

Sphagnum balticum (Russow)
C.E.O. Jensen.



PLANTLIFE

Baltic Bog Moss

SPHAGNACEAE

SYN.: *Syn: Sphagnum cuspidatum var. brevifolium.*

Sphagnum recurvum ssp. balticum Russow

Status:

Schedule 8 Wildlife & Countryside Act (1981)

English Nature Species Recovery Programme

Bryophyte Red Data Book – Endangered (2001)

UK BAP Priority Species

Status in Europe: Not threatened

Lead Partner: Plantlife International

UK Biodiversity Action Plan:

These are the current BAP targets following the 2001 Targets Review:

T1 - Maintain populations of this species at all extant sites.

T2 - Establish by 2005 *ex situ* stocks of this species to safeguard extant populations.

Progress on targets as reported in the UKBAP 2002 reporting round can be viewed by selecting this species and logging in as a guest on the following web page:

<http://www.ukbap.org.uk>

The full Action Plan for *Sphagnum balticum* can be viewed on the following web page:

<http://www.ukbap.org.uk/asp/UKPlans.asp?UKListID=580>

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1 Morphology, Identification, Taxonomy & Genetics

1.1 MORPHOLOGY & IDENTIFICATION

Description

Sphagnum balticum is a medium-sized bog moss (stems >15cm) which is usually fulvous brown to bright orange in colour, although green forms can occur in extremely wet or shaded situations (M.O. Hill, pers. comm.; see Figure 1). In well-grown plants its bright colour can be distinctive in the field. *Sphagnum balticum* has conspicuous lingulate, spreading stem leaves, and branches usually in fascicles of three (2 + 1). Specimens with branches in fascicles of four are, however, known from Northumberland and a now extinct site in Lancashire. Four-branched populations are common on the continent (Maas, 1965). A useful field character is the incomplete coverage of the stem by the poorly differentiated pendant branches, especially in populations with branches in fascicles of three. *S. balticum* also has rather secund, strongly five-ranked branch leaves that are relatively broad in relation to their width. These features can be distinctive and eye-catching in the field, especially when growing against a dark background of *S. magellanicum*.

Figure 1 -
Sphagnum
balticum
(Photograph by
Ron Porley)



Under the microscope diagnostic characters include stem leaves with many fibrils and fibril stumps, and a well differentiated stem cortex (see Figures 2 & 3).

Figure 2 - *Sphagnum balticum* stem leaf fibrils (Photograph by Alan Hale)

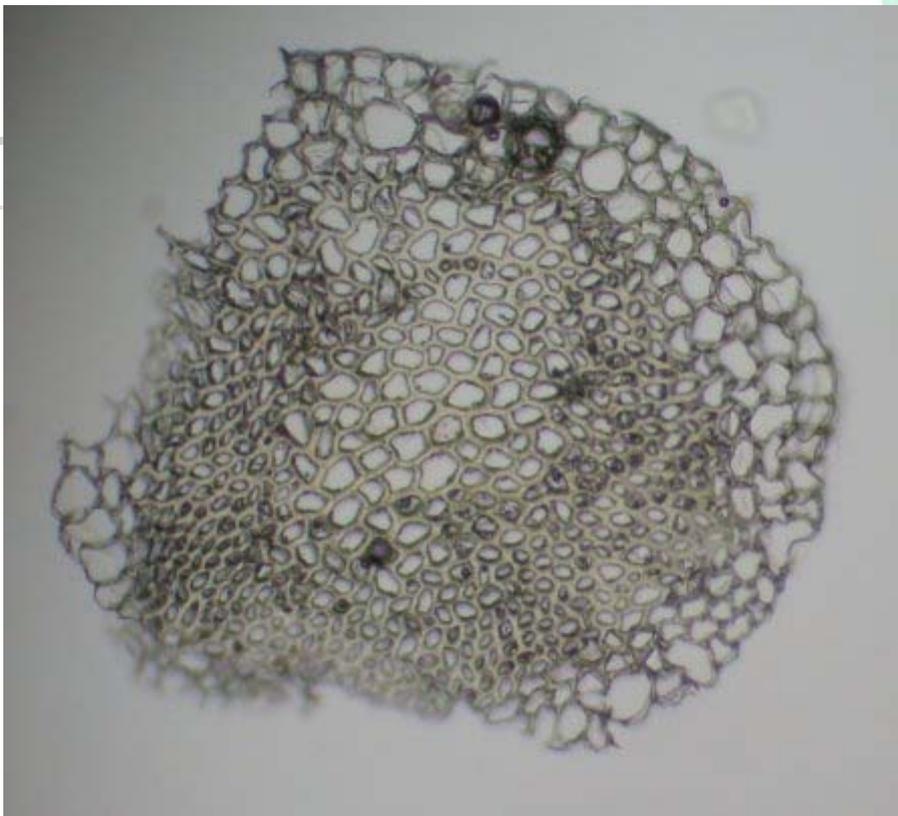
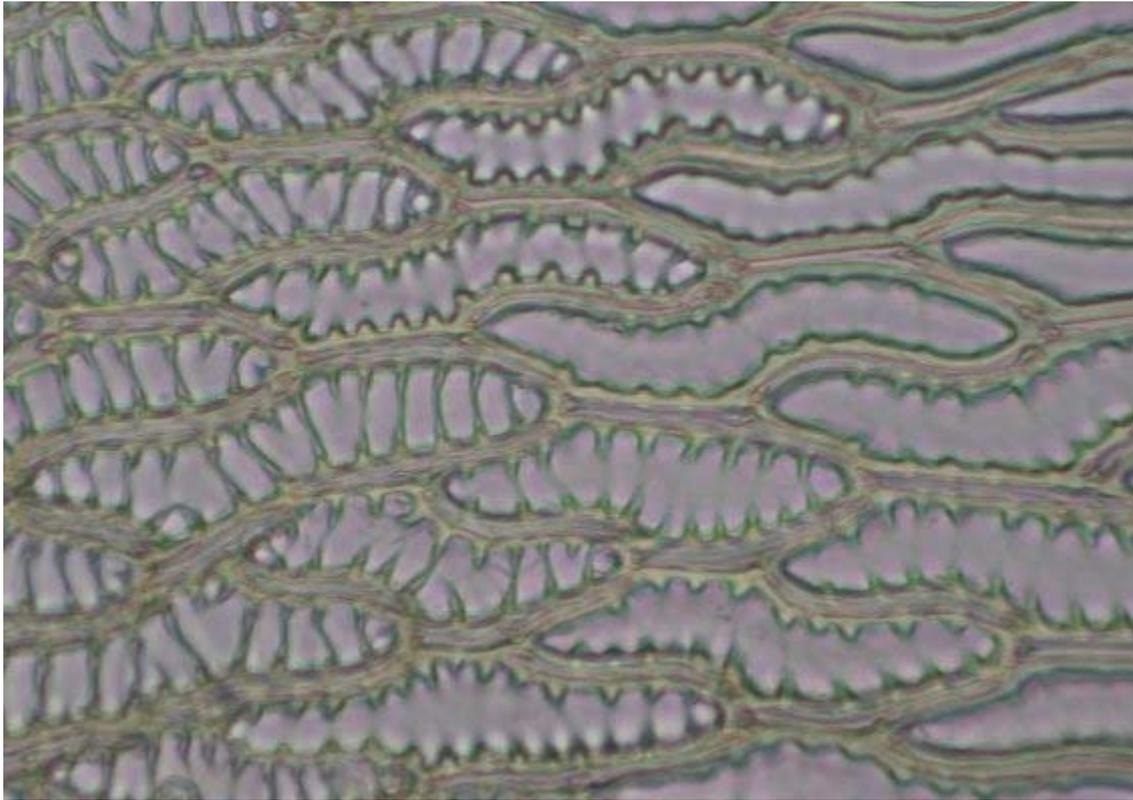


Figure 3 -
Sphagnum
balticum stem
section
(Photograph by
Alan Hale)

Sphagnum balticum has not been seen fruiting in Britain and it appears that most plants here are male, the dark brown [antheridial leaves](#) contrasting strongly with the rest of the plant.

While typical three-branched specimens may be identified with confidence in the field, confusion can arise with closely related species in Section Cuspidata, especially with *S. fallax* and some forms of *S. cuspidatum*. *S. balticum* also bears some similarity to *S. pulchrum*, although the latter differs in its dark stem and more robust stature. Several recent collections have been made and described of plants that are intermediate in character between *S. fallax* and *S. balticum*.

Further confusion arises with older herbarium material as a small number of Victorian collections of *S. balticum* were originally labelled *Sphagnum cuspidatum* var. *brevifolium*, by which name the species is known in Dixon's flora. Unfortunately, as the limits of the species were poorly known in the late Victorian age there are also collections of *S. fallax* that bear this synonym.

Some of this material, and plants examined from Ceredigion and Northumberland in 2001, could well be analogous with a form of *S. fallax* that Flatberg (1993) separated as *S. brevifolium*. However, Flatberg's *S. brevifolium* was shown to be inseparable from his *S. isoviitae*, which has since been reduced to *S. fallax* ssp. *isoviitae* (Blockeel & Long, 1998). In the light of recent genetic studies, Mark Hill now feels that even this taxon does not merit subspecies status (Mark Hill, pers. com.).

Flatberg's *S. brevifolium* is, however, very similar to *S. balticum* in that its stem cortex is more highly differentiated than in typical *S. fallax*. It also typically has fibrillose stem leaves, orange coloration and stem leaves that are less mucronate than that species and which can be held at an angle from the stem. Plants resembling this taxon have been encountered at The Lakes in Northumberland and at Cors Caron in Ceredigion. *S. fallax* seems to produce fibrillose stem leaves which are uncharacteristically spreading in very wet conditions, in which these plants were found at these sites. The distinction between the two species seems to be especially blurred at the edge of *S. balticum*'s range here in Britain. It is even possible that the British plants may be from relict populations that may well contain genes from other members of the section *cuspidata*, including *S. fallax* and even *S. pulchrum*. This confusion makes it especially difficult to distinguish true *S. balticum* in the field and could hamper efforts to find the species (if any more populations are to be found) away from its known stations or indeed to re-find the species at historic sites.

1.2 TAXONOMIC & GENETIC CONSIDERATIONS

Further research may be needed to establish the relationship between *Sphagnum balticum* and *S. fallax*.

2 Distribution & Current Status

2.1 WORLD

Sphagnum balticum has a circumpolar distribution and is found in Northern Europe, Greenland, North America and Northern Asia. It is particularly abundant to the northern part of its range, only fruiting in any quantity in the Arctic (Daniels & Eddy, 1995).

2.2 EUROPE

In Europe *S. balticum* extends south to the Alps and is found in the former Yugoslavia. It shows distinct continental tendencies and is principally a lowland species, although it occurs at 1250m in northern Sweden and 650m in Scotland. Britain is at the western edge of the plant's European range.

2.3 UNITED KINGDOM

Overview

In Britain *Sphagnum balticum* has a northern and eastern distribution, although it has been recorded from Wales (see Figure 1). Recorded from nine sites to date throughout the United Kingdom (5 in England, 1 from Wales and 3 from Scotland), *S. balticum* is now known to survive for certain at only two - Abernethy RSPB reserve in Perthshire, Scotland and Muckle Moss NNR, Northumberland.

Figure 4 - British distribution of *Sphagnum balticum*

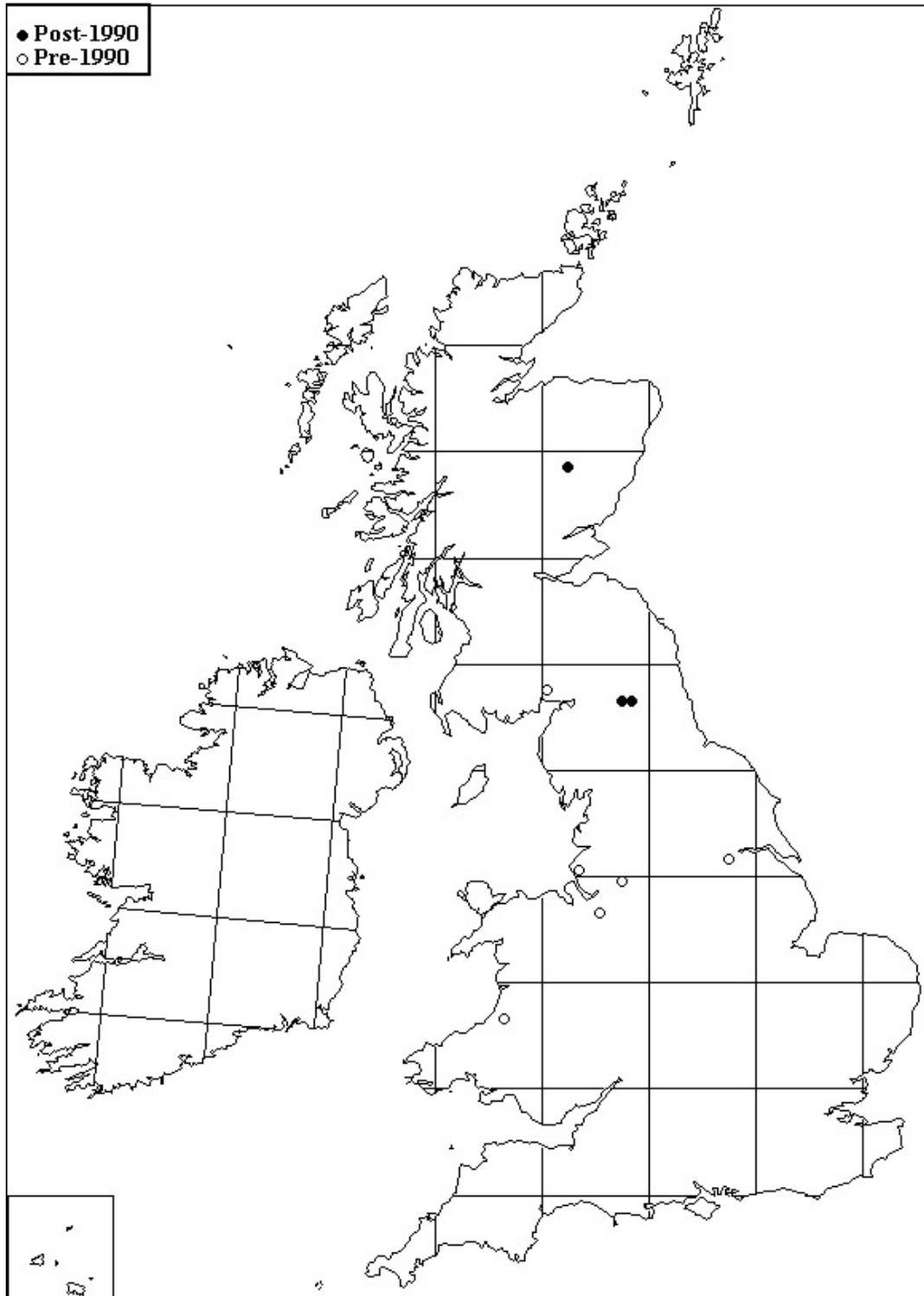


Table 1 - Records of *Sphagnum balticum* – historical and extant.

LOCALITY	COUNTY	V.C.	10 KM SQUARE	DATE	RECORDER	SOURCE
Oakmere	Cheshire	58	SJ56	1863	G.E. Hunt	A
Carrington Moss	Cheshire	58	SJ79	1863?	G.E. Hunt	J
Carrington Moss	Cheshire	58	SJ79	1886	Rogers & Holt	I
Oakmere	Cheshire	58	SJ56	1887	G.A. Holt	B
Netherton	South Lancashire	59	SD30	1889	G.A. Holt	A
Netherton	South Lancashire	59	SD30	1898	J.A. Wheldon	B
Thorne Moors	West Yorkshire	63	SE71	1932	A. Thomson	A
Rack's Moss	Dumfriesshire	72	NY07	1960	D.A. Ratcliffe	A
Muckle Moss	Northumberland	67	NY86	1961	Anon	A
Muckle Moss	Northumberland	67	NY86	1963	E.M. Lobely	A
Muckle Moss	Northumberland	67	NY86	1964	Anon	A
Muckle Moss	Northumberland	67	NY86	1966	Anon	A
Muckle Moss	Northumberland	67	NY86	1966	E.M. Lobely	A
Loch Muick	South Aberdeenshire	92	NO28	1966	D.A. Ratcliffe	A
Cors Caron	Ceredigion	46	SN66	1967	P. Coker <i>et al.</i>	A
Thorne Moors	West Yorkshire	63	SE71	1980	T.L. Blockeel	A
Muckle Moss	Northumberland	67	NY76	1985	F.J. Rumsey	C
Muckle Moss	Northumberland	67	NY76	1986	F.J. Rumsey	C
Muckle Moss	Northumberland	67	NY76	1991	R. Stern	D
Muckle Moss	Northumberland	67	NY86	1994	N.G. Hodgetts	A
Abernethy	East Inverness-shire	96	NJ01	1997	A.G. Payne	A,F
Muckle Moss	Northumberland	67	NY86	2000	J.M. Turner	E
Muckle Moss	Northumberland	67	NY76 & 86	2000	J.M. Turner <i>et al.</i>	E
Muckle Moss	Northumberland	67	NY76 & 86	2002	J.M. Turner	E
DELETED RECORDS						
Helmesdale	East Sutherland	107		1913	D. Lillie	G
Helmesdale	East Sutherland	107		1913	D. Lillie	H

Key to sources of records (Table 1)

- A BBS database, Biological Records Centre, CEH, Monks Wood.
 B NMW.
 C Dr. Fred Rumsey, NHM.
 D Mark Hill, Centre for Ecology and Hydrology, personal communication.
 E 2000 Plantlife survey.
 F A.G. Payne, *Sphagnum* survey of Abernethy Forest Reserve 1997 report to RSPB.
 G Maass, 1965 (see references).
 H BM, H.W. Dixon herbarium.
 I MANCH.
 J Flatberg (1992).

2.3.1 ENGLAND

Occurrences of *Sphagnum balticum* have been restricted to three distinct areas. Historically the area with most sites, in which it is now undoubtedly extinct, was the northwest of England, where *Sphagnum balticum* was recorded from 3 separate mires. The two remaining areas are Thorne Moors in West Yorkshire, where *S. balticum* was last seen in 1980, and Northumberland, at Muckle Moss near Hadrian's Wall where the species still thrives.

Cheshire and South Lancashire

Of the sites in the northwest only Oakmere in Cheshire still survives. Oakmere is a [candidate SAC](#) in private ownership. The site is largely occupied by shallow open water over a series of three kettle holes and is of interest as a large oligotrophic lowland mere (EN SSSI citation). The periphery of the site supports some raft vegetation. Two [kettle holes](#) which once supported [schwingmoor](#) are now forested (Robert Duff, pers. comm). No raised bog vegetation survives at the site and *S. balticum* is presumed extinct. Carrington Moss has been drained and developed for industry. The exact location of the site at Netherton is unknown but it is assumed the site has been drained and developed for industry, housing or agriculture.

West Yorkshire

Thorne Moors is a large (c2000ha), much degraded raised bog with a long history of human activity, including large-scale peat cutting, that has destroyed much of its wildlife interest in recent years. This history is well documented by Catherine Caufield (1991). Some of the remaining much-altered habitat is now managed for conservation as a [National Nature Reserve](#) and cSAC. One of the features of the core NNR (and a reminder of more sustainable human use) is a series of 'canals', separated by dry heather [baulks](#) and narrow drains, which were used to transport peat around and off the site. It was along one of these that Tom Blockeel found Baltic bog-moss in 1980 after a gap of 48 years.

A survey of the site in 2000 failed to turn up any *S. balticum*. In the light of what is known of the requirements of *S. balticum* in Britain (see section 3) it is thought that Thorne Moors no longer provides suitable conditions for the species, which is probably extinct. It is likely that high inputs of nutrients in the form of birch litter and [minerotrophic](#) water, past shading and drying out of the mire caused by large-scale peat cutting are likely to be the causes.

Northumberland

Muckle Moss is a sloping valley mire of 170 ha, bounded to the north and south by carboniferous sandstone ridges. The western part of the mire is minerotrophic with *Juncus*-dominated flushes giving way to a community of *Sphagnum* and *Calluna*-dominated mire, **M18** of the [National Vegetation Classification](#) (Rodwell, 1991).

The eastern end is more [ombrotrophic](#) in character. Muckle Moss is believed to be unique among British mires due to the fact that the peat body forms a flow, which slowly slips downslope causing splits in the [acrotelm](#) to create new, crescent-shaped pools. In this it shows similarities to the patterned sloping mires of continental Scandinavia where *Sphagnum balticum* grows abundantly. The mire occurs in two tetrads and *Sphagnum balticum* has been recorded in both. The most prominent feature of the increasingly ombrotrophic and [lagg zones](#) of the western section, are narrow crescent-shaped pools, some of which are recently formed, and a large pool bordered by a copse of mature Scots pine to the east of it. Parts of the bog were planted with pines, but much of this has since been removed. Conservation management has involved stopping drains, removal of pine and controlled grazing on the mire and adjacent heather-clad ridges.

Figure 5 – Muckle Moss NNR, *Sphagnum balticum* hunt (Photographs by Tom Collins)



Sphagnum balticum has been known from Muckle Moss since the 1960s. Surveys in 2000 and 2002 have shown that *S. balticum* is scattered within an area of approximately 5-5.5ha. Ecological information gathered from three visits to Muckle Moss during 2000 and 2002 forms the basis for much of the discussion of habitat requirements below.

As *Sphagnum balticum* is notoriously difficult to identify in the field it was thought that there might be mires in the Kielder Forest where the species may survive undetected. A sample of seven mires has been searched to date without success.

2.3.2 NORTHERN IRELAND

Not recorded.

2.3.3 SCOTLAND

Sphagnum balticum has been recorded from three sites in Scotland and is believed to be extinct at two of these. A recent search revealed that Racks's Moss, Dumfriesshire, has been so extensively coniferized that *Sphagnum balticum* has little chance of surviving here (Rothero & Long, 1995). At Loch Muick, South Aberdeenshire, *Sphagnum balticum* occurred on an area of [blanket bog](#) that now shows signs of considerable [peat-haggling](#).

S. balticum is still present at Abernethy forest reserve in a mire at Rynuie. There are frequent scattered stems of it amongst low *Sphagnum magellanicum* hummocks, in similar habitat to that in which it occurs in Northumberland (G. Rothero, pers. comm.)

2.3.4 WALES

Sphagnum balticum has only been recorded in Wales on a single occasion. It was found at Cors Caron in Ceredigion in 1967, by JJ Barkman, Paddy Coker and Hugo Sjors, during a survey for Project TELMA, an inventory of internationally important mires. The record is supported by herbarium material held at NHM. The material is very scanty and depauperate compared to collections from other sites but has been confirmed as *Sphagnum balticum*. Several attempts have been made to re-find the species at Cors Caron but with no success to date. The occurrence of *Sphagnum balticum* in Wales is rather unusual in light of its continental boreal distribution.

3 Ecology & Habitat Requirements

The ecology and habitat requirements of *Sphagnum balticum* have been assessed using observations and historical data from Muckle Moss and recent literature, most of which is Scandinavian. The Scandinavian literature has tended to be based on comparative studies of the plant's response to atmospheric pollutants or forms a part of larger [phytosociological](#) studies of mires. While these studies are of immense value, it must be remembered that *Sphagnum balticum*, a plant with a boreal continental distribution, is at the edge of its range in the UK and as such probably has a much narrower realised niche here than in Scandinavia, where it is far more widespread and abundant. The results of these studies should only be extrapolated within the framework of British climate and vegetation characteristics.

3.1 HYDROLOGICAL CONDITIONS

Records from Muckle Moss refer to *S. balticum* growing 'in the wetter parts of the bog' or 'immersed in bog'. Quadrat data shows that *S. balticum* grows most robustly and in greater numbers at about 5cm above the water table, although it was encountered at a higher level than this as scattered and depauperate individuals within hummocks largely composed of *S. capillifolium* ssp. *rubellum*. Its usual position close to the water table is not surprising in light of its branch morphology. *Sphagnum balticum* has poorly differentiated spreading and pendant branches and a poor coverage of the stem by the latter. This, together with its spreading lingulate stem leaves, means that it is less efficient at drawing up water from the mire than hummock species such as *Sphagnum capillifolium* ssp. *rubellum* or *S. fuscum* which have strongly differentiated pendant branches closely adpressed to the stem. In contrast to these species *Sphagnum balticum* shows poor desiccation resistance, but can be desiccation tolerant (Økland, 1989). This leads to lowered rate of photosynthesis and reduced competitive ability in dry conditions. Although its branch morphology tends to restrict it to low ridges and lawns, *S. balticum* can be found relatively high above the water table within hummocks composed of more desiccation-resistant species. Rydin (1985) found that parts of *S. balticum* transplanted into *S. fuscum* hummocks survived and recovered during periods of high precipitation. This commensal effect is produced by the surrounding species' more efficient capillarity -

S. balticum benefiting from lateral movement of water within the hummock. This phenomenon was noted at Muckle Moss where individual stems of *S. balticum* were found growing 20cm or more above the water table.

Despite the assertion that *S. balticum* grows submerged or as floating mats (Anon, 1998), this was not found to be the case at Muckle Moss. It is likely that this is due to the greater competitive ability of *S. cuspidatum* in bog pool habitats (see section 3.4. below).

3.2 HYDRO-CHEMICAL CONDITIONS & ATMOSPHERIC POLLUTION

In continental Scandinavia *Sphagnum balticum* grows in slightly mesotrophic poor fens (Rydin *et al.*, 1996) as well as in the [ombrotrophic](#) bogs to which it has been stated that it is restricted in the UK (Anon, 1998). The stated preference for ombrotrophic conditions in the UK is probably a reflection of greater oceanicity even in the most 'continental' regions. As previous records show it to have been present in the western part of Muckle Moss, it is evident that *S. balticum* can tolerate [minerotrophic](#) conditions in the UK. Maass (1965) mentions finding it in the 'lagg' zone at Muckle Moss, indicating a tolerance of minerotrophic sites. It is rather difficult to discern this 'lagg' on site, as transitions are gradual and varied. Hydrological and hydro-chemical conditions may have changed considerably at Muckle Moss since the 1960s and 1970s. The Nature Conservation Review account of the site (Ratcliffe, 1977) states, for example, that *Narthecium ossifragum* is absent from the mire. This species is now relatively abundant forming dominant stands in some areas, and was encountered as an associate of *S. balticum*, albeit at low cover.

Despite tolerance of a modest range of trophic conditions, *S. balticum* more frequently grows with species of broader tolerance in the UK (see section 3.3. below). Van der Heijden (2000) concluded that the predominantly oligotrophic *Sphagnum balticum* is less efficient at using nitrogen than more mesotrophic species such as *S. papillosum*, especially under elevated atmospheric CO₂ concentration. This has considerable implications in the long term as *S. balticum* would therefore be at a competitive disadvantage with *S. papillosum* on ombrotrophic sites, and probably also with *S. magellanicum*, its most common associate at Muckle Moss.

3.3 COMMUNITIES AND VEGETATION

Data from quadrats recorded at Muckle Moss show that *Sphagnum balticum* is restricted to very wet [microtopes](#) in a community that is closest to **M18a** *Erica tetralix* - *Sphagnum papillosum* mire (*Sphagnum magellanicum* - *Andromeda polifolia* sub-community) of the [National Vegetation Classification](#) (Rodwell, 1991).

Table 2 - Community associates from 13 quadrats at Muckle Moss.

SPECIES	FREQUENCY	DOMIN RANGE
<i>Sphagnum magellanicum</i>	V	5 - 9
<i>Eriophorum angustifolium</i>	V	4 - 7
<i>Sphagnum balticum</i>	V	1 - 6
<i>Andromeda polifolia</i>	V	1 - 4
<i>Vaccinium oxycoccus</i>	V	1 - 4
<i>Erica tetralix</i>	IV	1 - 5
<i>Sphagnum capillifolium</i> ssp. <i>rubellum</i>	III	3 - 7
<i>Sphagnum papillosum</i>	III	2 - 7
<i>Polytrichum commune</i>	III	1 - 7
<i>Eriophorum vaginatum</i>	II	2 - 7

SPECIES	FREQUENCY	DOMIN RANGE
<i>Sphagnum cuspidatum</i>	I	5
<i>Aulacomnium palustre</i>	I	1 - 4
<i>Empetrum nigrum</i>	I	1
<i>Sphagnum tenellum</i>	I	1
<i>Sphagnum fallax</i>	I	1
<i>Drosera rotundifolia</i>	I	1
<i>Betula</i> sapling	I	1

S. balticum is most frequently encountered at about 5cm above the water table on low ridges (T1 in Lindsay's classification (1995)) composed principally of *Sphagnum magellanicum* which usually surrounds it. Other constants of this vegetation are *Eriophorum angustifolium*, *Andromeda polifolia* and *Vaccinium oxycoccus*. Its rarity in the UK is rather puzzling in this light as there are still many good examples of this community within its geographic range in Britain. In fact this community is rather different from that found in continental Scandinavia where the plant is common and abundant on a variety of mire types. On these it also occupies the wetter parts of mire, but tends to be the dominant hollow species, interacting with *S. tenellum* (Rydin, 1985). *S. magellanicum* is less frequently encountered in continental Scandinavia having a more oceanic distribution (Daniels & Eddy, 1985). Given the predominantly continental and boreal distribution of *S. balticum* it has a distinct disadvantage over these species in the UK.

S. balticum does not appear to be associated with *S. cuspidatum* or *S. majus* at Muckle Moss despite its occurrence beside bog pools. Under stable conditions *S. balticum* cannot compete with *S. cuspidatum* due to the latter's considerably higher growth rate (Økland, 1989). Bog pools tend to be stable as *S. cuspidatum* has a relatively fast rate of decay compared to other *Sphagna*, preventing succession to hummock species (Rydin et al, 1996).

The relationship of *Sphagnum balticum* with *S. fallax* has yet to be determined. An area where *S. balticum* was present in the 1980s is now dominated by *S. fallax*. *S. fallax* was conspicuously absent from all but one quadrat.

3.4 DISPERSAL AND STRATEGY

Dispersal must take place entirely by fragmentation as *S. balticum* has not been seen in fruit in the UK. As with most of the *Sphagna*, fragmentation is the principal means of dispersal even where it does fruit (Økland, 1989). It has been noted that *S. balticum* is possibly a mobile species and an early successional colonist (Anon, 1998). This could certainly explain the fact that it has disappeared from some parts of Muckle Moss where it had recently been seen (Rumsey, pers. comm.) and now occurs in areas recently cleared of conifers and in flooded drains. However, it does not seem to be a pioneer species as it was not found to occur in open water, nor does it seem to colonise bare peat, as does the morphologically similar *S. tenellum*, and it always occurs within a matrix of other species forming lawns and low ridges.

It has been suggested that the ecological niche of *S. tenellum* falls entirely with that of *S. balticum* along the hollow-hummock and poor-rich gradients (Rydin, 1985). Both species occur lower down the gradient in permanently wet situations on the mire expanse, as would be expected from the morphological characters of the two species. It was suggested by Rydin (1985) that dominance by one or the other was related to priority of colonisation. This was refuted by Økland (1989), whose study of a boreal mire in Norway showed there to be a great niche differentiation between the two species along a [cline](#) associated with peat-producing ability. *S. balticum* occurs higher on this gradient suggesting that it is a better competitor than *S. tenellum*. According to [C-S-R strategy theory](#) (Grime, 1979), *S. balticum* can be said to exhibit a stress-tolerant,

competitive strategy, in contrast to the stress-tolerant, *ruderal* strategy of *S. tenellum*. This suggests that *S. balticum* is not such a good colonist of bare peat surfaces and probably replaces *S. tenellum* in a successional pathway that, under equilibrium conditions, would lead to its own replacement by hummock species. It is likely therefore that *S. balticum* thrives best under non-equilibrium situations where destabilising factors and stochastic events may determine its success.

At Muckle Moss all of the *S. balticum* found was growing within a matrix of *S. magellanicum*. As *S. balticum* does not seem to be a pioneer of open water or bare peat, this would suggest that *S. balticum* uses other species of *Sphagnum*, and *S. magellanicum* in particular, as a substrate within which to regenerate. Although under stable conditions *S. magellanicum* will replace *S. balticum*, a reversal of competitive ability may occur due to fluctuations in the water table. A sudden rise in the water table would have the effect of increasing productivity in *S. balticum* relative to *S. magellanicum*. Interestingly *S. magellanicum* is said to be an indicator of undisturbed conditions (Daniels & Eddy, 1985). It may be that low levels of natural disturbance caused by splitting *acrotelm*, fluctuations in the water table and cold winter temperatures, allow *S. balticum* to gain a hold in *S. magellanicum* hummocks and periodically to compete with it or to resist succession by that species.

3.5 HABITAT REQUIREMENTS IN THE UK - CONCLUSION

It appears that to thrive and compete within British mires, *S. balticum* requires a high water table with frequent destabilising factors such as fluctuations in the water table and very cold winters. It obviously survived at a number of sites into the second half of the twentieth century because small-scale peat cutting ensured a turn-over of early successional habitat that mimicked the natural habitat turn-over and suppression of competition experienced in the boreal and arctic mires in which it thrives elsewhere. Muckle Moss appears to present as near to ideal natural conditions for this species as can be met in the UK. It provides a dynamic, ombrotrophic and very wet mire surface that experiences a relatively continental climate. Current conservation management of Muckle Moss appears to be suitable for *Sphagnum balticum* as it is focussed on maintaining a high water table and minimising high levels of disturbance.

4 Threats

Table 3 - Summary of the threats to the survival and spread of *Sphagnum balticum* in Britain.

THREAT
<p><i>Climate change.</i></p> <p><i>Elevated nitrogen & carbon dioxide regimes.</i></p> <p><i>Changes in hydrology.</i></p> <p><i>Collection for horticultural purposes.</i></p> <p><i>Physical damage by trampling.</i></p>

Climate change

As *Sphagnum balticum* is a species of boreal continental distribution, at its most prolific and fecund in the arctic regions, there is real concern that the possible onset of warmer winters may benefit less exacting species of *Sphagnum* such as *S. tenellum* and *S. magellanicum* by giving them a competitive advantage. This factor may be difficult to distinguish from the possible competitive advantage that other *Sphagnum* may gain under elevated nitrogen deposition and atmospheric CO₂ (see below).

Elevated nitrogen and carbon dioxide regimes

Trophic conditions do not presently appear to be a threat at Muckle Moss, the Northumberland site. It is reasonably well protected from inputs of nutrients from ground water and also from spray drift due to its situation between the sandstone ridges and its preference for the more ombrotrophic parts of the mire. In the long term, however, increasing levels of nitrogen in rainfall and elevated atmospheric CO₂ levels could give species such as *Sphagnum fallax* and *S. magellanicum* a competitive advantage. The appearance and increase at Muckle Moss of a number of species characteristic of more mesotrophic parts of mires, e.g. bog asphodel (*Narthecium ossifragum*) and the hair-moss (*Polytrichum commune*), do suggest a possible change in the water chemistry and/or disturbance levels. This threat can only be assessed by long term monitoring of all the factors involved.

Changes in hydrology

The apparent decline in the *S. balticum* population at Muckle Moss in the early 1990s could be attributed to a drying out of the surface of the mire over a period of time. Currently the management of the Northumberland mire is improved and is providing the high water levels that are thought to be beneficial to this species. With continued sympathetic management there appears to be little danger of hydrological conditions changing to the detriment of the species in the short term.

Physical damage to the surface of the mire through trampling

Sphagnum balticum is an early successional species of recently open areas on mires and as such a certain amount of disturbance, such as light trampling, is likely to be beneficial. At Muckle Moss suitable habitat appears to be created by a reasonably stable high water level in the area of greatest concentration of the population and by natural splitting of the acrotelm caused by 'flow' of the peat body downslope. Scattered individuals higher above the water level are more at risk from damage to hummocks by trampling. Current visitor pressure is low and so this is not considered a threat, but prolonged trampling, e.g. by large groups of botanists carrying out monitoring, should be avoided.

Inappropriate collection for horticultural purposes

This is not currently perceived to be a threat due to the remote and secluded nature of the Northumberland site.

5 Management Implications

On an ideal naturally dynamic site like Muckle Moss little management other than maintaining a high water level is required to ensure the survival of *Sphagnum balticum*, at least in the short to medium term. However, it is clear from the records that *S. balticum* may have been dependant upon traditional management at other sites that were cut for peat. Neglect of small-scale peat cutting has probably caused its extinction at at least two sites, combined with large-scale peat extraction that involved total destruction and desiccation of habitat. It is essential therefore that a close eye is kept on the remaining populations.

6 Recommendations for Future Work

It is suggested therefore that the following recommendations be observed:

- Maintain current management practices at Muckle Moss.
- Monitor extent of population and record data from permanent plots every 5 years.

- Encourage genetic work to be carried out to discover relationship between *S. balticum* and *S. fallax*.
- Establish *ex-situ* stocks to safeguard sole English population and consider introduction to previously unoccupied sites should any suitable ones be found in north-eastern England.

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10 Links

- ARKive species web page for *Sphagnum balticum* <http://www.arkive.org/>.
- British Bryological society <http://www.britishbryologicalsociety.org.uk/>.

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