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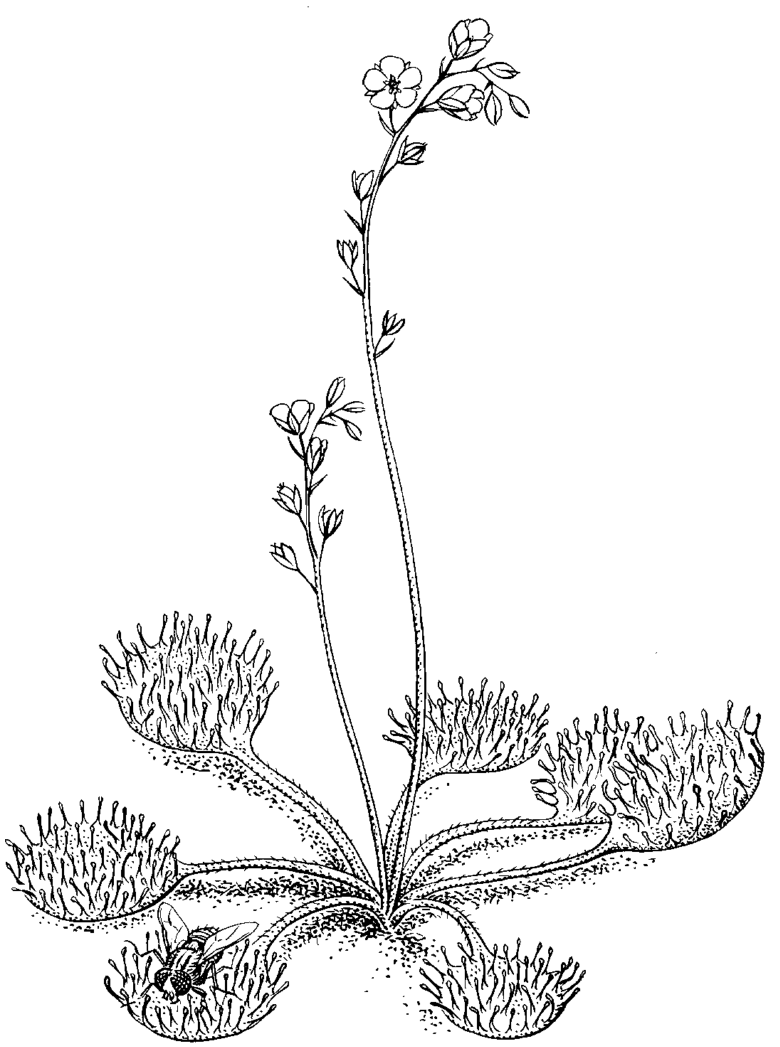
Management of water and trees on raised bogs

Papers and transcripts from a lowland peatland workshop
held at Hanmer, 10-12 June 1997

No. 407 - English Nature Research Reports



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English Nature Research Reports
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Papers and transcripts from a conference held at
Hanmer 10-12th June 1997

Edited by Sarah Whild,
Roger Meade and Joan Daniels

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Introduction

This report is intended to be a distillation of the wisdom and accumulated experience of peatland workers from all over Britain, on aspects of practical management. So often, the on-the-ground detail is not documented in scientific papers, or indeed, written up in any way. The Lowland Peatland Workshop held in Hanmer in 1997 was minuted in an attempt to prevent any loss of shared knowledge. During the conference there were papers that were delivered and these are presented here as their authors intended. The site visits, slide shows, discussions and informal presentations are delivered here, sometimes as transcripts, sometimes as summaries and information points although some of the more informative and entertaining discussions are presented verbatim.

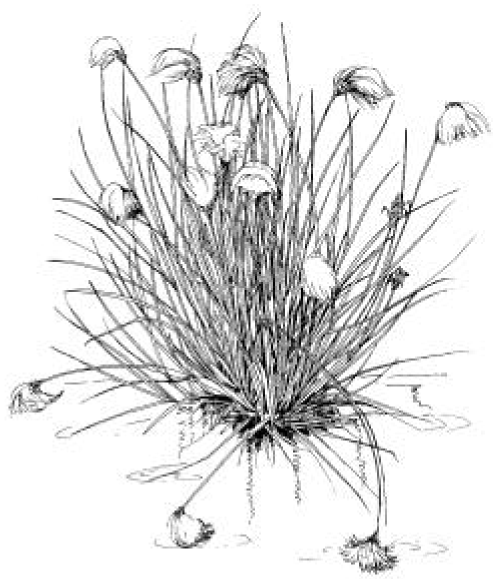
There are also two papers from another conference, by David Wilkinson and Frank Chambers, expanding the theme of the naturalness of trees on bogs; the event was a one-day workshop organised by the Mires Research Group of the British Ecological Society: ‘Wetlands, Trees and the Eco-manager.’

Almost fifty attended this workshop at Sheffield University on 11th November 1998. The morning's introductory papers set the scene for some useful discussion in the afternoon's break-out groups. It was attended by research workers and those involved in the conservation management of such wetlands. Although the introductory papers and discussions were to be written up and made widely available, not all contributors were prepared to co-operate by presenting scripts. As the subject matter is close to this workshop, the received papers are presented here, unless they duplicate material appearing elsewhere in this report.

The report is divided into three main sections; the first two deal with the two big problems facing managers of peat bogs – that of keeping the water on, and the trees off, while the final section deals with strategic issues.

The conference was introduced by Roger Meade, Peter Knights, Ioworth Rees and Joan Daniels, with all stressing the focus on practical issues. Holding the conference around Fenn’s and Whixall Moss demonstrates both the problems facing managers of lowland peatland sites and also many of the solutions. To set the context, it was acknowledged that there has been a shift in emphasis since the 1960’s from the natural history of peatland sites and many other types of habitat, towards stressing the management needs, particularly through changes in legislation such as the Wildlife and Countryside Act. This has resulted in much of the research and focus being on applied techniques rather than academic research.

Eriophorum vaginatum **Hare’s-tail Cotton-grass**



The most important aim of this conference was to exchange practical skills and ideas, for even after the division of the Nature Conservancy Council, the aims of conservation are still the same. English Nature and Countryside Council for Wales have focused a significant proportion of resources available for wetlands on the peat bog at Fenn’s and Whixall, so that experience gained here can be applied to other sites. The aim is to secure the integrity of the core of the peat body, but this is very expensive in terms of management; therefore the aims are not only to conserve and enhance but also to demonstrate best practice and exchange ideas with other site managers. It must be remembered that all sites are different, with different problems, so an exchange of ideas is particularly important.

The context

Paper 1 – Setting the scene for what follows

Roger Meade, Deputy Team Manager, English Nature, Wakefield

The purpose of this workshop is to consider techniques for keeping water on lowland raised bogs. In particular, arresting losses by surface flow, seepage and evapotranspiration. Put another way - damming, bunding, and cutting down trees. In case this should be dismissed as some sort of indulgent eccentricity it would not come amiss to start by explaining why we are doing it.

Why is it worth the effort?

Our peat bogs in the UK are important to us, the rest of Europe, and the world. As evidence of this, I would quote the large number of peatlands which have been designated as Sites of Special Scientific Interest (SSSI) in Wales, England and Scotland, and as Areas of Special Scientific Interest (ASSI) in Northern Ireland.

A proportion has also been put forward as possible Special Areas of Conservation (Fenn's and Whixall Mosses being one), and some as Ramsar sites. Doing a quick count of sites addressed in England's Lowland Peatland Programme (Money & Wheeler 1996) there are approximately 40 lowland peatland SSSIs and, incidentally, more than 50% of them occur in Cumbria.

Looking at the map of peatlands in Europe provided

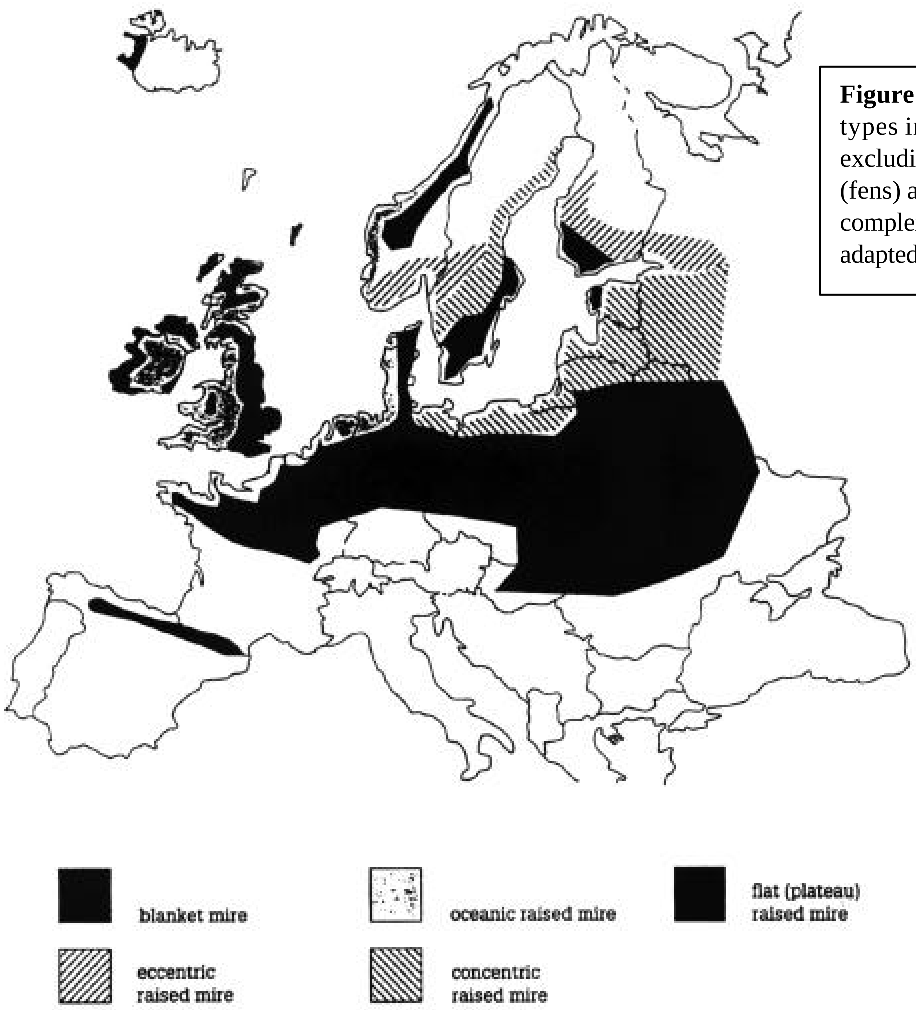


Figure 1.1. Predominant bog types in western Europe excluding minerotrophic mires (fens) and mountain mire complexes. From Lindsay (1995) adapted from Goodwillie (1980).

by Lindsay (1995) from Goodwillie (1980) (Figure 1.1) we see that the category of oceanic raised mire falls predominantly in the UK and Ireland and that our examples of flat (plateau) raised mire such as the Humberhead Peatlands are westerly outliers of a widespread central European type. Such comparisons depend very heavily on classificatory concepts, but it is not unreasonable to conclude that the westerly disposition of the UK confers a geographical distinctiveness to our raised mires.

Furthermore, we can conclude that the resource is seriously depleted in the UK. Again from Lindsay (1995) (Figure 1.2), it is possible to compare the extent of peat soils over one metre's depth in Scotland, Wales and England with the estimated present area of natural primary raised bog. In order to get a better estimate of the size of the resource we are contemplating for management we should add this estimated area of 3,826 ha to the extent of degraded and/or drained bog (5,017 ha), which gives a total of 8,843 ha.

Figure 1.2. Total area of deep peat soils for Britain. From Lindsay (1995).

These figures introduce a number of useful terms. A primary surface is one from which no peat has been removed; it is natural if no drainage or other physical damage has occurred, and of course this is often a matter of degree. Any surface on which peat formation is currently occurring is referred to as ‘active’, whether it is primary or secondary. It is in most cases down to the opinion of a competent mire ecologist as to whether the peat bog, or parts of it, are 'active' in this way, as to establish it experimentally would be costly and complex. There are areas of peat bog with a secondary surface (some peat removed within recent history) which are active, and conversely, primary surface which is not. The most valuable bog is likely to be active and have an (almost) natural primary surface. Such bogs are very rare.

Drawing on these concepts, the final figure from Lindsay (1995) (Figure 1.3) provides a good illustration as to why it is important to retain water on such bogs as we are able to influence. The statistics (numbers of sites rather than area) are taken from *An inventory of lowland raised bogs in Great Britain* (Lindsay & Immirzi 1996). For example, closed canopy woodland is present on many primary bogs in Scotland (200 sites) and scrub affects about 20 in England. A similar number in England are affected by drainage. It is interesting to note that active peat working affects a significant proportion of sites in England, but not so in Wales or Scotland. Conversion to agriculture has been by far the greatest cause of peatland loss in England and Wales, rendering them ‘archaic’ in the terms of the Inventory, and these are currently considered to be lost for all time as peat bogs.

Targeting water loss occurring by drainage or evapotranspiration will have major benefits for raised mire conservation in the UK.

What do we hope to create?

The ideal for which we strive is the active peat bog, whether the surface is primary, secondary, and perhaps not so very natural. To achieve it, we must keep the rain-derived water on and in the peatland. If we are to pursue this aim in isolation from any others it means blocking ditches and removing the trees and scrub. We are here to find the most cost-effective ways of doing so.

It is of course proper for us to concentrate on practical aspects in a workshop such as this. However, there are other factors to consider, and there will be an opportunity on the last day to look at them more closely. For example, what about invertebrates which may benefit from the drier conditions created by drainage and from the presence of scrub? Are we creating something natural and is it sustainable? What are our duties to neighbours - are we drowning their land? Who will pay for all the work identified in management plans? While we cannot guarantee to provide all the answers, at least our future judgements should be better informed as a result of these few days.

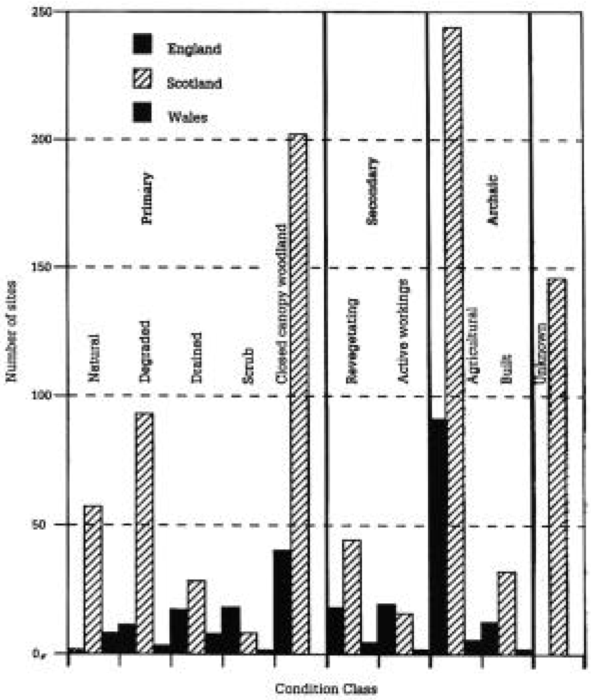


Figure 1.3. Number of raised bog sites classified according to their major land use.

The largest proportion of habitat change has been as a result of agricultural land-claim leaving archaic peat soils. An appreciable number of sites have been cut over and a substantial number have closed canopy woodland. Sites with natural or degraded areas are commonest in Scotland.

References

Goodwillie, R. 1980. *European Peatlands.* Nature and Environment Series No. 19. Council of Europe, Strasbourg.

Lindsay, R.L. 1995. *Bogs: The ecology, classification and conservation of ombrotrophic mires*. Scottish Natural Heritage. ISBN 1 85397 100 6.

Lindsay, R.L. & Immirzi, C.P. 1996. *An inventory of lowland raised bogs in Great Britain*. Scottish Natural Heritage Research, Survey and Monitoring Report No. 78.

Money, R.P. & Wheeler, B.D. 1996. *Prioritisation of Lowland Peat Programme resources*. English Nature Research Reports No. 179. English Nature, Peterborough.

Theme 1: stopping the gaps - techniques for controlling water

The Welsh perspective

Peter Jones, Countryside Council for Wales

The Welsh resource includes many fine large raised bogs, including Cors Caron, Cors Fochno and Rosgoch, although there are several smaller sites, about which very little is known even when they are afforded some legislative protection such as SSSI status. Twenty percent of Welsh lowland bogs are primary and active and it is important to focus on these sites to secure their ecological integrity. Low-tech techniques such as peat bunding have been used extensively on Cors Goch; plastic pile dams have been used and high capital works such as weir construction at Cors Caron. Techniques such as peat stripping have been used to remove enriched peat prior to raising water tables at Cors Goch.

There has been much emphasis on hydrological monitoring projects on a selection of Welsh lowland peatland sites. A range of monitoring procedures helps to inform hydrological management such as plastic piling and peat dams and helps to evaluate these various techniques.

There are four main points to emphasise:

1 There is an enormous backlog of data from monitoring. Only when it is distilled can it be used to inform management.
2 Some sites have no hydrological monitoring.
3 The Welsh peatland resource needs to be put into a national context as it is nationally important.
4 There is a lack of resources for management. Cors Caron has had £23,000 spent on management already and needs £40,000 more. It is hoped to look to Biodiversity funding for this when the mires Biodiversity Action Plan is published. As with many wetland sites, there is a continual problem with adjacent owners and occupiers, even if funding is available to raise water tables.

The Scottish perspective

Neil Wilcox, Scottish Wildlife Trust

The Scottish Wildlife Trust has eight peatland reserves and at these sites all ditches have been dammed using a variety of techniques such as elm wood, plywood, plastic piling and peat dams. All techniques have been low-tech, with no sophisticated capital-intensive techniques such as concrete dams.

The main problem is the presence of closed canopy woodland on peat bogs. Although all the ditches are dammed and monitoring has been conducted on every site, analysis of the monitoring data has shown that the ditch blocking has only been partially successful and indeed some sites are now even drier. There have been some successes however (although in many sites the success is localised around the ditches) but basically no high water tables have actually been created.

Obviously we need more radical management - we need to find a site where we can recreate lagg fen as this appears to be the most important way of maintaining the ground water mound. It is probable that the main reason for lack of success is that the bogs have actually changed shape, affecting the ground water mound so ditch damming does not help. The hypothesis is that lagg fen would help to restore the hydrology; however, it is likely that high-tech civil engineering techniques would be required in order to implement this.

Newly published this summer is *Conserving Bogs - The Management Handbook*, published by the Stationary Office. It is important that peatland managers should evaluate the techniques contained within this handbook and provide feedback to the authors, Rob Stoneman and Stewart Brooks of the Scottish Wildlife Trust.

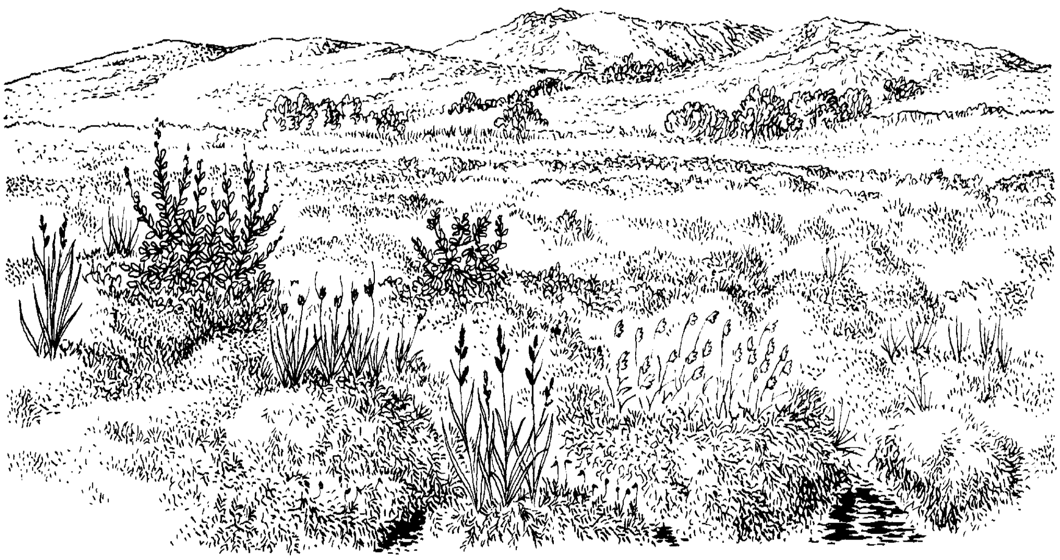
The English perspective

John Bacon, English Nature

All land managers worry! Either they have too much water, which impedes general management activities, or there is too little. Lack of rainfall in recent years and decades of land drainage on wet heaths, fens, valley mires, bogs and wet meadows has meant that one of the biggest tasks is holding back water rather than trying to get rid of it.

One of the problems at Wybunbury Moss was the inflow of polluted water so management at this site had to cope with diverting polluted water before the peat becomes more degraded, combined with raising the levels of 'good quality' water. The scale of rewetting across England has the potential to be on an enormous scale in the next five years as the potential of Biodiversity / Lottery / Life funding becomes available for undoing the damage done by the past five decades of drainage activity across valley mires, fens, wet heaths and wet meadows.

Whilst there is still a decade of work to complete on bog sites to hold back water and saturate the peat, the know-how developed on peat sites over the past decade will help those tackling similar but crucially different problems on other habitats (e.g. shallow peat over mineral ground where sealing dams underneath is more of a problem). Site managers must be inventive in adapting and developing new skills and techniques to manage the water.



Fenn's, Whixall & Bettisfield Mosses NNR

Site visit led by English Nature's Site Manager, Joan Daniels

Fenn's, Whixall & Bettisfield Mosses NNR is the third largest lowland raised bog in Britain, and is one of English Nature's and the Countryside Council for Wales's most expensive properties. The bog has been damaged in the past by the construction of the Shropshire Union Canal through the peat body in 1807, and a railway was constructed in 1863. Peat cutting has been carried out since prehistoric times, and especially since 1500, when the site was common land. Parts were enclosed in 1777 and again in 1823 and the field boundaries allotted to smallholders are still discernible. These areas were rented out for peat cutting, the resulting peat being moved by canal and later by rail. Large-scale commercial peat cutting has been carried out on Fenn's Moss since 1900, but in 1989 the horticultural peat suppliers Croxdens acquired a large part of the mosses and increased the scale of operations so, following a public campaign in protest, English Nature and CCW bought the company out in 1990.

Not all of the peat body is entirely protected. Only two thirds of the 948ha of peat within the SSSI boundary is also is within the NNR boundary, and therefore subject to direct management. Wem Moss NNR forms an outlier to the main peat body, connected by a narrow peat strip, and is managed by the Shropshire Wildlife Trust. Most of the semi-natural communities on Whixall and Bettisfield are owned within the NNR by EN & CCW. Fenn's Moss is on lease from Sir Guy Hanmer. The site, which lies across the Shropshire-Clwyd border, is managed by English Nature, half funded by CCW.

Some facts about Fenn's and Whixall

It is a Wetland of International Importance and a candidate Special Area of Conservation, important for its lower plants and invertebrate communities, including 250 nationally notable species. *Hagenella clathrata*, a caddis fly, is at one of only three sites in the UK, and the northern footman moth *Eilema sericea* is at its last global station!

The site has been devastated by the installation of a network of drains of up to 4m in depth, marking out 80m wide peat cutting flats. 1m deep peat cuttings every 10m drain into these ditches so rainwater immediately flows off site, and mire flora and fauna are lost. Because the site was sod-cut not surface milled, there is a relict 2m wide strip of mire vegetation every 10m, to act as a seed source on restored areas. Drainage ditches on old commercial and hand peat cutting areas have partly in-filled, resulting in colonisation by both bracken, heather, birch and pine and mire plants.

On Whixall Moss bog plants and animals have survived in small uncut areas and the relatively shallow, less intensively drained hand cuttings; and from here can potentially spread out onto the severely damaged commercial cuttings.

Three culverts below the canal form fixed level outlets for the main arterial drain which the peat cutters installed through the centre of the Moss. The invert levels of these culverts have prevented deep drainage of the Moss. Defects in the drainage network leading away from the Mosses results in flooding on the low-lying peaty fields on the edge of the Moss. Inevitably, English Nature's water level restoration scheme is blamed for the flooding.

Enrichment on bogs

Filter beds using Typha *were discussed; the disadvantages are that* Typha *can colonise other drier areas within the site, and the water is still not acidic, thus raising the pH.*

Politics plays a large part in resolving pollution running onto the moss – the Environment Agency and Water Authority have difficulty in determining who has authority, plus the margins of the peat bog are in private ownership.

Possible solutions?
Piping an arterial ditch to carry enriched water.
Extending the fen/lagg area to absorb the enrichment, by buying up more marginal land.

The marginal area of the peat bog is not in the NNR. Water chemistry is an issue for the restoration of ombrotrophic conditions as agricultural run-off and septic tank pollution from the Moss Cottages have been diverted up onto the Moss. Abundant stands of *Typha*, *Salix* and *Alnus*, all indicators of enrichment, have resulted. The polluted water must be treated and pumped or diverted around the margin of the Moss. Owners can be obliged to comply as long as flooding does not result. There are similar problems at Wybunbury Moss, where there is a pump drainage scheme which diverts domestic run-off away from the bog. Since its installation in 1984 there has been a dramatic improvement in water quality.

Water level restoration

Peat dams, metal dams and U-shaped pipe installations were demonstrated.

To restore mire communities, rainwater is being retained on the site at or just above peat surface, by damming the drains at 40m intervals with 3m wide excavator-constructed peat plugs, made from 'wet' peat dug from the base of the ditches.

Where there is a substantial flow of water over the peat dams, a spade-width channel is cut through the length of the peat dam to ca. 15cm below the required water level above the dam, and a 'gate' of plastic coated metal cladding 1m deep is inserted at right angles to the channel. The 'gate' is cut in by spade to 30cm depth then driven in by sledge hammer. Surplus water then flows over the 'gate' and can not erode the dam above the 'gate', lowering water levels. 'Gates' installed 8 years ago showed little sign of corrosion, but if the cladding is damaged they corrode after four years. The cost is £1-30 per sheet. These dams can handle water from up to 1ha.

Points about pipes and dams

Sewage pipes can be used, but it's important to check that they are UV stable.

Also, check for blockages in pipes and metal dams before the winter.

To install these pipes, the peat dams must be constructed first and then the low points need to be located and the pipes installed in these low areas.

It is important to have these erosion control points in peat dams otherwise peat erosion and water will destroy the dam.

Wet, black, humified peat is the best for dams and filling in around pipes. White, unhumified peat is useless for dams but grey, partially humified peat can be used. There are palaeontological implications in using peat – using peat is a last resort.

Because the peat cutting flats lie at different heights, there are differences in restored water levels. To permit storm water to be conducted off the site from level to level without eroding dams and tracks, U-shaped U-PVC twin-walled pipes, of diameter ranging from 150mm to 300mm depending on flow, fitted with a 90º upstream and 45º downstream bends, have been installed, using English Nature's Bigtrack and Smalley 808 excavators. Half railway sleepers are laid at the ends of the pipes to stabilise the construction. Costs - pipes ca. £100, sleepers ca. £20.

An area of commercial peat cutting fields, which was dammed up three years ago, was inspected. Before restoration the ditches were dry and there was no bog vegetation. Scrub was removed and brash piled in the peat cuttings, which occur every 10m. Ditches were dammed every 40m. As the area lies lower than surrounding less cut peat, it rewetted well after damming.

On the commercial fields the tracks lie at the same level as the cuttings, so rewetting is more difficult than in hand cut areas where the tracks are higher and can be used as bunds to raise water in the dammed areas. Additional peat dams are installed until the water is retained at or near surface for most of the year. Rainfall is crucial in this area of low rainfall. The dams retain spring and autumn rainfall as a reservoir through the summer. High water levels are changing the peat structure back from dry flaky 'dead' peat to 'live' gelled peat, which can supply water to surface *Sphagnum*, even when ditches go dry in summer, despite it being thought that the loss of colloidal structure when peat is dried was irreversible.

The dammed areas are now rapidly developing back to *Sphagnum cuspidatum* and *Eriophorum* species.

Acquisition Costs

- *£1-2,000 per acre on the smaller areas. It was assumed we could get away with £300 but in reality, anything fenny or agricultural commands £2,000 and with planning permission, £10,000.*

- *There is an acquisition strategy for England and Wales for Fenn's and Whixall, which has been approved by EN & CCW's Councils. Basically, bits of the adjacent SSSI can be bought when the land comes up for sale. This is the only realistic option as management agreements do not appear to work. Even when agreements are set up, the owners do not want to do anything other than continue with the present management and any mention of reversion is met with derision. Therefore, the best approach is to buy up because only then do we have absolute control.*

- *This experience is echoed in Scotland where it is also found that management agreements do not work and the only approach is acquisition. It is worth investing time and patience in buying up land as this is the only way to produce a workable long-term strategy.*

Discussion

Between 50-100 years are required before there is any real change in the vegetation as the change comes from a very small nucleus on degraded bogs such as Thorne Moors.

Wood is important in peat stratigraphy as in some sites the presence of wood can lead to different species of *Sphagnum* forming. In some Cheshire bogs, there is over 1m of wood in the peat.

One conclusion is that we need to take a wider look for factors influencing regeneration, as the issue is very complex.

There has been a dramatic change in the climate since these bogs were formed and this must be taken into consideration - we should be looking at the wider landscape in an effort to restore bogs. In Holland there is a strategy of buying up the lagg area and adjacent farmland and rewetting this. It is important to get a much wider hydrological picture.

The stratigraphy is important in examining climate change - we need to work on dating the layers in the last 7,000 years worth of peat. In the North York Moors, much of the peat has been formed from *Eriophorum* rather than *Sphagnum.*

Both *Juncus effusus* and birch are possible contributors to peat formation.

Hardware on Bogs

One of the biggest problems in winter is moving equipment in particularly wet conditions. Some of the equipment and vehicles used are displayed.

- *A 2-seater John Deere AMT 626 bought five years ago for £5,000 ago is useful in drier conditions.*

- *The Glencoe ATV is of limited use because the tyres are prone to puncture if the necessary tracks are used.*

- *Advantage of the Glencoe: it has a cab for shelter.*

- *Disadvantages: repair bills can be as high as £4,000 per year; it causes very bad dust in drier conditions; and it has a very noisy engine.*

- *New generation ATVs from Europe are currently between £50-100,000.*

- *There is a new tracked machine which is hinged, allowing greater manoeuvrability without scuffing damage on turning although there are reports that engine mountings require damping.*

A contractor has now produced a review of machines on peat bogs, reporting on 70 machines. (This is now available, entitled the ATV report - telephone 01694 723101 for details.)

Visit to Wem and Cadney Mosses - Hydrological Issues

Andrew Hearle, English Nature, West Midlands Region and John Tucker, Shropshire Wildlife Trust

The border drain separates Wem Moss from Cadney Moss and also acts as the national and county boundary dividing Shropshire in England from Clwyd in Wales. Wem Moss on the English side still consists of semi-natural bog communities although much of this is succeeding to wet heath and scrub, for a number of reasons. Cadney Moss, on the other hand, is a mixture of semi-improved pasture overlying peat, and conifer plantation which overlies a modified bog vegetation. Both Wem and Cadney Mosses form a discrete part of Fenn's, Whixall and Bettisfield Mosses and a narrow neck of peat links Wem and Cadney to Bettisfield Moss.

Wem Moss is a Ramsar Site, candidate SAC, NNR, SSSI and Shropshire Wildlife Trust Nature Reserve.

Site History

Wem Moss is believed not to have been dug for peat to any significant extent. Early botanists explored the Moss in the 19th century and the SWT became interested in it in the 1960's, when Charles Sinker drew attention to its importance. In the 1970's it became a Nature Reserve, but there was concern over the effect that effluent from an adjacent pig farm was having on the vegetation. In 1989 the SWT bought the 'Rights Manorial' (there being no registered freehold). The SSSI boundary, originally drawn up in 1981, was revised in 1994 to its current form, which includes the adjacent Cadney Moss as well as Fenn's, Whixall and Bettisfield Mosses to the north. Prof. David Bellamy declared Wem Moss a National Nature Reserve in 1994, and it is a candidate SAC.

The biggest problem on Wem Moss is loss of water due to peripheral drainage and consequent scrub invasion.

Site Layout

Wem Moss has been described (rather unkindly, some may say) as 'a pimple on the bottom of Fenn's and Whixall Moss.' At 28ha it is a small site relative to its neighbours but the peat body and the hydrology are contiguous with Fenn's/Whixall Moss and with Cadney Moss, which is over the border in Wales.

Rarities

Invertebrate rarities include Great Raft Spider *Dolomedes fimbriata*, Large Heath *Coenonympha tulia*, Bog Bush Cricket *Metrioptera brachyptera*, *Brachythops wuestneii* and *Pachynematus xanthocarpus* (sawflies). The White-faced Darter *Leucorrhinia dubia* has been extinct on the site for 10 years or so but is abundant on Fenn's and Whixall.

Sphagnum pulchrum, all three native Sundews *Drosera anglica*, *D. intermedia* and *D. rotundifolia*, Bog Myrtle *Myrica gale*, White Beak-sedge *Rhynchospora alba* and Bog Rosemary *Andromeda polifolia* are all present.

This site contains a relatively small area of peat- ca. 70ha. This mire developed at the edge of the natural climatic range for raised bogs and it is worth noting that the annual rainfall in recent years is less than 500mm, well below the average long term rainfall of 690mm required to maintain a raised mire.

Geological setting

Glacial till underlies much of the peat body, however, in the south-west part of the site the peat overlies glacial sands and gravels hence there is potential loss of water to the groundwater aquifer. Below this, the solid geology is formed from Triassic Mercia mudstones.

Peat Depths

The Wem Moss southern dome has peat to a depth of 3-5m while the north dome lies over peat to a depth of 10m. Cadney Moss peat depth records indicate depths of up to 7m and there is continuity of peat with Wem Moss beneath the Border drain.

Drains

Several major drains surround Wem and Cadney Mosses and the depth and level of maintenance of these drains plays an important part on the hydrology of the site:-

- Manor drain lies to the north west of Cadney Moss and carries enriched water from arable fields to the north west of the peat body.
- Border drain runs between Wem and Cadney Moss and carries acidic peaty water from Bettisfield Moss.
- Southern drain runs south of Wem Moss and drains surrounding arable land. It is a deep drain cut into the peat and is maintained vigorously by the neighbouring farmers.
- Cadney Moss contains many small internal drains, many of which have no directional flow on them.

- Surface peat cracks in Wem Moss act as effective drainage channels.

Abstractions
Aspinwalls have assessed the likely impact of licensed groundwater abstractions of which there are ten within 3 km of Wem and Cadney Mosses. They conclude 'due to small volume of abstractions and the nature of the deposit, it is unlikely that the Mosses are currently affected by abstractions.' So, a small, hydrologically isolated site, overlying a 'leaky deposit,' lying at the edge of the natural climatic range is inevitably sensitive to periods of drought and the damaging impacts of agricultural drainage and associated scrub and woodland development.

Wem and Cadney Mosses have undergone severe desiccation and vegetational change as a result of declining water levels. Whilst this process has been well documented, there was for many years no clear consensus as to the causes and hence solutions. A respected study undertaken in the late 1980's indicated that the drying of the moss was largely a function of its location, at the edge of the natural climatic range, and a sequence of dry years. The study went on to say that the drains had no or little effect on the moss water levels. Subsequent studies, however, highlighted the importance of the impact of the drains and of the increasing cover of scrub and woodland.

The most detailed and comprehensive study of the hydrology of the site was undertaken between 1990 and 1992 by the University of Birmingham and continued by a voluntary site warden who was also a professional hydrologist. This study involved monitoring a network of piezometers at various depths within the peat and trapezoidal flumes to record discharge from the main drains. This work enabled us for the first time to determine inputs and outputs and to establish a water budget for the site. It also enabled the use of a groundwater flow model to predict changes to moss water levels.

Main findings
- Overall, the site shows a sensitivity to small changes in rainfall.
- There is a significant outflow to the south west where the peat is in hydraulic contact with the glacial sands and gravels.
- Loss of water to the southern drain in particular, is significant. The model predicts that in the absence of this ditch, moss water levels would rise by 40cm.
- The high cover of scrub and woodland is contributing greatly to high losses of water by evapotranspiration.
- Heavy fracturing of the peat surface is a major limiting factor to the raising of water levels.

This study was an important step in identifying the main causes of declining water levels on the mosses and enabled us to consider practical solutions to begin the restoration of the moss. This process was taken forward by the Peatland Rehabilitation Plan. This Plan sets out a vision for the restoration of the mosses; a series of objectives to achieve this vision; a costed set of actions for meeting the objectives which enable us to budget and bid for resources and to negotiate with neighbouring landowners from a position of 'clarity and strong factual basis to our judgements.'

Southern drain - Key Points
- Just as there was no consensus as to the causes of water level decline, so no consensus as to solutions. Dr Butcher was commissioned by EN to consider options and propose a detailed scheme for raising moss water levels (Table 1 overleaf).
- Recommended solution - option F (dam existing drain) in conjunction with option D (install secondary drain - French Drain- in mineral ground parallel to existing drain). Recommendation made on basis of functionality, serviceability, life-span, and cost.
- The adjacent landowner claims the right to maintain the southern drain. The main purpose of this drain is to drain low-lying agricultural land to the south-east of Wem Moss.
- Discussions were held between EN and the landowner and all options were considered. The landowner is prepared to consider the recommended solution because in his opinion it is the only solution which could enhance the drainage of his agricultural land. Without this additional agricultural benefit, the landowner indicated that he wasn't prepared to interfere with the existing drain which provides him with good service.
- The landowner has requested a small deviation to the line of the secondary drain proposed by Butcher. EN have contracted a local firm of engineers to take levels and design the drain to meet both EN's and the landowner's requirements, the work to be completed by end June 1997.
- It is hoped that the secondary drain will be installed and the existing drain dammed by the end of 1997.

Table 1. Summary evaluation of options from Butcher *et al.* (1996)

	Solution	Benefits	Disadvantages	Costs
A	Wider, shallower existing ditch	Relatively low cost. Raises water tables on moss. No need to access agricultural land for works.	Significant flooding of adjacent farmland. Need for regular maintenance. Not acceptable to riparian owners.	£25k for works, probably more.
B1	Bentonite / steel / plastic piling cut off (moss side)	Raises water tables on moss. No need to access agricultural land. Long term solution.	Extremely expensive. Bentonite vulnerable to damage by machinery. Extreme hydrological discontinuity may encourage flow beneath barrier.	Steel piling £195k. Bentonite costs unknown.
B2	Steel / plastic piling within moss boundary	Raises water tables on moss. No need to access agric. land. Long term solution. Prevents downward seepage through permeable substrate.	Extremely expensive (especially steel). Extreme hydrological discontinuity may encourage flow beneath barrier.	Steel piling £150k, plastic piling £50k.
C	Waterproof existing ditch on moss side (Visqueen or steel piling).	Raises water table on moss. No need to access agricultural land.	Expensive to install. Extreme hydrological discontinuity will encourage flows beneath barrier.	£10k for Visqueen £190k for steel piling
D	Wavincoil French drain in agricultural land	Raises water tables on moss. Long term solution. Reduced maintenance costs. No loss of agricultural land.	High initial expense. Some maintenance costs.	£35k
E	Open ditch in agricultural land	Raises water tables on moss.	Significant loss of agricultural land. Will require regular maintenance.	Works £2.5k + compensation
F	Dam existing ditch	Raises water tables on moss. Very low cost solution. Long term stable solution. Reduced maintenance costs.	Significant flooding of adjacent land will involve compensation. Need for regular maintenance. Not acceptable to riparian owners.	Works £2k + compensation.
G	French drain in existing ditch	Long term solution. No need to access agricultural land.	Difficult to create sufficient fall. Liable to sinking in ditch base unless substrate installed. Difficult to obtain access for maintenance.	£30k.

Stopping the gaps – discussion

Chaired by Roger Meade

The presentations have thrown up several important issues so far:

1 *In England there are problems with keeping water on shallow peat bodies.*
2 *Does peat scraping have palaeo-ecological consequences?*
3 *It appears that a significant problem in Scotland is that of closed woodland canopy and scrub.*

Transcript of discussion

John Tucker: MSc students at University of Birmingham carry out hydrology theses. Can we use students for analysing monitoring data?

Joan Daniels: It depends on the quality of the students; they are useful for number crunching rather than interpretation.

Roger Meade: MSc students produce one year of data, which is not always useful, and often unfocussed.

Peter Jones: The data collected in Wales is from pristine sites where the function of monitoring is to detect any potential change.

Peter Roworth: Monitoring is of importance for site managers, as they answer to the economics of management. We need hard data to justify this.

Frank Mawby: We do need to collect data in a uniform way - methods of collection are different at every site. Perhaps we should investigate contracting out to a university.

Neil Wilcox: We do need to justify data collection - if we carry out a review of data we are likely to find problems with the methodology. For example, monthly dip wells only tell us if it rained the day before, so continuous data logging is the only way to collect good data.

Joan Daniels: I find that dip well data can be useful, and is cheap and easy to collect, particularly using work placement labour. With the RC16 continuous chart recorders there is a need for continuous analysis of chart information.

Mike Bailey: There is software available for processing RC16 data.

Peter Knights: Ease of collection of data does not justify monitoring. The aim of this workshop surely is to produce guidelines for monitoring.

Peter Rawlinson. I would like to ask Peter Jones how the data collected on Welsh sites has been analysed and interpreted?

Peter Jones and Mike Bailey: We used three RC16s on the dome of a primary mire and on the junction of a primary and secondary mire. Monitoring in this case is to determine how the whole site has responded to peripheral management. Ditch blocking has led to a rise in water and a stabilisation of the water table which has in turn reduced draw-down. The R16s were put in originally to study the over all objective of restoring the water table on the primary mire, rather than to pick up on individual management tasks.

Peter Rawlinson: What successes have you had in water table restoration?

Mike Bailey: Limited success with peat dams, the main problem being that they need continual upkeep. The R16s helped to prove that management work was working, but most of the data was not useful. Daily data is too much. Monthly manual readings would be most useful.

Frank Mawby: The peat composition is very important in affecting the hydrology. We need to look at peat structure more closely rather than at water movement.

Peter Roworth: This is true at Thorne Moors - we have little peat left on the site and one of the most important factors we need to determine is the physical nature of the peat so we can study how water movement will affect it. Can we determine the extent to which the quality of the peat affects the hydrology?

John Bacon: Peat quality is important. Good wet black peat is no problem to work with but dry brown peat is very difficult, presenting problems with damming where the dams are constructed from peat.

Roger Meade: Peat dams are only an option where there is peat available; otherwise there is a need for peat stripping which should be a last resort. Are there experiences of this?

Joan Daniels: All secondary bogs are disturbed archaeologically. Peat stripping has important consequences on primary sites where the palaeontology is intact.

Theme 2: scrub and tree control.

Paper 2.1 Trees and scrub on raised bogs

Roger Meade

Trees are bad, aren't they?

They must be, because conservation organisations expend a lot of time and effort in removing them. I would hope to persuade you that this may not always be true. Take a look at some continental raised bogs, where trees are plentiful; consider the evidence of stratigraphic wood from UK profiles.

Pine *Pinus sylvestris* and Spruce *Picea abies* are common constituents of Scandinavian peat bogs, and each gives rise to a series of mire types in the Finnish mire classification (Laine & Vasander 1996). Although they do not usually form dense stands, the pine and/or spruce can form a closed canopy in some of the types. For example, there is cotton grass pine bog and ridge-hollow pine bog.

Ingram (1995) considers the treelessness of our mires to be desirable but perhaps unnatural. If I interpret his views correctly, the interference of conservationists, in preventing traditional activities like burning and grazing, are enabling the undesirable but natural condition to return. The actual picture is a complex mix of what we are used to and have come to expect, and also perhaps a lack of understanding as to why things are as they are. We could take the view that naturalness is inversely proportional to human activity, but should take the trouble to check it out against what is known about the history of vegetation. For example, studies of the Cheshire peatlands (Leah *et al*. 1997) show that wood peat is a common component, and indicates that peatlands such as the Greater Manchester and Cheshire mosslands were not always treeless. There was a substantial periods of dominance by carr species and then a pine-dominated phase on Lindow Moss, contributing in excess of 1m of peat in places. Nevertheless, we do not consider that they ceased to be peatlands at the time this wood peat was forming under (presumably) a woodland.

As land managers, the arguments of historic precedent and naturalness only take us so far. Perhaps the rest is born of frustration. We know that active peat bog likes it wet, and that a dense stand of birch or other vigorous vegetation will lose a lot of the precious water. So it is a case of focusing on the water budget and cutting down on as many losses as possible. The situation we inherit is, after all, in many cases, unnatural, and we are practical folk.

Managers of lowland peatlands, especially cutover ones, are no stranger to the spectacle of dense, remorseless, regenerative birch scrub. It may be of interest to recount some of our experiences on Thorne Moors (Figure 2.1), where dipwell measurement of the groundwater level in the peat has been measured for some years.

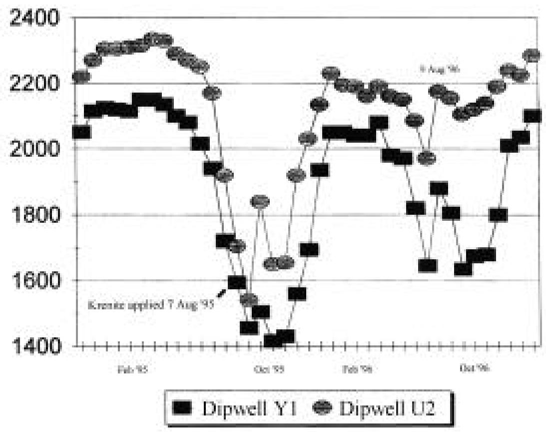


Figure 2.1
Dipwell U2 – krenite applied in August 1995; all birch subsequently died.
Dipwell Y1 – control with no krenite applied.

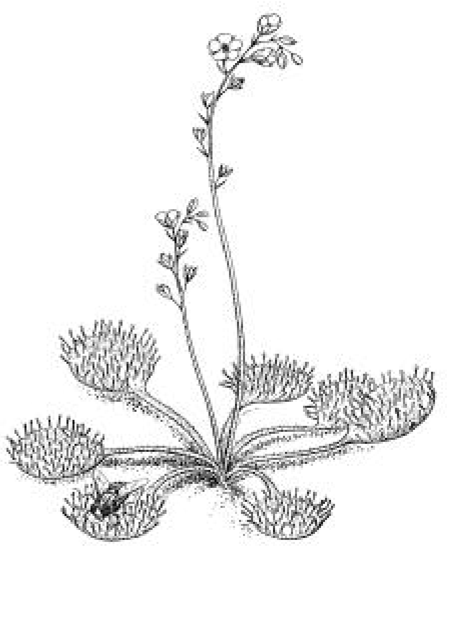
Moreover, it is possible to compare years when birch scrub was present with those when it was not, at the same location. The dip in summer water level of the scrub-free plot was about 20cm less severe than might have been expected, by comparison with a ‘control’ plot. It is not unreasonable to think that some of the difference is due to the birch trees.

Such findings confirm our intuitive belief that scrub vigour has to be reduced if active mire regeneration is to be achieved within our lifetime.

How big is the problem?

A questionnaire was circulated to a sample of raised mire managers prior to this workshop. They were invited to reveal the extent of their scrub, what sort of situation it occurred in, and the type of control undertaken.

Information was supplied for eighteen sites (some composite), giving a total of 5,640ha on which scrub has been managed. It includes primary bog surface, and in many cases respondents claimed it was also an active system. Birch *Betula* sp. was the predominant tree, but pine *Pinus sylvestris*, willow *Salix* sp. and Rhododendron *Rhododendron ponticum* were commonly included. Not all of these have been included in the table (Table 2). Scrub species were usually dense and scattered in different parts of the same site, at a range of heights, but commonly above three metres. In most cases scrub had been cut, and herbicide (glyphosate) applied to the stump. Regrowth was almost universal, usually described as stunted, but regeneration by seedlings was common. Fire was another means by which scrub was inadvertently controlled over large areas on a few sites.



Round-leaved Sundew *Drosera rotundifolia*

Maximum water levels were close to, at, or slightly above the ground surface, so that the prevailing conditions under which the scrub had developed could be described as the wetter end of the range. In most cases, it was claimed that managing the scrub had led to higher water levels, though it was down to estimates rather than hard data.

It is not unreasonable to conclude that there is great potential for finding an effective means of controlling scrub on raised mires, which does not result in widespread regeneration (of the scrub). There is some evidence that such control leads to dividends in terms of a higher water table.

References

Ingram, H.A.P. 1995. Conserving the cultural landscape? *Mires Research News*, quarterly newsletter of the Mires Research Group, British Ecological Society.

Leah, M.D., Wells, C., Appleby, C, & Huckerby, E. 1997. *The Wetlands of Cheshire*. North-west Wetlands Survey Report No. 4. Lancaster University Archaeological Unit/Cheshire County Council ISBN 1-86220-007-6.

Laine, J. & Vasander, H. 1996. Ecology and vegetation gradients of peatlands. *Peatlands in Finland*. H. Vasander (ed). Finnish Peatland Society. ISBN 952-90-7971-0.

Table 2. Analysis of quick survey - scrub on raised bogs and its control

	Scrub				Affected area of bog		water level max. cm			
Site name	area (ha)	main tree	height	Density	% primary	% active		scrub treatment	Scrub regrowth	Bog incrs wet?
Bowness Common	759	Birch + p	<3m	D+S	100	100	Nd	C+H+B	not known	
Cors Caron	670	Birch	>3m	S	48	100	50	C+H	S+seedl	(Y)
Cors Fochno	600	Birch	<>3m	S(D)	33	100	0	(C+H)	S+seedl	N
Crowle Moor	121	Birch	<>3m	D	0	4	Nd	(C+H)	SV+seedl	(Y)
Danes Moss	12	Birch +s	<3m			some	45	C	S	Y
Flanders Moss	675	Birch+(p)	>(<)3m	(D)+S	91	93	0	(C+H)	V	Y
Ford Moss	60	Birch + p	>3m	D+S	?	?	0	C+H	seedl	N
Glasson Moss	224	Birch	><3m	D+S	part	part	0	C+H+B	V+seedl	Y
Holburn Moss	50	Birch + p	>3m	S	?	?	-20			
Holcroft Moss	9	Birch	<3m	S	100	some	5	C	SV	
Humberhead Peatlands	1380	Birch	<>3m	D+S	0	some	?	burned	SV+seedl	Y+N
Rhos Goch	15	Birch	>(<)3m	D+S	0	100	-5	(C+H)	S+seedl	(Y)
Roudsea Moss	200	Birch +	>3m	D+S	100	100	0	C+H	SV+seedl	Y
Saltersley Moss	2	Birch	>3m	D	100	0	2	C	V	N
Wedholme Flow	270	Birch+(p)	>(<)3m	S			-10	C	V	Y
Wem Moss	28	Birch +			100	100		C+H	S	
Westhay Moor	12.5	Birch +s	<3m	S	0	100	0	C+H	V+seedl	(Y)
Fenn's & Whixall	553	Birch +p	<(>)3m	D+S	10	20	0	C+H	SV+seedl	Y+N
TOTAL AREA ha	5,640.5									

Key

Trees: p = pine

Density: D = dense, S = scattered

Treatment: C = cut, H = herbicide (standing or to stumps)

Regrowth: S = stunted, V = vigorous, seedl = seedlings

Increased wetness? Y = yes, N = no

Paper 2.2 An open place? A contribution to the discussion on trees on British mires

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Traditionally it has often been assumed that most British mire types would naturally be treeless and they have often been managed accordingly by conservationists. Most people who have done field work on lowland British mires are likely to have seen sites which were being actively managed to remove trees. During the course of the Sheffield meeting it became apparent that many of the people who were questioning the idea that trees are always/usually unnatural on British mires tended to have a background in Quaternary palaeoecology; a background I share. It is not surprising that palaeoecologists should question these ideas. It has long been known that tree remains underlie many British mires (e.g. 'A real farmer' 1768; Lyell 1832) and by the second half of the nineteenth century it was realised that multiple layers of tree remains could often be found *within the peat* (Geikie 1881). Clearly this shows that trees have grown on British Mires in the past at dates prior to the human caused drainage of mires (see paper by Frank Chambers). I will briefly discuss three points; firstly the importance of wet (carr) woodland on peats, secondly the status of trees on lowland raised mires (broadly defined) and finally the rôle of Quaternary palaeoecology in nature conservation.

The importance of peatland woodlands

In the past, wet woodland would have been an important part of the British vegetation. For example Bennett (1989), in his reconstruction of British forest types for 5000 years ago has large areas of alder *Alnus glutinosa* woodland around the Wash and up the east coast of England as well as around the Bristol Channel. They would also have been common in smaller wet areas such as valley bottoms. Such wet woodland sites are now much rarer and of conservation interest.

They present a problem for conservationists, being part of a hydroseral succession with a tendency to turn into other habitats (Bunting and Warner, 1998; Walker, 1970). In the case of one Lake District alder carr I have studied it appears to have remained as carr woodland for at least 1000 years, however this appears exceptional. This means that these woodlands seldom meet the formal definition of 'ancient woodlands' used by the nature conservation organisations, although they were an important part of the ancient woodlands of Britain. As such, existing wet peat woodlands are of conservation interest and it would also seem reasonable to want to extend the now limited area of this habitat by allowing new woodland to develop on some wet peatland sites. This conflicts with the management of all British mires as open treeless habitats.

Trees on lowland mires

A major approach to the management of lowland mires in Britain is tree removal, often of Birch *Betula*. However some of these sites have had periods in the past when trees have grown on them. For example wood remains are found in the peat stratigraphies of many of the mid Powys peatlands described by Slater and Wilkinson (1993). Clearly under some conditions one would expect trees to grow on such sites. This suggests that the correct question to ask is should there be trees on a given site at a given point in time, not a blanket no trees under any conditions. There is a danger of developing fixed ideas of what a site should look like (based perhaps on National Vegetation Classification communities) which could lead to the natural extremes of variation being excluded, with all sites being managed to look like what an average raised mire is expected to be. Consider a human example. It is possible to describe a mean height for British males, but there is a wide range of natural and interesting variation from jockeys to basketball players which would be lost if one only concentrates on the male of 'normal' height. Conservationists should be interested in the full range of natural variation not just 'typical' sites.

Palaeoecology and nature conservation.

Nearly all habitats in Britain are the result of thousands of years of human modification. This makes it difficult to define 'naturalness' (a concept given great importance by many conservationists) based on data from modern communities. Palaeoecology has a major rôle to play here. In the case of trees on mires it can be shown that such habitats have existed in the past in times when human impact on the environment was less. Another good example is the demonstration that many woodland herbs which have been used by conservationists as indicators undisturbed ancient woodland are in fact growing in woods which have been disturbed (including clear felling!) in the past (Willis 1993). A more detailed discussion of the rôle of palaeoecology in conservation is provided by Huntley (1991).

References

‘A real farmer’ 1768. *The modern farmers guide. Vol. II.* Edinburgh.

Bennett, K.D. 1989. A provisional map of forest types for the British Isles 5000 years ago. *Journal of Quaternary Science* 4, 141-144.

Bunting, M.J. & Warner, B.G. 1998. Hydroseral development in southern Ontario: patterns and controls. *Journal of Biogeography* 25, 3-18.

Geikie, J. 1881. *Prehistoric Europe.* Edward Stanford, London.

Huntley, B. 1991. Historical lessons for the future. In Spellerberg I.F., Goldsmith F.B. and Morris M.G. (eds.) *The Scientific management of temperate communities for conservation.* Blackwell, Oxford.

Lyell, C. 1832. *Principles of geology. Vol II.* John Murray, London.

Slater, F.M. & Wilkinson, D.M. 1993. The peatlands of mid-Powys - a literature review and preliminary description of new sites. *Brycheiniog* 26, 17-41.

Walker, D. 1970. Direction and rate in some British hydroseres. In Walker D. and West R.G. (eds.) *Studies in the vegetational history of the British Isles.* Cambridge University Press, Cambridge.

Willis, K.J. 1993. How old is Ancient woodland? *Trends in Ecology and Evolution* 8, 427-428.

Paper 2.3: When are trees natural on bogs?

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The conventional view of ombrotrophic bogs in Britain is encapsulated in those magnificent aerial views of the Flow Country, which show a vast, treeless, patterned-mire landscape. Such views became famous in the late 1970's after being depicted on the posters that accompanied the campaign of the Nature Conservancy Counci1 (1987) against the ploughing-up of the Flow Country mires and their planting with conifers. The outcry against the destruction of pools and flarks, hummocks and hollows, and their supposed characteristic plant assemblages, created in the minds of many a vision of a pristine, treeless landscape as the 'natural' bogland of Britain. That vision has, perhaps unconsciously, been transferred from the Flows to bogs elsewhere, to create an idealised bog landscape. It conjures up an image of what the degraded, cutover and birch-infested raised bogs of Britain *should* be like, and a similar idealised image is sometimes applied to the depauperate eroding upland blanket mires of England and Wales. The 'treeless' wet *Sphagnum* bog is now both an ideal and a perceived 'norm,' but it is very far from the present state of many bogs in Britain and Ireland.

Today, no-one would seriously dispute that the serried ranks of conifers that resulted from the planting of the Flow Country mires are anything other than echelons of aliens in a despoiled landscape. Those trees are certainly not 'natural' on those bogs. The question remains though, as to whether all British bogs are naturally treeless (cf. Chambers 1996)

The continental evidence

On the European continent it is commonplace to find trees growing on bogs. This is manifestly the case in Finland - a landscape that is dotted with thousands of lakes, many of which are separated by forested (or 'treed') bogland. It is also true of Estonia - a country with an even higher proportion of mires than Ireland, the archetypal 'bog' country: some 22.5% of Estonia is clothed in mires (Orru *et al*. 1992; Ilomets 1996), many of them (bogs and some fens) part-covered with trees, particularly pines. There, 'open' mires are distinguished from wooded mires (10-20 trees/100m^2) and mire forests (>20 trees/100m^2) (Aaviksoo *et al*. 1997). Bogs in the east have a greater antiquity; nevertheless the raised bogs in the west are well-developed and their plateau-bog centres do tend to be open (treeless, even) in character, but with bog-pine forest on the margins.

The 'British' view

It is somewhat curious that, in Britain, the conservationists' view of ombrotrophic bogs should typically be one of a vast treeless expanse of soggy moss. It is, however, largely a 'mental image' of what bogs should be like: in reality, many raised bogs today are cutover, drained, with a depauperate moss flora, some even devoid of *Sphagnum*. Those that are now being managed for conservation have in recent years become a mass of dwarf (though not *the* dwarf) birches colonising a damp and allegedly drying carpet. Many upland blanket mires are similarly *Sphagnum*-deficient, and are presently dominated by either cotton sedges, purple moor grass or ericaceous shrubs; some are severely eroded. The reality, then, does not match the mental picture of what a bog should be.

Eriophorum angustifolium **Broad-leaved Cotton-grass**

The culprit is assumed to be human interference, primarily on raised mires through draining and cutting; and for blanket mires, through overgrazing, burning, or perhaps (especially in the Pennine mires) air-borne pollution. This idealistic vision of what bogs should be like, strongly influences management plans for degraded boglands: trees are the villain. Allegedly, they draw water out of the bog in vast quantities; they shade out bog plants; and their litter militates against the continuance or re-establishment of bog moss.

Trees should be removed, or the bogs will dry out. So, the question naturally arises: how do the bogs on the continent continue to survive, often with large pools of open water, when those bogs naturally also carry trees, at least in part; whereas, the bogs of the Britain allegedly cannot cope with (nor, according to many conservationists, should they ever have any) trees on them? Indeed, is this view correct? Have bogs in Britain, or Ireland for that matter, ever naturally supported trees?

Evidence for trees on bogs in the past

One way to answer this question is to look at the palaeoecological evidence for the development of British and Irish ombrotrophic mires, and to see whether there is any evidence for trees ever having grown on bogs. In doing so, we find there is abundant macrofossil evidence for trees having grown in the past in areas that are now bogs: many lowland mire sites have their 'bog oaks' - often, large well-preserved timbers showing that trees formerly grew. Sometimes the 'bog oak' is not oak - it might be yew, or pine. Nevertheless, there is undoubtedly evidence that oak itself formerly grew in lowland mires in the British Isles: much of the 7,000-year Belfast oak dendrochronology is compiled from bog oaks (Baillie 1995) - although whether when those mires carried oaks they could really be classified as ombrotrophic is another question. Indeed, at some sites, the oaks were growing toward the periphery of sites, and clearly not in truly ombrotrophic conditions.

There is, however, at a whole series of sites - whether of blanket mire in western Ireland, or Former raised mire in England - evidence of there having been pine trees on bogs. Many of these pines would seem to have grown when the bog *was* in an ombrotrophic state. At some sites there is considerable longevity of individual mire-rooted pines: for example, a large pine with 339 years of tree-rings was uncovered at White Moss, Cheshire (Lageard *et al.* 1999). In Ireland, periods of pine growth at different sites seems to coincide: there are episodes centred on 6000 BC and 3000 BC (Pilcher *et al.* 1995). In Humberside, there are several episodes of mire-pine growth (Boswijk, pers. com.), but also periods when pines were scarce or even absent. New techniques have been devised to detect and record the pine macrofossils (Lageard *et al.* 1995) to produce 3-dimensional plots of their distribution in the peat. Such plots typically show 'layers' of pines, implying contemporaneity of growth. Dendrochronology can sometimes demonstrate that this was indeed the case (Pilcher *et al.* 1995).

The evidence would appear to show that for some individual mires, discrete episodes of pine colonisation have been a feature of their history. However, there remains this belief that British and Irish bogs 'should not' carry tree growth. The basis for this belief may be a combination of factors:

- The compelling images of the treeless Flow Country mires.
- The treelessness of upland blanket mires.
- The claimed prehistoric demise of Scots pine from Ireland (and so no pine trees could subsequently [nor should now] grow on bogs).
- The scant evidence for mire-pine growth in historical times in Britain.
- The relative absence of trees (other than scattered birch) from the 'best' examples of remaining raised mire in the country.

Limits to tree growth?

In considering the growth and ontogeny of raised mires, it is worth contemplating whether there is a point beyond which such mires will *never* carry trees. This view seems implicit in schematic models of how a raised bog develops (e.g. see Moore and Bellamy 1974). In theory, as the 'groundwater mound' (Ingram 1982) becomes elevated above the surrounding landscape, the bog will acquire a raised, wet centre and a drier sloping margin, or 'rand.' The centre is treeless, although some trees might grow on the slopes of the rand. In envisaging how raised bogs develop in Estonia, the model (Masing, in Aaviksoo *et al.* 1997) typically envisages trees formerly covering the bog, but in time, those growing on the wet centre would be sparse and stunted, whereas those on the margins would be taller, better-grown specimens. In a fully developed bog, trees might be absent from the central areas, but remain peripherally.

There is certainly a belief amongst many British conservationists that really wet *Sphagnum* bog will not support tree growth - that trees could either never become established there, or, if present on a mire undergoing restoration by artificially elevating water levels, that the trees will 'naturally' drown. The cohorts of dead pines at some re-wetted sites lend credence to this view. However, the reality of trees on some types of ombrotrophic bogs in the Baltic region would seem to deny the thesis that trees cannot exist on bog. If present on Baltic bogs, why not on Atlantic bogs? The answer, if there is one, might lie in the differing climatic regimes a more continental climate in the Baltic region, with long snow lie, and then warmer summers, compared with, in the British Isles, a largely wet and only intermittently frozen substrate in winter with little snow lie, warmish but moist summers, and with high winds, especially at the equinoxes. Perhaps the more continental climate regime is more permissive of tree growth on bogs, whereas a wet and windy Atlantic climate is inherently inimical to tree growth.

Climatic change

This climatic explanation is surely an over-simplification: exceptional individual years in either region might mimic the mean of the other. Furthermore, this explanation seems to presume that the climate is unvarying over millennia. Climate evidence from the bogs themselves denies this, and suggests a cyclicity of climate in the late-Holocene, some component of which appears to be solar-driven (Chambers *et al*. 1999) What the general model of raised mire development does not account for is the evidence in some bogs for repeated, but discrete episodes of pine colonisation. It is this evidence that suggests a link with changing climate (and of course was the basis for one of the first attempted divisions of postglacial time - the Blytt-Sernander scheme, which was based on the periodic abundance of tree remains in Scandinavian bogs: Blytt 1876; Sernander 1908).

If climatic regime is the explanation for the 'norm' of treeless mires in Britain, might changing climate explain the subfossil evidence for trees during particular episodes in the past? It might be speculated that tree growth on British mires takes place when the climatic regime makes a major excursion, for example in the periods *c*.4500-4000 BP and *c*.3200-2900 BP, or is particularly variable. Perhaps it should also have occurred during the historical times, but the (pine) inoculum was no longer here to provide the tree seedlings?

At present there is insufficient evidence to confirm this notion of a relationship between climate variability and tree growth on ombrotrophic mires in the British Isles; it remains an idle speculation. However, it is salutary to note the oft-repeated claims (e.g. in Houghton 1997) that, during the current century, global climate is changing at a rate unprecedented (allegedly) since the end of the last cold stage: could the current 'global warming' (howsoever caused) lead to the very conditions conducive for tree growth on British mires? What then of mire conservation? It might be flying in the face of the future climate to prevent tree growth on British bogs; the conservationist would be attempting vainly to keep the water level artificially high, while the forces of nature conspire to lower the water level and allow the march of trees out onto the bog. For conservationist believers in a human-induced, greenhouse-gas-forced global warming, there may be no future for treeless bogs in Britain! (Although this does beg the question as to what such supposed 'global warming' might mean for the British climate: warmer and drier is only one of several scenarios). However, for the sceptic, there may also be no escape from the trees in the immediate future: it may be no coincidence that tree growth on (admittedly degraded and cutover) British bogs is now so prevalent, whilst at the same time the latter decades of this century also mark the Contemporary Solar Maximum, which might be (at least in part) responsible for the recorded 'global warming'.

Blanket mires and raised mires

Ombrotrophic mires in the British isles have been classified principally into raised and blanket bogs. For many of the shallower upland blanket mires of England and Wales (and arguably also of the west of Ireland) their current treeless state is maintained by cultural methods of grazing and burning (Ingram 1995): grazing exclosures (as for example at Moor House and on the North York Moors) show that trees can and do colonise blanket mires in England in the absence of grazing and periodic burning. Indeed, much of the blanket mire itself might not be there but for human interference with woodland in prehistory (Moore 1975, 1993); and tree remains in Pennine peals attest to former woodland (Tallis 1975).

Raised mires in the British Isles have in historical times been grazed at low density, and some were burnt intermittently (Smout 1996), and so these practices might in part account for their relative treelessness during historical times. Without human interference one might expect trees on the rand, perhaps with sporadic forays onto parts of the plateau during episodes of warmer, drier climate.

Discussion and Conclusions

Wood (and other tree-derived) macrofossils attest to there having been tree growth on some of the bogs of Ireland and Britain in prehistory. Whilst some of this tree growth (particularly that of oak) may have been in conditions that would not be termed ombrotrophic, there is evidence for pine growth on individual ombrotrophic mires. Some of these episodes of tree growth appear to be contemporaneous between mires in different parts of the country (see, for example, Bridge *et al*. 1990; Pilcher *et al*. 1995; Chambers *et al*. 1997). It might be speculated that this mire-pine growth took place at times of highly variable climate, perhaps at times of pronounced solar maxima. These ideas remain to be tested. Indeed, if this climate-amelioration/mire-pine hypothesis were correct, then there ought to have been pine growth on mires in historical times during the Medieval Solar Maximum of the Early Medieval warm period - at the very least on the drier margins of bogs, and with more stunted specimens towards the central areas. However, whilst there is abundant evidence of continuous tree growth on Baltic mires, the evidence in historical times for periodic pine growth on raised mires in Britain and Ireland is completely lacking. In Ireland this is probably because the inoculum was already lost (pine apparently became extinct in Ireland in late prehistory) and so pine could not recolonise mires. In effect, the same limitations applied in much of Britain: pine had perhaps been lost from most of southern Britain, whereas, in the very far north, the pine range had already retreated south of the Flows (cf. Gear and Huntley 1990). It may be no coincidence that the bogs for which pine growth is today well-attested (and even conceded by some conservationists as being possibly 'natural') are the Abernethy mires, which are within easy reach of the inoculum of the Caledonian pine forest.

Whether ombrotrophic mires in the British Isles *should* be treeless is now a decision not for Nature but for the site manager. Whatever is produced as a result of site management will not be truly 'natural'. Plantations of pine on dry ground since the seventeenth century now mean that the pine inoculum is re-established over most of Britain. So, contrary to much conservation practice, perhaps we should accept that there should (or could) also be pine growth on some ombrotrophic mires in the 1ate-20th century during the current 'global warming' or 'Contemporary Solar Maximum'. Some site managers will not accept this, owing to the belief that trees should not be there and that if allowed to remain they will dry out the bog: in attempting to re-wet a drained bog, why make the task more difficult by retaining trees? However, it is worth site managers considering other options before arming themselves with weed-wipe and arboricide There are other cultural methods that might be applied to reduce tree 'infestation' on those mires that have been drained or cutover: they could perhaps be shorn of trees through a judicious combination of burning and light grazing. On the other hand, examination of both the palaeoecological evidence here, and the appearance of related mires in the Baltic region, suggests that the growth of some, albeit scattered or peripheral, pine trees might better approximate Nature than would a continuous expanse of treeless bog.

References

Aaviksoo, K., Kadarik, H. & Masing, V. 1997. *Aerial Views and Close-up Pictures of 30 Estonian Mires*. Ministry of the Environment, Tallinn.

Baillie, M.G.L. 1995. *A Slice Through Time: Dendrochronology and Precision Dating*. Batsford, London.

Blytt, A. 1876. *Essays on the Immigration of Norwegian Flora During Alternating Rainy and Dry Periods*. Cammermayer, Christiana.

Bridge, M.C., Haggart, B.A. & Lowe, J.J. 1990. The history and palaeoclimatic significance of subfossil remains of *Pinus sylvestris* in blanket peats from Scotland. *Journal of Ecology* 78, 77-99.

Chambers, F.M. 1996. Bogs as treeless wastes: the Myth and the implications for conservation. In Parkyn, L, Stoneman, R.E. and Ingram, H.A.P. (eds.) *Conserving Peatlands*, CAB International, Wallingford, pp. 168-175.

Chambers, F.M., Lageard, J.G.A., Boswijk, G., Thomas, P.A., Edwards, K.J. & Hillam, J. 1997. Dating prehistoric bog-fires to calendar years by long-distance cross-matching of pine chronologies. *Journal of Quaternary Science* l2, 253-256.

Chambers, F.M., Ogle, M. & Blackford, J.J. (1999). Palaeoenvironmental evidence for solar forcing of Holocene climate: linkages to solar science. *Progress in Physical Geography* (in press).

Gear, A. and Huntley, B. 1991. Rapid changes in the range limit of Scots pine 4,000 years ago. *Science* 251, 544-547.

Houghton, J. 1997. *Global Warming: the complete Briefing*. 2nd edn. Cambridge University Press, Cambridge.

Ilomets, M. 1996. Temporal changes of Estonian peatlands and carbon balance. In Punning, J.M. (ed.) *Estonia in the System of Global Climate Change*. Institute of Ecology, Tallinn. pp. 65-74.

Ingram, H.A.P. 1982. Size and shape in raised mire ecosystems: a geophysical model. *Nature* 297, 300-303.

Ingram, H.A.P. 1995. Conserving the cultural landscape? *Mires Research News* 1, 2-3.

Lageard, J.G.A.,Chambers, F.M. and Thomas, P.A. 1995. Recording and reconstruction of wood macrofossils in three-dimensions. *Journal of Archaeological Science* 22, 561-567.

Lageard, J.G.A., Chambers, F.M. and Thomas, PA 1999. Climatic significance of the marginalisation of Scots pine (*Pinus sylvestris*) ca 2500 BC at White Moss, Cheshire, UK. *The Holocene* 9 (in press).

Moore, P.D. 1975. Origin of blanket mires, *Nature* 256, 267-269.

Moore, P.D. 1993. The origin of blanket mires, revisited. In Chambers, F M (ed) *Climatic Change and Human Impact on the Landscape*. Chapman and Hall, London, pp. 217-224.

Moore, P.D. and Bellamy, D. 1973. *Peatlands*. Elek Science, London.

Nature Conservancy Council 1987. *Birds, Bogs and Forestry, The peatlands of Caithness and Sutherland*, Nature Conservancy Council, Peterborough.

Orru, M. Shirokova, M. and Veldre, M. 1992. *Eesti Turbavarud*. Tallinn. (in Estonian, with summaries in English and Russian).

Pilcher, J.R., Baillie, M.G.L., Brown, D.M., McCormack, F.G., MacSweeney, P.B. & McLawrence, A.S. 1995. Dendrochronology of subfossil pine in the north of Ireland. *Journal of Ecology* 83, 665-671.

Sernander, R. 1908. On the evidences of Postglacial changes of climate furnished by the peat mosses of Northern Europe. *Geologiska Foreningens i Stockholm Forhandlingar* 30, 467-78.

Smout, C. 1996. Bogs and people since 1600. In Parkyn, L., Stoneman, R.E. and Ingram, H.A.P. (eds.) *Conserving Peatlands*, CAB International, Wallingford, pp. 162-167.

Tallis. J.H. 1975. Tree remains in southern Pennine peats. *Nature* 256, 482-4.

Narthecium ossifragum **Bog Asphodel**

National perspectives on the need for tree and scrub removal

The Scottish Perspective

Neil Wilcox

Of the total resource of primary bog (not including archaic bog), 50% supports woodland, most of which is plantation. Flanders Moss is perceived as being the 'best' bog but only one third of it is in a natural state. 30% is scrubbed over with a dense canopy of birch and pine; centuries of cumulative damage have resulted in conditions for scrub invasion. However, the common opinion is that if we get the hydrological conditions right, the scrub will go. This is probably an over-simplification as there is no evidence on SWT sites that raising of the water table results in the decline of scrub.

On all Scottish Wildlife Trust reserves the ditches have been dammed, but it almost seems as if scrub invasion increases following this. It is possible that on drier sites which have been colonised extensively by heather, there are no niches for tree seedling establishment. We are now stuck with a programme of scrub removal as we have gone as far as possible with raising water tables. We now need to work on ground water mound reconstruction, in conjunction with scrub removal using radical means, even considering options such as use of helicopters.

On Cander Moss, there are areas of extensive pine and birch invasion. However, the part of the site which has been grazed has little or no encroachment there. This may give an indication towards possible management to limit scrub invasion - maybe we should be grazing more of our bogs.

Many bogs were traditionally burned resulting in very close heather, leaving no regeneration niches for scrub. Therefore, past management is very important in determining the extent of encroachment and also the character of the bog surface. Conservationists tend to want to avoid drastic management such as burning or grazing on peat bogs, but whether we like it or not, our bogs are shaped by their past management and we may need to consider introduction of grazing and / or controlled burning.

The English Perspective

John Bacon

Perhaps the most important point to be made regarding the extent and need for scrub removal, is one of perspective - is scrub a problem to be controlled or is it an asset to be managed? Whilst it is tempting to bury one’s head in the sand and hope the problem will go away, it does not and needs to be confronted and dealt with.

Of course, scrub is an almost universal problem, not just on raised bogs but on many habitats such as calcareous grassland, fens in East Anglia, the edges of the meres and mosses and many heathlands. Without grazing it can become impenetrable and the longer it is left, the more costly it is to remove. It is important to remove before major and irreversible changes occur to botanical communities. Often, many semi-natural communities have been lost or degraded when it is left too long before implementing management. In many cases, fire was a natural antidote to scrub invasion and formed a natural control.

Does the scale of the scrub and eventually tree invasion change the perspective? With regard to management techniques, this must be the case. Catching it young, we can use methods such as weed wiping or even seedling pulling, but as it gets bigger and bigger, the solutions have to become more technical and more expensive.

We can never really relax attitudes towards scrub and to reflect this the inter-organisational 'Forum for the Application of Conservation Techniques' has just decided to make it one of its three major problems to tackle. The aim is to find and develop ways of managing scrub that:

- Enable large scale control at an economical cost.
- Use techniques that avoid having to return time and time again to recut the same old coppice stumps.
- Use techniques that rely less heavily or not at all on herbicides, so that they can be more environmentally friendly and sustainable.

The experience in terms of both successes and failures at Fenn’s and Whixall NNR has been an important element in concentrating thoughts and developing ideas for the future approach.

The Welsh Perspective

Andrew Ferguson

What follows is a list of selected raised bog sites in Wales, some of which have a scrub problem, some of which do not. Not all of the sites are managed to control scrub.

Arthog Bog
The extensive rhododendron problem was tackled ten years ago, then left. For the past three years it has been dealt with using BTCV labour, local contractors (at £2,000 per annum) and CCW workers (5 man-days per annum). This will be ongoing for the next five years at least. Bushes are now removed and the stumps treated with glyphosate. The main thrust is seedlings being uprooted by hand. Birch scrub is developing in the ungrazed one-third of the site, but regeneration of rhododendron is the biggest problem.

Cae Hopcin
A site beset by many problems including drainage, fire and a peat extraction licence.

Cleddon Bog
Birch, alder and willow scrub developing, with no control implemented yet. There are hydrological problems caused by forestry roads and tracks diverting the water and this needs to be tackled first, before the scrub control.

Site	Scrub control	Area	Status	Main Comment
Arthog Bog, Meirionydd	Yes	20 ha	SSSI	Extensive Rhododendron regeneration. Cattle grazed. Contact Annie Seddon, CCW 01341 423750
Cae Hopcin, West Glamorgan	No	4 ha	-	Massive scrub problem. Contact Ian Morgan, CCW 01558 822111
Cleddon Bog, Monmouth	No	8 ha	SSSI, LNR Common	Hydrological and scrub problems. Contact David Worral, CCW 01222 485111
Cors Caron, Ceredigion	Yes	670 ha	NNR	Peripheral scrub encroaching at 12 ha per year. Contact Paul Culyer, CCW 01974 298480
Cors Fochno, Ceredigion	Yes	600 ha	NNR, part Common	Dense scrub in areas. Contact Mike Bailey, CCW 01970 828551
Cors Goch-llanllwch, Carmarthen	Yes	30 ha	NNR	Ditches have been dammed. Localised birch. Contact Steve Lucas, DWT 01269 594293
Craig y cilau, Brecknock	No	2 ha	NNR Common	Well-grazed so no scrub. Contact Richard Preece, CCW 01873 857938
Crawcwellt, Meirionydd	No	85 ha	-	Limited grazing, no scrub problem. Contact Annie Seddon, CCW 01341 423750
Esgyrn Bottom, Pembrokeshire	No	10 ha	SSSI	Dehydration a big problem - scrub is developing. Contact David Lloyd Thomas, CCW 01348 874602
Fenn's & Whixall, Clwyd	Yes	700 ha	NNR	Birch control. Contact Joan Daniels, EN 01948 880362
Gogarth, Meirionydd	No	10 ha	SSSI	Cattle-grazed. Rhododendron is a problem. Contact Fiona Walker, CCW 01341 423750
Illtyd Pools, Brecknock	No	?	SSSI Common	No scrub problem. Contact John Clarkson, BWT 01874 625708
Llay Bog, Clwyd	No	0.3 ha	SSSI	Nutrient input. Overtaken by woodland. Contact Morwenna Bolas, CCW 01352 754000
Nelson Bog, Rhymney Valley	No	8 ha	SSSI Common	No grazing - scrub increasing. Contact David Worral, CCW 01222 485111
Rhos Goch, Radnor	Yes	15 ha	NNR	Light common grazing. Extensive birch. Contact Andrew Ferguson, CCW 01874 730751
Vicarage Moss, Clwyd	No	5 ha	SSSI	Limited grazing, scrub not developing. Contact Morwenna Bolas, CCW 01352 754000

Cors Caron
The majority of the area is under agricultural tenancies. There are severe birch and willow problems, with encroachment at the rate of 12ha per year - it is almost impossible to keep up with this rate, which is probably increasing. About 30ha have been cleared since 1985, including everything from seedlings to dense stands of mature trees. There is still 200ha left to clear but control is not keeping up with encroachment. Methods include raising the water table with bunds and ditch blocking, pulling seedlings, felling and uprooting with a Bogmaster. Herbicides used include Roundup and Amcide on cut stumps but Roundup is the most effective. Krenite has been used on birch and willow regrowth, to great effect. The main recommendation is to pull seedlings whenever and wherever possible!

Cors Fochno
Birch, willow and rhododendron cover about 4% of the site. Accidental fires have given some control but may also have helped to increase the scrub. There is currently no grazing on site, hence the spread in scrub. Scrub control is limited to the edges so far. Standing trees are killed by injection while denser stands need to be cleared off site, with stump treatment. At present management runs to £3,500 per annum plus 20 man-days from CCW staff to cover about 2ha of dense scrub. This present annual input is keeping up with the encroachment. It is an important point to note that if this is not achieved, then scrub clearance is not worth carrying out.

Cors Goch-llanllwch
Access is the biggest problem here. Ditches were dammed in 1991 and the brief hydrological monitoring has now been discontinued. There is a railway line bisecting the site which is lined with birch acting as a seed source. Birch covers about one hectare of the site which has been part cut but not treated in 1996/7. This was probably a wasted effort as there will be rapid regrowth.

Craig y cilau
Three small exclosures show scrub development - this simple monitoring shows how grazing is helping to combat scrub invasion. The dome on this site is very clearly defined.

Crawcwellt
There are a number of owners of this site, about half of whom have signed up into the Tir Cymen scheme. The stocking rates within the scheme are 3.3 ewes per ha maximum which is probably too high; the scheme needs a special category for this habitat.

Esgyrn Bottom
Drying out on this site is demonstrated by tall *Calluna* and *Molinia* caused by peripheral drainage. Scrub is developing with some willow and rhododendron, but this is not yet a serious problem. Grazing is needed on this site.

Fenn's and Whixall Moss
This site is discussed elsewhere in depth in this report.

Gogarth
Willow and birch could become a problem along with rhododendron which is the main current problem.

lltyd Pools
There is relatively heavy grazing on this site and therefore no scrub problem.

Llay Bog
This is grazed intermittently when dry enough, but it is gradually becoming invaded by birch and alder woodland.

Nelson Bog
This site is on the edge of an area tipped by British Coal. The amount of willow is increasing but the best means of control has not yet been determined.

Rhos Goch
The site is grazed but this has virtually no effect on the raised bog; stock remain in swamp and marshy grassland, not moving onto the raised bog area. A fire in 1959 encouraged dense birch to spread across the site. Removal of birch commenced in 1987 and has continued since. About 8ha have been cleared by felling, treating stumps with glyphosate and airlifting out the main timber. Another technique tried is notch treatment of standing trees (costs £800/ha on contract). This is followed up by pulling seedlings and regrowth treatment with glyphosate and Krenite foliar and stump treatment. The costs are approximately £4,000 including the helicopter and chemicals, plus 50 man-days to achieve 2ha clearance each year plus keeping up with the cleared areas by pulling and weed wiping. Low-ground-pressure vehicles were used but surface damage encouraged more birch seedlings and damaged the pools. The present annual rate of clearance is more than keeping up with encroachment. Pulling seedlings is vitally important for success.

Vicarage Moss
This site is grazed only when dry enough. There is no other management. Willow is present but does not appear to be a problem.

Discussion

Chaired by Roger Meade

There are several points which can be summarised from these presentations:

1 There is certainly a link between past management and scrub invasion.
2 Where there is dense heather on drier sites, there is reduced or very little scrub invasion.
3 It is important to know whether control keeps pace with encroachment.
4 It is essential to remove scrub as quickly as possible.

Peter Roworth: Bracken can also be problem on drier areas. We have used Asulox from a helicopter on an area of heathland. Perhaps what we need to know is what volume of water is removed by birch into the atmosphere.

Andrew Ferguson: If we can determine water uptake by different species, then we can prioritise which species to remove.

Mike Bailey: Has any work been done on nutrient input from pines on peat bogs?

Neil Wilcox: There has been research done on Flanders Moss under Hugh Ingram at Dundee University.

John Bacon: Evaporation rates from the bog surface can be 2" per week in hot weather.

Joan Daniels: On Bettisfield Moss there is 65% interception of rain by pines and the rain reaches the moss in a different pattern.

Frank Mawby: Mature heather probably intercepts as much rain fall as mature pine.

Joan Daniels: The problem with heather is that although we have extensive heather cover in some areas, we can't burn because of the presence of *Molinia* which burns out of control.

Frank Mawby: Sometimes where there is good heather cover, the cover of *Molinia* is reduced.

Colin Hayes: There is an additional problem of air pollution which has a detrimental effect on *Sphagnum* growth but also nutrient deposition from air pollution encourages tree growth and these two factors are probably synergistic in their detrimental effect on the growth of *Sphagnum*.

Peter Roworth: Birch is probably the least harmful tree on a peat bog - scattered birch can increase the surface humidity and encourage *Sphagnum* growth.

Frank Mawby: Perhaps the answer is to thin the birch rather than remove it altogether.

Joan Daniels: On Fenn's and Whixall, where we have scattered birch, we get dry land plants such as bracken and reduced bog flora.

Frank Mawby: I disagree with this - my experience is that it depends on the scattering of the birch - there can be a rich *Sphagnum* flora below scattered birch scrub although this can be variable.

Colin Hayes: Can others confirm that burning does stimulate birch?

Andrew Ferguson: There was a deep fire on Rhos Goch in the 1950's and now there are numerous 40 year old birches.

Frank Mawby: It depends on the time of year; winter burns are not too bad but summer burns can be very destructive as they often burn into the peat. Frequency is also very important with respect to burning.

Mike Bailey: There was a recent fire on Cors Fochno which just burned off the top layer and we are waiting to see the results of this.

Roger Meade: There is obviously a need to collate this information across the UK. We need to set up a working group to disseminate this information effectively. There is the Northern Peatland Link for England but nothing in Scotland.

Scrub control on Whixall Moss and Bettisfield Moss

Joan Daniels, English Nature's Site Manager

The aim of the field visit was to evaluate scrub removal plant and machinery in action, and to share management experiences from different sites. The philosophy behind scrub treatment is to do it before raising the water level by damming as subsequent access would be difficult. Raised water levels should stunt regrowth of birch, if not prevent it. Two sessions are usually required, firstly to remove tall scrub, then to pick off regrowth, seedlings or missed plants.

Tall birch scrub has colonised the old commercial cuttings and shorter scrub the uncut and hand cut areas. The recent commercial cuttings were stripped of scrub but had large areas of bare ground which rapidly colonised with birch and pine seedlings. In the past the peat cutters burnt the site to keep scrub at bay and minimise the accumulation of plant litter which could fuel summer fires.

Compiling a map of drains for the site was a high priority to know where machinery could be taken as well as dams located, as the irregular lay-out of hand cuttings makes site work difficult. The detailed knowledge of the Fenn's estate workers, ex-peat cutters, particularly Bill Allmark, has proved invaluable.

Retention of scrub

The first area visited had scattered mature birch amongst bracken. Although this is the worst possible scenario for the development of bog vegetation, this area is maintained in this state especially for teneral Odonata. Large heath butterflies also favour some scrub cover and a small amount of *Molinia*.

Bracken control

Bracken can be a problem on drier sites as it probably has high evapotranspiration rates. Where this is the case, a Bracken Breaker (a roller towed behind a mini-tractor) can be used. This bleeds the bracken, reducing the vigour by between one-third to one-half on each operation. Several acres can be covered in a day, although care must be taken to avoid adder populations. Bracken cover reduces once the water levels are restored.

Cutting birch mechanically

A cast-off Parmiter swipe from the Stiperstones was demonstrated. The birch seedling re-growth was up to waist height on the untreated part of this area. The swipe cuts the birch then a weed wiper is used to apply Roundup to the plants while they are still small.

The advantages of swiping are that it is quick and cheap, and can be used repeatedly to keep scrub small until the area is dammed. The Bush Hog is a particularly good make. There are smaller sizes and a small tractor (25hp) can be used. The disadvantages are that swiping can't be used on a very wet site; it is only a temporary measure and has to be repeated every four years; and it cuts other ground flora. Also, for this particular model, at least a 50hp tractor is required to pull it, 70-90hp is ideal.

On sites with few deep ditches or pools, grazing will tackle small birch very well. The only cost is temporary fencing and Hebridean sheep are very good grazers on birch sites. If they graze for just two years this will kill off the birch as they are quite happy to eat birch along with grass and heather (Frank Mawby and Peter Rawlinson).

Cutting and treating birch manually

Manual clearance of birch takes at least 4 person days per hectare. Hand kit includes protective trousers, brushwood cutter or chainsaw, stump treatment kit (a bucket in a bucket plus a paintbrush on a stick), first aid kit, eye protectors made up from safety specs worn under a chainsaw visor. Plastic visors mist up and air circulated visors are very expensive (£200) but worth it. To avoid the use of an open bucket, a spot gun which carries 5 litres of herbicide and has variable nozzles can be used, cutting down on the risk of falling over with an open bucket. Currently, Laurie Clarke is developing a brush cutter with a built in herbicide applicator.

The advantages of manual treatment is that the equipment is cheap and less damage will be done to the ground flora. The disadvantages are that it is labour intensive and discouraging on very large areas, and spills can happen with open buckets. Spot guns are used extensively and are very effective, but the operative gets hand ache.

Chemicals

Roundup is used at Fenn's for stump treatment, with a blue dye to indicate which stumps have been treated. It is not very effective on stumps below finger diameter, which poses a problem on fire coppiced birch areas. Short, whippy birch regrowth is treated either by spraying or weed wiping with Roundup Pro-biactive, which contains a wetter. Krenite can also be used for spraying but not weed wiping, as unlike Roundup, it is not systemic. Roundup can be sprayed from July to early September, whereas Krenite can be used from August to when leaves go brown.

Coping with disaster!

An area where new developmental machinery was tried was visited. Initially a tractor-mounted McConnel power arm fitted with a Hydrocut 1m diameter circular saw blade was used to fell 3-4m tall birch. The brash was removed using a buck-rake. Unfortunately the recutting of stumps and stump treatment was left too long, (1-3 months) and the birch regenerated. The tractor mounted weed-wiper was under development at the time, available as a 'wick' rather than 'carpet' wiper, and this was used to treat the regrowth with Roundup. However the wick-wiper did not apply enough pesticide, and the area had to be retreated when the carpet-wiper was developed. The buck-rake has proved invaluable in clearing brash so subsequent access for manual treatment of regrowth is safe, but the investment in the power arm is high and a large tractor is needed to counter-balance it. Experience has shown that a long arm on a Hymac can be useful on uneven ground.

A burning issue

At the next site, 3-4m tall birch had been uprooted by excavators, for burning. Unfortunately the peat around the root balls burnt for days, so the rest will have to be chipped unless there is heavy snowfall. One problem with burning at Fenn's and Whixall is the presence of *Molinia* litter which is easily ignited by sparks from bonfires. Drains have been blocked to provide a water source for spraying round and putting out bonfires at night. Burning sites are wetted in drier conditions by spraying water from the boom of an adapted Hardi 3-point linkage pesticide spraying tank. A Honda pump is used to pump large volumes of water from the blocked ditches to extinguish the fires. Large bonfires are burnt on tin sheets on the peat, but when the peat is saturated in winter, smaller fires are lit directly on the peat. Other examples of burning include straight on the peat at Thorne Moors and on tin sheets on breeze blocks elsewhere. If burning is managed properly, it need not affect the nutrient balance if ash is removed from the site. If timber and brash are stacked on peat, this can mineralise, creating problems. Burning of large trees is not practical.

Uprooting

The advantages are that it is mechanised and relatively cheap (4 man days per hectare + £500/ha) and a one man job if using an excavator dumper. The disadvantages are regrowth from missed seedlings and difficulty in burning the root balls. It is hoped to develop techniques for removing the top of the plant and the bud area of the roots, in effect leaving the roots in the ground, but removing the growing point.

Weed Wipers

Carpet wipers have now replaced wick wipers which didn't put enough herbicide on. The Allman Eco-Wipe Carpet Wiper has been used extensively.

Advantages are that it can be used in windy conditions as long as it's dry. Each carpet is independent of the others on its own skid so on uneven ground all weeds get a lethal dose. It can be used up to 0.8m above the ground surface. (N.B. The higher 'scrub' skids should have been available from Allmans since 1998). Generally 90% birch control is achieved using this equipment. The disadvantages are that sometimes the tops of the heather get taken out as well, and often the skids hit the stumps. There is a problem with manoeuvrability as it is difficult to move backwards. However, this is hopefully going to be overcome with a new design. The cost is £5,000 capital. Roundup Biactive is used at an application rate of between 1:4 to 1:10 on the wiper - this is at a lower concentration than the 'label' recommendation at a 10l/ha application rate. Funding is the biggest problem with big pieces of capital equipment such as this. John Bacon is currently working on setting up a 'machinery ring' for increasing the availability of machines from contractors and for site managers.

Tractor with tank and operator using a hand lance

Advantages: it is fairly cheap at £55-£80 per person day. Although the immediate operator requires a licence, workers below him/her do not. Disadvantages: hoods on the spray lances drip everywhere. A lot of water is needed for washing and mixing, but here we can't use the water on site as it is not clean enough to go through the nozzles. Also, the low pH may affect the brass fittings on the equipment.

Herbicide-free techniques

An area was visited with a good bog vegetation which is being kept as a herbicide-free zone. In 1992 the birch was cut and once again since then. There has been some regrowth of between 2-3 feet. Recutting is not an effective management technique. Other techniques include chainsawing into the peat, using a specially tipped chain, to cut the roots and this is works on wet peat, although it blunts the chainsaws on drier peat. Although in Holland there is a hypothesis that cutting three times for three years kills birch, experience has shown this to be untrue at least on British bogs.

Timber removal on Bettisfield Moss

Joan Daniels and John Bacon

Bettisfield Moss was cut off from the Fenn's peat body when the canal was constructed. The peat is up to 12m in depth and there are still remnants of bog vegetation in spite of extensive conifer invasion from an adjacent plantation; burning was used to prevent tree invasion, but when this stopped, Christmas trees were cropped for a while, after which invasion became particularly severe. Now, the extent of conifer invasion resembles a plantation, so the techniques to be used for tree removal are more akin to commercial forestry operations. Commercial contractors were asked to consider the site but they judged it to be too wet and it was likely that they would lose machinery. David Jones from the Forestry Commission's Technical Development Branch found a Swedish machine, the Vimek Minimaster, to attempt to do the job.

Demonstration of timber extraction

The aim is to remove tree and brash from a 56ha site without damaging the bog surface. A permanent brash track is being created around the perimeter of the site and the 1 ton 16hp Vimek is used to move brash. The advantage over a conventional tractor is its light weight and driven trailer, minimising damage to the surface. It carries a mini-crane with a 0.5 ton capacity lift and can extract up to one ton at a time. The cost is around £20,000. One of the biggest advantages is that it can go over very wet ground and as the trailer wheels are PTO[1] driven it is less likely to get stuck. The larger standing timber is being removed by sky-lining, so whole trees are removed to brashtrack and there is no problem of removing brash separately. The maximum size of tree which can be removed on a 5mm cable (as used in this demonstration) is one ton. The strength of the line can go up to 8mm which will carry 1.5 tons. This line can go out to 500m in length and the longest is on a Timbermaster which can reach 600m. For an anchor, choose a strong standing tree of at least 4" diameter. A Vimek is used to bring the trees to the winch, and can travel on pure *Sphagnum* for up to three runs. Removing many trees in one area can leave a groove in the bog, which can then act as a drain, but the rope can be dragged up to 20m either side of the winch giving a potential 40m wide clearance corridor. With two speed settings, an empty chain can travel back to the winch operator at around 30 miles per hour, maximising time efficiency.

At Wybunbury and Chartley Mosses, English Nature have used a Glencoe although at Wybunbury the *Sphagnum* raft won't support machinery so everything is done by hand and burnt on site. At Chartley, timber was laid every foot to make a brash track.

A co-operative project set up by David Jones between the Forestry Commission and Llysfasi College, is producing a successful system of sledging out the timber on a winched trailer, which was redesigned to take it onto the road; it can pull itself into the wood where the timber is loaded, then removing the timber to the vehicle. On the wettest places, the skids drop down although tree stumps are difficult to manoeuvre around, but greater ground clearance is being designed.

Dealing with brash

Two chippers were demonstrated: the Mighty Ripper which is on wheels and very difficult to manoeuvre. A 'tracked' modification to the Arboreater Chipper is available on request with a wishbone axle for wet, uneven ground. The cost is between £13-14,000 and this machine will chip brash, logs, soft wood, hard wood and rhododendron. The throughput is 20 cubic metres per hour which is a fairly slow operation compared with burning, but is preferable on dry peat. To hire, the cost is £180 per day with an operator.

To avoid the use of pesticide, whole birch trees can be cut out with their root balls. A Holmac treelifter was demonstrated. The Holmac was originally designed for digging up whole live trees for nurseries but this can be adapted to leave the roots in the ground. Currently the tracks are too narrow and the machine is too heavy for use on bogs, but it can be adapted to have wider tracks.

Marketing timber with Dai Lewis, Vimek owner

The clearance operation is being partly funded by timber sales. Straight 18cm minimum diameter in 7 foot lengths can go for motorway fencing and contractors will purchase this if available in at least 24 ton lots. Bent red logs are no use; green bars can go for pallet making. Smaller diameter timber can be used for fencing stakes but below that it just goes for chipping. It is also very important to shift the timber as quickly as possible; after four weeks, blue-stain fungus sets in and when infected with this, stored timber can only be used for pulping and even then only by certain mills.

[1] Power Take Off (PTO) is via wheel drive.

Evening slide shows and informal talks

Not Just Neglect

Invertebrates & scrub management
David Sheppard

Scrub is often thought of as a near monoculture of mature shrubs with almost no ground flora, slowly progressing towards poor secondary woodland. This is true of abandoned scrub but a properly managed scrub system is nothing like that, being a dynamic equilibrium of an uneven aged, but predominately low, open-structured canopy of shrub and tree species over a mosaic of partially shaded and exposed ground floras. Its presence does not indicate poor or improper management but its absence suggests a stressed, over-grazed site subject to blinkered management attitudes.

Features of a Managed Scrub System

- Shelter: scrub provides shelter from wind and rain. Insects can be active for much longer periods than is possible on an over-grazed site.
- Warmth: insects need to absorb warmth from the air in order to raise their body temperature sufficiently. Scrub provides sun-traps so that vegetation warms up quickly and stays warm.
- Continuity of conditions throughout the day: scrub provides suitable conditions throughout the day, not just for a few hours while the sun passes.
- Structure: scrub provides a variety of physical structure from exposed soils and short turf through tussocky grassland, tall grass and herb stands, low shrub canopy and occasional standard trees. All occur in a mosaic which is very important for wingless or weakly mobile species.
- Edges/Ecotones: insects like junctions between differently structured vegetation, although it often does not matter much which vegetation is represented. Scrub has edges everywhere in a variety of habitat combinations.
- Continuity of habitat from year to year: scrub is basically the same from year to year. In this it differs from a coppice system where the ground flora is periodically suppressed until the cutting cycle is repeated, or the shrub layer removed abruptly and over a large area, regenerating evenly and densely. A managed scrub system supports habitat features which are represented every year, usually close to where they were the year before.
- Food / Prey: scrub systems encourage a great variety in vegetation structure, plant species composition, growth stage, age & orientation. etc. Consequently there are lots of food sources for the herbivore fauna. The variety of shelter, edges, food etc. encourages lots of predators and parasitoids as well.
- Territory and Mates: territories are defined by physical markers. These are rare in a heavily grazed grassland but are in plenty in a scrub system. Other marker plants provide vantage points for territories and landing pads for courtship, copulation or to check on the passing possibilities and competition.
- Needs of the entire life-cycle: unlike in the suppressed and stressed environment of an over-grazed grassland, scrub provides the needs of the entire life-cycle from oviposition sites, larval/nymphal host (plant or animal), adult food, dormancy/ hibernation sites, territory markers and mating areas.

Restoration of Abandoned Scrub

Check for shade demanding vegetation before removing large areas of shrubs or trees. Cut in at the edges, forming deep scallops. Cut wide paths through a scrub block and form glades within the scrub block. Always follow up with grazing/browsing by stock suitable for the highest quality of natural heritage landscape. Allow 10% regeneration.

Management of a Scrub System

Weed out unwanted species e.g. Turkey oak, sycamore. Cut out those bushes needed for other management or whose timber is saleable. Cut out single bushes or groups of bushes in an otherwise random pattern. Thin out large or coalescing stands and introduce suitable grazing animals (i.e. appropriate old breeds of sheep, cattle, goats). Do not use soppy downland breeds or those bred for fattening on degraded agricultural land. Maintain a varied age class of shrub and tree species. Practice raging ad-hockery whenever possible!

Summary

- Scrub is a natural part of grassland ecosystems.
- Managed scrub is a sign of a dynamic living grassland.
- Scrub will improve most sites, not cause them to deteriorate.
- Control of scrub is not possible, management of scrub is the challenge.

Restoring Blakemere Moss

Peter Rawlinson

In forestry terms, the Delamere resource is a very low productivity area as it is small, being only 1,000 acres; however, it is a huge tourist resource and is visited by anywhere between 250,000 to 500,000 visitors per year, creating pressure on the area. In addition to this, drainage on the site is problematic and stands of trees were dying due to blocked culverts and high water tables. As a result of this, it was decided to attempt to restore Blakemere Moss to wetland. This was set as a deliberately loose objective as it was uncertain as to how much water would be held on the site and also the quality of the water could not be predicted. The peat depth at Delamere has not been measured but is about 2m, overlying deep lake sediments. *Drosera rotundifolia* and *Vaccinium oxycoccus* are present in the ground layer together with *Erica tetralix*, and *Sphagnum* showing the presence of wet heath and bog species in the ground layer at Blakemere.

Mature hemlock died due to waterlogging (as a culvert was blocked) and therefore was uneconomic for the Forestry Commission to remove, so this was treated as a conservation exercise, rather than an economic one. 4,500 tons of timber was harvested leaving 3,000 tons of brash and residue. The felling took place over three months, together with a public relations exercise resulting in no complaints from the public. The timber was sold standing, fetching £6 per ton as it was low quality. Brash and residue was the biggest problem. It was decided to take this off with a harvester. The Forwarder carries 10 tons and weighs 16 tons so pools were avoided. There were problems in the damp areas as the harvester started to sink due to its weight but managed to remove most of the brash. 300 brash heaps were left to burn on site. After just one small fire an abatement order was issued from Vale Royal District Council against any further burning. An advisory group was set up with officers from Vale Royal and in the end all of the brash was burned.

Ditches within the site are thought to originate from Napoleonic times. The ditches hold water, so sluices were installed. Once the sluice is boarded, there is potential for the water levels to change although it is uncertain as to how much water the site will hold. Whatever happens, it is certain that this scheme will have a significant impact on the conservation value of Delamere Forest. There is a tentative hope for around 0.5ha of open water and a visitors centre is planned.

Wem Moss: problems & solutions

John Tucker

The southern drain on Wem Moss was deepened in 1985, after culverting the previous year. Prior to this there was a good wet bog flora with *Rhynchospora alba* and extensive stands of *Eriophorum* on the south side of the moss. Extensive birch invasion on the north side of the moss followed, with an increase in birch cover on the moss over the last ten years.

The birch invasion was so severe, Krenite was used in 1986. Krenite killed off everything under the birch including *Calluna* and *Eriophorum*. Unfortunately the birch survived.

In a desperate attempt to ‘follow the water down’ we dug pools, producing ‘floating’ turf with *Drosera* species on it following excavation around to bring up the water table locally.

There was more drain clearance in 1987. The southern drain was deepened to over 6 feet.

Questions:

Frank Mawby: There is a licence for krenite for use on certain species - perhaps the licence needs to be changed via MAFF. There is a possibility that the mix was not right as I've used krenite extensively and it has always been most successful.

Peter Roworth: I've found some kill on *Eriophorum* but generally it is most effective on birch. Perhaps the wetting agent caused the scorching and death of other species. There is the thought that there may be other ways of applying it, for example can we use aerial spraying - this would certainly be worth the research with proper trials there are many site managers who cannot get onto the site with vehicles.

John Bacon: Many of the existing trials for krenite and other chemicals are forestry based therefore there are no details of the effects on the ground flora in any of the sales literature. We need more trials, as there is obviously some difference in the experience of results from krenite.

Research on the restoration of blanket bog

Russell Anderson

There are extensive areas of commercial forest planted in the Flow Country and there is concern that plantations are drying out adjacent features and habitats in wetter areas. A thirty year old crop of conifers can have effects on an adjacent peat bog for up to 40m out onto the active bog surface. The aim of the experiment was to determine the most cost effective way of treating forest edges to prevent drying out of adjacent bogs, and also to determine effective restoration treatments for the forest margins. The plot sizes were 100m wide on a 40m strip of forest edge and there were six replicates:

- Treatment 1 - fell and leave.
- Treatment 2 - fell and move by hand.
- Treatment 3 - leave trees standing.

A further treatment involved either damming or not damming the plough furrows.

Dipwells were placed in the furrows to monitor ground water movement. Invertebrates and vegetation are also monitored. Although the plots were only set up early in 1997, already there are distinct changes taking place.

Severely cracked peat under the plantations at present appears as if it cannot be rewetted by damming although this may be a gradual process.

Questions:

Frank Mawby: In Ireland a mole plough has been adapted to put in a plastic membrane to cope with very badly cracked peat that is difficult to rewet.

Resource allocation

Frank Mawby

The management of peat bogs is necessarily capital and labour intensive and this means that one of the most difficult parts of any comprehensive peatland management programme is the allocation of what limited resources there are.

Black Snib in Cumbria is notified as a SSSI and measures 60 acres in total with 30 acres on deep peat. The owner had deep drained the site in order to replant with conifers after felling a mature crop. A management agreement cost between £40-50,000 while the actual management of re-damming, felling and either chipping or windrowing into drains and spraying with krenite cost a further £60-70,000.

Unsprayed birch scrub grows slower on deeper peat with 6-7 feet regrowth in two seasons from a substantial tree. The damming has been very successful, with good regrowth of *Sphagnum.*

Glasson Moss is an excellent site. Management here after a summer fire has involved cutting down birch and treating the regrowth. There are areas of prime bog surrounded by cut areas. These primary surfaces should receive most of the funding.

Questions:

Tim Jacobs: We do need to maintain regional bog types so we need a spread of resources to maintain the whole scope, not just concentrating all the resources into a few key areas. This is actually stated in SSSI guidelines.

Roger Meade: Probably the most contentious sites have the most resources and these hold the line for all SSSI bogs.

Colin Hayes: The Lowland Peatland Programme came up with a prioritisation, and I think we all assumed that there would be the cash to back up these priorities.

Frank Mawby: One of the most frustrating things in peatland management is the amount of money spent on controlling birch, when it should be spent on more ambitious proposals such as buying up agricultural land and creating lagg fens and generally recreating the hydrology of the site so that birch wouldn't be a problem.

Roger Meade: MAFF are currently examining agri-environment schemes for integration into conservation but this is totally voluntary.

Peter Rawlinson: As there is only so much money, can't we divide a site up into 'coupes,' coppice it and sell the birch? The general consensus was that there is no market for birch but there could be some investigation into the possible uses and marketing of birch products.

Management on Rhos Goch

Andrew Ferguson

Rhos Goch NNR, Radnorshire, measures 45ha in total with 15.5ha of raised bog which grades into lagg carr woodland with a transition zone into species-poor fen. Cattle graze the site but confine themselves mainly to the swamp area. Management problems are compounded by a well-developed hummock and hollow structure which makes it very difficult to get machinery on. There is dense birch woodland on the raised bog forming a W4c *Betula* - *Molinia* woodland, *Sphagnum* sub-community, compared to the ideal vegetation of M15 *Scirpus* - *Erica* wet heath, M25 *Molinia* - *Potentilla erecta* mire, M18 *Erica* - *Sphagnum* raised mire, M19 *Calluna* - *Eriophorum* blanket mire with M1 and M2b *Sphagnum* bog pool communities. When the birch gets over 0.5m high, management starts again to knock the birch back. One of the vehicles used was the Supacat, on hire from Traction Equipment (Stafford) Ltd (tel. 01785 223355). This is a six-wheel drive vehicle with a 1 tonne payload and a ground pressure of 3-5 psi. The cost is £729 per week including VAT and delivery. A disadvantage is that it cuts up the surface of wet bog vegetation and is susceptible to a high number of punctures. Although this level of damage could be acceptable on a cut over bog, on a primary bog surface, use should be considered carefully. We also used a Vee Pee, with a payload of about 0.5 tonnes; it produces surface damage, the tracks come off on stumps, it suffered gear box failure, got stuck in wet hollows and was slow in this terrain, so therefore not a great success.

Notch and inject Roundup treatment was used on the birch. The cost was £800 per ha which was done by a contractor, and 2ha were covered. Dead trees were left standing although these had to be removed eventually as they were unacceptable on aesthetic grounds. Notching produced an 80% total kill with 20% partial kill.

The timber was airlifted out in 0.25 tonne bundles, using a Jet Ranger helicopter capable of lifting 0.4 tonne maximum. It averaged less than 2 minutes per bundle and cost approximately £450 per hour flying including transit to site and return. It removed nearly 40 tonnes (2ha) of birch scrub, in 5.5 hours of flying time. There was no surface damage, but it is expensive and needs very careful planning and preparation. After the timber was lifted out the tops were burned, with the rest going to the commoners as firewood. This is very labour intensive but the commoners offered some help and it proved to be a good public relations exercise.

Managing Scottish peat bogs

Tim Jacobs

Flanders Moss measures 860ha in extent with a 40ha forestry plantation and an endotelmic stream[2] running through the centre of the site. There is a fen edge which borders onto an area of open water. Birch invasion dates from about 100 years ago, with very small stunted trees which are very lichen rich - we wouldn't dream of clearing these and this a point to bear in mind before adopting a blanket clearing strategy. Birch leaf beetle is present, resulting in a lack of birch growth in some years. In spite of this, birch control is carried out by felling and burning on raised sheets and also chipping fellings and brash. We tried lifting off bags of chippings using a helicopter but we would not use this again as it did not prove to be cost effective. Drilling and injecting was used to prevent regrowth from stumps.

Dams were installed to keep water on the site. Three dam types were used, metal, plastic and elm, with the plastic dams being by far the easiest to use. Fifteen tonnes of plastic piling were used for damming - we found that plastic dams would hold water back better if curved to give extra strength. The dammed ditches resulted in great mounds of *Sphagnum* around blocked ditches where the birch can't colonise.

Following damming of ditches, some conifers in the plantation looked very unhealthy, especially Sitka Spruce which cannot tolerate wet conditions. In contrast, Lodgepole pine which can tolerate wet looks very healthy. Lodgepole litter is very deep and we need to use whole tree extraction techniques to remove these.

Managing West Hay Moor

David Reid

This site is surrounded by commercial cuttings and deep ditches. A Visqueen membrane (very thick black plastic) was used on one side of the ditch, with clay on top and this holds back a 2m head of water. We could install around 100m per day. Where there is no drainage ditch we dug down with a Hymac about 4m deep and 5m long. The membrane was unrolled and pinned into place with clay on top and peat on top of that. This membrane now separates the nature reserve from Fison's cutting field. The Hymac costs £14 per hour including the driver. The local mill paid to take the trees off (£3 per cord) but they didn’t stump treat and didn't clear brash. Obviously we don't want to encircle the site with membrane, but this does help to keep the summer water on the site and this can be demonstrated graphically. When the membrane went in, the water levels rose. We can now pump water from outside of the reserve into the reserve, from where it drains off across the site.

[2] A stream which flows through the living peat dome, as opposed to a lagg stream which is marginal

Theme 3: strategic issues

Paper 3.1 Good neighbours as good friends? The spin-off of mire rewetting for neighbouring landowners.

Kevin Gilman

The importance of water in peatlands

- Peatland plants are adapted to adverse rooting conditions and a substrate that is often extremely nutrient-poor - a change in water quantity or quality can favour more vigorous competitors.
- Peat is nearly all water - a change in water content can bring about drastic changes in other physical properties.
- Peat consists of ancient organic material, protected from rapid decay only by water, which excludes oxygen.
- Control of water levels by the mechanisms of an undisturbed bog is very precise - about 10cm - bog restorers have difficulty in achieving this.
- Quality change can be brought about by a drop in water levels - release of nitrate.
- Water constitutes up to 98% of unhumified peat, but most of it is not drainable but is contained in intracellular pores.
- Other processes may cause or assist peat formation, e.g. acidity, nutrient poverty, low temperatures.

The aims of water management from the viewpoint of mire conservation

The two main zones in a mire are (i) the mire expanse, which is the central zone where the mire largely makes its own conditions; and (ii) the periphery, which is affected by surface stream, groundwater, mineral soils and development of adjoining land.

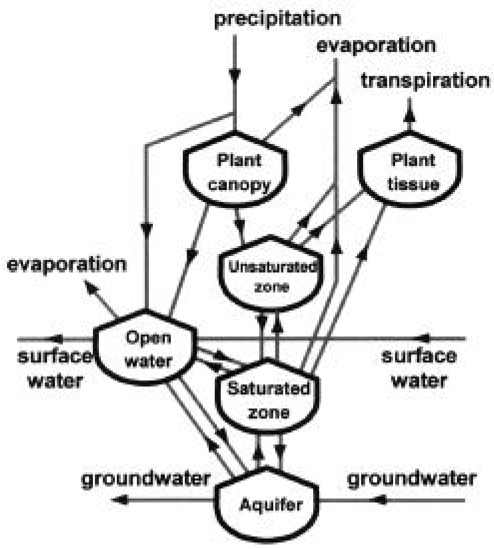
The aims are:

1 On the mire expanse, to mimic conditions found on an undisturbed and healthy mire by reversing the effects of human interference e.g. drainage and peat cutting

2 Around the margins of the mire to control or reverse the impacts of peripheral activities on the long-term integrity of the mire such as spray drift or lowering of regional water table. Also propagation of unfavourable conditions inward from the edge, e.g. dewatering, peat digging, eutrophication, seeding of unwanted species.

The mire water budget

Changes in the water budget can cause problems in the interaction of the mire with adjoining land. Drainage of mires tends to increase flood storage, wetting-up may do the reverse. Abstraction from aquifers for water can increase infiltration and lower the mire water table. Maintaining high water levels on the edge of the mire can impact on the drainage intentions of neighbouring land users.



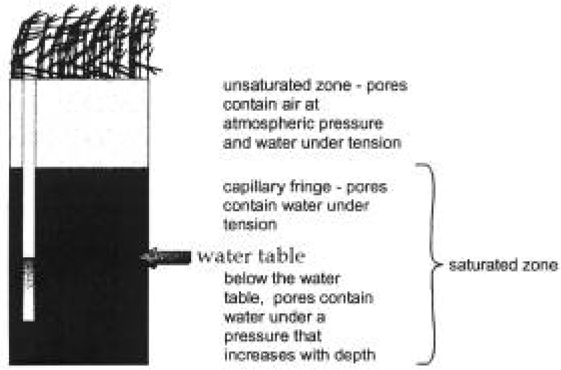
The mire water budget

- Not all mires have all of these components but it is unwise to assume that an inactive component could not become active in the future.
- In the Netherlands acid bogs are known to sit on sand aquifers without interaction until the piezometric surface is lowered by abstraction.
- Wetlands do not provide seasonal flood regulation, but at most short term floodwater retention.
- Draining creates fast channels to outflow but also increases the size of the unsaturated store - wetting-up reverses this.

Storage of water in peat

Peat is a complex medium, containing gas, liquid and solid and its complex physical behaviour depends on the interaction of these phases. Liquids do not normally withstand tension but in small pores this is possible as surface tension supplies missing forces across the curved meniscus. The water table can be defined as the surface at which pore water is at atmospheric pressure; a dipwell shows the position of the water table. The diagram (below) is very simplified and that gas bubbles, particularly air or methane, can exist in the saturated zone, but under pressure.

Storage of water in the peat



Hydraulic properties of a porous medium

- Permeability - this is defined as the volumetric flow of water through a unit area under a hydraulic gradient and is measured in units of either m/d or cm/s.
- Specific yield - this is defined as the quantity of water added to or removed from storage when the water table rises or falls a unit distance, and the units are non-dimensional fractions or a percentage.
- Permeability depends on the pore size and shape, and the presence of bubbles. It decreases rapidly with depth in the acrotelm - therefore horizontal flow on bogs is mostly in the acrotelm. In drained or cut-over mires there is no acrotelm so water flows rapidly over the surface there is little or no horizontal flow through the peat.
- Specific yield defines the response to rainfall and evaporation

Determination of permeability

1 In the field - by measuring the response of the water table in an auger hole or piezometer to addition or removal of water. Caveat: measurements of peat permeability can be difficult as elastic properties of the peat skeleton and pressure from the observers weight can lead to misleading results.
2 In the laboratory - by applying a known hydraulic gradient to a sample in a permeameter. Caveat: peat is easily disturbed by sampling.
3 As an optimised parameter in a mathematical model. Caveat: models can be seductive and lead you astray!

Why measure permeability?

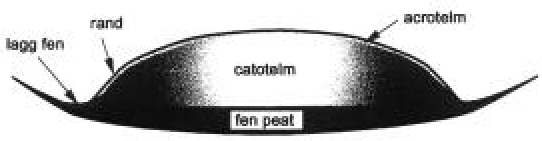
We can easily measure differences in water level and hence the hydraulic gradient but this does not give us flow. Near the mire margin the water is usually flowing outwards - this is an outgoing in the water budget that has to be balanced by inflows such as rainfall or artificial water supply. In some restored mires we can obtain and use external water supplies by pumping or channelling upland water to maintain levels around the margin. We need to know how much water is required or how far the available water will go towards solving the problem.

Groundwater mound theory for raised mires

Raised mires always have radially outward drainage, i.e. a rainfall excess. Towards the periphery (rand) there is more flow, so gradients become steeper.

The water table has a small range of fluctuation relative to the surface, and peat above the water table is either actively forming and adding to the catotelm or, if the water table falls too far, it is wasting and creating a "recurrence surface".

Groundwater mound theory for raised mires

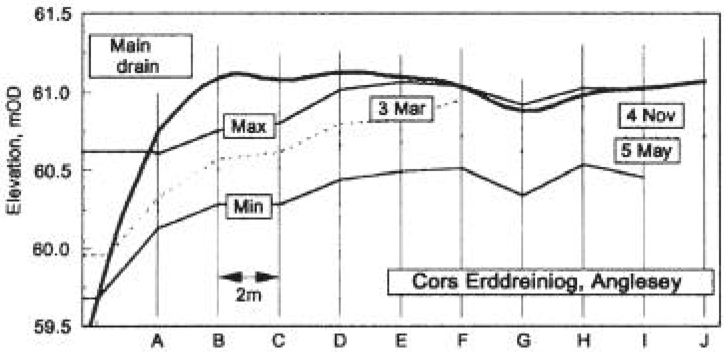


The average summer flow of water through the catotelm defines the form of the water table and that in turn defines the landform. Ultimately the raised mire accommodates itself to the prevailing conditions (such as space available, rainfall and evaporation) but the process can be painful; ‘recurrence surfaces’ may be an indication of past dry phases.

Previous changes in mire hydrology took place in an environment that had lots of refugia for species temporarily displaced from the bog. Although the catotelm gives the mire its shape, how the mire deals with excess water (e.g. winter rainfall) depends on the integrity of a high-permeability upper layer - this is difficult to create on an artificially landformed peat surface. Perhaps one approach would be to "terrace", initially.

Seasonal changes in water level near an open drain

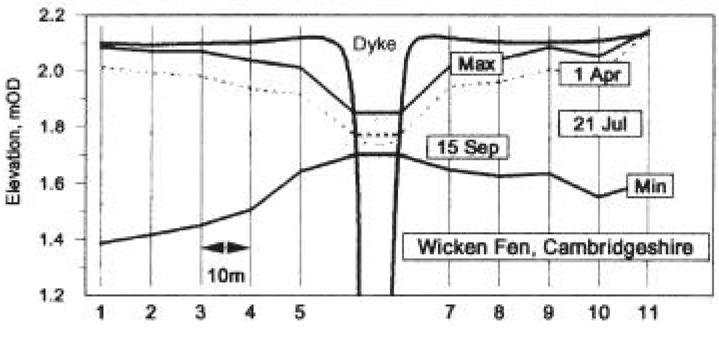
Cors Erddreiniog was a site where ditch levels were kept very low, so water was constantly draining out from the site.



Note from the graph (above) that the influence of the ditch was not felt more than about 50m away. Also, the site is reed fen so a large range of fluctuation is tolerable.

Seasonal reversals of lateral flow near an open drain

What would happen if drain fluctuations were kept small and drain water levels high?



This is classic Wicken Fen behaviour (see graph below); dyke water which is upland water supplemented by springs helps to sustain the water table in field areas. Wicken Fen is one of the areas in the fens where the remnant semi-natural peat is a couple of meters above the surrounding drained land, so it is very important to retain as much water as possible over the summer. Dyke banks where they border the reserve have been strengthened and raised, but there is still talk of stripping peat to bring ground levels down to meet the water.

Why make mathematical models?

- to predict future behaviour based on how the system functioned in the past;
- to predict the consequences of changed controls E.G. the impact of development, climate change, extreme dry / wet years;
- to help in understanding the system;
- to determine or estimate unmeasurable water budget components.

Models are only one of a whole range of approaches and they do not excuse anyone from fieldwork! All models must be informed by and tested against field measurements. What a model can do that a field experiment cannot is to explore 'what if' scenarios at relatively little cost and test the plausibility of ideas that generally originate with the people on the ground.

Modelling groundwater flow near a drain - West Sedgemoor, Somerset

The problem - to predict the effects of changed water levels in drains on the water table in 'field' areas, given climate records and a sequence of groundwater level measurements in a transect of dipwells. The solution depends on some simplifying assumptions - a horrendous non-linear partial equation - and of course, a computer.

The main challenge with modelling is to incorporate the complex behaviour of hydraulic properties. Models have practical implications - one based on the same data has been used by Silsoe College in their water level regime work on Tealham and Tadham Moors.

Using a model to estimate seasonal variation in lateral flow

The model of groundwater flow in a peaty field adjacent to the dyke demonstrates 'tidal' flow of water to and from the dyke - an important component of the water budget that controls water level fluctuations. Amplitude of lateral flow decreases with distance away from the dyke so the central region of the field receives little or no ditch water, with important consequences for nutrient cycling and chemical conditions for wetland plants.

Lateral flow is a significant component of the water budget but most water lost by evapotranspiration is withdrawn from storage, resulting in drawdown of the water table over the summer. This is tolerable for grassland but probably beyond the range of tolerance for fen species.

Estimation of leakage through a bund at Ham Wall, Somerset

- This is a restored reedbed site isolated from peat diggings by a clay-cored embankment.
- Leakage through bund and control structure was assessed by balancing outputs against inputs and change in storage of water over a period between January and July 1996.
- This water budget method works best in winter when it is easier to estimate storage.
- Leakage is reasonably constant and averages 0.9mm/d.
- There is evidence that leakage reduces with time (sealing of cracks with fine material).

We often meet up with a problem where there are too many components to the water budget, so it is useful to be able to eliminate one or two from the analysis. At Ham Wall the reedbed would normally be sustained by pumping therefore it is usually difficult to measure the total input. Taking advantage of the diversion of the pump to other duties, the water budget was used to estimate leakage occurring either along 1.3km length of bunds or around the cut-off wall of the stoplog weir and between the boards etc.

Rewetting at Fenn's and Whixall Moss.

At sites like Fenn's and Whixall, does the underlying sand have an influence on isolating the mire from adjacent farmland using a water-filled ditch? Small effects can propagate under a ditch if there is a highly permeable layer beneath the peat. Rewetting leads to a groundwater mound on the other side of the ditch and draining the farmland lowers the mire water level slightly. More dramatic effects are expected with a deep sand layer.

Good fences make good neighbours - how do you fence around a mire?

- A water-filled drain is an effective boundary.
- Water has to be supplied, but provided water movement is mostly outward, its quality need not be good.
- Even in acid bogs, interactions with groundwater can mean effects will propagate across the boundary.
- Mires are not effective at flood storage - run-off from a rewetted mire may be a problem. The aim is to maximise effective specific yield by creating a mosaic of small open water bodies and re-creating a superficial layer to take on the hydrological functions of the acrotelm.
- Consider restoration of lagg fens as well as the mire expanse - they are an integral part of a functioning mire system.

Transcript of discussion

Frank Mawby: When a site is drained, the top layer can become compacted. What is the hydrological effect of this?

Kevin Gilman: On an unsaturated zone, breaking up the compacted layer is necessary before wetting up again.

Tim Kohler: How do we create a superficial layer?

Kevin Gilman: If there is a bare peat surface, then rotavate to produce loose peat, then cover this with water. Terracing is helpful to produce horizontal areas to hold water.

John Bacon: Do we need a lagg fen outside of the mire surface?

Kevin Gilman: Definitely. The marginal land is a very important part of the whole mire.

Peter Roworth: What happens after burning? Does this affect water movement?

Frank Mawby: At Glasson, fire actually helped rejuvenate the vegetation and the surface.

Andrew Ferguson: In order to create a mosaic of water bodies on the site, do we literally dig holes?

Kevin Gilman: This has been tried on sites, but this was intended for degraded or extracted bogs in order to create a hummock and hollow pattern.

Joan Daniels: In Holland there have been experiments with ploughing short, unconnected furrows every five metres.

Andrew Hearle: At Wem Moss holes were dug to provide breeding pools for dragonflies, but we were subsequently told that this was inadvisable.

Joan Daniels: With regard to flood storage, is run-off a problem if the entire surface is rewetted?

Kevin Gilman: It is important to have a connected drain network. At Fenn's and Whixall the drainage leaving the mire has fallen into disrepair.

Paper 3.2 Management of Peatlands for Invertebrates

David Sheppard

There are approximately 30,000 species of large invertebrates in Britain, of which approximately 23,000 are insects. Many species of invertebrates require more than one habitat to complete their life cycle. All of the required habitats must be present every year and in close proximity to each other.

Peatland Fauna

- Peatlands are naturally poor in species, but many are specialists adapted to peatlands and unable to survive well in other habitats.
- Lowland oligotrophic mires are richer in species than northern dry heaths, as rich as upland grassland or blanket bog, and poorer than edge peat or mixed moorland.
- Lowland valley mires can support lower numbers of individuals than blanket bog.
- More than 30 species of invertebrates under threat of extinction in Britain are associated with peatland systems.

Invertebrate Habitats on Peatlands

- Peatlands are naturally changing habitat complexes. Invertebrates exploit those changes.
- Habitat mosaics are the preferred habitats of most species of invertebrates.
- Large areas of uniform habitat are bad features.
- There is an invertebrate fauna associated with exposed peat, both where this occurs naturally (e.g. where the water table fluctuates, animals trample, after fires etc.) and in other situations (e.g. where management has occurred or where peat has been extracted).
- Peatland restoration projects must include the management of exposed peat surfaces.
- The early, weedy stages of vegetation succession on exposed peat supports a fauna which is both different to that of exposed peat and that of mature peatland vegetation.
- Peatland restoration projects must include the management of these early successional stages of re-vegetation.
- The low productivity of a mire system is mirrored in the paucity of the herbivore fauna. Much of the vegetation remains uneaten and dies. Because of the lack of herbivores, there is not much dung and consequently the decomposer fauna is also very small. Much of the dead vegetation remains undecomposed, creating peat.
- Invertebrates in a mire system must be able to withstand low temperatures, exposure to wind and rain, and annual winter inundation.
- The mire fauna tends to be adult in the early summer, larval feeding takes place during the warmest time of the year and the winter is spent in a dormant phase (larva or pupa) inside a water-proof protective cell. Species spending the winter in an exposed state are more closely associated with mire edge features which rarely suffer winter inundation.

A vegetated mire surface provides

- Shelter from wind and rain.
- Shade from the sun
- Higher humidity
- Higher temperatures
- Security from predators

A tussocky vegetation enhances these features

- Nutrient rich seepage lines are valuable features, providing nectar and pollen in early summer.
- Peat pools support a poor but specialised fauna.
- The invertebrate interest is not confined to the water. The saturated peat margins and encroaching *Sphagnum* is also valuable.
- Bare peat ditches do not hold much interest but their importance increases rapidly as the ditch vegetates. The fauna of vegetated ditches is different to that of peat pools.
- Scrub is a valuable part of the peatland system.
- Scrub removal reduces biodiversity, reduces the number of habitats, reduces the availability of food for passing and resident predators.
- Scrub removal increases exposure to wind, increases surface drying and increases the impacts of surrounding land use.
- Abandoned scrub systems should be restored and managed. Scrub cannot be 'controlled'.

Management

- Burning is an undesirable, catastrophic management tool which should only be used over very small patches as part of a site restoration programme and, even then, only in exceptional circumstances.
- Cutting is almost as catastrophic as burning and produces an even-aged sward. Cutting of numerous small patches is preferable to one large area and cutting at various times of the year is preferable to cutting all patches at the same time.

- Grazing is the preferred management tool. This produces an uneven sward together with desirable by-products such as localised trampling, dung and carrion.
- Draining will reduce or eliminate the wetland fauna and replace this with more generalist fauna derived from the surrounding land (e.g. heathland, plantation, grassland).
- Flooding will drive out the dry-land species and encourage the spread of the surviving wetland fauna. It is, therefore, important to flood areas around existing wetland patches.

Ideals

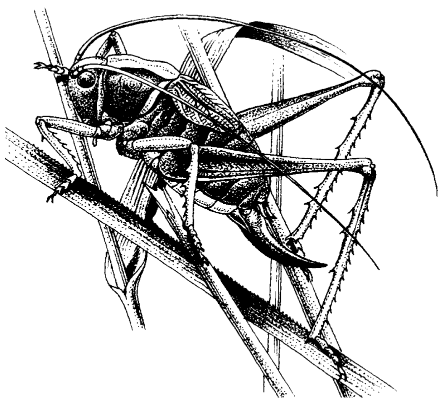
- Provide all stages of succession from bare peat, through vegetated swards to scrub as a dynamic mosaic of habitats.
- Maximise variety, minimise uniformity.
- Improve what you have already got before trying to create new habitats.
- Remember every site is different, but most sites are too small to support the full peatland fauna.

Mean Densities of Invertebrates

			Blanket Bog	Lowland Mire
			(mean number per square metre)	
Worms				
	Lumbricidae		1	2
	Enchytaeidae		80,000	25,000
Collembola			33,000	22,000
	Mites		60,000	25,000
Insects				
	Diptera			
		Tipulidae	700	70
		Other	320	100
	Coleoptera			
		Carabidae	1	3
		Staphylinidae	21	10
		Others	2	5
	Lepidoptera		4	44
	Hemiptera		3,500	1,200
	Araneae		130	34
	Opiliones		3	1

Reference

Coulson, J.C. 1988. The structure and importance of invertebrate communities on peatlands and moorlands and effects of environmental and management changes (pp. 365-380). In Usher, M. B. & Thompson, D. B. A. *Ecological Change in the Uplands*. Blackwell, Oxford.



***Metrioptera brachyptera* Bog Bush-cricket**

Transcript of discussion

Joan Daniels: What percentage of birch cover is optimal for invertebrate diversity?

D. Sheppard: 25-30% maximum is good, up to when birch influences ground flora. Don't remove it in blocks - remove on a more random basis.

Francesca Griffith: What are the requirements of *Dolomedes fimbriata*?

D. Sheppard: Small ones can survive on leggy heather, even *Myrica gale*. They don't make webs.

Peter Rawlinson: Are conifers useful at all?

D. Sheppard: No. Old trees have no low branches - most peatland invertebrates prefer to shelter in willow and birch.

Peter Jones: Are monocultures of *Molinia caerulea* of any invertebrate interest?

D. Sheppard: In small amounts which are grazed, but it is generally not palatable to invertebrates.

Mike Bailey: Grazed, tussocky *Molinia* is richer for invertebrates at Cors Coch.

Morag Milne: Is a network of sites important?

D. Sheppard: A network is important for species which don't disperse readily. It depends on the wind strength; hedges do have uses as edge, but can be a barrier in another direction.

Peter Roworth: What is the value of dead timber?

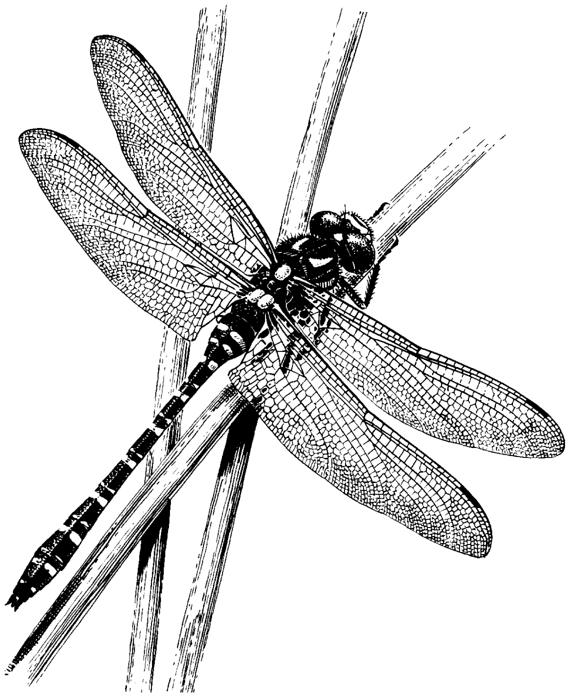
D. Sheppard: Birch does not rot in a good way for deadwood fauna, so if there is a market for chippings, do it.

Colin Hayes: How about artefacts such as human drainage activities - are any of these worth maintaining?

D. Sheppard: Broadly, yes but this depends on the micro-habitat within the artefact..

John Bacon: Should we use herbicides?

D. Sheppard: No, the dispersant affects the waxy cuticle. It is preferable to use mechanical methods



Cordulegaster boltonii **Golden-ringed Dragonfly**

Paper 3.3 Maintaining progress - have we the knowledge and the means?

Roger Meade

Maybe it is an inescapable fact of life that everything changes; what one generation takes for granted, the next challenges. At present we strive to come to terms with our much reduced but remaining peatland resource, by focusing on how we might keep it wet and render it active. Others, with the benefit of hindsight, will deride our efforts as attempting to steer the inevitable. We therefore have to have due regard to principles and policies, and check that our actions are consistent with contemporary thinking.

Naturalness is one of those 'NCR' criteria with which many of us will be familiar. it is defined in rather negative terms (to paraphrase) as being that which is least modified by man (Nature Conservancy Council 1989). For the peat bog, it may enable us to conjure up a picture of a *Sphagnum*-rich surface, with hummocks, hollows and pools, on a domed peat structure lying within the landform on which the underlying hydrological circumstances depend. Its validity rests on the treelessness of raised bogs being natural, and not the consequence of burning and grazing, as introduced by man.

Land management is undertaken for a number of probably diverse reasons, but when supported by scarce funds, public or private, there is the presumption of long-term benefit arising; that the land managed will not revert quickly to what it originally was, or develop into something undesirable. Here, the word 'sustainability' is used to represent the outcome of land management as something which will, in the long-term, achieve the vision for several millennia. As discussed in earlier sessions, we manage scrub, and block ditches from a variety of starting conditions; from active primary surface, through to one which may be described as moribund secondary. The starting point ranges from the natural to the extremely unnatural. To what extent can we expect to reverse the naturalness index on degraded raised bogs?

Western Europe, and probably beyond, is relatively rich in lowland raised mires laid waste by decades or centuries of peat extraction, or other damaging activity, such as conversion to agriculture. Very similar sites can be found in Britain, the Netherlands, Germany and France. Amongst these, there are widespread examples of attempts being made to regenerate such cutover mires by reconstituting an active surface. The standard prescription, as in Germany's Moorschutz-programme of the early 1980's (Der Niedersächsische Minister für Ernährung etc, 1981, 1986), is to re-soak the peat body and rewet the surface by damning outflows, and add suitable propagules to the peat surface (if bare) in the bunkerde, or 'top spit' (Eigner & Schmatzler 1980).

The early responses to rewetting are reviewed by Wheeler & Shaw, 1995. Commonly, on cutover peat surfaces where there is no minerotrophic influence, there is an early growth of cotton grass *Eriophorum angustifolium* and *Sphagnum cuspidatum*. Where insufficiently wet for these species, *Molinia caerulea* and birch may well become established and soon dominate, leading to a pattern familiar to anyone who knows the Greater Manchester or Cheshire mosslands, for example. There are variations on this pattern, where minerotrophy can encourage plants of poor fen, such as *Juncus effusus* and *Typha latifolia*. While these may be examples of early stages in different successional routes to raised bog with the desired M18 *Erica tetralix*-*Sphagnum papillosum* raised mire community, there is little, if any, published evidence of the successional link being established. However, two sites in the Netherlands give two different indications that it may be achievable.

Haaksbergerveen has been cutover and rewetted in parts. The first rewetting phase commenced before the second world war, the second in the 1960s. Rafts of *Eriophorum angustifolium* and *Sphagnum cuspidatum* have developed over many of the flooded cuttings. In some, the rafts have degenerated, but in others further species of *Sphagnum* (*S. magellanicum, S. capillifolium*) have become established. There is a hummock-hollow microtopography, with pools, and *Andromeda polifolia* is spreading. This supports the assertion that the early stages in mire regeneration on cutover surfaces can develop in the required phytosociological direction. The Weerribben Mire has been cut over and is now flooded with minerotrophic water. Some of the cuttings sustain diverse rich fen communities, others tall reed bed. In some parts, the reeds have been regularly cut, and the cuttings removed. Although some of the rich fen plants are still to be found, such as the mosses *Scorpidium scorpioides* and *Campylium stellatum*, at least one cutting is now covered by *Sphagnum* mosses and other acidophiles. Species include *S. palustre*, *S. recurvum*, *S. subnitens*, *S. papillosum*, and *S. capillifolium*. This change has occurred within 25 years of the commencement of the management regime. It shows that, even starting with rich fen on a minerotrophic cutover peatland surface, it is a relatively short space of time before the close precursors of raised bog communities develop. The problem at the Weerribben is how to maintain the fen as fen. It is examples such as these which support our rewetting activities and suggest that the emerging naturalness may be sustainable at least within the short to medium term.

The topographical circumstances in which raised bogs have arisen are well-documented, as by Lindsay (1995). They generally imply a situation in which precipitation exceeds evaporation, and where the mineral ground remains suitably saturated, such as in a terrestrialising basin, where a river periodically floods, or simply where the groundwater level is high, or discharging. There is the mire expanse, with characteristic micro-topography, and the mire margins, grading into the environment, bearing natural vegetation, and which gave rise to the peat body. How many of our highly valued peat bogs lie within such natural surroundings today? Their circumstances have changed dramatically over the last few centuries.

Perhaps the most common scenario is one within which the marginal peat has been removed; the emerald green mantle of the derived agricultural land creates an abrupt transition with the peatland, and is sustained by maintaining the groundwater within it at a considerably lower level than when the peat bog was forming. Fertiliser, pesticides and alien seeds drift from one to the other. Not only is the regional groundwater level lowered by agricultural drainage. The underlying groundwater aquifer, reliant on recharge from above and perhaps bearing a reserve which accumulated over centuries, is falling. Little wonder, then, that in spite of all the best efforts of the land manager to retain rainfall within the peatland, it still seems to dry out in summer. Being resourceful, he or she resorts to pumping, taking back any available water being lost through uncontrollable drainage. All these circumstances occur around and beneath the Humberhead Peatlands, and are added to by the loss of surface water from the peatland itself as a consequence of peat cutting. This is neither natural nor sustainable. To tackle water losses inside the peatlands without having a strategy for its total hydrological context is to only do half a job. We need to raise our sights, to see our peat bogs 'in to have the vision which will make our efforts sustainable. Agri-environment schemes applied to fields on the mire margin, water conservation for wildlife and agriculture, curbs on surface water abstraction and over-exploitation of aquifers are all part of the jigsaw. Our quest for 'favourable conservation status' for peat bogs will require us to look outwards, and enlist the help of our friends.

Finally, will our efforts to conserve raised bogs and value them for their own sake be sustainable? While paying attention to the physical side, such as structure, function, flora and fauna we must not ignore their place in our culture and affections. A balance must be struck between resources going into damming and tree removal, and the persuasion of the next generation to find out, understand and enjoy.

References

Der Niedersächsiche Minister für Ernährung, Landwirtschaft und Forsten. 1981. *Niedersächsiches Moorschutzprogramme Teil 1*. Calenberger Str. Hannover.

Der Niedersächsiche Minister für Ernährung, Landwirtschaft und Forsten. 1986. *Niedersächsiches Moorschutzprogramme Teil 1*. Calenberger Str. Hannover.

Eigner, J. & Schmatzler, E. 1980. Bedeutung, Schutz und Regeneration von Hochmooren. *Naturschutz actuel*, 4, 77pp, Kilda-Verl., Greven.

Lindsay, R.L. 1995. *Bogs*: *The ecology, classification and conservation of ombrotrophic mires*. Scottish Natural Heritage. ISBN 1 85397 100 6.

Nature Conservancy Council. 1989. *Guidelines for Selection of Biological SSSIs. Rationale, operational approach and criteria*. Joint Nature Conservation Committee (JNCC), Peterborough. ISBN 0-86139-544-1.

Wheeler, B.D. & Shaw, S.C. 1995. *Restoration of Damaged Peatlands, with particular reference to lowland raised bogs affected by peat extraction*. HMSO, London. ISBN 0117529788.

Paper 3.4 Appealing to the Majority

Peter Roworth & Kevin Bull

For many years peatlands have had the appeal of the minority - in the form of the naturalists who ventured onto these areas of mystery in search of natural history records. For example, Thorne Moors has well documented evidence of naturalists visiting the moors from the mid-1800's. It was a site particularly favoured by entomologists and indeed the White-faced Darter *Leucorrhinia dubia,* was first recorded in Britain there in July 1837 (Limbert in press).

There are several references to Thorne Moors as a "quaking bog" and Rannoch-rush *Scheuchzeria palustris* occurred there in profusion until 1871 (Limbert 1987). So there was much interest by botanists and ornithologists who seasonally visited the area in search of their respected disciplines. This interest remains today.

The moors have also, over the years, been the centre of "issues, controversy and campaigns". This has basically stemmed from the days when planning permission was granted for peat extraction, in the mid-1950's, to the British Moss Litter Company. During the 1970's there were suggestions that Thorne Waste (a name by which it has been known historically and is labelled as such on maps) could be used for the deposition of fly ash (waste from the local power stations) and then the site of Humberside Airport.

These suggestions aroused the concern of many naturalists/conservationists and local people and I am sure from this era the peatland developed an appeal for the majority. In other words, it was becoming more of a conservation issue, but local feeling entered the debate too. Due to the 1970's threat a 200 acre area of cut-over peatland, identified as the best remaining bit of bog habitat, was purchased by the Nature Conservancy Council from Fisons (formerly the British Moss Litter Co. in the 1950's) (Roworth 1991).

From this era, public and conservation interest increased, but it was not until the late 1980's when the method of peat extraction changed to surface milling and the huge scale of the loss in bog vegetation and water that the peat debate fully developed. The peat campaign, which was launched in 1990, brought to public attention the importance of peat bogs and the scale of loss of such a valuable habitat - the appeal to the majority was in full flow. During 1992 the English Nature/Fisons agreement was announced and in June 1995 the 1,300ha of the Humberhead Peatlands was declared a National Nature Reserve (NNR).

Thousands of people have been taken on guided walks on the NNR, to show them the importance of a peat bog and what makes it so special. For years local people and naturalists have found access to the moors very difficult - EN's policy is open access to the NNR and visitors are welcome to visit the site for their natural history interests or just to enjoy the 'space' which surrounds the peatlands.

In 1994 EN, in partnership with Doncaster Metropolitan Borough Council appointed a project officer to develop activities and interests about the Humberhead Peatlands in the local communities. The project, known as P.A.T.H. (Public Appreciation of Thorne & Hatfield Moors) ran very successfully for 18 months.

Kevin Bull, the assistant site manager for the NNR, has now developed a full guided walks programme, is involved in visits to schools and has successfully developed a good link with the local media. Work parties are held during the winter months and an education pack, pioneered in the P.A.T.H. era, is being redeveloped.

This brief presentation, I hope, gives an insight as to how the Humberhead Peatlands have now an appeal to the majority from the days when daring naturalists visited the quaking bog of mystery many years ago in search of rare plants and animals which were found on the largest lowland raised bog in Britain.

References

Limbert, M. 1987. Materials for a history of botanical investigations on Thorne Moors. *Naturalist* 112: 117-124.

Limbert, M. (in press). The White-faced Dragonfly *Leucorrhinia dubia* (Vander Linden) on Thorne Moors.

Roworth, P.C. 1991. Thorne Moors National Nature Reserve, South Yorkshire. *British Wildlife* 2: 164-166.

Discussion and summary

Philip Immirzi: Water level management plans don't appear to work. What do others think?

Colin Hayes: Few have been completed, so it is hard to judge. They are not a financially backed system, but a way of drawing a strategy.

Frank Mawby: The RSPB buys (the adjacent) land. Then they are the master of it and this is the only realistic option.

John Tucker: National Bog Day is very good publicity. Usually 50 or 60 locals turn up on Wem Moss. It makes a big impact.

Kevin Bull: Also on Thorne Moors. We need to get people out and onto the sites.

There was a general consensus that National Bog Day should be held earlier in the year to avoid biting insects.

John Bacon: When the Lowland Peatland Project ended, was the money allocated to Local Teams?

Joan Daniels: A recent question which was put to the EN directors - what happens now after the Lowland Peatland Project (LPP)? The handover down to the local teams has been very poor. The LPP allowed ten year plans to be drawn up but since then there has been no funding for this. The LPP gave prioritisations but there is still the need for extra money to carry this through. One problem is the structure of EN funding - if external funding is provided, this is taken out of the budget, with no gain. The priority should be for a big block of funding for work on bogs.

Peter Jones: In theory, biodiversity funding should give lots of funding to a national strategy for peat bogs.

Roger Meade: We need to be ready to use the money when it is forthcoming, so we need to have our strategies and priorities in place.

Colin Hayes: It was a great surprise to managers that the LPP stopped when and how it did, with the entire scheme being sidelined into a different habitat.

John Bacon: I agree. Peatlands are not now receiving the resources which were anticipated through the LPP.

Roger Meade: While we continue to depend on money through agencies, the situation is less than ideal as there is no statutory room for long-term planning.

Philip Immirzi: Experience in Scotland shows that a co-ordinated plan requires a lot of money. A public consultation document was sent out to the agencies saying 'this is what needs doing, so how can we use our resources creatively?'

Peter Roworth: If we don't get the resources to manage and to continue managing, scrub invasion will undo all of the management work carried out in the past six years resulting in a waste of time and money and in degradation of habitat.

Final Acknowledgements

Roger Meade thanked all of the speakers who had attended over the three days of the Workshop. He also thanked Kathy Everitt and Juliet Mills of English Nature staff at West Midlands office for the administration of the conference including the choice of accommodation. Thanks also to John Bacon for organising the machinery show and to Joan Daniels for her enthusiasm and hard work in organising the conference and also to Joan's team on the reserve. Thanks are also due to Scottish Natural Heritage for allowing the reproduction of figures from Lindsay (1995).

Osmunda regalis **Royal Fern**

References

Aaviksoo, K., Kadarik, H. & Masing, V. 1997. *Aerial Views and Close-up Pictures of 30 Estonian Mires*. Ministry of the Environment, Tallinn.

'A real farmer'. 1768. *The modern farmers guide. Vol II.* Edinburgh.

Baillie, M.G.L. 1995. *A Slice Through Time: Dendrochronology and Precision Dating*. Batsford, London.

Bennett K.D. 1989. A provisional map of forest types for the British Isles 5000 years ago. *Journal of Quaternary Science* 4, 141-144.

Blytt, A. 1876. *Essays on the Immigration of Norwegian Flora During Alternating Rainy and Dry Periods.* Cammermayer, Christiana.

Bridge, M.C., Haggart, B.A. & Lowe, J.J. 1990. The history and palaeoclimatic significance of subfossil remains of *Pinus sylvestris* in blanket peats from Scotland. *Journal of Ecology* 78, 77-99.

Bunting M.J. & Warner B.G. 1998. Hydroseral development in southern Ontario: patterns and controls. *Journal of Biogeography* 25, 3-18.

Butcher, D.P., Davey, R. & Labadz, J.C. 1996. *Wem and Cadney Mosses: Recommendations for Hydrological Management*. Confidential Report to English Nature from the Centre for Water and Environmental Management, University of Huddersfield.

Chambers, F.M. 1996. Bogs as treeless wastes: the myth and the implications for conservation. In Parkyn, L., Stoneman, R.E. & Ingram, H.A.P. (eds.). *Conserving Peatlands*, CAB International, Wallingford.

Chambers, F.M., Lageard, J.G.A., Boswijk, G., Thomas, P.A., Edwards, K.J. & Hillam, J. 1997. Dating prehistoric bog-fires to calendar years by long-distance cross-matching of pine chronologies. *Journal of Quaternary Science* l2, 253-256.

Chambers, F.M., Ogle, M. & Blackford, J.J. 1999. Palaeoenvironmental evidence for solar forcing of Holocene climate: linkages to solar science. *Progress in Physical Geography*, (in press).

Coulson, J. C. 1988. The structure and importance of invertebrate communities on peatlands and moorlands and effects of environmental and management changes. In Usher, M.B. & Thompson, D.B.A. *Ecological Change in the Uplands.* Blackwell, Oxford.

Der Niedersächsiche Minister für Ernährung, Landwirtschaft und Forsten. 1981. *Niedersächsiches Moorschutzprogramme Teil 1*. Calenberger Str. Hannover.

Der Niedersächsiche Minister für Ernährung, Landwirtschaft und Forsten. 1986. *Niedersächsiches Moorschutzprogramme Teil 1*. Calenberger Str. Hannover.

Eigner, J. & Schmatzler, E. 1980. Bedeutung, Schutz und Regeneration von Hochmooren. *Naturschutz actuel* 4, 77. Kilda-Verl., Greven.

Gear, A. and Huntley, B. 1991. Rapid changes in the range limit of Scots pine 4,000 years ago. *Science* 251, 544-547.

Geikie, J. 1881. *Prehistoric Europe*. Edward Stanford, London.

Goodwillie, R. 1980. *European Peatlands.* Nature and Environment Series No. 19. Council of Europe, Strasbourg.

Houghton, J. 1997. *Global Warming: the complete Briefing*. 2nd edn. Cambridge University Press, Cambridge.

Huntley, B. 1991. Historical lessons for the future. In Spellerberg I.F., Goldsmith F.B. & Morris M.G. (eds.) *The Scientific management of temperate communities for conservation*. Blackwell, Oxford.

Ilomets, M. 1996. Temporal changes of Estonian peatlands and carbon balance. In Punning, J.M. (ed.) *Estonia in the System of Global Climate Change*. Institute of Ecology, Tallinn.

Ingram, H.A.P. 1982. Size and shape in raised mire ecosystems: a geophysical model. *Nature* 297, 300-303.

Ingram, H.A.P. 1995. Conserving the cultural landscape? *Mires Research News*, quarterly newsletter of the Mires Research Group, British Ecological Society.

Lageard, J.G.A., Chambers, F.M. & Thomas, P.A. 1995. Recording and reconstruction of wood macrofossils in three dimensions. *Journal of Archaeological Science* 22, 561-567.

Lageard, J.G.A., Chambers, F.M. & Thomas, P.A. 1999. Climatic significance of the marginalisation of Scots pine *Pinus sylvestris* ca. 2500 BC at White Moss, Cheshire, UK. *The Holocene* 9 (in press).

Laine, J. & Vasander, H. 1996. Ecology and vegetation gradients of peatlands. In Vasander, H. (ed). *Peatlands in Finland*. Finnish Peatland Society. ISBN 952-90-7971-0.

Leah, M.D., Wells, C., Appleby, C. & Huckerby, E. 1997. *The Wetlands of Cheshire*. North-west Wetlands Survey Report No. 4. Lancaster University Archaeological Unit/Cheshire County Council, ISBN 1-86220-007-6.

Limbert, M. (in press). The White-faced Dragonfly *Leucorrhinia dubia* (Vander Linden) on Thorne Moors.

Limbert, M. 1987. Materials for a history of botanical investigations on Thorne Moors. *Naturalist* 112: 117-124.

Lindsay, R.L. 1995. *Bogs: The ecology, classification and conservation of ombrotrophic mires*. Scottish Natural Heritage, Edinburgh. ISBN 1 85397 100 6.

Lindsay, R.L. & Immirzi, C.P. 1996. *An inventory of lowland raised bogs in Great Britain*. Scottish Natural Heritage Research, Survey and Monitoring Report No. 78.

Lyell, C. 1832. *Principles of geology. Vol II.* John Murray, London.

Money, R.P. & Wheeler, B.D. 1996. *Prioritisation of Lowland Peat Programme resources*. English Nature Research Reports No. 179. English Nature, Peterborough.

Moore, P.D. 1975. Origin of blanket mires. *Nature* 256, 267-269.

Moore, P.D. 1993. The origin of blanket mires, revisited. In Chambers, F.M. (ed.) *Climatic Change and Human Impact on the Landscape*. Chapman and Hall, London.

Moore, P.D. & Bellamy, D. 1973. *Peatlands.* Elek Science, London.

Nature Conservancy Council. 1987. *Birds, Bogs and Forestry, the peatlands of Caithness and Sutherland,* Nature Conservancy Council, Peterborough.

Nature Conservancy Council. 1989. *Guidelines for Selection of Biological SSSIs. Rationale, operational approach and criteria*. Joint Nature Conservation Committee (JNCC), Peterborough. ISBN 0-86139-544-1.

Orru, M. Shirokova, M. and Veldre, M. 1992. *Eesti Turbavarud*. Tallinn. (in Estonian, with summaries in English and Russian).

Pilcher, J.R., Baillie, M.G.L., Brown, D.M., McCormack, F.G., MacSweeney, P.B. & McLawrence, A.S. 1995. Dendrochronology of subfossil pine in the north of Ireland. *Journal of Ecology* 83, 665-671.

Roworth, P.C. 1991. Thorne Moors National Nature Reserve, South Yorkshire. *British Wildlife* 2, 164-166.

Sernander, R. 1908. On the evidences of Postglacial changes of climate furnished by the peat mosses of Northern Europe. *Geologiska Foreningens i Stockholm Forhandlingar,* 30, 467-78.

Slater, F.M. and Wilkinson, D.M. 1993. The peatlands of mid-Powys - a literature review and preliminary description of new sites. *Brycheiniog* 26, 17-41.

Smout, C. 1996. Bogs and people since 1600. In Parkyn, L., Stoneman, R.E. & Ingram, H.A.P. (eds.) *Conserving Peatlands.* CAB International, Wallingford, pp. 162-167.

Tallis, J.H. 1975. Tree remains in southern Pennine peats. *Nature* 256, 482-4.

Walker, D. 1970. Direction and rate in some British hydroseres. In Walker, D. & West, R.G. (eds.) *Studies in the vegetational history of the British Isles.* Cambridge University Press, Cambridge.

Wheeler, B.D. & Shaw, S.C. 1995. *Restoration of Damaged Peatlands, with particular reference to lowland raised bogs affected by peat extraction*. HMSO, London. ISBN 0 11 752978 8.

Willis, K.J. 1993. How old is Ancient woodland? *Trends in Ecology and Evolution* 8, 427-428.

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