JOINT NATURE CONSERVATION COMMITTEE

The conservation of lower plants in Britain and Ireland

by N.G. Hodgetts

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Cover.
Hygrocybe splendidissimus, a toadstool of acid pastures. (P. Marren)

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What are lower plants?

The unflattering term 'lower plants' is used to describe a huge range of plant groups. Those covered by this leaflet are bryophytes (mosses and liverworts), algae (except seaweeds), fungi and lichens: in other words, plants that have neither flowers nor a system of channels for conducting food and water. Therefore ferns, which do not produce flowers but do have such a vascular system, are excluded. All these groups reproduce by means of spores but they have little else in common.

Bryophytes are small green plants which produce their spores in capsules which are usually raised on stalks above the main body of the plant. The two main groups of bryophytes - mosses and liverworts - differ from one another in a number of features, most importantly in the structure of the capsule. Mosses tend to have a stem and spirally arranged leaves. Liverworts tend to be more delicate than mosses, and either have a stem with two main ranks of leaves, or are composed of an undifferentiated flat body called a 'thallus'. Liverworts in particular tend to grow in humid conditions.

H.L.K. Whitehouse

▲ Norfolk flapwort *Leiocolea rutheana*, a liverwort.

H.L.K. Whitehouse

◀ Hedgehog moss *Grimmia pulvinata*.

J. Malinson

Foxtail stonewort *Lamprothamnium papulosum*, an alga. ▶

Many species of algae are either single-celled or filamentous, composed of a simple string of cells. Algae differ from bryophytes by having their sex cell-producing structures exposed rather than being surrounded by a protective jacket of sterile cells. As a consequence, algae are even more rigidly confined to wet places than bryophytes, and in fact most are aquatic.

P. Marren

Orange-peel fungus *Aleuria aurantia*.

Fungi are arguably not plants at all: they do not possess chlorophyll, so cannot make their own food using light energy (photosynthesise), but collect their nutrients saprophytically (from dead animal or plant material) or parasitically. Spores are produced in a wide variety of structures, the most familiar of which is the toadstool.

Lichens are 'composite plants', part alga and part fungus. This relationship enables them to grow in places that would otherwise be out of bounds to either partner. Fungal spores are produced, which germinate and combine with an

F. Dobson

Ophioparma ventosum, a lichen.

alga, if available, and the two partners grow together to form the body of the lichen. Vegetative reproduction can be achieved by fragments breaking off the body of the lichen and forming new plants.

D.A. Ratcliffe

Tree lungwort *Lobaria pulmonaria*, one of our largest lichens.

Although lower plants are often overlooked because of their small size, they greatly outnumber vascular plants, in terms of numbers of species. In Britain alone there are about 1,000 bryophytes, 1,500 lichens, at least 10,000 fungi and several thousand algae. Many species are known to be under threat, and the issue of their conservation is now being addressed.

Why are lower plants important?

Ecological importance

Nutrient cycling Fungi are important decomposers in most natural systems. In particular, their ability to decompose wood is vital in forests. As forest covers nearly one sixth of the world's land area, and 90% of forest biomass is woody, fungi are clearly very important in the global carbon cycle. Woodland bryophytes and lichens can sometimes be considerably more important, in terms of biomass, than flowering herbs: this is so, for example, in ravine woodland in western Britain, where conditions are ideal for the growth of these plants.

Nitrogen fixation Blue-green algae and lichens with a blue-green algal component are able to turn atmospheric nitrogen into nitrate, which is then available for the manufacture of protein food.

Water retention In western British woodlands, bryophytes play an important part in holding moisture, thus contributing to the retention of a humid atmosphere. Bog moss, *Sphagnum*, is a vital component of bog vegetation, because it acts as a sponge. Areas where *Sphagnum* has disappeared from hillsides and hilltops are particularly prone to flash floods.

Colonisation and soil stabilisation Lower plants are often the first plants to colonise newly-exposed ground, and are important in stabilising the soil both in new habitats and in areas such as steeply sloping western woodland.

Dominance in certain habitats *Sphagnum* is often the most important plant in bogs and in peat formation. Bryophytes and lichens frequently dominate in severely stressed situations such as exposed mountain summits and toxic

R. Lindsay

Bog moss, *Sphagnum*.

environments like heavy-metal-rich soil, where most vascular plants are unable to compete successfully. Bryophytes and algae are particularly important in upland stream and river communities, and stoneworts (types of alga) often dominate in certain clean freshwater habitats.

Relationships with invertebrates Many invertebrates depend on lower plants for a food source. Slugs, for example, graze bryophytes (particularly the nutrient-rich capsules) and lichens. Fungi are also extensively used for food, even species that are poisonous to humans. Some invertebrates depend on lower plants for their entire life cycle. Fungus gnats use the fruiting bodies of fungi for food, shelter and breeding. A whole range of invertebrates live exclusively in *Sphagnum* bogs. In freshwater systems, the tiny algae that float in the water and encrust other plants and rocks (phytoplankton) form the basis of the food chain, providing sustenance for numerous invertebrates, and therefore ultimately for fish and other vertebrates. Many very rare woodland insects are entirely dependent on the action of wood-rotting fungi for their habitat. There are innumerable other examples of associations between lower plants and invertebrates.

Mycorrhizal systems A mycorrhiza is an intimate relationship between the underground filaments (mycelium) of a fungus and the roots of a vascular plant. Mycorrhizae are still not fully understood, but it is thought that the fungal component makes nutrients such as phosphates and nitrates available to the vascular plant while deriving sugars from it. This relationship is particularly important to trees, and therefore woodlands; and to orchids, where the small seeds are incapable of sustaining themselves immediately after germination without the presence of the fungus.

P. Marren

Fly agaric *Amanita muscaria* is mycorrhizal with birch.

Indicator species

Many lower plants are extremely useful indicators of a variety of natural and man-made conditions.

Pollution indicators Many lichens and some bryophytes, particularly those growing on trees (epiphytes), are extremely sensitive to atmospheric pollution, and are killed when the level of certain chemicals in the air, notably sulphur dioxide, rises beyond a certain level. This means that the presence of these species is indicative of clean air. Conversely, a few species of lichen are pollution-tolerant, and only occur in any quantity in polluted areas. In cleaner areas they tend to be out-competed by more vigorous but pollution-sensitive species.

Ecological indicators Lower plants can be better indicators than vascular plants in some circumstances. For example, calcareous bands in a rock face can be traced by following the growth of calcicolous mosses.

Indicators of habitat continuity Some lower plants are indicators of ancient woodland. They are sensitive to loss of canopy cover, which causes reduction in humidity, and they have limited powers of dispersal and colonisation. Together, these factors tend to restrict certain lichens and bryophytes to places with a long continuous history of woodland cover. Some fungi also appear to be indicators of ancient woodland. Many species that grow in bogs and wet heathland are extremely sensitive to fire, so their presence indicates that an area of bog or wet heath has not been burned for a very long time.

Economic value

Many drugs now in use are derived from fungi, including some species that are rare in their native habitat. An example is cyclosporin A, a drug used in organ transplants, which is derived from a fungus found on the coast of Norway. The alkaloid ergotamine, used in treating migraine, is derived from the ergot *Claviceps purpurea*. Many biologically-active compounds have been identified in liverworts, including cancer-inhibitors, which may have potential uses in medicine. The gastronomic value of wild fungi is well known. Indeed, there is some concern that continental mushroom collectors are raiding the New Forest for its fungi, many sites on the continent having been over-exploited. A species of microfungus is currently being marketed as a vegetarian meat alternative. There is of course a negative side to the economic importance of fungi. Many species are pathogens of crops and trees.

However, some mycologists suggest that the problem of honey fungus in woodlands, for example, is largely because of human interference: if forest managers were not so scrupulous when clearing away or burning dead wood and leaf litter, then other species of fungi, able to out-compete honey fungus but not harmful to trees, would be able to survive.

Sphagnum (bog moss) is perhaps the most economically important moss. Over millennia, *Sphagnum* has grown and died in bogs, leaving behind vast deposits of peat, essentially dead plant material preserved against the effects of decay by the acid conditions it creates. Peat has been harvested as a fuel since ancient times, and has therefore been important in the development of human settlements and society in the areas where it occurs. Although it burns much less efficiently than coal, it was always cheaper and more readily available in these areas. It is only recently that very large scale peat extraction has posed a threat to peatlands.

Scientific and educational value

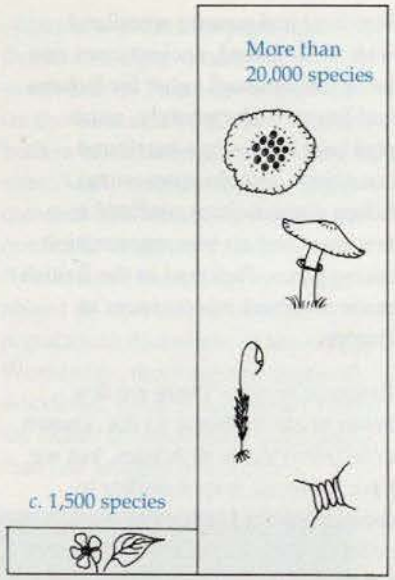
Lower plants show a great diversity of structures, physiologies, ecologies and reproductive strategies, both between the different groups and within each group, making them excellent subjects for study and research. They are also very useful in biogeographical studies, as many species have disjunct distributions which suggest they were once much more widespread. For example, there is a species of liverwort (*Scapania nimbosa*) found only in the British Isles, Norway and Yunnan in China. This kind of pattern is not exceptional.

Cultural value

Mossy woods are magical places to walk in. People like to see toadstools. The plants themselves are things of great beauty. These features are difficult to quantify, but should not be underestimated. We have a responsibility for taking care of our best lower plant sites, just as we do for our other natural assets and, indeed, for our man-made treasures such as great works of art or ancient monuments.

Why are the British Isles special for lower plants?

The flowering plant flora of the British Isles is relatively poor in international terms but, in contrast, the lower plants attain an astonishing diversity and luxuriance: nearly 70% of the total European bryophyte flora occurs in the British Isles. This compares with a figure for vascular plants of about 18%. There are a number of elements of our lower plant flora which are unique to the British Isles:



The relative numbers of higher and lower plants in Britain and Ireland.

The Northern Atlantic Hepatic Mat

This is an oceanic liverwort community confined to the west of Scotland and Ireland. This distinctive vegetation type attains its best development in the British Isles, though a less well-developed version is found in Norway. It consists of a number of species, mostly large leafy liverworts, growing under and among heather *Calluna vulgaris* on north- and north-east-facing slopes in areas of the highest rainfall. It is very sensitive to changes caused by burning and over-grazing.

The mixture of northern and southern elements in the Atlantic flora

The geographical position of the British Isles means that there is an unbroken gradation of these elements from north to south, and a unique mingling of northern and southern species at many sites. For example, in some of the western British and Irish oakwoods northern liverworts such as *Herbertus aduncus* or *Pleurozia purpurea* and southern ones such as *Acrobolbus wilsonii* and *Plagiochila atlantica* can be found growing in close proximity.

N.G. Hodgetts

Plagiochila atlantica, an Atlantic liverwort.

Machair The machair is species-rich calcareous grassland that has developed on blown shell-sand in parts of the Hebrides and Ireland. It can be very rich in bryophytes and the lichen communities can also be important, particularly where acidic rocks protrude through the sand. This flora is largely dependent on traditional low-intensity agriculture. As with other kinds of grassland, the richest areas are those which have not been ploughed for a long time or fertilised.

S.G. Ball

Ancient Caledonian pine woodland at Abernethy Forest.

Caledonian pinewoods These native Scottish woodlands are very important for their characteristic lichen and fungus communities, with many species restricted to this habitat. Historical continuity is important, and even pine plantations with a known history of several centuries have an impoverished flora compared with ancient pinewood.

Parkland and pasture woodland with well-spaced, ancient trees can be of unsurpassed value for lichens and fungi. Unfortunately, much parkland is now in a moribund condition, with the interesting lichen communities confined to a few trees and no tree regeneration taking place. Parkland in the British sense is almost non-existent in Europe.

Endemic species There are few lower plants endemic to (i.e. known only from) the British Isles, but we have a special responsibility to conserve them. At least two endemic mosses have not been seen for many years, and must be presumed extinct, having been collected out by botanists.

Other communities of international importance

There are several other communities particularly well represented in the British Isles, mainly because of the predominantly cool, wet weather with few temperature extremes. This leads to a luxuriant development of oceanic, or 'Atlantic', lower plant communities, especially in the west. Particularly important are:

Atlantic woodland bryophyte, lichen and slime mould communities These are at their best on the west side of the British Isles, both in luxuriance and in number of sites. Many species occur in these communities which, in Europe, are confined, or almost confined, to Britain and Ireland, and are either absent or have only scattered populations elsewhere in the world. Worldwide, there are few areas of woodland, even in the tropics, that are richer in bryophytes and lichens than our western oakwoods.

D.A. Ratcliffe

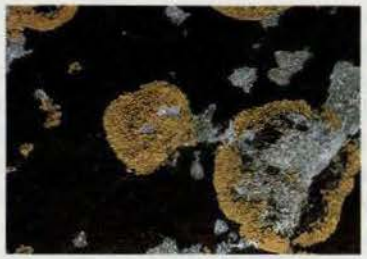
Lodore Falls, Cumbria, a ravine rich in lower plants.

Atlantic-influenced arctic-alpine communities Many of the arctic-alpine communities in Britain are similar to those of Scandinavia, but differ subtly because of our oceanic climate. Ben Lawers has more in common with mountains further south in continental Europe but is slightly different from these because of the oceanic influence.

Bogs The high rainfall of the British Isles has led to extensive bog formation. It is estimated that the islands have no less than 13% of the world's blanket bog, much of it in the 'Flow Country' of the north of Scotland. This haunting landscape is, of course, important for far more than lower plants, supporting internationally important numbers of greenshank and other waders, but it is essentially the *Sphagnum* that supplies the structure.

Lowland lichen heath This is an oceanic community confined to the western fringe of Europe. It is sensitive to burning, and lichens such as the rarer species of *Cladonia* may take many decades to recolonise a burnt area. The heathland often contains wetter areas with rich *Sphagnum* and leafy liverwort associations.

Maritime lichen and fungus communities The extensive rocky coastline of Britain provides a wealth of habitats for maritime lichens, and indeed there is a greater diversity of these in Britain than elsewhere in Europe. They are often sensitive to both atmospheric and sea-borne pollution. Coastal dune systems have recently been found to be of great importance for fungi.



F. Dobson

A mosaic of lichens on coastal rock.

Pollution-sensitive species The west of Britain is also important for pollution-sensitive species that have declined or disappeared elsewhere in Europe. The most obvious examples are certain lichens, such as *Lobaria scrobiculata*, but there is evidence that many other lower plants are also sensitive.

Conservation

For many years lower plants were not adequately considered in conservation programmes, largely because so little was known about their distribution, their ecology or their management requirements. The position has improved substantially in recent years, with the advent of new information and the rise of interest in the conservation of all groups of animals and plants. However, the threats to lower plants continue to operate relentlessly.

The threats

The main threat to lower plants, as to many other groups of organism, is undoubtedly habitat destruction. The drainage of wetlands, felling of semi-natural woodland and planting of vast areas of moorland and bog with alien conifers, together with the steady attrition of the countryside by urban encroachment, have all led to a decline in lower plant habitat. Some species have even disappeared from Britain completely. For example, the rare

P. Wakely

Commercial peat extraction at Wedholme Flow, Cumbria.

and beautiful moss *Paludella squarrosa* vanished after all its sites were drained for agriculture earlier this century. More minor, but still significant, habitat destruction has taken place through 'improvements' made to riverbanks and coastal defences, scrub encroachment onto grassland and heath, in-filling of old quarries, ploughing up of old pastures and quarrying of limestone and shingle.

Agricultural practices such as burning heathland and moorland can be very detrimental to some species and communities. Over-grazing is a severe threat to western woodland. The creation of vast reservoirs has swallowed up many good lower plant sites, particularly wetlands.

Some threats, such as pollution, are more significant for lower plants than they are for other groups of organism. Lichens are particularly sensitive to pollutants such as sulphur dioxide, an inescapable by-product of coal-fired power stations, and species such as tree lungwort (*Lobaria pulmonaria*) have declined catastrophically because of pollution. Epiphytes (plants that grow on trees) seem to be particularly sensitive. Many species are also sensitive to increased levels of nitrates derived

F. Dobson

Lobaria scrobiculata, a lichen very sensitive to air pollution.

from fertiliser application, farm animals and aerial deposition. This particularly affects lower plants because many of them grow in naturally nutrient-poor areas. When the level of nitrates increases, a rank growth of nettles and other nutrient-demanding species replaces the lichens and bryophytes. Heathland tends to be especially affected by this phenomenon.

Pollution of freshwaters by nutrient enrichment poses a threat to algae. Stoneworts are particularly sensitive to freshwater pollution because they require clear water, and have declined markedly over the last few decades. The notorious algal blooms that have blighted reservoirs in recent years are due, at least in part, to the presence of excessive nutrients such as nitrates and phosphates, which have increased because of higher sewage inputs and the use of fertilisers. The change in nutrient levels leads to a change in the balance of algal communities, and species diversity rapidly declines as the growth of a few vigorous, nutrient-demanding species increases, eventually causing the algal blooms, and leading to the disappearance not only of other species of algae such as diatoms and desmids, but also bryophytes, flowering plants, invertebrates and fish.

Pollution from 'acid rain' may also seriously affect freshwater algal communities, and there is some evidence that acid rain has caused a decline in fungi, particularly mycorrhizal species. The widely publicised deterioration of the forests in central Europe and elsewhere may be as much to do with the effect of pollution on the mycorrhizal fungi as directly on the trees.

Climate change poses a new potential threat to lower plant communities. Nobody yet knows what will happen, but it is possible that arctic-alpine species may decrease or disappear, while species with a Mediterranean distribution, currently at the northern limit of their range in southern Britain, may become more widespread.

The often more competitive vascular plants have tended to push lower plants into more marginal habitats. Many species of lower plant are capable of colonising open ground more quickly than vascular plants, and often have very specialised habitat requirements. It is surprising how many of the bryophytes on the list of threatened species are ephemeral plants of bare ground.

Many threatened lower plants are relict species, with a few isolated populations that have probably survived in the same place for thousands of years. These plants occupy habitats that have remained stable for a long time, but are now rare because of man's influence or long term climate change. These habitats are often rich in many different kinds of wildlife and therefore many have some degree of protection already, in nature reserves or Sites of Special Scientific Interest (SSSIs).

In woodland, removal or burning of dead wood and ancient trees is a major problem for fungi. Many of these rely on a supply of dead wood, and species diversity is seriously reduced by its removal. There is also a detrimental effect on the woodland as a whole, the elimination of fungal diversity often leading to the uncontrolled spread of a few notorious disease-producing species, such as the honey fungus *Armillaria mellea*.

Conservation objectives

There are many areas where the conservation of lower plants can be taken forward.

Site safeguard Few nature reserves or Sites of Special Scientific Interest (SSSIs) have been established specifically for lower plants. However, many important lower plant sites have been included incidentally in sites regarded as important for other reasons. The SSSI selection guidelines published by the JNCC now allow sites to be selected for their lower plant interest, and a number of SSSIs have in fact now been notified for their bryophytes and lichens.

N.G. Hodgetts

Beinn Eighe NNR, important for lower plants.

Site management It is not enough simply to declare a site protected: it must then be managed. In a western oakwood rich in lower plants this may mean minimal intervention, perhaps reducing grazing by sheep and other animals but doing little other positive management. This may contrast with woodland management in other areas, where relatively intensive techniques such as coppicing may be used for the benefit of the flowering plants.

Each site must therefore be managed according to its biological interest and in many areas, particularly in the west, lower plants are likely to figure largely in this.

Species protection Sixty-one species of lower plants have been given special protection in a recent (1992) amendment to the Wildlife and Countryside Act 1981: 26 lichens, 24 mosses, 9 liverworts and 2 stoneworts. More will probably be added to the list eventually, including some fungi. Meanwhile, all plants, including lower plants, are given general protection under the Act from uprooting or removal by unauthorised persons.

F. Dobson

Golden hair-lichen *Teloschistes flavicans*, now protected by law.

International conventions can also be used to protect them, and some bryophytes are listed in the Bern Convention and in the EC Directive on the Conservation of Natural Habitats and of Wild Fauna and Flora. There is an international obligation on signatories to these agreements to give adequate

protection to the species listed in them.

Production of Red Data Books is also useful in conservation of rare species. These publications list the rare species, assign them each a threat category (Endangered, Vulnerable, Rare, etc.) and make conservation recommendations. There is a Red Data Book for stoneworts, volumes for lichens and bryophytes are in preparation and it is intended to produce one for fungi.

Research and survey To protect these plants properly, we need to know as much as we can about their distribution, biology and ecology. Recently, surveys of Scottish woodlands and late-lying snowpatches have contributed an enormous amount towards our knowledge of Atlantic and arctic-alpine bryophytes respectively. The

N.G. Hodgetts

Looking for lower plants on the Tansley Bog, Beinn Eighe NNR.

snowpatch survey has even resulted in the discovery of some bryophytes new to Britain. Further initiatives under way include a survey of coastal lichens and a survey of sand dune fungi. There have also been wide-ranging studies involving the effects of pollution on lichens. We still need to know a great deal about grazing management in woodland and grassland, and the detailed ecological requirements of most species.

The information on species distribution has improved markedly in recent years, and we now have a good idea of which species are rare and where they grow, at least for bryophytes, lichens and stoneworts. Several mapping projects are now taking place, with the bryophyte atlas project nearing completion.

Publicity Lower plants desperately need to be noticed! This can be achieved by publications such as this pamphlet, as well as more detailed works such as Red Data Books, popular guides and notes on the management of lower plant habitats and sites.

Voluntary societies All the groups of lower plants have specialist societies devoted to their study. These have much to offer, and constitute bodies of expertise that should be tapped to further the conservation of these plants. The

addresses of some of the main societies are listed below.

International conservation

As people worldwide become increasingly aware of conservation issues, lower plant matters are also gaining ground. Lichens and bryophytes are particularly well represented in tropical cloud forest of the type found at high altitudes in the Andes and on some of the African mountains. Many of these are highly endangered and their conservation is a priority. Certain areas of lowland tropical rain forest, for example in the Philippines, are also known to have a high degree of lower plant diversity and

N.G. Hodgetts

Bryophyte- and lichen-rich forest on Mount Mulanje, Malawi.

endemism. Most of these areas will disappear soon unless action is taken to stop the destruction of the forest. The International Union for the Conservation of Nature and other worldwide bodies are taking active steps towards lower plant conservation in all parts of the world.

Sources of information about lower plants

There are several popular guides in the shops, illustrated with colour paintings or photographs, for the identification of the various groups of lower plants. Those available for fungi are particularly helpful. There are also more detailed Floras for those who want to go into the subject more deeply. A microscope is not absolutely essential for the examination of most species, but it is certainly useful, and becomes essential for the serious student. The purchase of a x10 hand lens opens up a marvellous new world for those with a more casual interest.

There is no substitute for going into the field with an expert, and courses such as those run by the Field Studies Council are ideal for this.

Those interested in the conservation of these special and beautiful plants could try to raise their profile in the county Wildlife Trusts, making sure that nature reserves rich in lower

plants are managed in an appropriate way, and that these plants are not overlooked.

Names and addresses of some relevant societies:

British Bryological Society (mosses and liverworts).
Mr A.R. Perry,
Department of Botany,
National Museum of Wales,
Cardiff,
CF1 3NP.

British Lichen Society.
Dr O.W. Purvis,
Department of Botany,
Natural History Museum,
Cromwell Road,
London,
SW7 5BD.

British Mycological Society.
Dr D.N. Pegler,
The Herbarium,
Royal Botanic Garden,
Kew,
Richmond,
Surrey,
TW9 3AE.

British Phycological Society.
Dr D. John,
Department of Botany,
Natural History Museum,
Cromwell Road,
London,
SW7 5BD.

Plantlife.
c/o The Natural History Museum,
Cromwell Road,
London,
SW7 5BD.

Royal Society for Nature Conservation.
The Green,
Witham Park,
Waterside South,
Lincoln,
LN5 7JR.

Field Studies Council.
Preston Montford,
Montford Bridge,
Shrewsbury,
SY4 1HW.

Further reading

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The UK Joint Nature Conservation Committee was established by the Environmental Protection Act 1990 "for the purposes of nature conservation, and fostering the understanding thereof" in Great Britain as a whole and outside Great Britain. It is a committee of the three country agencies (the Countryside Council for Wales, English Nature and Scottish Natural Heritage), together with independent members and representatives from Northern Ireland and the Countryside Commission, and is supported by specialist staff. JNCC and the three country agencies carry forward duties previously undertaken by the Nature Conservancy Council.

JNCC's statutory responsibilities include:

> the establishment of common scientific standards; undertaking and commissioning of research; advising Ministers on the development and implementation of policies for or affecting nature conservation for Great Britain as a whole or conservation outside Great Britain; the provision of advice and the dissemination of knowledge to any persons about nature conservation. JNCC also has the UK responsibility for European and international matters affecting nature conservation.

This is one of a range of publications produced by JNCC. A catalogue listing current titles is available from Publications Branch, JNCC, City Road, Peterborough PE1 1JY.

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