

Lycopodiella inundata (L.) Holub



PLANTLIFE

Marsh Clubmoss, Cnwprwsoglau y Gors

Lycopodiaceae

SYN.: *Lepidotis inundata* (L.) P. Beauv., *Lycopodium inundatum* L.

Status:

Nationally Scarce

61 / 233 10-km squares post 1987

UK BAP Priority Species since 1998

Lead partner: Plantlife

UK Biodiversity Action Plan (BAP):

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

T1 - Maintain viable populations at all extant sites.

T2 - Achieve an increase of 20% in population size of this species at 5 sites by 2008.

T3 - Establish three additional populations by 2003 within the historic range.

T4 - Assess the feasibility of supporting the conservation of this species through an ex-situ programme.

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

The full Action Plan for *Lycopodiella inundata* can be viewed on the following web site, <http://www.ukbap.org.uk/UKPlans.aspx?ID=431>

Work on *Lycopodiella inundata* is supported by:



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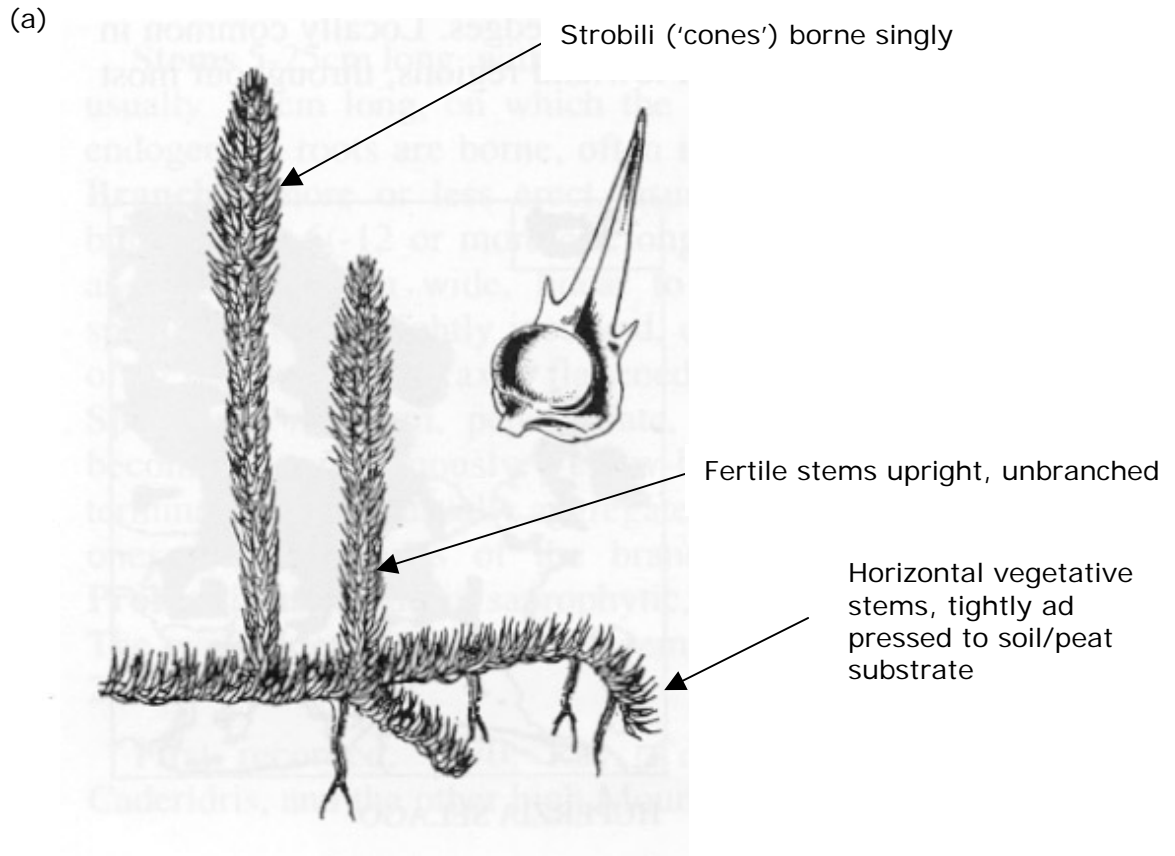
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1. Morphology, Identification, Taxonomy & Genetics

1.1. MORPHOLOGY & IDENTIFICATION

Perennial. Procumbent stems dying back quickly behind, to c. 20 cm; erect stems to 8(-10) cm; leaves 4-6 mm, erecto-patent, linear to narrowly ovate, entire; sporangium-bearing leaves broader at base; $2n = 156$ [from Stace (1997) *New Flora of the British Isles*].

Figure 1: Diagrams of *Lycopodiella inundata* (a) stems, (b) sporangium and (c) habit (Images taken from Jermy & Camus, 1993; Hutchinson & Thomas, 1996)



Lycopodiella inundata can be distinguished from other British members of the family Lycopodiaceae (belonging to four genera in total) by the following combination of characters: plant bearing horizontal sterile and upright fertile stems; fertile stems always unbranched; both sterile and sporangium-bearing leaves are similar, borne in whorls (alternately or spirally), without either a hair-point or scarious, toothed margins (Figure 1 and 2).

Figure 2 - Images of *Lycopodiella inundata* plants in situ.

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1.2. TAXONOMIC CONSIDERATIONS

None.

1.3. GENETIC IMPLICATIONS

Crane (2002) has undertaken basic genetic studies on material of *L. inundata* from four sites in Devon, North Wales and Cumbria using the horizontal starch gel electrophoresis technique. Initial findings suggest that the material used was the same genetically for the few enzymes tested. A number of reasons were put forward to explain the lack of variation, including:

- (i) that sexual reproduction is unsuccessful and that the plant relies on vegetative spread and fragmentation;
- (ii) reproduction takes place via intragametophytic selfing;
- (iii) insufficient numbers of enzymes were tested; or that
- (iv) these particular isozymes are not genetically variable in this taxon.

Crane concluded that if sexual reproduction is unsuccessful or intragametophytic selfing is only occurring, *L. inundata* could be the same genetically across the British Isles. Crane concluded that if this is the case, then only a few sites need to be protected in order to preserve the entire gene pool (there are, however, other good reasons, over and above genetics, to protect as wide a range of sites as possible). Crane concluded that the situation could only be finally elucidated if further work is undertaken, using different tools to further characterise the population structure of the species.

2. Distribution & Current Status

2.1. WORLD

Lycopodiella inundata is scattered through most of non-Mediterranean Europe south of the Arctic Circle, including the Azores (Hulten & Fries 1986). It is locally frequent in parts of the UK (New Forest) and France (Vosges, Jura and Massif Centrale) but it is considered rare and declining throughout much of its range and is certainly highly vulnerable in lowland heathland habitats (Lansdown 2000a).

It is frequent in eastern North America where it extends from Wisconsin and the Great Lakes to Labrador and New Jersey. It also occurs, albeit more sparsely, in western North America from Oregon to southern Alaska and Japan. There is also an isolated record from Lake Baykal (Hulten & Fries 1986). The world distribution of *L. inundata* is shown in Figure 3.

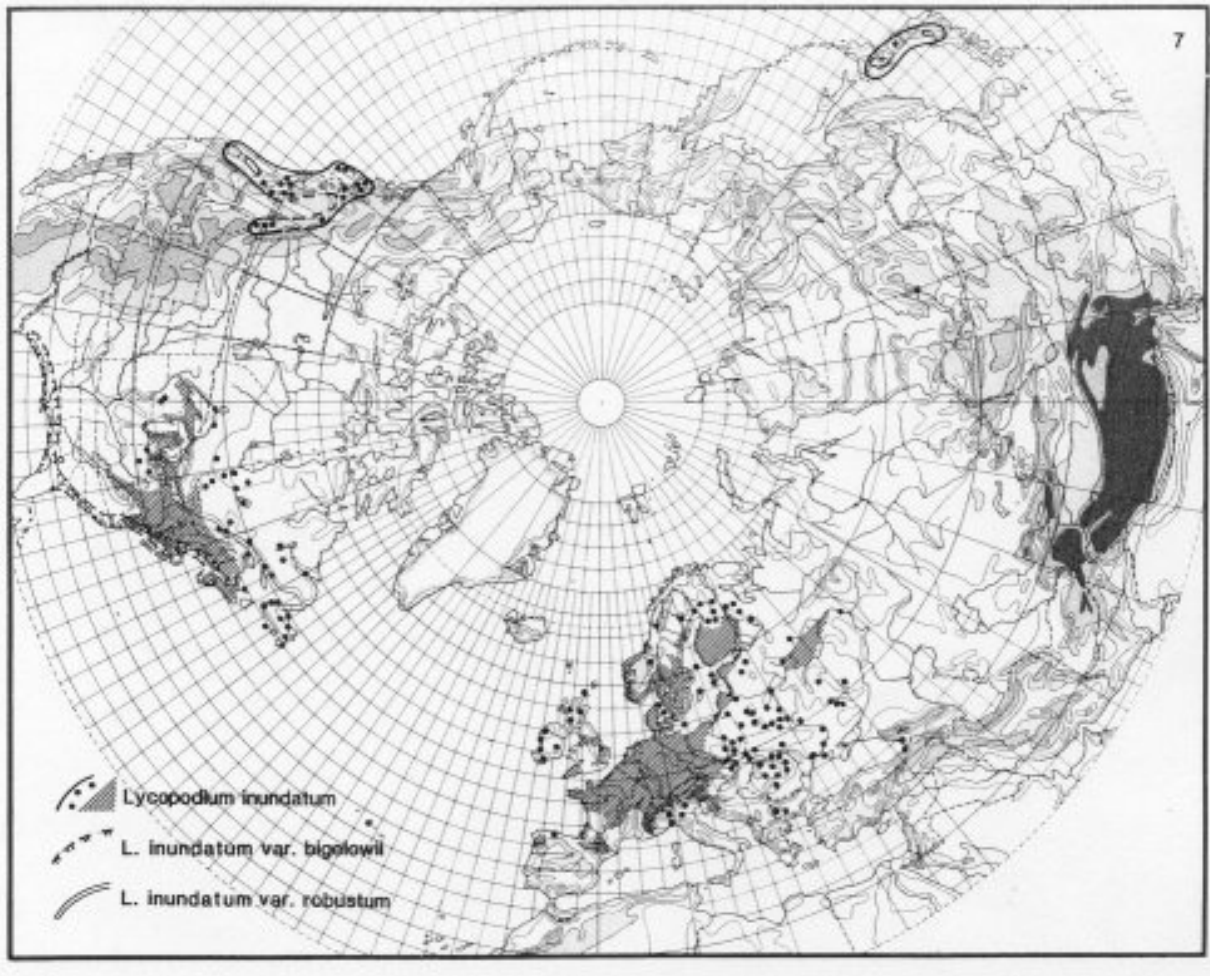


Fig. 3 The World Distribution of *Lycopodiella inundata* in 1986 (Hulten and Fries, 1986)

2.2. EUROPE

Lycopodiella inundata occurs through most of Europe, except the Mediterranean region and much of Western Russia. Figure 4 illustrates the distribution of the species in Europe, whilst Table 1 lists the countries in which the species has been recorded, with an indication of the current status where known.

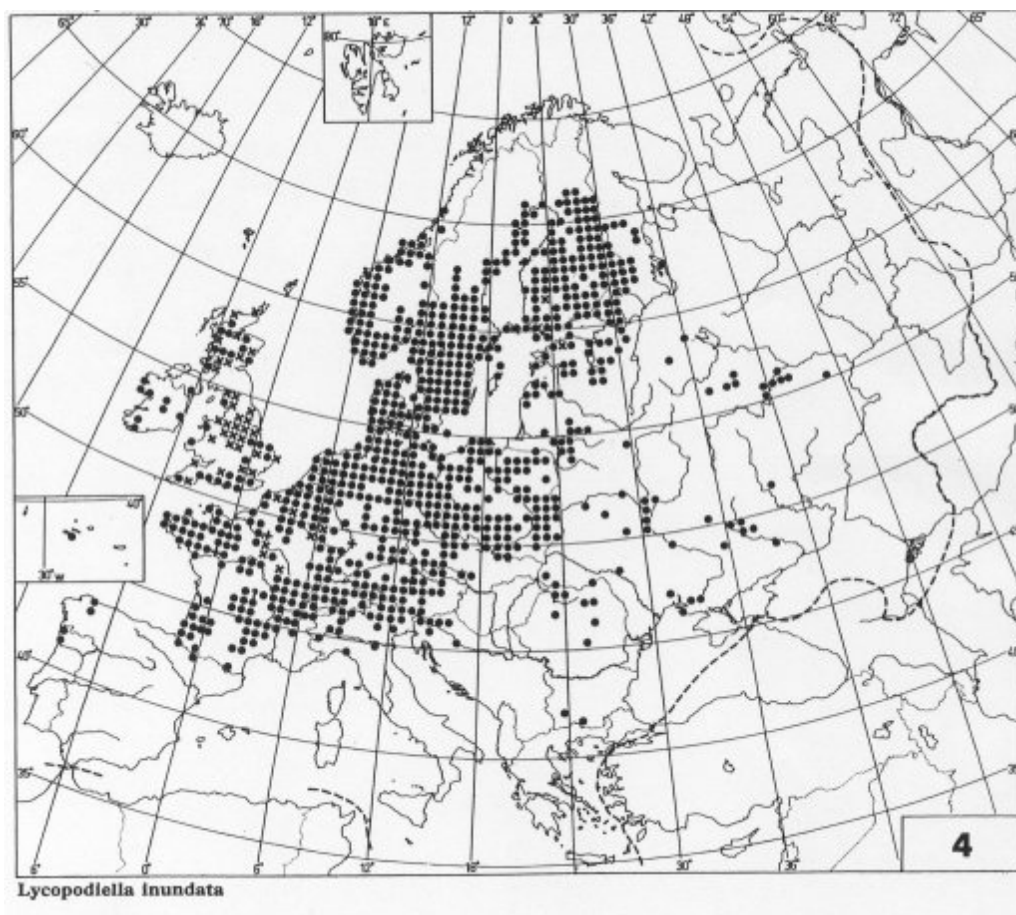


Fig. 4 Former distribution of *Lycopodiella inundata* in Europe (Jalas, J. & Suominen, J, 1972)

Table 1 - Country by country status of *Lycopodiella inundata* across Europe (*Country codes are taken from Flora Europaea as of 1964 with red data book listings where available [Definitions of the red list categories].)

COUNTRY *	IUCN LISTING	STATUS NOTES	SOURCE(S)
[Au]			
[Az]			
BRITAIN [Br]	Not listed	Regarded as Nationally Scarce in Britain (occurring in 100 or fewer 10-km sqs of the national grid). The species has declined catastrophically across much of its range, and today is largely confined to a few strongholds. Of the total of 220 10-km squares for which the species has been recorded, it has only been seen in 53 since 1987, representing a loss from 76% of its former range.	Lockton (2000)

COUNTRY *	IUCN LISTING	STATUS NOTES	SOURCE(S)
[Bu]			
[Cz]	CR [Slovak Republic], EN [Czech Republic]	Scattered in sites in north and south Czech Republic; extremely rare in Slovak Republic, largely confined to extreme north, with isolated populations in the extreme east.	Čeřovský <i>et al.</i> (1999)
DENMARK [Da]	NT		Ingelög <i>et al.</i> (1993)
FINLAND [Fe]	Not listed	[Listed as R in the Åland region of Finland; in Ingelög <i>et al.</i> (1993)]	Ingelög <i>et al.</i> (1993); Kotiranta <i>et al.</i> (1998);
FRANCE [Ga]	R	Olivier <i>et al.</i> (1995) indicate that the species is widely scattered through France but is declining across all of its range. They map the species as formerly occurring in 96 of the 281 grid squares used for recording the French flora, but it has only been seen in 42 of these since 1970, represent a decline of approximately 56% since 1970.	Olivier <i>et al.</i> (1995)
[Ge]			
[Hb]			
[He]			
[Ho]			
[Hs]			
ITALY [It]	VU		Conti <i>et al.</i> (1997)
YUGOSLAVIA [Ju]			
[Lu]			
[No]			
POLAND [Po]	Not listed (in Kaźmierczakowa & Zarzycki, 2001); V (in Ingelög <i>et al.</i> , 1993)		Ingelög <i>et al.</i> (1993); Kaźmierczakowa & Zarzycki (2001)
Rm			
Rs(N)			
Rs(B)	E [Lithuania], V [Estonia], V [Latvia]	"The localities of <i>Lepidotis inundata</i> are scattered sparsely and confined to moody depressions of transition and mire bogs. A drainage and peat industry, regulation of water level in lakes might be harmful" – Lazdauskaitė in Lithuanian Red Data Book.	Environmental Protection Department of the Republic of Lithuania (1992); Ingelög <i>et al.</i> (1993)
Rs(C)			

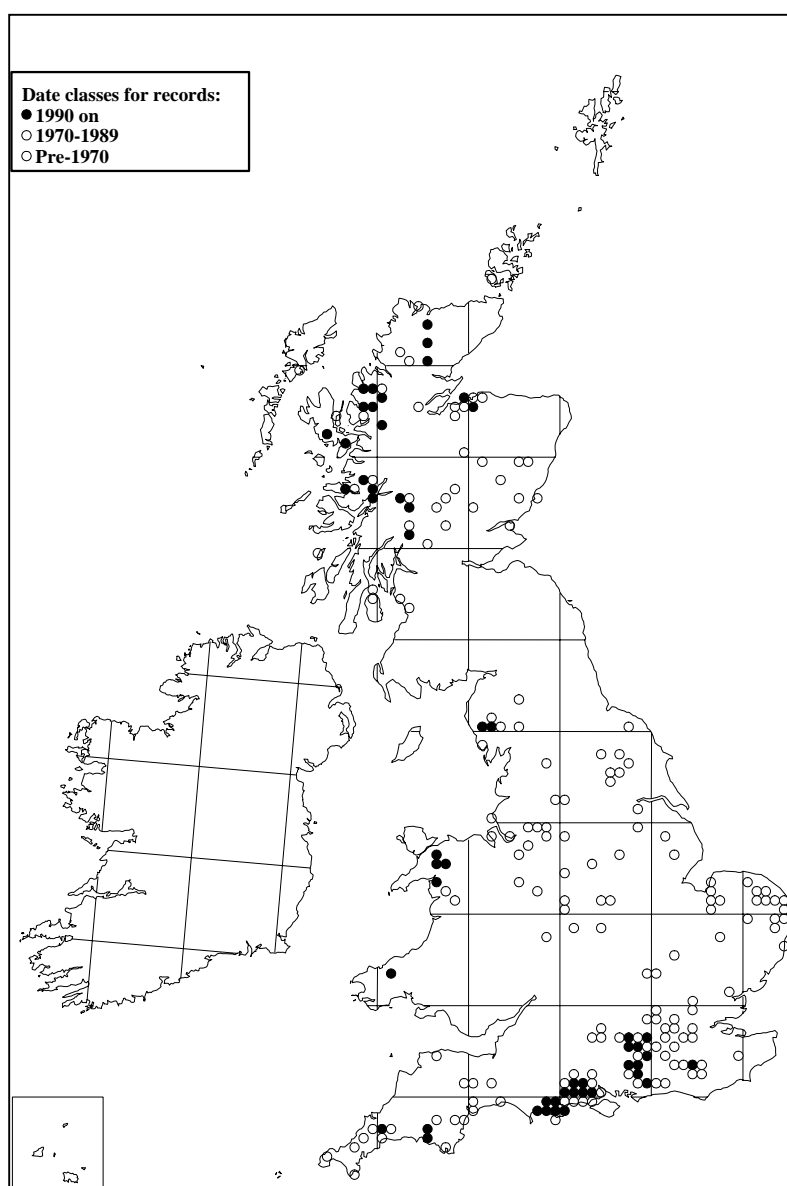
COUNTRY*	IUCN LISTING	STATUS NOTES	SOURCE(S)
Rs(W)			
Rs(E)			
SWEDEN [Su]	NT		Gårdenfors (2000)
TURKEY	Not listed, but severely threatened	At two sites on blanket peat, at c. 2000m, on Eastern Black Sea Mountains of NE Turkey, here at southern edge of range in Europe. Threatened by peat cutting at one site.	Byfield (1995)

2.3. UNITED KINGDOM

Overview

Marsh clubmoss was formerly widespread through much of Britain where acid soils outcrop, but has undergone a massive decline through much of the twentieth century. Lockton (2000) records the plant as historically occurring in 220 10-km squares but post 1987 records are only present in 53 of these squares, representing an area of occupancy of just 24% of its total historic extent. Accordingly the species is regarded as Nationally Scarce in Britain. Figure 6 shows the past and current distribution of the species in Britain. However, it has disappeared from many areas, particularly across central and eastern England and eastern Scotland.

Figure 5 – A map of the European distribution of *Lycopodiella inundata*



2.3.1 ENGLAND

(Based on English Nature's [Natural Areas](#))

Lycopodiella inundata has declined – and is continuing to decline - catastrophically across England and is today largely confined to two strongholds in Hampshire and Dorset. Formerly it was recorded from 40 vice-counties, but is found in only 11 today. Figure 7 paints a sorry picture of a steady loss of the species from counties across England, with the earliest declines from the Midlands and parts of northern England - where the species was often restricted to just one or a handful of sites per county – so that by 1950 the species was largely confined to a few strongholds. The decline has continued to the present day: the species was finally lost from East Anglia in 1978 (despite conservation efforts) and has gradually contracted southwards within the Thames Basin heaths, disappearing from Buckinghamshire and Berkshire in 1950 and 1975 respectively. Furthermore, it seems inevitable that the species will become extinct in additional counties (notably in West and East Sussex) without urgent conservation action.

The **New Forest** (Hampshire) today represents the UK stronghold (and indeed one of the European strongholds) for *L. inundata*, with substantial and widely scattered populations through much of the southern and central parts of this extensive heathland ecosystem.

In the Dorset Heaths of the **Poole Basin** (42 sites post-1980), the plant remains widespread, though often as rather limited populations, and here the conservation programme to link sites and restore traditional grazing will hopefully benefit this species to a great extent.

The heaths of the **Thames Basin** (Hampshire / Surrey) and the **Western Weald** (Hampshire / Surrey) remains the only other area in the UK where there is a relatively high concentration of populations (17 sites post-1980, many on Ministry of Defence training areas), but many of these colonies are both small and the species is declining in this area: the species is in need of urgent conservation action here.

Elsewhere in England *L. inundata* is both rare, often occurring in highly isolated colonies, and also remains in major decline. *Lycopodiella inundata* survives at Retire Common on the northern edge of **Hensbarrow** (the area associated with the china clay deposits of central Cornwall); two sites associated with the china clay pits of the south-western skirt of **Dartmoor** (Devon); two post-1980 colonies in the northern and western parts of the Cumbrian High Fells, and an outlier on **Wan Fell**, part of the Permian Sandstone ridge bisecting the Eden Valley immediately to the north-east of the Cumbrian Fells.

Table 2 - Present & former distribution of *Lycopodiella inundata* in England by vice-county (after Lockton 2000; Stewart et al. 2000)

V-C No.	Vice-county	Total Number of extant sites (Post 1990) / extinct sites	% Decline	Date & Place(s) of last record
11	SOUTH HAMPSHIRE			2001 Kingston Common
9	DORSET			2006 Ringwood Forest
12	NORTH HAMPSHIRE			2005 Aldershot Common

V-C No.	Vice-county	Total Number of extant sites (Post 1990) / extinct sites	% Decline	Date & Place(s) of last record
13	WEST SUSSEX	3 / 10	70%	2001 Stedham Common
17	SURREY	c. 3 / 30	90%	2000 Several sites
3	SOUTH DEVON	2 / 12	83%	2000 (Smallhanger Waste; and Cadover Bridge)
2	EAST CORNWALL	1 / 6	83%	1999 (Retire Common)
8	SOUTH WILTSHIRE	1 / 3	67%	2002 (Plaitford Common)
14	EAST SUSSEX	1 / 7	86%	1994 (Chelwood & Isle of Thorns)
69	WESTMORLAND & NORTH LANCASHIRE	1 / 10	90%	1992 (Fell Foot)
70	CUMBERLAND	1 / 9	89%	2004 (Wast Water)
25†	EAST SUFFOLK	0 / 4	100%	1978 (Westleton Heath)
22†	BERKSHIRE	c. 0 / 13	100%	1975 (Swinley Brick Pits)
27†	EAST NORFOLK	c. 1 / 16	96%	1999 Buxton Heath
28†	WEST NORFOLK	c. 0 / 7	100%	1962 (Ling Common & North Wootton)
54†	NORTH LINCOLNSHIRE	c. 0 / 6	100%	1954 (Woodhall Spa)
24†	BUCKINGHAMSHIRE	0 / 5	100%	1950 (New Wavendon Heath)
4†	NORTH DEVON	0 / 2	100%	1937 (Tiverton)
16†	WEST KENT	0 / 4	100%	1930 (Keston Common)
37†	WORCESTERSHIRE	0 / 1	100%	1929 (Hartlebury Common)
62†	NORTH-EAST YORKSHIRE	c. 0 / 10	100%	1923 (near York)
38†	WARWICKSHIRE	0 / 2	100%	1922 (Wolvey Heath)
1†	WEST CORNWALL	0 / 4	100%	1909; at Silverwell Moor; and Newlyn East
29†	CAMBRIDGESHIRE	0 / 2	100%	1892 (Beeston Bog)
55†	LEICESTERSHIRE & RUTLAND	c. 0 / 3	100%	1889 (Blackbrook Reservoir)
15†	EAST KENT	0 / 1	100%	1884 (Hothfield Common)
64†	MID-WEST YORKSHIRE	0 / 2	100%	1876 (Askham Bogs)
19†	NORTH ESSEX	0 / 3	100%	1874 (Kelvedon)
58†	CHESHIRE	c. 0 / 12	100%	1872 (Oxton Heath)
59†	SOUTH LANCASHIRE	0 / 3	100%	1872 (Formby Dunes)
21†	MIDDLESEX	0 / 3	100%	1869 (Harefield Common)
26†	WEST SUFFOLK	0 / 1	100%	1867 (Tuddenham)
57†	DERBYSHIRE	0 / 2	100%	1864 (Tansley Common)
18†	SOUTH ESSEX	0 / 1	100%	1862 (near Epping)
5†	SOUTH SOMERSET	0 / 1	100%	1850 (Staple Fitzpaine)
40†	SHROPSHIRE	0 / 1	100%	1849 (Brown Moss)

V-C No.	Vice-county	Total Number of extant sites (Post 1990) / extinct sites	% Decline	Date & Place(s) of last record
39†	STAFFORDSHIRE	0 / 5	100%	1844 (Offleyhay)
63†	SOUTH-WEST YORKSHIRE	0 / 3	100%	1840 (Halifax)
56†	NOTTINGHAMSHIRE	0 / 1	100%	1839 (Rainworth Water)
30†	BEDFORDSHIRE	0 / 1	100%	1798 (Amphill)

[NOTE: *Lycopodiella inundata* still extant in vice-counties highlighted in bold; in vice-counties where the species is thought to be extinct are highlighted by the symbol '†']

2.3.2 NORTHERN IRELAND

Lycopodiella inundata is restricted to a single site (Peatlands Park, Co Armagh) in Northern Ireland where it was first found in 1964.

2.3.3 SCOTLAND

The *New Atlas of the British & Irish Flora* (Preston *et al.*, 2002) shows a decline in the range of *Lycopodiella inundata* across Scotland from east to west. The trend reflects a clear retraction of *L. inundata* from eastern Scotland where drainage and a lack of grazing in the past has effectively destroyed suitable habitats. However work by Phil Lusby (Lusby, 1999) has significantly increased the number of recorded sites in the Highlands, where it is likely that *L. inundata* has been under recorded. While the range of *L. inundata* has retracted therefore, the number of sites may not have done.

Today, it is most commonly associated with loch edges, in the highlands and islands, in populations ranging from a few plants within 1m² to discontinuous bands stretching for several hundred metres along loch shores. Large populations have been recorded at Loch Sgeireach, West Sutherland and Dubh Lochan, Rannoch Moor. The species' particular combination of habitat requirements (suitable topography, shelter and substrate) is itself scattered and relatively scarce in Scotland and this accounts for the species' scarcity.

Given that *L. inundata* has probably been under recorded in Scotland in the past, it is difficult to identify a current trend. It occupies a relatively stable habitat in the Highlands, where the only threats come from rapid changes in water levels through management. Where water levels gradually change over gently sloping loch sides, any long-term change in mean water level may result in displacements of the population rather than local extinction.

2.3.4 WALES

In Wales, *L. inundata* is a species of wet, bare, peaty or sandy margins of lakes, pools, flushes and trackways, and has always been relatively rare in the country. In total, 16 localities have been recorded for the plant, of which 6 have been seen since 1987. The species has grown in two principal regions of Wales: its stronghold lies in the headwaters of tributaries of the Afon Conwy (Caernarfonshire) draining the eastern flanks of the Snowdonia massif, and it remains most abundant in this area today. It has also been recorded from wetlands in the foothills of mountains to the south of Snowdonia – it survives at one site here, at Llyn Cwm Bychan (on the western flanks of the Rhinog range). The species' second stronghold is on the sheep-grazed moorland on the northern flanks of the

Mynydd Preseli (Preseli Mountains) centred on Brynberian Moor, where the species survives (table 3).

Table 3 - Present & former distribution of *Lycopodiella inundata* in Wales by county

V-C No.	Vice-county	Total Number of extant sites (Post 1987) / extinct sites	% Decline	Date & Place(s) of last record
45	Pembrokeshire	1 / 7	86%	1997 (Brynberian Moor)
48	Merioneth	1 / 3	67%	1999 (Llyn Cwm Bychan)
49	Caernarfonshire	4 / 6	33%	2005 (Llyn Cwmffynnon)

3. Ecology & Life Cycle

Lycopodiella inundata is a small, bright green homosporous creeping herbaceous member of the Lycopodiaceae. The vegetative stems are prostrate and creeping, rooting along their full length and therefore clinging tightly and closely to the substrate. The strobili (spore-bearing bodies) are borne on vertical stems, and are typically less than 8 cm in height (often considerably less); with individual strobili reaching 10 cm under exceptional circumstances (see figures 1 and 2). The strobili appear in June and July and are green at inception, becoming progressively yellowish in colour as they mature in October and November. Spores are produced in abundance, and primarily dispersed by wind (Crane 2002), though Headley (1994) reports that they may be distributed by water within intact sporangia if the plant becomes submerged.

As with other ferns, the life cycle of all clubmosses is formed of two principal stages: the insignificant, short-lived gametophyte, derived directly from the spore and whose fertilised female sex organs give rise to the long-lived sporophyte phase. The latter life-form is the spore-producing plant, as typically seen in the wild. Most clubmosses have saprophytic gametophytes that grow several centimetres underground and can take ten years or more to mature (e.g. Bruce 1972). However, in the genus *Lycopodiella*, the gametophyte stage is green, photosynthetic and has a much shorter life. Relatively little is known about the gametophyte of *L. inundata*: no published papers exist that record the presence of *L. inundata* gametophytes in Britain, although Stewart & FitzGerald (2000) reported the existence of "sporelings" at Chobham Common (Surrey). Bruce (1972) reports the first record of gametophytes in the field, from North America, where he discovered great variation in the size of gametophytes, some being large and bearing up to 5 young sporophytes, whilst others were smaller and lacked sex organs. The gametophyte of *L. inundata* consists of an inconspicuous upright cylinder, about 3 mm in diameter, and partially imbedded in the soil with the exposed portion being slightly more expanded. The distal expansion is covered with lobes several cells thick and the sex organs are situated at the base of these lobes. Literature about other species from North America highlights the crucial role played by the presence of endophytic fungi that seem to be important both in the germination of the spore and in the continued growth of the gametophyte. They apparently enter the plant early on in development, occupying a specific part of the gametophyte in the basal portion. For example, Koster (1941), describing *L. alopecuroides*, noted that in older gametophytes the actively growing green portions were often embedded in older yellowed portions with abundant fungal hyphae. Conversely, De Bary (1858) was unable to grow *L. inundatum* in vitro beyond a few cells without associated fungi.

In some simple experiments, Koster (1941) grew gametophytes of *L. alopecuroides* and *L. caroliniana* from spores on soil from one of his sites and these developed to a good size within one to three months, indicating that the whole life cycle of the gametophytes is completed within a few months. In the wild, he found gametophytes throughout the year but most frequent in the autumn but also he found no gametophytes in one year. This he attributes to the conditions being unsuitable for the associated fungus. Bruce (1972) found healthy green gametophytes of *L. inundata* below several centimetres of ice in April, indicating that it can happily survive the winter.

Lycopodiella inundata usually forms patches and it is thought that these are the result of vegetative spread from a single germination or the establishment of a vegetative fragment. As the plant grows at the tips, the older parts die off so that branches become separate individuals. This branching also results in the patches remaining largely contiguous rather than a "fairy-ring" pattern, providing competition from other plants remain low. Headley (1994) indicates that stems remain green for two years before senescing. This certainly seemed to be the case at Smallhanger Waste, Devon when visited by NFS in January 2001. Here the plants typically had a section that was moribund and another section of equal length that was still green although more yellowish than in the summer. The change was frequently marked by the position of the cones (also moribund) which presumably therefore form at the tips of the previous year's growth. However, casual observations by various observers (e.g. G. Groome, M. Larther, pers. comm.) suggest that die back almost to the tip can occur during the winter. The reasons for winter die-back are unknown, though waterlogging and frost have been suggested. However the connection with cone production could indicate that it is purely physiological.

The horizontal, sterile stems of *L. inundata* typically grow about 3 cm per annum. Headley (1994) indicates that growth of up to 10 cm per year is possible but general observations suggest that rates over 6 cm per year are exceptional. At this growth rate, a 'patch' 30-50 cm diameter is likely to be 5-10 years old. This is a frequent size for well-defined patches, but much larger patches occur and it seems probable that some of these are at least twenty years old.

The indications from American studies is that *L. inundata* can probably grow quite quickly by **sexual reproduction from spores** under suitable conditions, an assertion supported by the appearance of sporelings in scraped patches at Chobham Common. The spores are also light and most probably easily dispersed at least over several metres. However, the patchy nature of this species – even where apparently suitable habitat exists close by - may either reflect a poor ability to disperse (instead largely relying on vegetative spread) or the exacting requirements for gametophyte establishment. Further understanding of the germination process may therefore depend on a better understanding of the ecology of associated fungi.

Vegetative reproduction by fragmentation has also been suggested as a means of colonisation and may be one reason for its association with paths and tracks. The less exacting conditions required for this form of increase may make this a more important method of reproduction than spore germination. Studies at Lille University have successfully propagated plants from shoot apices as well as from somatic embryogenesis from callous tissue.

At Thursley Common (Surrey), isolated plants that have survived a year or two have occasionally been found some distance from the main core population (M. Larther, pers. comm.). These have been on pathways and it seems most probable that either fragments or spores were brought on the feet of humans or animals. However, continued and heavy disturbance on the pathways was probably also the reason for the plants failing to survive.

No information has been traced on the length of viability of spores. Some clubmoss species have long spore viability, but the different nature of the germination process means that it is unwise to assume that this is also the case for *L. inundata* (F. Rumsey, pers. comm.). One example of its apparent reappearance from a dormant spore bank after a long absence of records was observed at Tadnoll in Dorset, where the species regenerated after management in 1999 at a site where it was last seen in the 1930s. The site lies over a kilometre from the nearest extant sites. This, however, seems to be an exception, and should not be taken as proof of long-lived spores unless supported by further evidence. Indeed the population may have arisen through new colonisation by airborne spores there and a number of other sites exist where suitable habitat has been restored yet there is no evidence of the species reappearing from buried spore banks.

Further information on spore viability, dispersal and germination ability is needed with a fair degree of urgency.

4. Habitat Requirements

4.1. THE LANDSCAPE PERSPECTIVE

Lycopodiella inundata is typically found in three habitat types in Britain:

- Open areas in wet heathland, often associated with extensive grazing or other forms of low-level disturbance (Figure 6), particularly in lowland sites in England.
- At the edges of oligotrophic lakes where it grows in or immediately adjacent to the inundation zone, but where it is sufficiently sheltered to allow the deposition of organic silt. This lakeside habitat is most frequent in more upland situations in Scotland and Wales, but is very rare in England.
- Abandoned sand, gravel or *granitic* china clay quarries where it typically occurs at the base of slopes of spoil heaps or the quarry sides in a transition between open *xerophytic* heath and well established bog communities. Such sites typically occur within heathland districts of lowland England.



Figure 6 - *Lycopodiella inundata* on wet heath in Argyllshire (Image by Dr A.J. Silverside).

We are building up a picture of *L. inundata* as a species whose populations can normally only survive in metapopulations, i.e. where the plant is represented as a series of adjacent colonies within an extensive habitat, disappearing and appearing in any one spot over time as conditions become suitable for colonisation, yet probably in many cases decline over time. This is illustrated particularly well by comparing the heaths of Dorset with those of the New Forest in the adjacent part of Hampshire. These two adjacent areas share many similarities: both lie within the same Tertiary basin (the Hampshire Basin) and both historically were managed as extensive, unenclosed heathlands under a regime of low intensity grazing, undertaken particularly by commoners' de-pastured cattle and horses. Today this extensive grazing regime still survives largely intact in the New Forest, but in Dorset, grazing (and associated heathland uses) have declined over the past century to virtually nil by the late 1980s, whilst the combined effects of agricultural reclamation, afforestation, mineral extraction and urban spread have greatly fragmented the once-extensive and largely contiguous heathland blocks.

Byfield & Pearman (1996) documented the fate of 48 populations of *L. inundata* on the Dorset heaths precisely mapped by Professor Ronald Good in the 1930s, at the time when traditional management practices were still in operation (just), across extensive, un-fragmented heathland blocks. Of the 48 populations recorded in the 1930s, just 6 survived into the 1990s, representing an overall decline of 87.5%. Yet whilst habitat destruction is to blame for some of these losses, no fewer than 39 of the sites in which *L. inundata* had occurred in the 1930s, still supported semi-natural habitat in some form. Thus, with six of these still supporting the plant, there had still been a decline of 84.6%, even where the habitat was still present. Gross habitat destruction could thus only be blamed for the loss of the plant in one in every 6 or 7 sites: the remaining losses were attributed to lack of management at some stage in the intervening 60 years, combined with the effects of fragmentation, which made populations vulnerable to damaging external factors, leading to extinction, and meant re-colonisation of these sites was often difficult or impossible due to their isolation. By comparing the number of tetrads that the species currently occurs in on the Dorset heaths and the New Forest heaths (adjusted to take account of the differing sizes of these two areas), the species was found to be 50% more widespread in the New Forest, not taking account of the greater number of populations and population sizes within each tetrad. The relative abundance of *L. inundata* in the New Forest was attributed to the fact that the heathlands were un-fragmented and still managed through extensive grazing: in other words, in the New Forest, populations of the species can still function as part of larger metapopulations.

4.2. COMMUNITIES & VEGETATION

Despite the differences in situation and origin of open conditions, at a small scale the habitats have many features in common. The clubmoss grows where there is a thin covering of peat over a firm sandy or gravelly base in places that are often waterlogged (though usually not flooded) during the winter and spring. In Britain the species is typically lowland, with the highest population recorded at 390 m from Llyn Cwmffynon in Snowdonia (N Wales).

In the southern heathlands the plant is most abundant in the National Vegetation Classification community **M16c: *Erica tetralix*-*Sphagnum compactum* wet heath *Rhynchospora alba*-*Drosera intermedia* sub-community**, where it is often associated with *Rhynchospora alba*, *Drosera intermedia*, *Drosera rotundifolia* and *Sphagnum auriculatum*. Indeed the occurrence of colonies of *Rhynchospora alba* at the margin of valley mire systems is a very good way of 'homing' in on potential sites for *L. inundata*. In such situations it is also frequently associated with the purplish alga *Zygonium ericetorum*. Such sites are typically very open in nature, with a low cover of vascular plants and a high

cover of *Z. ericetorum*. Water levels are high enough to keep the area moist through the summer (and sodden during the winter months), although in dry seasons the cover of *Z. ericetorum* characteristically dries, cracks, and peels back, though still probably acts as a mulch helping to keep the soil moist underneath. Typically such habitats are too dry (at certain times of year) or too freely drained for the development of Sphagnetalia vegetation (i.e. *Sphagnum*-dominated mire/bog communities) and too wet for Calluno-Ulicetalia heaths (i.e. dry heaths dominated by *Calluna vulgaris* and *Ulex* spp.). However, *L. inundata* can survive in wetter facies of the community – with a higher cover of *Sphagnum compactum* reflecting the more permanently damp conditions – if heavy grazing maintains the necessary short vegetation required by *L. inundata*.

At a few southern sites, *L. inundata* extends from the **M16c** community into proper 'spongy' bog communities (**M21: *Narthecium ossifragum-Sphagnum papillosum* valley mire**). Two of us (AJB & BE) witnessed long vegetative shoots of the species extending across amorphous floating rafts of *Sphagnum auriculatum* in bog pools on Cranemoor in the New Forest in 2002. There are additional records for *L. inundata* occurring in the **M21** mire community at Fort Bog (New Forest) and in shallow flushed bog pools on Hyde Heath and Holt Heath (Dorset). Nevertheless, this habitat seems atypical.

In Scotland, Rasmussen & Lawesson (2002) report that *L. inundata* occurs around the margins of lakes, kept open by fluctuating water levels and moving ice at the shoreline. Under these conditions the plant recorded in a wider range of community types than those in southern England, with a higher number of associates. Here they identified three communities in which the species occurred:

- ***Drosera anglica-Myrica gale* community**, characterised by the presence of *Breutelia chrysocoma*, *Juncus conglomeratus*, *Pellia epiphylla*, *Pleurozia purpurea* and *Polygala serpyllifolia*. A species-rich community occurring on thin depositions of organic silt in sheltered situations around lakes. The authors equate this and the next community most closely to **M15a: *Scirpus cespitosus-Erica tetralix* wet heath**, *Carex panicea* sub-community of the NVC.
- ***Eleocharis multicaulis-Narthecium ossifragum* community**, characterised by *Eleocharis multicaulis*, *Carex viridula* ssp. *oedocarpa* and *Carex panicea*. Again occurring in the sheltered inundation zone around lakes, on slightly more neutral substrates.
- ***Hydrocotyle vulgaris-Leontodon autumnalis* community**, characterised by *Littorella inundata* and a high abundance of *Carex nigra*. Found only on the Loch Maree islands, occurring on soil several centimetres deep and inundated from winter to spring, but found about 3 metres from the shoreline and growing well above the water-level during summer.

The nationally scarce *Rhynchospora fusca* is a characteristic associate, whilst both *Deschampsia setacea* and *Hammarbya paludosa* have been recorded as associates by Headley (1994), although we suspect that the latter two species are rather infrequent associates as in our experience they typically occupy rather different communities from *L. inundata* (although *Deschampsia setacea* is reported as growing with *L. inundata* at Loch Maree).

4.3. SUMMARY OF HABITAT REQUIREMENTS

A wide range of habitat features is important to *L. inundata* across Britain, and these have been summarised in Table 4.

Table 4 - Habitat features important to *Lycopodiella inundata* in Britain

Type	Description
Physical & topographical	<p><i>Low altitude</i> extending up to 390 m in Wales</p> <p><i>Flat to gently sloping</i> sites</p> <p><i>Within or adjacent to the winter inundation zone</i> of northern lakes</p> <p>Often <i>along the seepage line at the margin of valley mires</i> in southern heathland sites</p> <p><i>Winter waterlogging</i>, or more rarely, inundation for limited periods</p> <p><i>Damp summer conditions</i>, with occasional, short periods of drought</p> <p>Typically on <i>shallow, firm peats or other thin organic deposits, over damp sands, clays and gravels</i></p> <p><i>Periodic disturbance/erosion</i> for establishment of new colonies from spore or vegetative fragments</p> <p><i>Extensive grazing</i> by cattle or horses/ponies (to maintain open conditions) ideal</p>
Vegetation/structural	<p>In wet heath at the <i>boundary of heathland and valley mire system</i> in heathland sites</p> <p><i>Open vegetation</i>, often with cover of vascular plants of <50%</p> <p>Low vegetation, typically less than 15 cm tall</p>
Chemical	<p><i>Acidic site</i> with low to very low levels of plant nutrients. pH values as low as 4.37 and 5.81 (mean 4.88) have been recorded at Chobham Common (Jane Gunn, pers. comm.)</p>

Moisture plays a critical role in the survival of *Lycopodiella inundata*. The specific epithet 'inundata' implies that this species requires inundation and Headley (1994) notes that "these areas are normally submerged under water in winter and spring". However our observations in southern England (for example during the extremely wet autumn of 2000) suggest that whilst the species may grow in areas sodden in winter, by-and-large the species does not occur in seasonally-flooded situations. As ever, there are exceptions to the rule: populations may be submerged for short periods of time (a matter of days) after very heavy rain; and at a few sites in the New Forest (Hampshire) and the Poole Basin heaths (Dorset), the species 'strays' from its typical wet heath communities into **M21: *Narthecium ossifragum-Sphagnum papillosum* valley mire** in one instance forming elongated horizontal stems floating on sopping *Sphagnum* across bog pools. Ultimately we suspect that moisture plays the following role in the survival of the species: under permanently waterlogged conditions *Sphagnetalia* bog communities (typically dominated by *Sphagnum* species) develop, and *L. inundata* is apparently out-competed. Conversely, whilst *L. inundata* can withstand short periods of drought, protracted drying-out leads to its death. Hence the species favours the intermediate moisture levels typically found at the wet heath-bog interface, often where a degree of seepage occurs on the slopes along the margins of valley mire systems.

The situation around lakes in the more upland regions of Scotland and Wales requires more discussion. Under such conditions *L. inundata* is described as occurring in the inundation zone at the margin of the lake. However, observations in summer 2002 at Llyn Cwmffynnon (in Snowdonia, and at 390 m the highest British locality) indicated that the fine populations of the plant at this locality did not occur in the inundation zone, but in *Rhyncosporion* communities over firm peat immediately adjacent to the inundation zone. It seemed most unlikely that this zone was regularly flooded, if at all. However, strangely whilst these

peatland communities extended some distance away from the lake, *L. inundata* was restricted to a zone just a few metres from the lake shoreline. One possible explanation – albeit wholly unsubstantiated – is that the plant is intimately associated to habitat close to the lake's edge for climatic reasons (possibly relating to winter cold). However at least one worker (Alistair Headley) suggests that this is not the case. The situation merits further investigation.

It is quite clear that **disturbance and erosion** play an important role, in terms of providing suitable niches into which *L. inundata* can colonise by spore. This is perhaps most graphically illustrated by the occurrence of former or current substantial populations of the species in damp abandoned gravel and clay pits, at places such as:

- China clay pits at Smallhanger Waste (SX5759) and Cadover Bridge (SX552652) on the south-western margin of Dartmoor (Devon)
- Stokeford Heath (Dorset), the largest colony in Dorset
- Holmsley gravel pit (SU217011) in the New Forest (Hampshire)
- Disused gravel/sand pits, re-graded and restored for forestry at Bramshill Plantation (Hampshire)

Suitable niches for establishment and spread have also been provided following heavy military vehicle use (Aldershot training area in North Hampshire), by forestry track grading machinery (Dorset), and on heavily eroded footpaths/tracks across heaths (created by heavy walker/horse riding pressures, as seen in the New Forest). Typically colonisation occurs on the bare ground once these pressures are removed or relaxed: thus, a typical habitat for *L. inundata* in the New Forest is to be seen where path restoration work results in the closure of eroded and braided footpaths/bridleways at the point where the paths cross the seepage line descending into the numerous valley mires. Under such conditions the damp, exposed sands become colonised over time by plants such as the alga *Zygonium ericetorum*, together with *Drosera intermedia*, *D. rotundifolia* and in time *Rhynchospora alba*, and *L. inundata*.

It should be stressed that whilst such gross acts of disturbance provide niches valued for colonisation by *L. inundata*, such activities can equally destroy existing colonies. Thus heavy vehicle movement has certainly caused the loss of some colonies in northern Hampshire (C. Hall, pers. comm.). Here, the practice of restricting vehicle movement to well-defined routes on Ministry of Defence land - introduced in recent years for other nature conservation reasons - may therefore be less advantageous for marsh clubmoss, by both repeatedly eroding ground and not allowing a window of opportunity for colonisation. Short term use followed by abandonment would probably be better for this species.

In trying to understand the management requirements of *Lycopodiella inundata*, it is worth thinking of the species as a relatively slow and low growing perennial attempting to behave as a pioneer in open and often disturbed habitats, more normally occupied by fast growing, rapidly spreading, and often annual, pioneer species. Thus, whilst *L. inundata* needs to grow in open vegetation (often 30-60% bare ground), both to establish and grow, it cannot re-colonise disturbed ground on an annual basis, like more typical ephemeral pioneers. In short, it is a relatively slow growing perennial that requires short and open vegetation at all times, yet still requires a fair degree of stability in the habitat. Contrast this with many other ephemerals of open heathland habitats - *Ranunculus tripartitus* (Three-lobed water crowfoot), *Illecebrum verticillatum* (Coral-necklace), *Anagallis minima* (Chaffweed), *Cicendia filiformis* (Yellow Centaury), *Radiola linoides* (Allseed) spring to mind – which can

rapidly colonise freshly disturbed ground, flower and seed within a few months, and survive as dormant, buried seed as the habitat becomes more densely vegetated, from the growth of coarser growing, perennial species. Little wonder that *L. inundata* is so rare across much of Britain.

To maintain populations the species requires protracted periods of stability, best provided on habitats subject to long periods of uninterrupted traditional management. The traditional **extensive grazing** of heathland by de-pastured stock provides this stability perhaps better than any other form of management, and this should form the ideal management of extant populations of *L. inundata*. Certainly the most extensive and largest populations of the species in England today occur in the New Forest of south Hampshire where the 'commoning' tradition remains largely intact, and involving the de-pasturing of ponies and cattle across the extensive unenclosed heathlands of the Forest. Such traditional systems would have historically been present on most if not all of the historic sites for *L. inundata* (in England at least) but have died out over time.

The '[Tomorrow's Heathland Heritage](#)' initiative means that heathland restoration is in progress (both in terms of clearance of overgrown sites and reinstatement of grazing) at a fair number of sites throughout its southern English range. This could provide an excellent opportunity for the *L. inundata* to regain some of the ground it has lost, particularly while restoration is in progress and providing significant areas of bare ground.

Whilst we believe that grazing offers the most secure means of achieving long-term stability within the short wet heathland communities favoured by *L. inundata*, many populations of this species have survived for considerable periods without such management, particularly in counties such as Dorset and Surrey. Discussion with land managers in Surrey identified a number of examples of relatively long-term survival in unmanaged/undisturbed sites:

- At **Hagthorn Bog** on Pirbright Ranges there has been no access, even for army personnel, for about 15 years due to worries about unexploded ordnance. The only possible management factor during this period has been fire but this has not affected the area where *L. inundata* occurs (R. Hutchings, pers. comm.).
- **Folly Bog** on Pirbright Ranges has been monitored regularly and in detail by Giles Groome. Here the *L. inundata* occurs within an area which is much more open than both the bog and the dryer heathland but there has been no physical disturbance for at least ten years and probably much longer. A pipeline was laid close to the colony in the 1970s and it might be that some disturbance occurred then, but unfortunately there is now no information to confirm this.

It seems clear that the niche in which *L. inundata* occurs reflects both the highly acidic nature of the sites, and the fact that such areas whilst waterlogged in winter can largely dry out in summer. It may be that some of the populations in sites that have apparently not been managed in recent years may actually represent relict populations arising from major disturbances by army exercises in the Second World War followed by lack of grazing and neglect. Accordingly we should stress that we believe that the apparent stability of the southern heathland communities is only relative, and in time they become overgrown. There are far too many examples of unmanaged sites deteriorating over time, with the eventual extinction of *L. inundata* from the site. In short, whilst doing nothing may be an acceptable management decision in the short term, mechanical management and/or grazing really must be introduced in the longer term.

In addition, trampling may play a significant role in the survival of the species. *Lycopodiella inundata* is frequently associated with paths and trackways, probably reflecting a number of

benefits that trampling generates. These include the effect that trampling has in keeping the vegetation open (and slowing succession), as well as the role that moving humans and stock may have in spreading vegetative propagules of the plant. In addition, trampling may lead to soil compaction (itself leading to waterlogging) and may indeed help the plant survive severe fires, as these have often been seen to jump tracks without greatly affecting the short and broken vegetation of the trackway itself.

Fire has been attributed as the cause of loss of some colonies, but there are other reports of occasions where it has provided benefit by opening up the vegetation. The evidence is limited to casual observations and it would be useful to have more objective measurements, particularly as fire could be a useful management tool in sites where grazing is not possible. The evidence suggests that timing and the nature of the fires is critical; those that skim rapidly over an area seem generally to be good for the clubmoss, which is often protected by the dampness of the ground. However, where the fire burns into the peat the clubmoss is killed off. In general, therefore, it seems that fires should be avoided when the ground is dry and when there is a substantial build up of dead material. This can be a problem on sites with high public usage and consequently a risk of summer fires (e.g. from cigarette ends). If fires are to be used as a deliberate tool they should probably be done in the winter or early spring when the ground is wet and it may be that regular fires to prevent the build up of vegetation are better than ones at long intervals.

5. Management Implications

Active management is required in the long term to maintain suitable habitat for *L. inundata*, particularly in its heathland sites in England. The following management suggestions are suggested:

- Use **moderate grazing regimes with cattle, horses or ponies** to produce poached and short vegetation at that edge of valley mires and along lake margins.
- **Periodic disturbance** to areas immediately adjacent to existing *L. inundata* colonies will permit the establishment of new plants from spores, and allow the spread of existing plants by vegetative means. Land managers should experiment with sporadic disturbance and erosion followed by periods of stability to permit the establishment of new colonies of *L. inundata*. Such activities carried out adjacent to existing colonies may provide suitable territory for the plant to spread vegetatively, but care should be taken not to grossly disturb existing populations. It is likely that the more severe such disturbance is, the longer it takes for pioneer wet heath communities to establish, and for *L. inundata* to spread into such habitats. Disturbance could perhaps best be achieved by use of heavy vehicles or machinery, mimicking the horse and cart traffic across heathland when it was more actively used.
- It seems clear that the traditional practice of **turf cutting** was beneficial to *L. inundata*. Turf cutting in southern heathland districts typically comprised the removal of the top few centimetres of peat and roots from wet heath areas, typically dominated by species such as Cross-leaved Heath (*Erica tetralix*) and Purple Moor-grass (*Molinia caerulea*). At Chobham Common (Surrey) success has been achieved on a small scale, by skimming off the surface of the peat in patches of about 25 cm in diameter immediately adjacent to extant clubmoss patches. This creates bare ground for colonisation, and reduces the cover of the mat-forming alga *Zyggonium ericetorum*, and other plants. The Chobham experience suggests that the skimming operations need to be very shallow to be successful, and sporeling clubmoss plants have appeared within a few months in many of these scrapes. This work commenced in c. 1995. (A. Wragg, pers. comm.).

- **Annual mowing** of wet heath vegetation with removal of clippings has been suggested as a possible means of management, but we do not know of any places where such management is undertaken.
- **Low intensity, winter fire** may prove to be a useful tool for the management of the species, opening the vegetation, removing the litter layer, and under grazing regimes, encouraging an early season graze of the wet heath habitats favoured by this species. However, we advise caution here, as anecdotal evidence suggests that intense summer fires have caused the loss of colonies of *L. inundata*, as at Winfrith Heath (Dorset) after the intense summer fire of 1976.

6. Threats/ Factors leading to loss or decline or limiting recovery

Lycopodiella inundata has proved particularly vulnerable to a range of threats, including gross destruction that has resulted in the loss of habitat altogether, as well as successional changes to the habitat resulting principally from the cessation of grazing. Table 5 provides a summary of the factors leading to the decline and extinction of *L. inundata* at sites in Britain.

Table 5 - threats to the survival of *Lycopodiella inundata* in the UK.

Type	Threat
Habitat destruction	Agricultural reclamation Afforestation Drainage Industrial/urban development Mineral extraction Conversion of lakes into water storage reservoirs
Successional	Loss of grazing Cessation of turf cutting

In Dorset, Byfield & Pearman (1996) studied the fate of 48 populations of *L. inundata* recorded (and precisely mapped) by Professor Ronald Good in the 1930s. Just six populations had survived out of the original 48 representing a decline of 87%. Table 10 identifies the fate of the lost colonies. Just 14 of the 42 extinct populations – one in every three colonies – was lost through gross habitat destruction, including (in order of significance) agriculture, drainage, afforestation and industrial development. In the remaining two-thirds of the sites where the plant had disappeared, succession had played an important role in the loss of the plant: put simply, the conditions have grossly changed (for example to dense birch woodland or to thick and matted Moorgrass/gorse dominated vegetation) and were clearly currently unsuitable for the plant. Interestingly at 18 (42%) of the lost sites there had apparently been little major change to the vegetation: however none of these sites were under a current management regime other than burning and we suspect that subtle vegetational changes – resulting from lack of management and taking place over decades – is the principal reason for the loss of the species from these sites. We should add that of the six extant populations recorded both by Good in the 1930s and Byfield & Pearman in the 1990s, two of these were associated with areas either mown or along the margins of lightly-used footpaths, although the remaining four again received no management. All populations were small and vulnerable.

Table 6 - The fate of 42 'lost' populations of *Lycopodiella inundata* in Dorset

Factor	Number of Sites Affected	Percentage of Total
No change	18	42
Succession	10	23
Agriculture	7	16
Drainage	4	9
Forestry	2	4
Industrial development	1	2

7. Current Conservation Measures

7.1. IN-SITU MEASURES

- **Formal protection**

Table 11 gives an indication of the number of extant sites for *L. inundata* receiving protection as Sites of [Special Scientific Interest \(SSSIs\)](#). It is clear that the vast majority of extant sites for the species in England and Wales are formally notified, though coverage in Scotland is much more patchy. It is also important to note that many sites are further protected through designation as [Special Areas of Conservation \(SACs\)](#) as part of the European Union's Natura 2000 network, or as nature reserves.

Table 7 - Degree of protection afforded to extant *Lycopodiella inundata* populations, by country

Country	Total number of sites	Number protected	% protection
ENGLAND*	61	57	93
NORTHERN IRELAND**	1	1	100
SCOTLAND***	106	58	61
WALES	6	5	83

*Stewart & Fitzgerald 2001

**[UKBAP website](#)

***Based on populations not sites. This is formal protection under SSSI, NNR & SAC designations (there is at least one non-statutory protected site that is under agreement with FE) based on SNH database (2002).

Current conservation schemes;

A number of countryside conservation schemes offer assistance to land managers conserving heathland and other sites currently or formerly supporting populations of *L. inundata*. Amongst the most appropriate are:

- **Environmentally Sensitive Areas**

The ESAs scheme aims to maintain and often to enhance the scientific, landscape, historical and cultural values of key environmental areas across England. To date 22 areas have been identified as ESAs, and 10,915 agreements signed, encouraging the sympathetic management of 532,000 hectares of land. Agreements typically last for a ten year period. Few heathland areas are included within the scheme, but the following areas may be of importance to *L. inundata*: West Penwith (Cornwall), Dartmoor (Devon), Avon Valley (Hants/Wilts) and the Lake District (Cumbria). The scheme is administered by [DEFRA](#).

- **Countryside Stewardship**

The Countryside Stewardship scheme is the Government's principal scheme for the sustainable management of valued areas in the wider countryside, through the payment of grants to enhance, restore and recreate targeted landscapes and sites. It operates outside Environmentally Sensitive Areas. Through the scheme, farmers and land managers enter 10-year agreements to manage land in an environmentally sensitive manner in return for annual payments. Like the ESA programme, this scheme is administered by [DEFRA](#).

- **Tomorrow's Heathland Heritage**

A £25 million-plus, ten-year programme that seeks to restore and recreate lowland heathland in local communities around the United Kingdom. The programme includes up to 26 separate site-based heathland projects, where scrub/tree clearance, heathland recreation, and reinstatement of traditional management practices is helping to make a significant contribution to the Government's heathland biodiversity action plan. The project is led by [Natural England](#), with the support of over 140 partner organisations. The project is financially supported by the [Heritage Lottery Fund](#).

For more information about each programme access the appropriate link by clicking on the scheme title.

7.2. *EX-SITU* MEASURES

In vitro studies at Lille indicate that a blue-green alga is important in the establishment of plants when moved from culture medium to soil (N. Atmane, in litt.). Further information on this work is being sought but this may provide a connection with air pollution as a threat as discussed in Stewart *et al.* (2000).

To our knowledge, attempts to grow *L. inundata* have largely proved unsuccessful. Furthermore, over the past decades a number of cases of transplanting of the species from one site to another have been undertaken (for example by Dr Francis Rose) but whilst some of the transplants are thought to have survived for a few years, none have survived to the present day.

7.3. RESEARCH DATA

None.

7.4. MONITORING *LYCOPODIELLA INUNDATA* AND THE COMMON MONITORING STANDARD

- *Lycopodiella inundata* does not lend itself to easy monitoring, largely because its creeping, diffuse mat-forming habit makes it very difficult to determine what a single plant is. Accordingly we recommend using one of the following two means of recording the abundance of the species within an individual site:
- to count individual strobili (cones) for small populations this will clearly favour sites where strobili production is prolific.
- to measure the extent of a colony in terms of both colony size and the abundance of the plant therein: for example, frequent in a colony extending for 5 x 85 metres.

8. References

- Biodiversity Steering Group (1995). *Biodiversity: the U.K. Steering Group report*. H.M.S.O., London.
- Brewis, A., Bowman, P. & Rose, F. (1996). *The Flora of Hampshire*. Harley Books, Colchester.
- Bruce, J.G. (1972). Observations on the occurrence of the prothallia of *Lycopodium inundatum*. *American Fern Journal*, 62: 82-87.
- Byfield, A.J. & Özharan, N. (1995). *A Future for Turkey's Peatlands*. Society for the protection of Nature (DttKD), Istanbul, Turkey.
- Byfield, A.J. & Pearman, D. (1996). *Dorset's disappearing heathland flora*. Report for Plantlife and RSPB.
- Cadbury, J. (1999). *The recording of non-avian Biodiversity Species of conservation importance at RSPB nature reserves 1998*. Internal Report, RSPB, Sandy, Bedfordshire.
- Conti, F., Manzi, A. & Pedrotti, F. (1997). *Liste Rosse Regionali delle Piante d'Italia*. Associazione Italiana per il World Wildlife Fund & Società Botanica Italiana, Camerino, Italy.
- Crane, H.L. (2002). *A study investigating the genetic structure of Lycopodiella inundata (Marsh Clubmoss) using enzyme electrophoresis*. M. Res. Thesis, School of Biological Sciences University of Manchester.
- Čeřovský, J., Feráková, V., Holub, J., Maglocký, Š. & Procházka, F. (1999). *Červená kniha ohrožených a vzácných druhů rostlin a živočichů ČR a SR. Vol. 5. Vyšší rostliny*. Příroda a. s., Bartislava.
- De Bary, A. (1858). Sur la germination des Lycopodes. *Ann. Sci. Bot.*, IV, 9: 30-35.
- Environmental Protection Department of the Republic of Lithuania. (1992). *Red Data Book of Lithuania: Rare and Endangered Species of Animals, Plants and Fungi*. Vilnius, Lithuania.
- Gärdenfors, U. (2000). *Rödlistade arter i Sverige 2000 – The 2000 Red List of Swedish Species*. ArtDatabanken, SLU, Sweden.
- Gunn, J. (2000). *An assessment of the distribution of the marsh clubmoss, Lycopodiella inundata, at Chobham Common National Nature Reserve*. Unpublished thesis for School of Environmental Management, Farnborough College.
- Headley, A.D. (1994). *Lycopodiella inundata* (L.) Holub. IN: Stewart, A., Pearman, D.A. & Preston, C.D. (eds.). *Scarce Plants in Britain*. Joint Nature Conservation Committee, Peterborough.
- Hulten, E. & Fries (1986). *Atlas of north European vascular plants north of the Tropic of Cancer*. Koeltz Scientific Books, Königstein.
- Hutchinson, G. & Thomas, B.A., (1996), *Welsh Ferns*, National Museums and Galleries of Wales.
- Ingelög, T., Andersson, R. & Tjernberg, M. (1993). *Red Data Book of the Baltic Region: Part 1 – Lists of threatened vascular plants and vertebrates*. Swedish Threatened Plants Unit, Uppsala, Sweden.
- Jalas, J. and Suominen, J. (eds) 1972, 1973, 1976, 1979, 1980, 1983, 1986, 1989, 1991, 1994, 1996. *Atlas Florae Europaeae*. Vols. 1-11. The Committee for Mapping the Flora of Europe and Societas, Biologica Fennica Vanamo, Helsinki.
- Jermy, C. & Camus, J. (1993), *The illustrated field guide to ferns and allied plants of the British Isles*, The Natural History Museum, London.
- Kaźmierczakowa, R. & Zarzycki. (2001). *Polish Red Data Book of Plants*. Polish Academy of Sciences, Cracow, Poland.
- Koster, H. (1941). *New Lycopodium gametophytes from New Jersey*. *American Fern Journal*, 31: 53-58.

- Kotiranta, H., Uotila, P., Sulkava, S. & Peltonen, S.-L. (eds). (1998). *Red data book of East Fennoscandia*. Ministry of the Environment, Finnish Environment Institute & Botanical Museum, Finnish Museum of Natural History, Helsinki, Finland.
- Lane, D.M. & Bogle, A.L. (1974). *A second report of the prothallia of Lycopodium inundatum in North America*.
- Lansdown, R.V. (2000a). *A preliminary report on the ecology and distribution of threatened British wetland plants in southern continental Europe*. Report published by Plantlife, London.
- Lansdown, R.V. (2000b). *Review of the research requirements for selected threatened British plants*. Internal report for Plantlife, London.
- Lockton, A. (2000). *The status of Lycopodiella inundata in Britain in 2000*. Report from the BSBI Threatened Plants Database.
- Lusby, P. (1999). *Species account: Lycopodiella inundata*. Unpublished report, Scottish Rare Plants project, Royal Botanic Garden Edinburgh.
- Preston, C.D., Pearman, D.A. & Dines, T.D. (2002). *New Atlas of the British & Irish Flora*. University Press, Oxford.
- Stace, C.A. (1997). *New Flora of the British Isles (2nd ed.)*. University Press, Cambridge.
- Stewart, N.F., FitzGerald, R. & Lansdown, R.V. (2000). *The conservation of marsh clubmoss Lycopodiella inundata in England: Interim report no. 1*. Report no. 150, Plantlife, London.
- van Dobben, H.F., de Wit, T. & van Dam, D. (1983). *Effects of acid deposition on vegetation in the Netherlands*. VDI-Berichte, 500: 225-229.
- Wiggington, MJ. Ed. (1999). *British Red Data Books 1 Vascular plants 3rd edition*, Peterborough: Joint Nature Conservancy Committee.

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