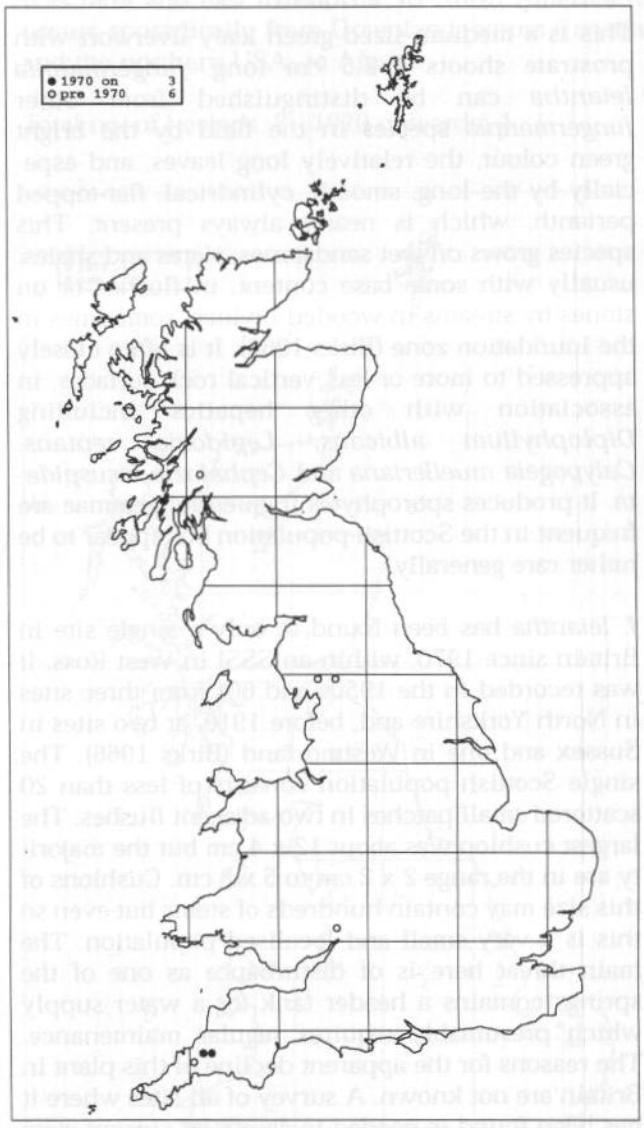
Jamesoniella undulifolia (Nees) Müll.Frib.

Marsh earwort
Status in Britain: *ENDANGERED*. WCA Schedule 8
Status in Europe: *Critically Endangered*

This medium-sized leafy liverwort has broad, rounded leaves similar in shape to those of *Odontoschisma sphagni*, with which it grows, but no flagelliform shootlets. The upper leaves on opposite sides of the shoot are often pressed together and undulate, whereas the lower leaves are spreading. *Mylia* species have much larger leaf cells, and *Nardia* species have much more distinct underleaves. *J. undulifolia* grows over and amongst *Sphagnum* in mires, where it seems to prefer relatively level ground. Most sites are in valley mires but it can also occur in raised bogs. *Jamesoniella undulifolia* has a western distribution in Britain, and has been recorded at some time from nine sites in Cornwall, Gloucestershire, Westmorland and Argyll. It has declined markedly over the years, and has been recorded from only four localities in Cornwall and Argyll in recent times. It was thought until very recently that the species had disappeared from Cornwall, but new survey work has shown it still to be present, although sparsely, at two sites. *J. undulifolia* is locally common at its Argyll site; a baseline survey in 1996 recorded the plant on 96 *Sphagnum* hummocks on two neighbouring mires.

The Argyll site has no protection but is regularly monitored. The Cornish site where it was recorded in 1993 is an SSSI. This plant has disappeared from some of its sites as a result of conifer planting, flooding for a new reservoir, and deterioration of the habitat because of eutrophication and poaching by livestock. Threats to existing populations include drainage (the main Cornish site, a raised bog, has had a drainage ditch dug next to it), damage from livestock and fertiliser run-off from pastures. The site where it is known to survive is fragile and requires regular site quality monitoring to detect any deterioration in the habitat. All Cornish sites require further survey to establish whether or not the plant is still present and, if so, at what level of abundance. SNH has produced a species dossier for the Scottish population of *J. undulifolia*, as part of the Scottish Cryptogamic Conservation Project 1993–1995 (Long and Rothero 1995–96), which contains a number of recommendations. These include initiation of baseline monitoring (now done), establishing an *ex-situ* population, and taking measures to determine the ecological requirements of the plant in more detail. It is also the subject of a Biodiversity Action Plan. *J. undulifolia* is widely, but very sparsely, distributed in Europe, and is absent from the Mediterranean region. It also occurs in eastern Asia and North America, and is included on a list of the world's most threatened bryophytes (Hallingbäck and Hodgetts 2000).

Total no. of hectads: 9 1970 onwards: 3



Jungermannia leiantha Grolle

(*J. lanceolata* auct.)
Status in Britain: *CRITICALLY ENDANGERED*
Status in Europe: *Not threatened*

This is a medium-sized green leafy liverwort with prostrate shoots 1–2.5 cm long. *Jungermannia leiantha* can be distinguished from other *Jungermannia* species in the field by the bright green colour, the relatively long leaves, and especially by the long, smooth, cylindrical, flat-topped perianth, which is nearly always present. This species grows on wet sandstones, slates and shales, usually with some base content, in flushes or on stones by streams in wooded ravines, sometimes in the inundation zone (Birks 1966). It is often closely appressed to more-or-less vertical rock surfaces, in association with other hepatics including *Diplophyllum albicans, Lepidozia reptans, Calypogeia muelleriana* and *Cephalozia bicuspidata*. It produces sporophytes frequently; gemmae are frequent in the Scottish population but appear to be rather rare generally.

J. leiantha has been found at only a single site in Britain since 1970, within an SSSI in West Ross. It was recorded in the 1950s and 60s from three sites in North Yorkshire and, before 1910, at two sites in Sussex and one in Westmorland (Birks 1966). The single Scottish population consists of less than 20 scattered small patches in two adjacent flushes. The largest cushion was about 12 x 4 cm but the majority are in the range 2 x 2 cm to 5 x 8 cm. Cushions of this size may contain hundreds of stems but even so this is a very small and localised population. The main threat here is of disturbance as one of the springs contains a header tank for a water supply which presumably requires regular maintenance. The reasons for the apparent decline of this plant in Britain are not known. A survey of all sites where it has been found is needed to assess its current state before conservation recommendations can be made. This species is widely distributed, and sometimes locally abundant, throughout most of Europe, as far east as the Caucasus. It is also found in Japan and North America.

Total no. of hectads: 10 1970 onwards: 1

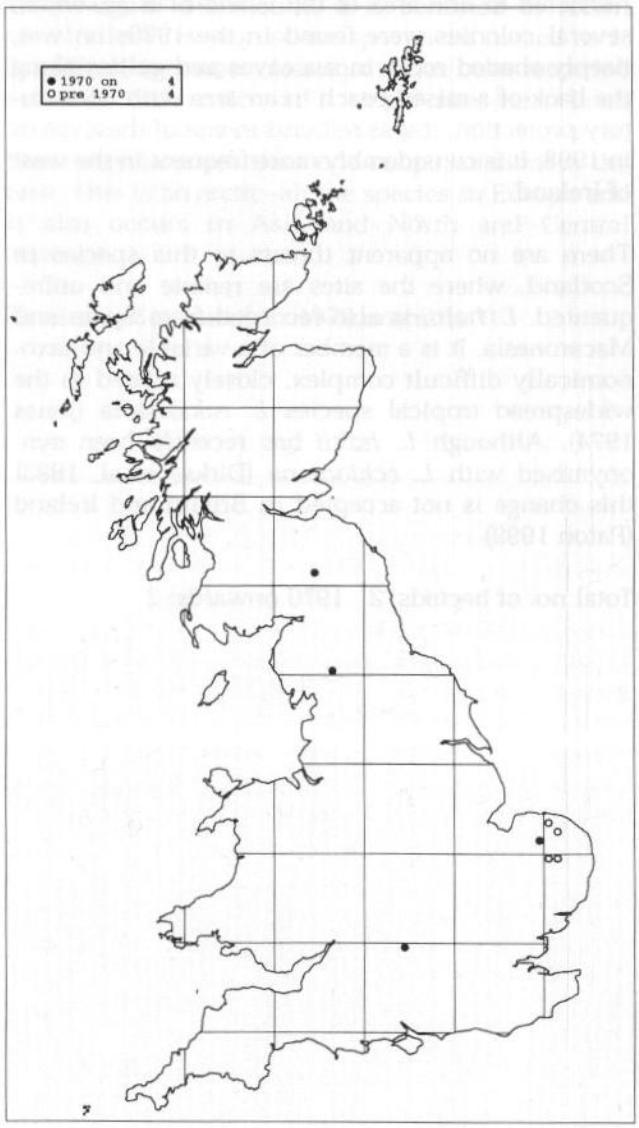
Leiocolea rutheana (Limpr.) Müll. Frib.
(*Lophozia rutheana* (Limpr.) Howe)
Norfolk flapwort
Status in Britain: *ENDANGERED*. WCA Schedule 8
Status in Europe: *Not threatened*

This olive-green leafy liverwort forms tufts with ascending, unbranched shoots up to 6 cm long. The blunt, shallowly two-lobed leaves are typical of *Leiocolea*. *L. gillmanii* is similar but has smaller leaf cells and shorter underleaves. *L. bantriensis* and *L. alpestris* also resemble *L. rutheana* but they are dioecious rather than paroecious. Two distinct varieties of *L. rutheana* are recognised in Britain by Paton (1995), var. *rutheana* and var. *laxa*. This is a species of wet, highly calcareous fens where it is usually found on the sides of mossy hummocks or among pleurocarpous mosses at the base of sedges, reeds and, most characteristically, black bog rush *Schoenus nigricans*. It can also grow in tall reed or rush swamps. Sporophytes are produced occasionally.

In Britain this species was until recently thought to be almost confined to Norfolk (Petch and Swann 1968; Swann 1982), where it has been found in five sites (both varieties), but is now reduced to one population of var. *laxa* at a single site, which is an SSSI. Of the other Norfolk populations of *L. rutheana*, one was last recorded in 1927 and another two in the 1950s. At the fourth site it was present 'in great profusion and in large swelling tufts' in 1951 (Rose 1952a), but it was reported as 'now very sparse' in 1967 and was last seen in 1969. Elsewhere it is known from one site in Oxfordshire (var. *laxa*), where it was discovered in 1983, but it could not be found when the locality was surveyed in 1993 (Bates 1995), and from one site in Westmorland (var. *rutheana*), where it was discovered in 1982 but has not been seen since, in spite of searching. Recently (1998) it has been discovered at a 'new' site near Hawick in Roxburghshire (var. *rutheana*).

Because of a reduction in grazing, and perhaps also eutrophication and lowering of the water table, the vegetation at most of the Norfolk sites for *L. rutheana* has become coarser since the 1950s and 1960s, and several of the characteristic bryophytes, including this species, have been drastically reduced or eliminated. The only remaining Norfolk site is very small and may be under threat from the same external influences, as well as from developments such as road-widening schemes. However, EN is aware of the presence of this species and manages the site accordingly. Improved management, including the re-introduction of a traditional cattle-grazing regime, is also now under way at some of the other Norfolk sites where it has been recorded in the past. The Westmorland site needs new survey work. *L. rutheana* is the subject of a Biodiversity Action Plan. This liverwort has a scattered but localised distribution across northern Europe, reaching south to northern Germany (where it is rare) and east to Eurasia. In North America it occurs sporadically from Greenland, across Canada and the northern USA, to Alaska.

Total no. of hectads: 8 1970 onwards: 4



Lejeunea holtii Spruce
Status in Britain: *VULNERABLE*
Status in Europe: *Not threatened*

This small, green, leafy liverwort forms thin patches of irregularly branched stems up to 2.5 cm long. *Lejeunea holtii* differs from most other British and Irish species of *Lejeunea* in the tapering upper leaf lobes, and from *L. mandonii* in its larger size and relatively small lobules. In Britain this species is restricted to one area of the island of Islay, where several colonies were found in the 1970s on wet, deeply shaded rocks in sea caves and gullies along the back of a raised beach in an area with no statutory protection. It was refound in one of these caves in 1998. It is considerably more frequent in the west of Ireland.

There are no apparent threats to this species in Scotland, where the sites are remote and unfrequented. *L. holtii* is also recorded from Spain and Macaronesia. It is a member of a variable and taxonomically difficult complex, closely related to the widespread tropical species *L. eckloniana* (Jones 1974). Although *L. holtii* has recently been synonymised with *L. eckloniana* (Dirkse et al. 1993) this change is not accepted in Britain and Ireland (Paton 1999).

Total no. of hectads: 2 1970 onwards: 2

Lejeunea mandonii (Steph.) Müll. Frib.
Status in Britain: *ENDANGERED*
Status in Europe: *Rare*. Endemic

This minute, yellow–green leafy liverwort forms thin patches of irregularly-branched stems up to *c.* 1 cm long. The upper leaf lobe is noticeably longer than wide. This, combined with the smooth perianth, small oil bodies in the leaf cells, and the very small size of the plant, distinguishes *Lejeunea mandonii* from other British and Irish *Lejeunea* species. *L. mandonii* has a strongly oceanic distribution, and is restricted to areas with an average of over 160 wet days per year. It grows, often over other bryophytes, on dry, or sometimes periodically inundated, rocks that are at least slightly base-rich, or on old ash, elm, or oak trunks. It is found in shaded and sheltered woodland, in ravines, on north and north-east facing cliffs, under rock overhangs and in block scree near the sea. Perianths and sporophytes are produced infrequently, but have been seen on several gatherings.

In Britain *L. mandonii* is recorded from five groups of sites in Cornwall, Westerness and Skye, several of which are within SSSIs, although about 80% of Cornish plants are in a single unprotected site. *L. mandonii* occurs within a managed forestry plantation at its most important Cornish site, and needs careful monitoring to ensure that forestry work causes no harm. EN and Plantlife have commissioned surveys of Cornish populations of *L. mandonii* from 1997–1999 (Holyoak 2000), and it is clear that several populations have declined over that period, most notably the largest one in the plantation. A number of possible reasons have been suggested for this decline, including shading from ivy, shrubs and saplings. However, Holyoak (2000) considers it likely that there is a relationship between the vigour and growth of *L. mandonii* and the growth, persistence and decay of the mosses on which it usually grows, according to prevailing environmental conditions. Thus, year-to-year variations in the abundance of *L. mandonii* could be a 'natural' phenomenon and no cause for concern. However, further investigations are necessary to test this hypothesis. The Scottish sites for *L. mandonii*, which were surveyed recently as part of the Scottish Cryptogamic Conservation Project 1993–1995 and are currently being re-surveyed, are apparently not threatened at present, although some of the populations are very small. *L. mandonii* is the subject of a Biodiversity Action Plan in Britain, as it is a rare plant worldwide and the British populations are therefore of international importance. This liverwort occurs on the Atlantic fringe of Europe, in Britain, Ireland, Spain and Portugal, and in Macaronesia.

Total no. of hectads: 7 1970 onwards: 5

Lophozia capitata (Hook.) Macoun
Status in Britain: *VULNERABLE*
Status in Europe: *Not threatened*

Although variable, *Lophozia capitata* may be distinguished from related species by the erect or ascending stems, the large leaf cells and the more-or-less spherical gemmae. It grows on damp, acid substrates in the lowlands, occurring as a pioneer on otherwise bare soils or mixed with mosses. More rarely it grows among vascular plants such as rushes, but is unable to tolerate much competition. Although *L. capitata* may occur in extensive colonies, they tend to be short-lived as they are replaced by the vegetation of more advanced stages in the succession. A number of sites are disused sand or clay pits, where it typically grows on flat areas on the bottom beside temporary or permanent pools. The other typical habitat is in marshy or boggy areas in heathland, but it has also occasionally been reported from woodland glades or rides. Sporophytes are rare but gemmae frequent.

This plant has a predominantly south-eastern distribution in Britain and has been recorded from 16 sites in Buckinghamshire, East Sussex, North Essex, North Hampshire, West Norfolk and Surrey, although only in the latter three vice-counties recently. It has not been seen at one site since the early 19th century, and was last seen at another in 1951. It has also been recorded since 1970 at two sites in Cheshire. Principal threats include loss of heathland habitat, reclamation of old pits, and increasing competition and shade from vascular plants. *L. capitata* has a scattered distribution around the North Sea and Baltic Sea regions, north to southern Fennoscandia and east to Poland. It also occurs in eastern North America. It tends to be associated throughout its range with areas of Tertiary or Quaternary sand deposits.

Total no. of hectads: 17 1970 onwards: 6

Lophozia longiflora (Nees) Schiffn.
(*L. guttulata* (Lindb.) A.Evans)
Status in Britain: *DATA DEFICIENT*
Status in Europe: *Not threatened*

Lophozia longiflora is close to the common species *L. ventricosa* and, until a recent revision of the specimens, was confused with it. *L. longiflora* can be identified reliably only by characters of the perianth, which is often tinged reddish and has cilia 3–4 cells long at the mouth. It is confined to rotten wood. Since revision of the specimens named as *L. longiflora*, it is now clear that it has been recorded correctly only twice at a single site, near Loch Morlich in Easterness, in 1948 and 1956. However, there may be more than one subpopulation in the area. This is an arctic–alpine species in Europe and it also occurs in Asia and North and Central America.

Total no. of hectads: 1 1970 onwards: 0

Marsupella arctica (Berggr.) Bryhn et Kaal.
Status in Britain: *VULNERABLE*
Status in Europe: *Rare*

Marsupella arctica differs from the other British *Marsupella* species in having strongly concave leaves that are only shallowly bilobed. It is more likely to be mistaken for *Anastrophyllum minutum*, but this species often has gemmae and more deeply bilobed leaves. *M. arctica* — which was discovered in Britain in 1989 (Long et al. 1990) — is restricted to two localities in the Cairngorms above 800 m where snow persists late into the summer. The habitat differs at the two localities, although both are in areas of late snow-lie; in one locality the plant grows in block scree which may be periodically inundated, and in the other it is part of the hepatic mat growing on fine gravel in the outwash below late lying snow. The Scottish plants are sterile, and the species lacks gemmae. One site lies within an NNR and the other is in an SSSI.

There are no known specific threats to this species, but general threats to the snow-bed habitat are of concern. One site is close to a footpath, but it is most unlikely that any minor repairs or improvements would damage the block scree. Further work is required to determine the extent of the population at both sites. This is a high arctic species, occurring in Svalbard and arctic Asia, North America and Greenland. The presence of such a markedly arctic species in Scotland is of great phytogeographical interest.

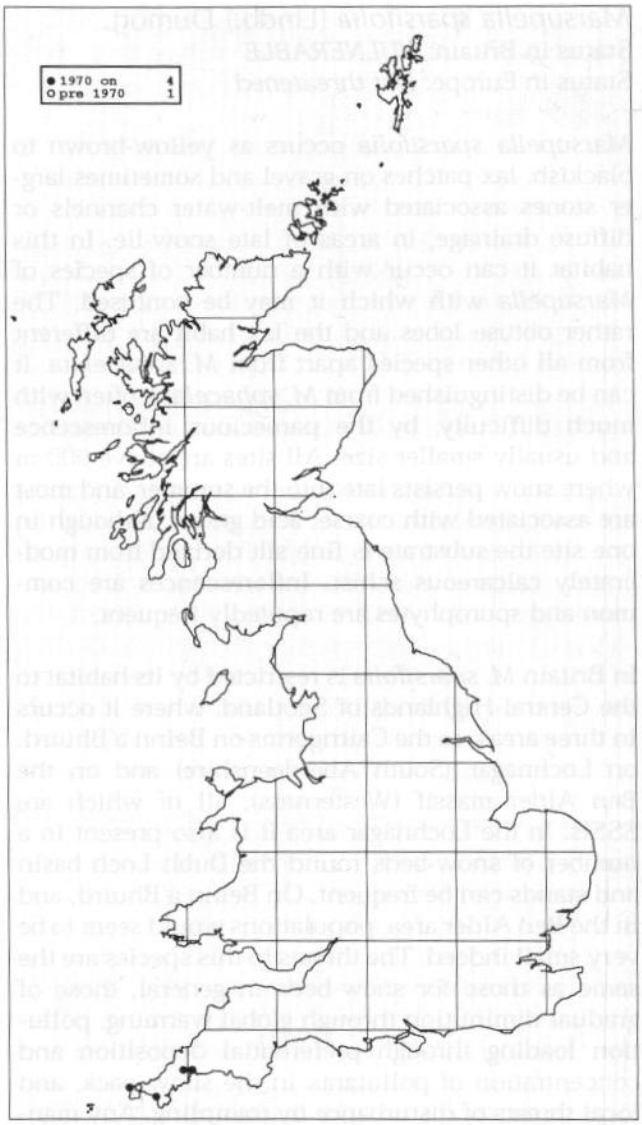
Total no. of hectads: 2 1970 onwards: 2

Marsupella profunda Lindb.
Western rustwort
Status in Britain: *VULNERABLE*. WCA Schedule 8
Status in Europe: *Vulnerable*. Bern Convention, Appendix 1; EC Habitats & Species Directive, Annex IIb. Endemic

This is a small patch-forming leafy liverwort with erect, blackish-purple to green shoots and bilobed leaves. It differs from the similar *Marsupella sprucei* in having blunt leaf lobes, and often slightly wider shoots. *M. profunda* grows on acidic clay and soft, crumbling granitic material in disused china clay workings. It is apparently a colonist confined to the early stages of plant succession, being replaced by more vigorous flowering plants after one or two decades. It produces sporophytes in abundance. This species was not recognised in Britain until 1990, having previously been overlooked as *M. sprucei* (Paton 1990). It has now been recorded from a total of 13 sites, all in Cornwall, which were surveyed in detail in 1996–99. It is still present in 10 sites, and is locally abundant at four. Three of the extant sites are now SSSIs.

In the past this species presumably spread from site to site in West Cornwall, colonising suitable patches of spoil, and then gradually succumbing to competition from other species. As the extraction of china clay has now ceased in that area, positive management is needed to ensure that the open habitats required by the species remain available to it there. This could be achieved by periodic scraping of the topsoil from overgrown spoil in the vicinity of existing colonies. Active management must prevent scrub encroachment. Sites in East Cornwall are on edges of working china-clay quarries, with these quarrying works creating new habitat. Recent experimental work at one of the sites where *M. profunda* is most abundant has suggested that it can readily and successfully be transplanted onto suitable ground (Holyoak 1996b, 1997). *M. profunda* is the subject of a Biodiversity Action Plan. It is also the only British plant listed on the Annexes of the EC Habitats & Species Directive as a 'priority species'. Outside Britain, this species is known only from Portugal (about four sites), the Azores (a single site) and Madeira, and is included on a list of the world's most threatened bryophytes (Hallingbäck and Hodgetts 2000). A record from the Canary Islands (Düll 1980, 1983) cannot be verified, as it cannot be traced back to a specimen (D T Holyoak, pers. comm.).

Total no. of hectads: 5 1970 onwards: 4



Marsupella sparsifolia (Lindb.) Dumort.
Status in Britain: *VULNERABLE*
Status in Europe: *Not threatened*

Marsupella sparsifolia occurs as yellow-brown to blackish, lax patches on gravel and sometimes larger stones associated with melt-water channels or diffuse drainage, in areas of late snow-lie. In this habitat it can occur with a number of species of *Marsupella* with which it may be confused. The rather obtuse lobes and the lax habit are different from all other species apart from *M. sphacelata*. It can be distinguished from *M. sphacelata*, often with much difficulty, by the paroecious inflorescence and usually smaller size. All sites are above 900 m where snow persists late into the summer, and most are associated with coarse, acid gravel, although in one site the substrate is fine silt derived from moderately calcareous schist. Inflorescences are common and sporophytes are reputedly frequent.

In Britain *M. sparsifolia* is restricted by its habitat to the Central Highlands of Scotland, where it occurs in three areas, in the Cairngorms on Beinn a'Bhuird, on Lochnagar (South Aberdeenshire) and on the Ben Alder massif (Westerness), all of which are SSSIs. In the Lochnagar area it is also present in a number of snow-beds round the Dubh Loch basin and stands can be frequent. On Beinn a'Bhuird, and in the Ben Alder area, populations would seem to be very small indeed. The threats to this species are the same as those for snow-beds in general, those of gradual diminution through global warming, pollution loading through preferential deposition and concentration of pollutants in the snow pack, and local threats of disturbance by trampling. Any management to conserve the vegetation of areas of late snow-lie will presumably benefit this species. This is an arctic-montane species which occurs in the Faeroes, Fennoscandia, north-western Russia and the central European mountains. It is also known from Greenland, north-eastern and north-western North America, the Azores, East and South Africa and New Zealand. It would appear to be rare throughout its range.

Total no. of hectads: 3 1970 onwards: 3

Nardia insecta Lindb.
Status in Britain: *DATA DEFICIENT*
Status in Europe: *Not threatened*

A small, slightly fleshy and brittle pale green leafy liverwort growing in thin mats, *Nardia insecta* has bilobed leaves and, like other species of *Nardia*, small, narrow underleaves diverging sharply from the stem. In contrast, *N. geoscyphus* has the leaves rounded or retuse, or only shortly and inconsistently bilobed, and less conspicuous underleaves. In Britain, it grows on steep soil banks in the upper flood-zone of a burn associated with other bryophytes, notably *Calypogeia muelleriana*, *Cephalozia bicuspidata*, *Dicranella heteromalla*, *Diplophyllum albicans* and *Pellia epiphylla* (Blackstock 1995). This is very similar to its habitat in the Ardennes, Belgium (Schumacker et al. 1986).

N. insecta was first collected in Britain in 1964, at Seven Linns, South Northumberland, but the specimens were named *N. geoscyphus* until further investigation (Blackstock 1995) revealed them to be *N. insecta*. Fieldwork in 1993 found *N. insecta* at three localities in the area. Nicholson (1911) reports a plant from Sussex that may have been *N. insecta*, but this was never confirmed. However, it is not unlikely that further localities for this plant, probably by moorland streams, will be found in the future. At Seven Linns, conservation measures may be required because catchment afforestation may affect the stream hydrology, and encroachment of surrounding vegetation, formerly kept in check by livestock grazing, may threaten *N. insecta* directly (Blackstock 1995). In Europe it is a widespread but uncommon boreal-suboceanic species (Schumacker et al. 1986), extending from France in the west to the Czech Republic in the east, and north to Fennoscandia and northern Russia. It also occurs in North America.

Total no. of hectads: 1 1970 onwards: 1

Pallavicinia lyellii (Hook.) Carruth.
Status in Britain: *VULNERABLE*
Status in Europe: *Vulnerable*

This is a pale green thalloid liverwort with sparsely-branched thalli up to *c.* 4 cm long. It is usually narrower and less branched than species of *Pellia*, and differs from both *Pellia* and *Moerckia* in that its well-defined midrib has a central strand of thickened, elongated conducting cells, which are visible by transmitted light as a dark line. *Pallavicinia lyellii* typically grows among tussocks of purple moor grass (*Molinia caerulea*) or rush (*Juncus* spp.) in the marginal parts of raised bogs or in old cut-over areas, around the bases of trees in carrs and on the peaty or sandy banks of ditches and streams (Bates 1993; Paton 1956). It has also been found growing on rotten wood, and even on rotten leather in boggy places (it was famously found on Wimbledon Common in 1948, 'growing on an old boot' (Gardiner 1981), although later records from the same locality were, more prosaically, from rotting stumps). In East Sussex it grows on wet sandstone rock outcrops in the Weald. Detailed studies at Silwood Park (Berkshire) have shown that most of the growth takes place in summer (Bates 1995). Sporophytes are produced rarely: only one sex is present at some sites.

This plant has been recorded from 26 sites in England and Wales in the last 200 years, north to North Yorkshire and Westmorland. It may have declined significantly, at least in the north, and has been seen in only 17 sites since 1950 and 10 since 1970. It is now apparently extinct in North Yorkshire, South Lancashire, Westmorland and West Sussex (Paton 1954). Five of the recent British sites for this species are SSSIs, two of which are owned by the Forestry Commission and another is an NNR. The reasons for the decline of this species are unclear, although most of the losses have probably resulted from drainage. The inability of single-sex populations to colonise newly available sites by spores may be a significant factor reducing its mobility. *P. lyellii* is the subject of a Biodiversity Action Plan in Britain. This liverwort is widespread throughout Europe, as far north as southern Fennoscandia. It has a wide-ranging but disjunct distribution elsewhere, often occurring in areas with an oceanic or suboceanic climate. *P. lyellii* is widespread in the tropics.

Total no. of hectads: 27 1970 onwards: 8

Petalophyllum ralfsii (Wils.) Nees et Gottsche
Petalwort
Status in Britain: *NATIONALLY SCARCE*. WCA Schedule 8
Status in Europe: *Vulnerable*. Bern Convention, Appendix 1; EC Habitats & Species Directive, Annex IIb

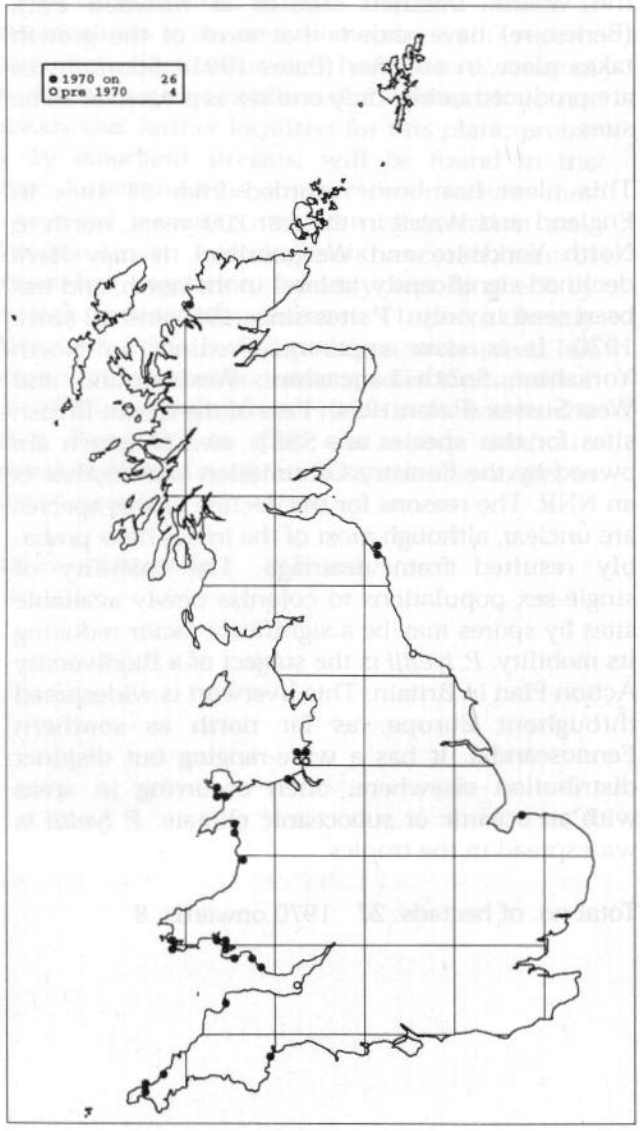
Petalophyllum ralfsii is a small, pale green thalloid liverwort with erect lamellae on its upper surface. The base of the thallus is tuberous and embedded in the substrate. Sporophytes develop on the upper surface of the female thallus sheathed in a pseudoperianth. This plant is usually found on damp, calcareous sand in dune slacks, where it is wet or even subject to inundation in the winter. *P. ralfsii* seems to favour the sides of paths where the soil receives some disturbance, leading to gaps in the vegetation. It does not grow in slacks that are water-filled for long periods or are heavily shaded. It has also been recorded growing over metalliferous mine-spoil and old masonry. Until recently it was thought to grow on thin soil over limestone on clifftops near Torquay, but it is now known that these records are mistakes for *Fossombronia husnotii* (D T Holyoak, pers. comm.). It usually disappears from view when the substrate dries out in the summer, surviving as tubers. It can vary in apparent abundance from year to year, depending on weather conditions. Sporophytes are produced mainly between March and May.

Recorded from about 30 sites around the coast, *P. ralfsii* has apparently disappeared from a few, probably no longer occurring in North-east Yorkshire or North Somerset. However, it occurs in abundance elsewhere, notably at sites on the Welsh coast, and there are also important populations in North Northumberland, South Lancashire, West Cornwall, North and South Devon and West Ross (its northernmost world locality). It was recently rediscovered in West Norfolk. In North Devon, it has apparently disappeared from its prime dune slack habitat at Braunton Burrows, where the vegetation has become too rank, but small populations survive along tracks and in a car park (Holyoak 1999a). *P. ralfsii* appears to be increasing at some of its Cornish sites as a result of increased trampling (D T Holyoak, pers. comm). Of the sites where *P. ralfsii* has been recorded since 1970, seven are within NNRs, a further eight within SSSIs, and only the Scottish site has no statutory protection.

It is possible that *P. ralfsii* may have suffered an overall decline but its life strategy, and the fact that recent years have seen a great deal more targeted survey work on this species than ever before, makes any change in population difficult to assess. Because of the fragility of the habitat and its specialised ecology, *P. ralfsii* is potentially threatened by a large number of factors, including holiday developments, recreational activities, removal of turf, desiccation due to water abstraction or afforestation, and the spread of sea buckthorn and conifers. Fortunately, most of its sites are protected and site managers are now aware of the presence of the plant. A reduction in grazing by livestock, and especially by rabbits, may threaten the plant at some sites, as it needs a short, open sward in order to grow: any spread of coarser vegetation into the dune slacks constitutes a threat to its survival. Although it is likely that a small amount of disturbance may be favourable for this plant, more extreme forms of disturbance may be detrimental. The Scottish site was surveyed as part of the Scottish Cryptogamic Conservation Project 1993–95 (Long and Rothero 1995–96), and the statutory agencies have also funded surveys at sites in England and Wales. It is the subject of a Biodiversity Action Plan.

This Mediterranean–Atlantic species is widely but sparsely distributed in southern and western Europe, and has also been recorded in North America. It may be declining in parts of its range because of the extreme vulnerability of the habitat, and it can be assumed that the British and Irish populations are of international importance — some Irish populations reportedly comprise millions of thalli (D T Holyoak, pers. comm.).

Total no. of hectads: 30 1970 onwards: 26



Phaeoceros carolinianus (Michx.) Prosk.
(*Phaeoceros laevis* subsp. *carolinianus* (Michx.) Prosk.)
Status in Britain: *ENDANGERED*
Status in Europe: *Not threatened*

Phaeoceros carolinianus is a hornwort resembling a medium-sized, rosette-forming thalloid liverwort. The two British *Phaeoceros* species have thalli with lobed but not strongly undulate margins. *P. carolinianus* differs from *P. laevis* in being monoecious rather than dioecious. *Phaeoceros* differs from *Anthoceros*, the other genus of hornworts found in Britain, in having yellow, rather than black, spores. *P. carolinianus* grows on bare, moist soil in arable fields, ditches and on trampled tracks. It is an annual, producing sporophytes from September to December. European studies indicate that it may reappear in arable fields after an absence of several years, germinating from dormant spores (Bisang 1995).

P. carolinianus has been recorded from a total of seven sites, but only once at most of these. It has been recorded from four localities since 1970, in East Cornwall, Surrey (two sites, including Wimbledon Common in Greater London) and Monmouthshire, but not since 1909 at the other three (in West Sussex, South Essex and a further site in Surrey). A recent attempt to refind it in Cornwall was unsuccessful. None of the recent sites for this species has any designated site protection. Early ploughing for winter crops, heavy applications of herbicides and fertilisers on cultivated ground, and perhaps even the introduction of more competitive crop varieties may be contributory factors in the decline of this species. However, periodic disturbance is necessary to maintain the open soils that it needs. The known sites, and potentially suitable areas nearby, need to be surveyed to ascertain the current state of populations and to identify any management requirements. This species is widespread throughout northern and central Europe. *P. carolinianus* has declined in central Europe as a result of modern agricultural practices (Bisang 1992). It is more common than the related *P. laevis* over most of its European range, whereas it is much rarer than that species in Britain. It is rare or absent in the Mediterranean region, but is recorded from the Canary Islands. Elsewhere it is widespread in Africa, temperate Asia and North America.

Total no. of hectads: 7 1970 onwards: 4

Plagiochila norvegica H.H.Blom & Holten
Status in Britain: *DATA DEFICIENT*
Status in Europe: *Critically Endangered*. Endemic

This recently described leafy liverwort is very closely related to the common *Plagiochila porelloides*, and may prove to be nothing more than an aberrant form of it. Morphologically, it is easily distinguished from that, and other species of the *P. asplenioides* complex, by the distinctive leaves, which have a bilobed apex and prominently toothed margins. However, a recent study (Cronberg 2000) has failed to detect any genetic difference between *P. norvegica* and *P. porelloides*. Thus, until the status of this plant is clarified with more studies on its genetics and reproductive biology, it must, although exceedingly rare, remain *Data Deficient*. In Britain, *P. norvegica* overgrows flints on a steep slope facing north-east, in a mixed woodland in Dorset, amongst a large population of *P. porelloides*. The underlying soils are derived from chalk.

P. norvegica was discovered in 1997 in western Dorset (Hill et al. 1998) and this remains the only record from Britain. The site receives no official protection, but EN is aware of it and the landowner (who found the plant initially) is an enthusiastic naturalist and conservationist. At present the plant is known only from one large flint stone, and would certainly be regarded as threatened if it proved to be a good species. This liverwort is otherwise known only from two localities in western Norway (where it was first discovered) and one in southern Sweden, where the populations are reported to be small and, as in Britain, mixed with *P. porelloides*.

Total no. of hectads: 1 1970 onwards: 1

Radula carringtonii J.B.Jack

Status in Britain: *VULNERABLE*
Status in Europe: *Rare*. Endemic

The olive-green or brownish stems of *Radula carringtonii* are up to 4 cm long and grow as compact patches or straggle over other bryophytes. It can be distinguished from other *Radula* species by the ovate dorsal leaf lobe, the rarity of perianths and the absence of gemmae. It is most likely to be confused with *R. aquilegia* from which it can, with difficulty, be distinguished by the flat leaves, quadrate lobule and straight keel. Sporophytes and gemmae are unknown. A strongly oceanic species, *R. carringtonii* has been recorded from a number of scattered sites in western Scotland, but has not been refound at two of these this century, and only occurs in small quantity at the remaining localities.

R. carringtonii is confined to shaded and mildly basic rocks by streams in humid wooded ravines at low altitudes on the west coast of Scotland, where it grows with other oceanic liverworts such as *Acrobolbus wilsonii, Aphanolejeunea microscopica, Colura calyptrifolia, Drepanolejeunea hamatifolia, Harpalejeunea molleri* (*H. ovata*), species of *Lejeunea* and *R. aquilegia*. At one site, in Knapdale, it was described by the finder as growing on the 'shaded wall of a cave formed by a jammed rock in the bed of a ravine'. The stronghold of this species in Britain seems to be in the coastal ravines and woods of south-east Mull (A B J Averis, pers. comm.), where it was located at about nine sites during a survey in 1994, two of which are within an SSSI. The same survey also found it at three sites in mainland Argyll, none protected. It was last seen at its single known site in Skye in 1992, and at one of its Westerness sites in 1988: both these sites are SSSIs. There are older records from other Westerness sites, all in the Loch Sunart area, where *R. carringtonii* doubtless still occurs. No specific threats are known to most of the localities, which are protected to some degree by their inaccessibility. However, *Rhododendron ponticum* is abundant at one of the Mull sites and, although some clearance has taken place, still poses a threat to *R. carringtonii* and the oceanic bryophyte communities. All known populations are small and therefore vulnerable to management activities that might reduce shade and humidity, such as felling. Disturbance or pollution of burns upstream of *R. carringtonii* sites might also constitute a threat. Outside Britain, this species is recorded only from south-western Ireland (where it is somewhat more frequent than in Scotland), Spain, the Azores and Madeira.

Total no. of hectads: 10 1970 onwards: 7

Riccia bifurca Hoffm.

Lizard crystalwort
Status in Britain: *VULNERABLE*. WCA Schedule 8
Status in Europe: *Not threatened*

This small thalloid liverwort forms rosettes up to 1.5 cm across. It differs from other British *Riccia* species in the pale brown or orange-brown older parts, which contrast with the green or glaucous green younger parts. There are also microscopic differences in the surface cells of the thallus and the surface sculpturing of the spore. *R. bifurca* is restricted to about five sites on the Lizard Peninsula in West Cornwall, where it grows on gravelly or peaty soils in damp hollows and tracks on cliff-tops and heaths, sometimes in association with *R. beyrichiana*. It lives as an annual in sites that dry out in summer but may perennate if a site remains moist, and can survive intermittent inundation. Sporophytes mature between January and June.

All the sites where this species has been recorded since 1970 are within SSSIs. Although a number of sites are close to paths, and some trampling may be beneficial to *R. bifurca* in reducing competing vegetation, excessive trampling is likely to be detrimental. Hard-coring of paths where *R. bifurca* grows, as has occurred in the past at some places on the Lizard, may be a threat. At least one site is at risk from shading by encroaching gorse scrub. A survey of the species and habitat management plans are needed. This species is widespread throughout most of Europe, extending to Iceland, Macaronesia, north Africa and Turkey. It is also present in North America (where it is rare) and Australasia.

Total no. of hectads: 3 1970 onwards: 3

Riccia canaliculata Hoffm.

Status in Britain: *VULNERABLE*
Status in Europe: *Not threatened*

Riccia canaliculata, like *R. cavernosa*, *R. crystallina* and *R. huebeneriana*, is a member of subgenus *Ricciella*. These species have a thallus which contains air chambers, and usually grow in water or in winter-flooded habitats. *R. canaliculata* differs from the others in having thick, channelled thalli which form interwoven patches rather than neat rosettes. This species grows on damp non-calcareous mud or sand around ponds, lakes and reservoirs, where it is exposed by falling water levels during dry summers. It is sometimes found in association with other rare specialist bryophytes of this habitat, including *R. huebeneriana*, *Micromitrium tenerum* and *Physcomitrium sphaericum*. It produces sporophytes in abundance between July and February.

The records of this species are concentrated in the central lowlands of Scotland, where it has been recorded from six sites. Elsewhere it has been recorded from six scattered sites in England and Wales, but has not been seen at half of these this century. There are recent records from five sites, three from Scotland — in Dunbartonshire, Stirlingshire and West Perthshire — one from the Shropshire mosses, and one from Anglesey. The Shropshire site and one of the Scottish sites are SSSIs. Reducing the fluctuation in water levels, which is sometimes done in reservoirs and ponds for the benefit of fishing activities, may have contributed to the demise of this species at some of its sites. Water pollution may also be a threat, particularly if this leads to a build-up of algae. *R. canaliculata* is widespread in Europe east to Poland and Hungary, has also been recorded from north Africa and may occur in North America.

Total no. of hectads: 12 1970 onwards: 5

Riccia huebeneriana Lindenb.

Status in Britain: *VULNERABLE*
Status in Europe: *Rare*

This is a small, green thalloid liverwort, often tinged with red or violet, forming rosettes up to 1 cm across. The older parts have a spongy appearance which, combined with the narrow, channelled thallus less than 0.8 mm wide and the colour, distinguishes *Riccia huebeneriana* from other British and Irish species of *Riccia* (Paton 1967). This liverwort grows on non-calcareous mud in the draw-down zone of large ponds, lakes and reservoirs that is exposed in dry summers. It has also been found on disturbed riverside mud on the Afon Teifi in Wales. It produces sporophytes abundantly in late summer and autumn. The very large spores indicate a 'shuttle strategy' for this plant (During 1992), which presumably survives as a spore bank in the mud until conditions for growth reappear. It then has a brief season of growth and reproduction in which it produces more spores that restock the spore bank.

R. huebeneriana has been recorded from a total of 23 widely scattered sites in Britain. However, it has only been recorded since 1970 from eight localities. One of the post-1970 sites is within an SSSI and another within an NNR, but the remainder have no designated site protection. As a 'shuttle species' with large spores, it is unlikely to be very mobile, in contrast to ephemeral species with small spores (colonists), so it may not disappear from some sites and appear at others with great regularity. Any decrease in the fluctuation of water levels in reservoirs with *R. huebeneriana* (for fishing purposes, for example) could threaten this species. It may also be affected by nitrate and phosphate pollution, but this requires investigation. *R. huebeneriana* is the subject of a Biodiversity Action Plan. This species is widespread throughout most of Europe, but absent from northern Fennoscandia and the eastern Mediterranean. It also occurs in eastern North America. Elsewhere it has been recorded from Asia and Africa, but there is some uncertainty about its world distribution because of confusion with other species.

Total no. of hectads: 24 1970 onwards: 8

Riccia nigrella DC.
Status in Britain: *VULNERABLE*
Status in Europe: *Not threatened*

Riccia nigrella is a small thalloid liverwort distinguished from other species in the genus by its dark green, deeply furrowed thallus and dark, blackish-purple underside. It grows on thin soils in places that are damp in winter but dry out in summer, such as rocky slopes, clifftops, paths, banks, mud-capped walls and occasionally in fields. Many of the clifftop sites are on the lightly trampled fringes of paths, particularly where there are protruding rocks and stones to prevent erosion. An annual species, it releases its large spores between December and May and disappears during the summer. Like many other species of *Riccia*, *R. nigrella* has adopted a 'shuttle' strategy (During 1992), whereby it occurs sporadically over limited areas, surviving as spores in the soil, and appearing as plants only when conditions allow.

This south-western species is recorded from about 10 sites on the Lizard Peninsula, West Cornwall and from three scattered sites in Gwynedd (Merioneth) and Powys (Radnorshire). There is also a 1912 record from Herefordshire. Most of the Cornish sites and the Powys site are within statutory nature conservation areas and not under immediate threat. Although excessive trampling and subsequent erosion may be detrimental to individual colonies, a certain amount of trampling may be beneficial in keeping soil open for colonisation. *R. nigrella* is widespread throughout the Mediterranean, and extends along the Atlantic fringe of Europe from Macaronesia to Britain: it is relatively frequent in the Channel Islands. It also occurs in Australasia and North and Central America.

Total no. of hectads: 5 1970 onwards: 4

Scapania parvifolia Warnst.
Status in Britain: *DATA DEFICIENT*
Status in Europe: *Not threatened*

Scapania parvifolia is a small species with relatively narrow leaf lobes, related to *S. curta* and *S. scandica*, from which it differs primarily in the smaller leaf cells. However, some taxonomists regard *S. parvifolia* as conspecific with *S. scandica* (Potemkin 1999). It grows on acid soils on exposed mountain ridges and cliff ledges. Sporophytes are unknown, but gemmae are usually present. *S. parvifolia* has been recorded recently at four sites, in Argyll and West and Mid Perthshire, with another slightly older record (1967) from Argyll and the original British record by MacVicar from Beinn Gaire in Westerness (1899). *S. parvifolia* is not a well understood taxon. Not only is it taxonomically dubious, but also its distribution and status in Britain cannot be ascertained with any certainty at present. Although it appears to be rare, from the low number of records overall, it was recorded four times during and shortly after a BBS meeting in 1981, which surely indicates that, if it is indeed a species, it must be under-recorded. Genetic studies on *S. parvifolia* to determine its relationship with *S. scandica* would be useful. No significant threats have been identified. It is a circumpolar boreal–arctic species, with a scattered distribution in northern, central and eastern Europe, Siberia, Japan, Canada and Greenland.

Total no. of hectads: 6 1970 onwards: 4

Scapania praetervisa Meyl.
(*S. mucronata* auct.)
Status in Britain: *VULNERABLE*
Status in Europe: *Not threatened*

Scapania praetervisa is a member of the *Scapania curta* group of closely related species. These are distinguished by their very small size (the stems of the British and Irish plants do not exceed 1 cm in length), and leaves which have unequal lobes, lack spinose teeth and are not decurrent at the base. *S. praetervisa* is characterised by the long teeth at the mouth of the perianth. *S. praetervisa* grows on moist, mildly basic boulders and rock outcrops by rivers in wooded gorges and ravines. Sporophytes are unknown in Britain but gemmae are usually present.

This species has been recorded recently at two sites: one on base-rich schistose rocks by the River Braan in Mid Perthshire, and the other on a base-rich rock ledge by the River Findhorn in Moray. It has also been recorded near Ribblehead in the Craven limestone area of Mid-west Yorkshire in 1952, and on sandstone conglomerate on the banks of the River North Esk in Kincardineshire in the 1960s, where it was found in several places. Only one site is within an SSSI. No threats to this species have been identified, but its sites should be checked occasionally to ensure that the species is still present and to identify any management needs. This applies especially to the two sites where it has not been seen since before 1970, but where it is probably still present. *S. praetervisa* is widespread in northern Europe and in the mountains farther south. It has also been reported from Asia and North America, but its exact distribution is unclear due to confusion with *S. mucronata*.

Total no. of hectads: 4 1970 onwards: 2

Southbya nigrella (De Not.) Henriq.
Blackwort
Status in Britain: *VULNERABLE*. WCA Schedule 8
Status in Europe: *Not threatened*

This is a small, dark green leafy liverwort, becoming black when dry, with prostrate, occasionally branched shoots up to *c.* 5 mm long. The leaves are opposite and rounded, like those of *Southbya tophacea*, but have a characteristically dark underside. *Gongylanthus ericetorum* also has rounded, opposite leaves but is larger (up to 2 cm), green and grows in base-poor habitats. *S. nigrella* grows in short, broken turf, often around half-buried rocks, on thin, clayey or sandy limestone soils in clifftop turf, stabilised screes and on abandoned quarry floors, frequently among *Weissia* spp. or *Trichostomum crispulum*. More rarely it occurs directly on limestone rock faces: on the Isle of Wight, it has been found on boulders in a coastal landslip. It grows during the winter months, when its habitat is moist, becoming virtually undetectable in the summer, when it dries out and the leaves curl round the stem. All the extant sites are near the sea and are on Portland or Purbeck limestone. Sporophytes are produced occasionally in the autumn and spring.

S. nigrella has been recorded from two areas of Britain: the Isle of Portland in Dorset and the Isle of Wight. A recent survey has indicated that it is present at 16 localities in Portland, several of which contain hundreds of plants, but most are very small. All but two of the sites are within SSSIs and one site is also owned by the National Trust. Records from Wales and Cornwall originally thought to be this species have been redetermined as *S. tophacea*. Threats to this liverwort include habitat destruction by dumping, quarrying, recreational pressure, changes in land-use and the encroachment of coarse vegetation. On Portland, none of the sites has any formal management, and the habitat is kept open by a combination of rabbit grazing, thin soils, summer drought and trampling (Edwards 1996). On the Isle of Wight, the boulders on which the plant grows are breaking up and causing the plant to flake off. Collecting by botanists may also be a threat at some sites. This species is frequent in the Mediterranean region, east to Iraq, and occasional along the Atlantic fringe from the Canary Islands to Britain and Belgium.

Total no. of hectads: 3 1970 onwards: 3

Sphaerocarpos texanus Austin
Status in Britain: *VULNERABLE*
Status in Europe: *Not threatened*

Sphaerocarpos is a distinctive genus of tiny, delicate thalloid liverworts with relatively large club- or pear-shaped, balloon-like involucres on the upper surface of the thalli. Female plants are larger than the very tiny males. *S. texanus* can be distinguished from the commoner *S. michelii* only by microscopic examination: the surface pattern of the spores provides the only character. In Britain this species is virtually restricted to cultivated ground where the soil is a non-calcareous loam or sand. It is usually recorded from places where chemical sprays are not used extensively, such as gardens, nurseries, bulb fields, allotments, or among vegetable or fodder crops. It can also occur among arable crops on light sandy soils, particularly in unploughed stubble fields. Typical associates include *Riccia glauca*, *R. sorocarpa*, *Dicranella staphylina* and *Pottia truncata*. It appears to fluctuate in abundance from year to year, presumably adopting a 'shuttle strategy' (During 1992), the large spores remaining together in tetrads and persisting in the soil until conditions are favourable for growth. Sporophytes are produced freely in winter and spring. *S. texanus* is a difficult species to survey, as plants with ripe spores can be found only for short periods of the year, and appear to be more frequent in some years than others. The dry spores retain their viability for several years.

Within the last 40 years this species has been recorded from 12 sites in south-east England and a few sites in the south-west, none of which receives special protection. It has not been refound at a number of former sites, and this may well reflect a genuine decline, as the large spores mean that *S. texanus* is unlikely to be a very mobile species. In the Isles of Scilly, it has persisted in some bulb fields. The main threat is probably agricultural intensification, principally the increased use of autumn ploughing and chemical sprays. A new survey of all sites where this species has been recorded, as well as potentially suitable sites nearby, is required. This species has a predominantly Mediterranean distribution, extending as far south as north Africa, east to Turkey and north to Britain. It also occurs in southern North America, temperate South America and Australia, although possibly as an introduction in the latter.

Total no. of hectads: 22 1970 onwards: 8

Telaranea nematodes (Gottsche ex Austin) M.Howe
(*T. sejuncta* auct.)
Status in Britain: *VULNERABLE*
Status in Europe: *Rare*

This is a very small, pale green, delicate leafy liverwort, smaller than *Telaranea longii* and *T. murphyae* and with more deeply cut leaves, divided almost to the base into two or three threadlike lobes. *Blepharostoma trichophyllum* is superficially rather similar but has underleaves as big as the normal leaves. *Kurzia* species differ in having their leaf lobes mostly two rather than one cell wide. This species has a highly oceanic distribution, being restricted to areas with a high rainfall (above 1,400 mm per year) and high winter temperatures (January mean temperature above 6°C). Although it is considerably more frequent in south-western Ireland, it is restricted to a single known site in Britain, in West Cornwall (Paton 1969). Here it grows at low altitudes (up to 70 m) on peaty or sandy-peaty soils over acid rocks in dense, humid woodland and under *Rhododendron ponticum* and other evergreen shrubs. In western Ireland it also rarely occurs on *Molinia caerulea* tussocks in marshland and in turf on coastal slopes. It often produces sex organs but sporophytes are rare. It reproduces vegetatively by bulbils (Paton 1987).

T. nematodes is apparently under no immediate threat at its Cornish site, which does not have any statutory protection, but any management activities that could reduce the shade and humidity should be avoided. Surprisingly, the presence of *Rhododendron ponticum* does not seem to be detrimental to this plant, and may even be beneficial in ensuring continuing dense shade and high humidity. This is an amphi-Atlantic species, occurring along the Atlantic fringe of Europe from Britain and Ireland to Portugal, and also in Macaronesia and Tristan da Cunha. It is a common plant in tropical Africa and in the Americas from northern Brazil to New England (USA).

Total no. of hectads: 1 1970 onwards: 1

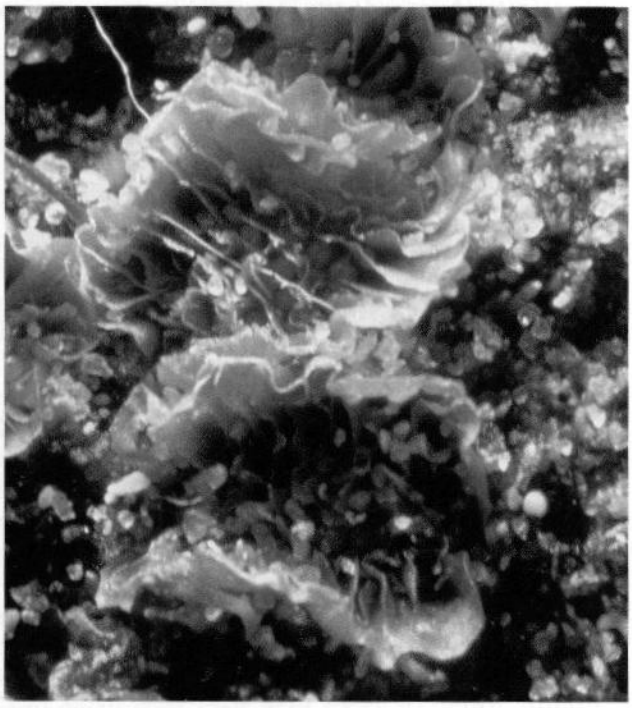
Herbertus borealis
This is a large liverwort of the northern Atlantic mixed hepatic mat community that is known only from western Scotland and Norway. (Photo by H.L.K. Whitehouse)

Scorpidium turgescens
One of the most striking of the Ben Lawers rarities, this glacial relict moss is confined to a single large flush, where it is locally abundant. (Photo by N.G. Hodgetts)

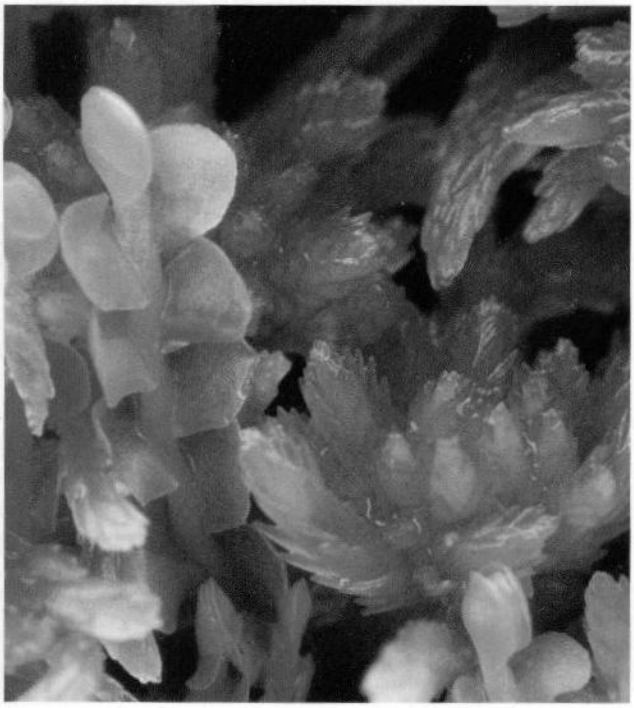
Thamnobryum angustifolium
Known at a single site in Derbyshire for over 100 years. This is still its only known locality in the world. (Photo by H.L.K. Whitehouse)

Sphaerocarpus texanus
This strange liverwort, with extremely inflated female involucres, is characteristic of acidic stubble fields in southern England. (Photo by R.D. Porley)

Timmia austriaca
One of the suite of rare arctic-alpine species that grows on high altitude-calcareous mica-schist, as on Ben Lawers. (Photo by R.D. Porley)

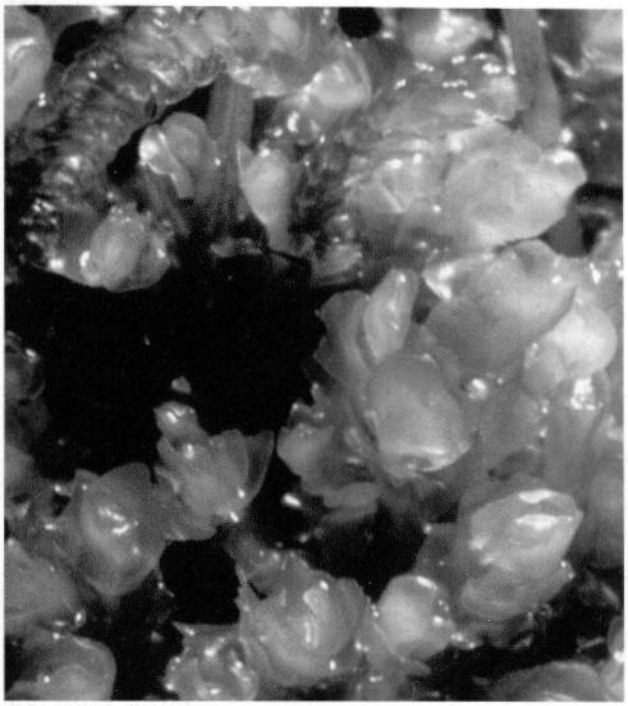


Petalophyllum ralfsii
This dune-slack liverwort is one of four British bryophytes protected by international law. (Photo by H.L.K. Whitehouse)

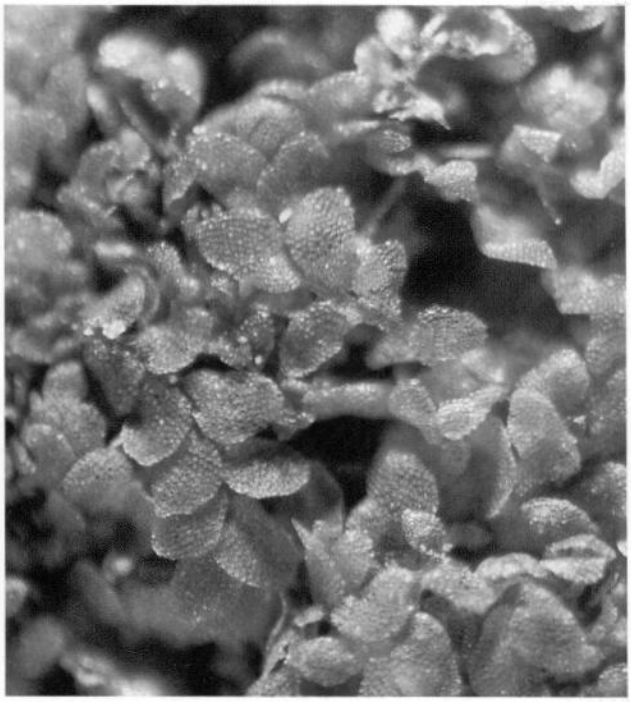


Jamesoniella undulifolia
A bog leafy liverwort, restricted to *Sphagnum* hummocks at one site in Argyll and two in Cornwall. (Photo by L. Gill)

Buxbaumia viridis
Sometimes called 'bug-on-a-stick', this bizarre moss with a large sporophyte and greatly reduced gametophyte grows on rotting pine logs at two sites in Scotland and is protected by international law. (Photo by L. Gill)



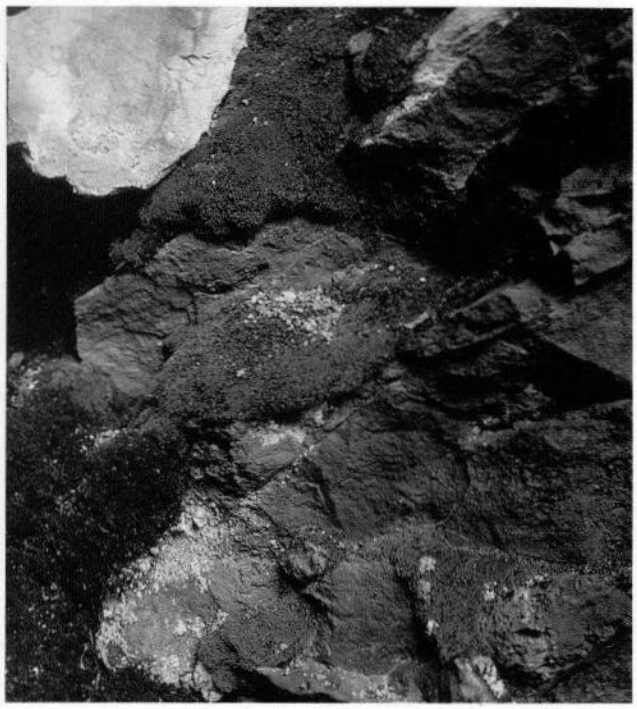
Leiocolea rutheana
This is a large leafy liverwort of highly calcareous fens. It has declined sharply, especially in its one-time stronghold of Norfolk. (Photo by H.L.K. Whitehouse)



Lejeunea mandonii
A tiny oceanic liverwort restricted to a small number of wooded ravines in wetsern Scotland and a few sites in Cornwall, *L. mandonii* is a globally rare species. (Photo by P. York)

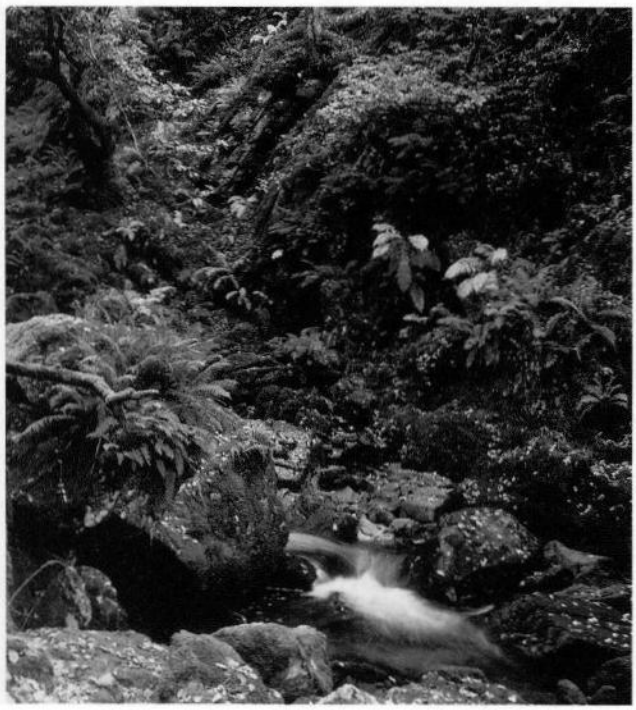
Sphagnum majus
A large bog-moss occurring partially submerged at the edges of bog pools. (Photo by R.D. Porley)

Sphagnum balticum
A bog-moss of very wet ground that is apparently sensitive to the effects of eutrophication, being replaced by common species such as *S. fallax*. (Photo by R.D. Porley)



Mielichhoferia elongata
This moss forms cushions on the rare habitat of acidic rocks rich in heavy metal sulphides. (Photo by F.J. Rumsey)

Southbya nigrella
An example of a Mediterranean species at the northern limit of its distribution in southern England.
(Photo by H.L.K. Whitehouse)



Lodore Falls, Cumbria
Atlantic ravines are one of the richest bryophyte habitats in Europe. (Photo by D.A. Ratcliffe)

Sematophyllum demissum
This strongly oceanic moss is confined to a handful of oak-woods in west Wales. (Photo by A. Hale)