SSSI BOUNDARIES OF THE HUMBERHEAD PEATLANDS

Ecological and geomorphological considerations in determining the boundaries of the Sites of Special Scientific Interest at Thorne and Hatfield Moors

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SSSI BOUNDARIES OF THE HUMBERHEAD PEATLANDS: ECOLOGICAL AND GEOMORPHOLOGICAL CONSIDERATIONS IN DETERMINING THE BOUNDARIES OF THE SITES OF SPECIAL SCIENTIFIC INTEREST AT THORNE AND HATFIELD MOORS

A technical report in support of the Peatlands Campaign Consortium and the Thorne & Hatfield Moors Conservation Forum submission in response to English Nature's proposal to denotify parts of Thorne and Hatfield Moors SSSIs

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1. EXECUTIVE SUMMARY

This report is intended primarily for discussion and information within the PCC and the Forum. As such, it contains potentially sensitive information, about rare species, about parts of the two moors, and about peat milling operators. It should not be disseminated outside the commissioning organisations without their permission.

BACKGROUND

This report has been commissioned by the Peatland Campaign Consortium (PCC) and the Thorne & Hatfield Moors Conservation Forum ('the Forum'), as part of a project to develop a hydrological, biological and palaeo-environmental case in favour of retaining and extending the boundaries of the Thorne and Hatfield Moors Sites of Special Scientific Interest (SSSI), prompted by English Nature's proposal to denotify parts of the SSSIs later in 1997.

It considers all aspects of ecological, geological and geomorphological interest on the two moors, present and future. It provides a summary of existing *factual information*, linked to underpinning *ecological theory and conservation principles*, and presents these critically. Published sources are cited whenever possible.

Thorne and Hatfield Moors, in the Humberhead Levels, are the two largest lowland raised mires in Britain. Raised mires are a rare geomorphological feature, especially so in eastern England. As such, the sites merit SSSI status in their entirety. Hatfield Moors has the unique distinction of being a raised mire surrounding a large 'island' of glacial moraine at Lindholme. The region is one of the driest in Britain, and it has been argued that Thorne and Hatfield Moors are better considered as Britain's only 'continental' mires.
A crucial instrument in the relationship between EN and the major peat extractors is an agreement between EN and Fisons/Levington signed in 1994. It is deemed by the signatories to be 'commercially confidential'. As its terms are kept strictly secret, known only to senior staff at EN headquarters, it has hampered discussion between EN and the voluntary bodies, and continues to cause problems, particularly because the local team of EN, who deal with voluntary bodies (and with Levington staff) on a daily basis, have seen only a summary of the main points of the agreement.

It has recently been disclosed by EN that, although the freehold of the land has transferred to EN, the mineral rights, to underlying sand and gravel deposits as well as the peat, remain in the ownership of Levingtons.

The secrecy underpinning the EN/Fisons/Levington agreement is a major concern, not only to the non-statutory bodies, but also to the local authorities, especially now that they have been charged with reviewing the mineral planning consents under the 1995 Environment Act.

CURRENT SSSI STATUS AND JUSTIFICATION

The sequence of scheduling of the two SSSIs, especially Hatfield, is described briefly. The bulk of the peat body was not scheduled until the mid 1980s. Important areas remain outside the Hatfield SSSI despite lobbying by scientists and the voluntary bodies for over a decade.

Reports of intensive and detailed surveys in the early 1990s seemed to convince the authorities and the peat company of the value of most of the remaining parts of the Moors. For the next five years,

discussions centred on the mechanisms for conservation, rather than debating the intrinsic importance of the sites.

'Rare species' provide an easily understood measure of the conservation value of an area. The conservation of many habitats on the two moors can readily be defended in terms of rarities. However, the more severely damaged areas retain few rarities during the period of most intensive peat extraction. In such areas, the keystone species of raised bog flora may still be present, and in any case, their propagules can easily reach the cut-over surface when needed.

No bird survey has been undertaken with particular regard to the areas now proposed for denotification, yet the Moors support many bird species which are listed in the Wildlife & Countryside Act, Biodiversity Action Plan, EU Habitats Directive, or EU Birds Directive; EN's management plan for the moors summarises the status of several of them. Surviving patches of vegetation within or bordering the areas support several species of conservation concern, including skylark *Alauda arvensis*, turtle-dove *Streptopelia turtur*, tree sparrow *Passer montanus*, linnet *Carduelis cannabina*, reed bunting *Emberiza schoeniclus*, whinchat *Saxicola rubetra*, lapwing *Vanellus vanellus*, grey partridge *Perdix perdix* and nightjar *Caprimulgus europaeus.* Recolonisation, even if initially mainly ruderal or dry-heath species of plants, provides habitats for some of the key breeding bird species and wintering raptors. Seasonally flooded areas support waders and wildfowl.

Mammals, reptiles, amphibians: inadequate survey data make it impossible to evaluate the fauna of the denotification zone.

Thorne Moors is the richest site for invertebrates in northern England, and the richest raised mire in Britain. Hatfield was in the top ten such sites. No recent survey of the invertebrates of the denotification zone has been carried out. The recorded insect fauna of the two moors exceeds 5000 species (almost 25% of the British fauna). Over 30 threatened species (Red Data Book), over 250 nationally scarce species, have been found, including five known from no other sites in Britain. Three of the latter were new to Britain in the 1990s. Additional high-quality species are still regularly added to the site lists. Some of the rarest species are endangered at a European as well as a national scale, and occur within the denotification zone, though no recent survey of the areas has been attempted.

The south-eastern part of the denotification area on Hatfield Moors had populations of bog rosemary *Andromeda polifolia* in the 1980s, and bog-myrtle *Myrica gale* was widely scattered in throughout the area. Other scarce plants have the potential to re-establish within a few years of abandonment by peat extraction.

If conditions on a bare peat surface are suitable, a rich lichen flora can establish within a decade, if suitable refugia are present in the vicinity. Several scarce species have been found, including *Cladonia sulphurina*, a nationally scarce and mainly upland species found in the northern part of the proposed denotification area on Hatfield Moors.

EUROPEAN AND OTHER INTERNATIONAL LEGISLATION

Thorne and Hatfield Moors have been accepted by the UK Government to qualify as Ramsar wetlands of international importance, and as Special Protection Areas under the EU Birds Directive.

The southern parts of Thorne Moors are proposed by the UK Government as a candidate Special Area of Conservation under the EU Habitats and Species Directive. However, recent UK and European case law makes it clear that the UK Government are not at liberty to exclude areas from a candidate SAC if they qualify ecologically: a member state has discretion as to where a candidate SAC is geographically located, but once a location is chosen, all of the areas eligible must be

included in the boundary. Both Thorne and Hatfield Moors are included by EN in the Humberhead Peatlands National Nature Reserve, confirming that they are, indeed, considered by the Government's statutory agency to be part of the same site.

EFFECTS OF DENOTIFICATION; LONG-TERM FRAGMENTATION; RESTORATION POTENTIAL

If denotification would be followed by more severe degradation than will occur within the SSSI (if not, why denotify?), the sites will becomes fragmented. Non-mire will act as barriers between areas with peatland vegetation. Plant and animal species will cease to maintain active metapopulations, and eventually lead to extinction on the whole site; in the case of Hatfield's rarest species, this would mean extinction in Britain, and quite possibly globally.

Denotification of the SSSI may well remove areas of land from funding from EN for management work, now or in the future; the SSSIs for a key element in the statutory agencies' setting of priorities.

The two area of Hatfield Moors designated 'wet heath to raised mire in medium term' in EN's management plan lie in the area proposed for denotification. Restoration of raised mire is EN's principle management aim. The exclusion of these key priority areas from the SSSI in hard to understand. No mention of denotification is made in EN's management plans for the moors (1993) nor in a subsequent publication by EN staff of their vision for the moors (1997).

The areas proposed for denotification have the deepest peat. The prospects for restoration are greater, and the options for management are wider, the deeper the peat.

For mire vegetation to re-establish when the moors are under the conservation management, all the key species must survive on site, and within colonisation distance of the available land surfaces. Refugia should thus ideally be distributed across the whole of the site.

There is no agreement as to the size of habitat patch or 'refugium' large enough for a species to survive within. Minimum suggested areas range from 100ha (1km x 1km) to 1ha (100m x 100m). The answer will vary from species to species, and is time-dependent: a species may survive in a small patch for 2 or 3 years; if it remains isolated for 20 or 30 years of intensive milling, even the largest remaining patches on the Humberhead Levels may be insufficient. The Peat Producers' Association Code of Practice requires refugia within each major milling area. In this respect, the secret Levington/EN agreement is less strict than the PPA code.

Current working methods on Hatfield Moors, although tacitly approved by EN, breach the codes of practice of the Peat Producers Association. EN should negotiate for the maintenance of refugia of vegetation and fauna across the site, throughout the period of peat extraction.

EXTENSIONS TO THE EXISTING SSSIS

Peatland scientists and conservationists have been pressing for extensions to the SSSI boundaries on both moors for over a decade. The arguments and the evidence are summarised. Significant areas of deep peat were left out of the Hatfield SSSI, including one area which may lack peat cutting planning permission.

Sandy heathland areas on the edge of Hatfield have affinities with East Anglian Breckland and with coastal sand-dunes. This habitat has declined in the region even more severely than has peatland. Sandy heathlands on the western edge of Hatfield Moors supported a unique invertebrate fauna which may soon be extinct.

On the western edge of Thorne Moors, around Bell's Pond, salt-marsh has developed. It contains many rare and scarce species. Based on recent surveys, it may rank as the most species-rich, and rarity-rich, saltmarsh in northern England for insects. The land-owner, RJB Mining, is sympathetic, but EN has not yet moved to notify the area.

The case for including the glacial moraine at Lindholme Island in the SSSI has been put to NCC and EN repeatedly since 1987. The moraine has a fauna which has been buffered from surrounding land use change by the barrier of raised mire. The large oaks have an insect fauna similar to that of medieval parkland and pasture-woodlands. The sandy grass-heath on the moraine at Lindholme supports a lichen-rich turf containing species otherwise unknown from southern Yorkshire. The invertebrate fauna of the grassland is akin to north Lincolnshire and Breckland heaths and dune-grasslands

2 BACKGROUND TO THE CONTRACT

2.1 Commission

This report has been commissioned by the Peatland Campaign Consortium (PCC) and the Thorne & Hatfield Moors Conservation Forum ('the Forum'), as part of a project to develop a hydrological, biological and palaeo-environmental case in favour of retaining and extending the boundaries of the Thorne and Hatfield Moors Sites of Special Scientific Interest (SSSI), prompted by English Nature's proposal to denotify parts of the SSSIs later in 1997. This work is being supported by many organisations, including the Forum, Hatfield Town Council, the RSPB, the Yorkshire Wildlife Trust, Lincolnshire Trust for Nature Conservation, Plantlife, WWF-UK (World Wide Fund for Nature), Friends of the Earth, Doncaster & District Ornithological Society, Doncaster Naturalists' Society and the Council for British Archaeology.

2.2 Scope and status of this report

As far as practicable in the time available, this report considers all aspects of ecological, geological and geomorphological interest on the two moors, present and future. Its main purpose is to bring together, in one place, a summary of the wealth of existing *factual information*, provide strong links to underpinning *ecological theory and conservation principles*, and to present all these critically. Where appropriate, links to the other contracts in progress (section 1.3) are made. It seeks to relate this to the legislative and advisory framework within which EN and its predecessors the Nature Conservancy (NC) and Nature Conservancy Council (NCC) have worked since their establishment in 1949.

Although this report has been produced against a tight deadline (see section 1.4), wherever possible, published reference sources have been included in support of factual statements whenever possible. Some unpublished sources have also been cited. Most of these are reports commissioned by, or copied to, EN or its predecessor. Hence, it seems reasonable to assume that EN should be aware of the content, and should have taken due account of it in preparing its proposal to denotify parts of the two SSSIs.

The emphasis on facts rather than politics is deliberate. It is also because the author is *not* a legal specialist, so the links to statutory instruments are at best tentative. It is hoped that this theme will be examined in more detail by the professional staff of the Wildlife Trusts and the RSPB.

This report is intended primarily for discussion and information within the PCC and the Forum. It contains potentially sensitive information, about rare species, about parts of the two moors, and about peat milling operators. It should not be disseminated outside the commissioning organisations without their permission.

2.3 Parallel studies

This is one of three contracts from 'consultants' to scrutinise and advise on the information provided by English Nature (EN) in preparing their proposal, and to collate available information on important matter omitted by EN.

The other two contracts are:

Hydrological: Dr Hans Joosten, Botanical Institute, Greifswald, Germany (edited in collaboration with Dr Richard Lindsey, University of East London)

Palaeo-environmental: Nicki Whitehouse, University of Sheffield, and Dr Mark Dinnin, University of Sussex; Dr Paul Buckland, University of Sheffield, advising)

Both of these contracts overlaps somewhat with the present: the hydrology is crucial to the maintenance and enhancement of the flora and fauna of the site, and the palaeoecological content of the peat is a major component of its geological interest (Eversham *et al.*, 1994). Since the three reports were written in isolation, specific cross-reference has not been possible.

2.4 The author

Co-chair of the Thorne and Hatfield Moors Conservation Forum, having chaired the group since 1989, and previously been its secretary. Son of a local peat-worker, Brian has known the moors well since the early 1970s. He is author of many papers on their flora and fauna, and led the major invertebrate and botanical surveys carried out in 1990. Brian is currently President of the Conchological Society of Great Britain & Ireland, President-elect of the British Entomological & Natural History Society, and on the Council of the European Invertebrate Survey. He is long-standing member of the Yorkshire Naturalists' Union and the British Lichen Society, and a Fellow of the Royal Entomological Society.

An ecologist by profession, he is currently Research Co-ordinator and former head of Zoology at the national Biological Records Centre, ITE Monks Wood. He has led ecological work for bodies as diverse as government departments (Transport, Agriculture, Environment, Scottish Office), Defence Estates Organisation, MCA, and Anglian Water plc. He has worked on wildlife corridors for English Nature; biogeographic zones for Scottish Natural Heritage; and species selection for the Biodiversity Action Plan for the Joint Nature Conservation Committee. His current research includes the effects of climate change and landscape fragmentation on biodiversity, and the ecology and re-establishment of rare insects. He is author/editor of the *Atlas of the Dragonflies of Britain and Ireland*, a contributor to the *British Insects Red Data Book*, and editor of the *Ordnance Survey Nature Atlas*. From October 1997, he will be Director (Operations) for the Wildlife Trust for Bedfordshire, Cambridgeshire and Northamptonshire.

3. INTRODUCTION TO THORNE AND HATFIELD MOORS

Lowland peatlands are a conservation priority in Britain, the focus of a national campaign by the Peatland Campaign Consortium, a grouping of fourteen separate non-governmental conservation organisations (Barkham, 1995). The two largest lowland raised mires in Britain, Thorne and Hatfield Moors, are in southern Yorkshire, in the Humberhead Levels. This is an ancient wetland area at the confluence of the rivers Trent, Don and Ouse, forming the estuary of the Humber. The region is one of the driest in Britain, annual precipitation less than 500mm, and for this reason, it has been suggested (Eversham, Skidmore & Buckland, 1995) that Thorne and Hatfield Moors are better considered as 'continental' rather than the more usual British 'Atlantic' mires (see section 8).

4. LEGAL AND ADVISORY INSTRUMENTS

Many different statutory, administrative and advisory frameworks have been used since concern for the conservation of Thorne and, later, Hatfield Moors arose in the 1950s, from an *ad hoc* approach to SSSI designation in the early days of the Nature Conservancy, to more and more formal guidelines and vetting processes in the 1980s. Although the consequences of denotification are unclear, and EN staff have provided assurances (Meade, 1997) that EN 'still believes the Moors to

be special' and that nothing 'has suddenly changed on the ground', concerns remain. In particular, EN is always concerned to target its limited resources on areas of conservation priority. It may in future be difficult for the organisation to expend resources on habitat management outside of the SSSIs, even in areas where restoration to raised mire is a stated aim (Dinnin, 1993; Kohler, 1997).

The following annotated list shows some of the range of mechanisms and criteria to which the Moors' conservation case has been, or will be, subject.

The *Nature Conservation Review* (1977)

The formal criteria for acquiring reserves, for preferring one area over another, were first expounded in detail in Britain in the 1970s. These official criteria for the selection of national nature reserves were published by D.A. Ratcliffe in the *Nature Conservation Review* (1977). The first of Ratcliffe's two volumes was a discussion of the extent of the wildlife resource in Britain, a classification of habitats within which it could be assessed, and the detailed criteria which might be used. Volume 2 was a 'shopping list' of potential National Nature Reserves, and includes a favourable account of Thorne Moors. (Hatfield was overlooked, largely because it was not well known among naturalists in the 1970s, although it had been highly regarded in the 1940s, and was about to regain popular awareness (Eversham & Lynes, 1983).)

Ratcliffe's criteria were rapidly adopted as a framework for considering biodiversity and conservation, in Britain and elsewhere in the world (Margules & Usher 1982), and they remain the most widely used set of descriptors of conservation value. They lie at the heart of the main NCC guidelines for selecting SSSIs, although have been lost from the revision for bogs. The criteria are presented in Appendix 3, and can still be useful in providing a reasoned intellectual frame for decision-making and discussion.

NCC's *Guidelines on the selection of biological SSSIs* (1989)

The framework introduced, largely after the event, to encompass the majority of SSSI (which were originally scheduled prior to the guidelines being written). Used to provide a more objective and explicit justification for all sites when these had to be renotified during the 1980s and later.

JNCC's revision of SSSI guidelines for bogs (1994)

The first of a proposed series of updates and refinements to the main SSSI guidelines, allegedly intended to be used in conjunction with the main volume, but in many ways incompatible with it. A brief critique appears as Appendix 1 of this report.

EU Habitats Directive

This is a potentially powerful tool for site conservation, which recognises the value of bogs, intact and cut-over. Wildlife Trusts, RSPB and WWF staff are well versed in its operation, and in the arguments over designation of Special Areas of Conservation (SAC). British legislation is currently interpreted by the statutory agencies as requiring proposed SACs to be SSSI; hence, denotification of large parts of the two moors would limit the potential for future, stronger protection.

The definition of boundaries of proposed SACs is also subject to recent UK and European case law. As a result of the Lappel Bank and Santona Marshes cases, the UK Government are not at liberty to exclude areas from a candidate SAC if they qualify ecologically. The point was made very clearly in Santona Marshes - a member state has discretion as to where a candidate SAC is geographically located, but once a location is chosen, all of the areas eligible must be included in the boundary. Once delineated, the Government can then follow the procedure established in Article 6 of the Directive, which may result in compensating the landowner if planning permission is revoked or modified. The Government does not have the discretion to leave qualifying areas of Annex I habitat, or the habitats of Annex II species out of the boundary of a candidate SAC (C. Taylor, WWF-UK, pers. comm.). The fact that both Thorne and Hatfield Moors are included by EN in the Humberhead Peatlands National Nature Reserve confirms that they are, indeed, considered to be

part of the same site, which has been chosen as a candidate SAC (although the currently proposed boundary includes only the southern part of Thorne Moors).

Additionally, SACs may attract central government funding for achieving 'favourable conservation status'. The Directive *requires* the restoration where habitats and/or species are not currently in 'favourable conservation status'. This is particularly relevant to raised mires, since this is the only priority habitat within the Directive for which a separate *degraded* category is listed for action.

Ramsar Convention

The UK Government is a signatory to this convention, and has acknowledged that Thorne and Hatfield Moors are eligible for scheduling as wetlands of international importance under the convention.

Wildlife & Countryside Act (1981; amended 1981; subsequent quinquennial reviews)

Although focused on species rather than habitats (the successor to the Wild Creatures and Wild Plants Act), this appears to offer protection to a number of species of bird, mammal, plant and invertebrate which occur on the moors. One species, the mire pill beetle or bog-hog, *Curimopsis nigrita*, occurs in several of the areas where denotification is proposed. It was added to Schedule 5 of the Act at the last quinquennial review.

English Nature, Fisons, Levington Agreement (1994)

A crucial instrument in the relationship between EN and the major peat extractors, but deemed by the signatories to be 'commercially confidential'. As its terms are kept strictly secret, known only to senior staff at EN headquarters, it has hampered discussion between EN and the voluntary bodies, and continues to cause problems. Not least of these is that the local team of EN, who deal with voluntary bodies (and with Levington staff) on a daily basis, have seen only a summary of the main points of the agreement. The current situation appears to be that the freehold of the moors has transferred to EN, but the mineral rights, both peat and underlying deposits of sand and gravel, remain with Levington. This point was clarified publicly only recently.

Biodiversity Action Plan

This broad statement of government policy following the Rio conference on biodiversity has gradually acquired more detail and more focused targets for species and habitat conservation. Raised bog is one of the priority habitats for which costed action plans are being produced. Among the priority species on the 'long list' of the published Action Plan are *Bembidion humerale* and *Curimopsis nigrita*, which are Humberhead Levels endemics within Britain. The only 'long list' species for which a Species Action Plan is currently being drafted is *C. nigrita* (by the author of this report, under contract to the Biodiversity Challenge Group) .

Sustainability

As part of the UK Government's response to the Rio Convention, it is developing national and regional strategies for sustainable development. One essential of sustainability is the wise use of natural resources. Peat extraction is among the least sustainable of industrial activities, both environmentally and economically. According to the peat producers' own predictions, the peat reserves at Thorne and Hatfield will be exhausted within 25 years: a deposit which has taken 4500 years to develop will have been destroyed.

Proposed protocol for determining areas of SSSI to denotify

This is probably the least satisfactory, and the most crucial, of all the elements in the conservation process for the moors. According to Dr R. Meade of English Nature (Forum meeting, 9 June 1997), a formula was derived from a recent Institute of Hydrology report. The formula proposed a 300m

buffer zone around mire vegetation on Hatfield Moors, and a 500m buffer around mire vegetation on Thorne Moors; the latter is greater because of the supposed greater hydrological conductivity of the peat on Thorne (see Joosten's report for a critique of these hydrological extrapolations). On both moors, a 100m buffer zone is proposed around areas with breeding nightjar populations.

This is an inadequate and ultra-simplistic way of evaluating components of a site which supports in excess of 6000 species of plants and animals. In particular, there are many other species which are of equivalent status to that of nightjar, and whose requirements are likely to be more stringent, but which receive no specific consideration in the denotification plan. The mire pill-beetle or bog-hog *Curimopsis nigrita*, a Biodiversity Action Plan long list species, 'protected' on Schedule 5 of the Wildlife and Countryside Act, is one such species. This and others will be present in some of the small fragments of vegetation which remain within the denotification zone (*C. nigrita* was recorded in the northern part of the denotification zone on Thorne, and in both the northern and the south-eastern parts of the Hatfield zone (Eversham (1996), and the fact was brought to the attention of EN.) As vegetation patches develop in future, a proportion of these species is likely to colonise.

5. FACTORS AFFECTING THE ECOLOGICAL VALUE OF PARTS OF THE MOORS: OVERVIEW

5.1 Background

The wildlife value of Thorne and Hatfield Moors was for many years disputed, both by the peat industry and by the statutory conservation bodies, who were slow to recognise the merits of Hatfield Moors in particular.

A small rectangular part of the south-western corner of Hatfield Moors became an SSSI in the 1970s, together with a block of adjacent farmland (included because of the ditches flowing through it, which support a rich aquatic flora and many important invertebrates). The bulk of the peat body was not scheduled until the mid 1980s, and important areas which were omitted then still remain outside the Hatfield SSSI (see section 11) despite lobbying by scientists and the voluntary bodies for over a decade.

The large and intensive survey commissioned by the Forum in 1990, and funded jointly by Fisons plc, NCC (later English Nature) and WWF-UK, addressed the apparent scepticism of NCC and Fisons (Eversham, 1990). The resulting reports (Heaver & Eversham, 1991; Holland, 1990a and 1990b) finally seemed to convince the authorities and the peat company of the value of most of the remaining parts of the Moors. For the next five years, discussions centred on the mechanisms for conservation, rather than the intrinsic importance of the sites.

This section introduces the main components of wildlife value, especially as they relate to SSSI boundary definitions, which are discussed in more detail in section 5 to 10.

The conclusions from a discussion of the flora, the vegetation, and the ecology of the moors were summarised in a few points by Eversham (1997):

> both moors retain many plant and animal (especially invertebrate) species of regional or national importance;
>
> modern surveys are needed to establish which of the scarcer plant species are still present, and where they are recorded;

the structure of the vegetation may be as important as its species composition in explaining the occurrence of vertebrate and invertebrate fauna and microflora;

areas which are similar in gross vegetation may be very different in invertebrate fauna;

microhabitats may be far more diverse from an invertebrate perspective than they first appear; it is likely that this may also prove to be the case for fungi, lichens and bryophytes;

the small-scale mosaic of microhabitats may be vital if the totality of species on the moors is to survive into the future.

These points are well reflected in English Nature's draft management plan for the moors (Dinnin, 1993), but the denotification proposals appear to ignore them. No additional biological survey has been commissioned; later sections of this report highlight where essential information is unavailable or out of date.

5.2 Species, habitats and recorded history

As is discussed in section 3, species and habitats have often been treated as independent criteria for site assessment, even though 'habitat' is very often defined in terms of the species which it comprises. 'Rare species' provide an easily understood measure of the conservation value of an area. The conservation of many habitats on the two moors can readily be defended in terms of rarities. However, the more severely damaged areas retain few rarities during the period of most intensive peat extraction. In such areas, many of the keystone species of raised bog flora will still be present in small quantities, and their propagules can easily reach the cut-over surface, and will begin to re-establish as soon as conditions are suitable for their growth. See section 10 for a discussion of the colonisation process and the need for refugia during peat extraction.

The importance of the plants on the moors is due as much to the fauna (vertebrate and invertebrate) which they support, as to the plant species themselves. Some insect species feed on a specific host-plant, so the importance of flora is obvious. However, for most of the fauna, the role of plants is as 'vegetation' rather than 'flora'. The key difference is *structure* - many animal species rely on plant architecture to provide living-space, in which to forage and breed, rather than requiring a particular plant species.

This report therefore considers the botanical aspects of the moors in two parts. First, it assesses the current flora, arranged by major habitat; then it examines the role of vegetation composition and structure in supporting a diverse fauna.

As discussed in Appendix 3, Ratcliffe (1977) recognised the 'recorded history' of a site as an additional feature of value to nature conservation. This was partly because of the need for conservationists to learn form previous experience, and the consideration that retaining well-studied sites will increase the chances of understanding long-term ecological and management processes.

Thorne Moors was a focus of pioneering ecological research in the early years of the present century (Woodruffe-Peacock, 1921). More recently, there have been some experimental studies of the vegetation (Smart, 1983; Smart *et al.*, 1986), especially in the Dutch canal system on Thorne Moors. Recent fieldwork involving members of the Forum and amateur naturalists on Thorne and Hatfield Moors has produced new insights into the ways in which the flora and fauna inter-relate, and in particular, into the role of vegetation structure in maintaining the rich invertebrates fauna for which the moors are famous. Several examples are provided by Eversham (1997).

6. POPULATIONS OF PROTECTED, RARE OR DECLINING SPECIES

6.1 Birds

No bird survey has been undertaken with particular regard to the areas now proposed for denotification, yet the Moors support many bird species which are listed in the Wildlife & Countryside Act, Biodiversity Action Plan, EU Habitats Directive, or EU Birds Directive; EN's management plan for the moors summarises the status of several of them. Surviving patches of vegetation within or bordering the areas support several species of conservation concern, including skylark *Alauda arvensis*, turtle-dove *Streptopelia turtur,* tree sparrow *Passer montanus,* linnet *Carduelis cannabina,* reed bunting *Emberiza schoeniclus,* whinchat *Saxicola rubetra,* lapwing *Vanellus vanellus,* grey partridge *Perdix perdix* and nightjar *Caprimulgus europaeus.* The bare peat itself obviously cannot support birds, but the small, scattered patches of vegetation which remain over much of the denotification area may hold a few pairs of skylark and meadow pipit *Anthus pratensis.* The rapid recolonisation by acidophilous flora (even if initially mainly ruderal or dry-heath species of plants) provides much greater opportunities for the key breeding bird species, as well as wintering areas for raptors such as hen harrier *Circus cyaneus* and merlin *Falco columbarius.* Some of the areas proposed for denotification are seasonally flooded, and at these times of year will support numbers of waders and wildfowl, including snipe *Gallinago gallinago* and teal *Anas crecca*.

6.2 Mammals

Inadequate survey data make it impossible to predict the fauna which occurs in the areas proposed for denotification. Harvest mouse *Micromys minutus* has occurred on the northern edge of the part of Thorne Moors under threat, and water vole *Arvicola terrestris* has been seen in ditches adjacent. Brown hare *Lepus capensis*, a priority species on the national Biodiversity Action Plan, occurs in the proposed area of denotification on both moors.

6.3 Reptiles and amphibians

Small populations of the commoner amphibians may be found in parts of the area proposed for denotification. Until recently, a substantial population of adders *Vipera berus* was present, probably of regional significance in the lowland zone. Neither group has been surveyed comprehensively on Hatfield Moors in recent years, and the data for the northern parts of Thorne Moors which are threatened with denotification are very limited. A population currently survives on Lindholme Island (outside the SSSI) and on other parts of Hatfield Moors (H Kirk, pers. comm.).

6.4 Invertebrates

The invertebrate fauna of the two moors has long been known to be uniquely diverse and rich in rarities, including conspicuous nationally-scarce species such as the bog bush-cricket *Metrioptera brachyptera* and the large heath butterfly *Coenonympha tullia,* the latter at the extreme south-eastern edge of its range in Britain. (Skidmore, 1970; Skidmore, Limbert & Eversham, 1987). By the late 1980s, Thorne Moors was the richest recorded site for invertebrates in northern England, and the richest raised mire in Britain, judged on its rare and threatened species. Hatfield was in the top ten such sites. Thorne's total recorded fauna exceeded 3000 species, around 500 of them nationally or regionally scarce (Key, 1988). Despite this uniquely impressive total, the site was still regarded as

under-recorded: "Many groups of insects have received scant attention....even [among the beetles and moths] many additional species will be found" (Skidmore *et al*., 1987). Hatfield has, both historically and recently, been far less intensively studied than Thorne, to the point of neglect for many decades (Eversham & Lynes, 1983; Limbert, 1985).

Unfortunately, until 1990, records of most of the scarce species at both sites had not been properly localised within the Moors; and, coming from amateur naturalists (or professionals in their spare time), the observations were entirely *unquantified,* with far more time spent on some parts of the Moors than on others. It was thus very difficult to evaluate the relative importance of different parts, which is vital in defining the size and location of refugia, or to decide priorities for invertebrates in those parts already being managed for conservation. The Forum identified the lack of *compartmental information on the invertebrates* as the most crucial gap in our knowledge of Thorne Moors. To put this right, and to establish how much of the former value remained, a co-ordinated survey work was undertaken in the early 1990s. The main report of the 1990 survey (Heaver & Eversham, 1991) was made available to Fisons, EN (regional and national office) and others, and copies were lodged at Doncaster Museum. The key conclusions of the survey are reproduced as Appendix 2. Despite significant losses (Eversham & Skidmore, 1991), the sites remain of national and international importance.

The total insect fauna now exceeds 5000 species (almost 25% of the British fauna). Among the results so far have been over 30 threatened species (Red Data Book), over 250 nationally scarce species, and five which are known from no other sites in Britain. Three of the latter were new to Britain in 1992. The six national-endemic insect species on the sites are:

Coleoptera: Carabidae:	*Bembidion humerale*
Coleoptera: Byrrhidae:	*Curimopsis nigrita*
Diptera: Ephydridae:	*Pelina guttipennis*
Diptera: Tachinidae:	*Siphona ingerae*
Diptera: Muscidae:	*Phaonia jaroschewskii*
Diptera: Sciaridae:	*Cotyna wasmanni*

Additional species have been added to the lists since (P. Skidmore, pers. comm.), and this is likely to continue. The status of these mire insects is surprising, since peatlands are among the better-known habitats for invertebrates in Britain, having been the subject of four major surveys in the past decade, including almost 400 sampling stations across England and Wales (Ball, 1992). Although it is comparatively common to make additions to the British list of insects in the more obscure families of Diptera, some of the Thorne and Hatfield national endemics are in well recorded groups; and all six species are very distinct from their closest relatives, and would not be passed over by anyone studying the groups. Suggestions that the beetles might be recent arrivals at Thorne (considered by Eversham & Arnold (1992)) can be discounted because *Curimopsis nigrita* was first found as a fragment in a Bronze Age trackway beneath the peat (Buckland & Johnson, 1984), and has since been found from deposits of similar age on Hatfield Moors (N.J. Whitehouse, pers. comm.). *Bembidion humerale* has since been recorded from the late Neolithic in the Somerset Levels south-west Britain, though apparently long extinct there, and has recently been recovered from deposits on Hatfield Moors believed to date from *c.* 4000BP (Whitehouse, pers. comm.) . The rarity of these species is thus not considered to be an artefact of recording.

The two beetle species are of particular significance to conservationists, and are a particular responsibility for EN, because of their status: both are category 1 (Endangered) Red Data species, both are listed as priorities in the Biodiversity Action Plan (a Species Action Plan is currently being prepared for *C. nigrita*), and *C. nigrita* is protected under Schedule 5 of the Wildlife and Countryside Act. The available information on the distribution, ecology and behaviour of both *C. nigrita* and *B. humerale* has recently been collated for English Nature (Eversham, 1996).

The invertebrate fauna is particularly relevant to the denotification proposal, because some of the rarest species, which are endangered at a European as well as a national scale, occur within some of

the surviving fragments of vegetation in the denotification zone; though no recent survey of the areas has been attempted.

6.5 Vascular plants

Accounts of most elements of the flora of the two moors have been published in recent years, or are in preparation. They reveal an impressive species-richness in most groups: over 800 species of flowering plants and ferns have been recorded on and around the two moors (Eversham & Lynes, in prep, a and b; Eversham, 1997).

Peat makes up about 80% of the area of the moors, and supports a wide range of acidic, nutrient-poor habitats. The wettest parts of the mire probably saw the first extinctions at Thorne and Hatfield, although these are inferred from studies of subfossil remains rather than historical documentation: for instance, among the main peat-forming mosses, *Sphagnum imbricatum* appears to have become extinct in the medieval period, and *S. magellanicum* more recently (Buckland & Smith, in press). The threat of future extinction is a key argument for the retention of SSSI status. It also provides a strong argument for the maintenance of all surviving habitat patches (see sections 10.4 -10.7).

The first historical losses of plant species to be documented by botanists come from the deep peat pools or 'wells' of the original mire surface at Thorne. Most famous of these was the Rannoch-rush (*Scheuchzeria palustris*), which was present until at least the 1870s (Lees, 1888), although it might possibly have lingered much later, perhaps until the 1950s. It is currently known in Britain only from Rannoch Moor, in Perthshire, although the subfossil record reveals that in the past it formed a dominant part of the vegetation of many lowland raised mires in England. Other plants associated with the wettest parts of the bog, such as mud sedge (*Carex limosa*) and great sundew (*Drosera longifolia*) must also have been among the first victims of the drainage of the moors (Limbert, 1990).

The paths on Crowle Moors support two rare plants: dune helleborine (*Epipactis leptochila dunensis*), another green-flowered orchid, is seldom seen away from coastal sand-dunes. It is not abundant, but probably still survives in small numbers. The greater yellow-rattle (*Rhinanthus angustifolius*), recently added to Schedule 5 of the Wildlife & Countryside Act, now dominates long stretches of the path on Crowle, encouraged by management work by the Lincolnshire Trust. It was formerly widely scattered in two distinct habitats in England - the enriched fringes of raised mires in northern England, and the poorly-drained areas of clayey grassland adjacent to chalk downland in the south-east. In both habitats, is has declined drastically: apart from the huge population on Crowle Moors, and one or two scattered plants on disused trams on Thorne Moors, it is now known in Britain from a single small population in Surrey.

As no comprehensive vegetation inventory has been carried out prior to EN's proposals, it is uncertain which of the above species occur in the areas proposed for denotification. The south-eastern part of the denotification area on Hatfield Moors has a population of bog rosemary *Andromeda polifolia* in the 1980s, and bog-myrtle *Myrica gale* was widely scattered in throughout the area. Certain species may have the potential to re-establish within a few years of abandonment by peat extraction.

6.6 Lower plants

The published accounts of the two moors list over species of 100 mosses and liverworts (Wall & Limbert, 1987; Eversham & Lynes, 1981, 1983), around 300 fungi (Taylor, 1987) and about 100 lichens (Eversham, 1987; Eversham in prep.). Additions are still being made. Although many of these species are common to both moors, and occur widely within each, several are very restricted in their distribution, and there is limited evidence that they are slow to colonise 'new' habitat, and require refugia of stable habitat from which to spread.

The lichen flora of peat on the two moors is dominated by a few common crustose species (especially *Lecidea granulosa* and *Lepraria incana*) and a diverse range of species in the genus *Cladonia.* Most of these species can reproduce by wind-blown fragments of thallus, as well as by aerial spores. If the conditions on a bare peat surface are suitable, a rich lichen flora can establish within a decade, if suitable refugia are present in the vicinity. Several scarcer species have been recorded. *Cladonia sulphurina*, found in the northern part of the proposed denotification area on Hatfield Moors, is a nationally scarce and mainly upland species.

The rarer moss and liverwort species on both moors are much more hygrophilous than the lichens, and so most are associated with damp of wet peat. They are thus less likely to be found within the areas proposed for denotification in the immediate future, though they are essential to EN's longer-term plans for the area (see section 10.1).

7. GEOLOGY AND GEOMORPHOLOGY

The case may be put simply:

The two moors are the largest lowland raised mires in Britain. Raised mires are a rare geomorphological feature, especially so in eastern England. As such, the sites merit SSSI status in their entirety.

Hatfield Moors has the unique distinction of being a raised mire surrounding a large 'island' of glacial moraine at Lindholme (section 11.7). This is an important geomorphological feature in its own right, irrespective of its ecological and genetic value in permitting the survival of isolated populations of species which have disappeared from the rest of lowland England.

It is impossible to separate 'geomorphology' from landscape history, and hence the report on palaeo-environmental considerations will also inform this aspect. Whether a strong and independent geological and geomorphological case should be assembled depends on one's view of EN's geologists. They have a reputation for being strongly attached to 'hard rock and fossils', and most geomorphological SSSIs are coastal or riverine 'process' sites. The post-glacial is a long-standing gap in SSSI coverage, which is being tackled from the palaeo-environmental side (Eversham, Buckland & Dinnin, 1994). These issues are discussed in detail in the report by Whitehouse & Dinnin.

8. SITE INTEGRITY

A very obvious argument stems from Ratcliffe's (1977) inclusion of site size as a key factor in the selection of Nature Conservation Review sites. Thorne Moors is the largest, and Hatfield the second largest, lowland raised mires in Britain. This alone is a strong reason for their SSSI status, regardless of the temporary condition of parts of the mire surface. Denotifying parts of the site reduce the area which is recognised by EN (and presumably by planning authorities) as being an integral part of the site.

If denotification is to be followed by more severe degradation than will occur within the SSSI (and if not, why denotify?), the result will be that the site becomes fragmented. Areas of non-mire will act as barriers between areas with peatland vegetation, or the potential for peatland vegetation. Plant and animal species, which have, for millennia, occurred across the sites, forming active metapopulations (networks of smaller populations which are inter-linked by the process of

dispersal, so that the species can recover from short-term population crashes on part of the site by recolonisation from elsewhere (Gilpin & Hanski, 1990; Eversham, 1996) will have these vital links severed. The predicted long-term result of this is extinction on the whole of the site (Harrison, 1990); and in the case of Hatfield Moors' rarest species, this would probably mean extinction in Britain, and quite possibly globally, too.

There are important unresolved questions about species survival in habitat fragments. The current models favour metapopulation theory, as outlined, but hey are unable to answer key questions about patch size, quality and duration. Southwood's (1977) habitat templet theory provides the closest to a working model, as discussed for *Curimopsis nigrita* and *Bembidion humerale* by Eversham (1996). This is of great practical importance to EN, and to the survival of the moors, because of the need to plan for the 'conservation after-use' which the Fisons/Levington/EN agreement appears to promise. The issue is discussed further in section 10.

There is an equally strong hydrological argument in favour of maintaining site integrity, which will be made in another consultant's report.

9. THORNE AND HATFIELD MOORS IN A EUROPEAN CONTEXT

The two moors remain nationally important for invertebrates (Ball, 1992; Eversham, 1991a). Their recorded fauna is richer in rare and threatened species than all but three sites in Britain, all of which are in the extreme south-east (the centre of insect species-richness in Britain (Eversham, Harding *et al.* 1993)). It is from their invertebrate fauna that the clearest biogeographic placing of the sites has so far been attempted (Eversham, Buckland & Skidmore, 1995).

Like most wildlife habitats, the classification and evaluation of British lowland peatlands has been carried out within a British framework (Ratcliffe, 1977). However, the recorded European distribution of the most important members of the insect fauna at the two sites, both modern and subfossil, places them as western outliers of a bog type otherwise typical of sites in Poland, Germany and the Baltic states. Although raised mire, rather than forest, may represent the end point of seral succession over much of lowland Britain (Walker, 1970), the very low rainfall in eastern England makes the area marginal for the growth of ombrotrophic mire vegetation. The two moors are thus better seen as the sole British examples of a largely non-British biotope, rather than damaged and impoverished 'Atlantic' mires such as occur frequently in western and upland Britain (Eversham, Buckland & Skidmore, 1995).

10 SHORT- TO MEDIUM-TERM RECOVERY FROM PEAT EXTRACTION

10.1 Hand-graving, machine block-cutting and milling

This brief history of the peat industry at Thorne and Hatfield Moors, and assessment of its effects on wildlife, is taken mainly from Heaver & Eversham (1991), modified after Eversham (1991b). It is crucial to an understanding of the moor surface, and to planning the future of the site.

10.1.1 Hand-graving

Peat digging by hand, known locally as 'graving', had begun on Thorne by the 14th century and continued until the early 1960s. By the 1820s, it was having a major impact on the moors, the peat being dug on a large scale for fuel; but no cut-over surface from this era is known to survive.

The earliest diggings which now support peatland vegetation probably date from about 1880, and are in the Ponybridge Marsh area in the south-east of Thorne Moors. The peat industry began to expand at this time, when peat was used as litter for horses and other livestock. Most of London' s trolley-bus horses were probably stabled on Thorne Moors peat at the turn of the century. Three types can be seen, one very local and specialised, the other two affecting large areas of the moors. A small area in the north-west of Thorne Moors was dug deeply, to provide the dense, black peat that was used to fuel the steam engines at the Paraffin Mill. When abandoned and flooded, these workings became the 'Paraffin Ponds', on the north-west edge of Thorne Moors.

From about 1880 till the 1920s, two very different techniques of hand-graving were being used simultaneously on different parts of the moors. Dutch graving, which produces wider, somewhat shallower cuttings, occupied about 500ha on the western side of Thorne Moors, as far east as Thousand Acre Drain. The best known surviving feature of the Dutch peat industry on Thorne is the network of canals in the original Thorne NNR and the area immediately north of it. These canals were used by horse-drawn barges, transporting peat to the Paraffin Mill, from 1895 till 1922, and they now support vegetation and invertebrates with more of a fenland character than the cuttings themselves.

Elsewhere on Thorne and Crowle Moors, a different method of digging, English hand-graving, was used. This produced rather narrower, deeper cuttings, and was the method used in most of Ponybridge Marsh and on Crowle Moors.

The two forms of graving are believed to have had different effects on the vegetation succession which developed in the cuttings. The Dutchmen may well have thrown the wettest vegetation into already-flooded cuttings (which may be why only the Dutch cuttings seem to have developed multispecies Sphagnum hummocks). English gravers tended to make more use of the cut surface vegetation, as a cushion on which to rest the cut turves. Some plant and invertebrate species, perhaps those associated with intermediate wetness, would be expected to survive better in this cutting regime.

Peat production on Thorne was probably greatest in tonnage and volume c. 1910, after which horses gave way to petrol engines and the litter market declined. The canals were not used by barges after the 1920s, and the whole extractive industry had reduced to less than a tenth its maximum extent by the 1950s. The period 1920 to 1965 (roughly the end of the hand-graving) produced a range of surface patterns, all of which left dry baulks standing between wet cuttings, but in various configurations and doubtless with subtly different effects on the flora and fauna. As well as 'Dutch' and 'English' a complication appeared in the 1930s-1950s, when Irish workers arrived and used their own modification of the Dutch method.

Despite their heterogeneity, it is convenient to lump together all the post-1920 hand gravings; importantly, most post-1920 cuttings were doubtless second cuts over areas that had been drained and

worked earlier. Hand-graving can thus be placed in three categories: pre-1920 Dutch, pre-1920 English, and post-1920.

10.1.2 Mechanical block-cutting

Since the development of a horticultural peat industry, and the arrival of Fisons at Thorne and Hatfield, in the 1960s, mechanical cutting has replaced hand graving.

Until the 1960s, most of Hatfield Moors had never been cut over, although it had been partially drained in the 19th century. The introduction of mechanical block-cutting opened up Hatfield and larger areas of Thorne. Initially, block-cut areas resembled hand-graving in having all the more tolerant of the characteristic bog plants growing in their wetter parts, and heather-dominated communities on the drier baulks. The area south of the original Thorne NNR is typical of mid-late 1970s cuttings, in this case, abandoned c. 1977.

Around 1980, changes in the management of cut peat on the moor took place, which substantially reduced the amount of vegetation in block-cut areas. Goole Moors, in particular, had very little vegetation by 1982.

10.1.3 Peat milling

At about the same time, peat milling was introduced, first on Hatfield, then about 1985 on Thorne Moors. This method differs mainly in the shallowness of the cut, the flatness of the resulting surface (no baulks and bottoms), and the frequency of repetition of cutting (routinely, on a 3-6-week cycle, and in very dry weather, more than once a day).

No areas of milled peat have yet been abandoned long enough for the vegetation succession to be studied, or for their colonisation by invertebrates to be commented upon. The first area where these could have been carried out was the area of Hatfield Moors north of Lindholme Bank Road (compartments H28 and the northern part of H34), which has recently been set aside. Milling on part of Goole Moors ended in 1991. This also offered the chance to monitor the fate of a milled peat surface. Unfortunately, the protracted negotiations between Fisons/Levington and EN, and the subsequent antipathy of Levington management to Forum members, prevented these research opportunities from being pursued.

The above account, which shows that milling of peat is much more difficult to reconcile with a rapidly achievable, directed, nature conservation afteruse for peatlands, is relevant to possible modification of peat cutting planning permissions which SAC designation might facilitate. There is also a long-standing issue of whether current working methods on Hatfield Moors, although tacitly approved by EN, are in breach of the codes of practice of the Peat Producers Association. EN should be urged to negotiate for the maintenance of refugia of vegetation and fauna scattered across the site, throughout the period of peat extraction. There is no evidence that this is taking place, and an aspect of the Fisons/Levington/EN agreement appears to be that the peat extractors enjoy carte blanche over their working methods.

10.4 Conservation value of abandoned workings

Lack of recent survey and monitoring makes it impossible to evaluate the abandoned milled areas on Goole Moors or on the northern part of Hatfield Moors. However, the exclusion of worked-out milled areas which have been abandoned for less than five years from the proposed denotification zone on Hatfield implies that vegetation of SSSI quality can arise in less than five years. That being so, denotification must presumably run the risk of being an extremely short-lived process.

11. LONG-TERM RE-ESTABLISHMENT OF RAISED BOG COMPLEXES

EN's draft management plans and published vision for the Moors (Dinnin, 1993; Kohler, 1997) place great emphasis on the establishment of raised mire vegetation on the moors. Hence, this section of this report discusses the effects of SSSI denotification on that aim. However, it should be noted that such a single-minded aim would overlook the fact that natural raised bogs would be set within a wide range of associated fen, heath and woodland habitats, each of which would also be rich in rare and declining species. Remnants of all these habitats remain, and another of the aims of the EN vision is to safeguard the current diversity of habitats and species (Kohler, 1997). This implies, but does not make explicit, the need for the full range of habitats to be maintained, within or around the current extent of the moors, when the raised mire develops.

Neither the draft management plan (Dinnin, 1993) nor the more recent published description of that plan (Kohler, 1997) make any mention of SSSI denotification. Both documents were written by EN staff in the regional office; the management plan was also subject to thorough consultation with, and revision by, staff at EN headquarters (M. Dinnin, pers. comm.).

11.1 Location of main centres of bog re-establishment

The draft management plan for the two moors (Dinnin, 1993), and a recent paper by EN's county officer in charge of the sites, and advised by their national peatland programme (Kohler, 1997, based on unpublished figures by R. Meade) both agree in a fundamental respect: the two area of Hatfield Moors whose afteruse is designated 'wet heath to raised mire in medium term', to the north-west and south of Lindholme Island, lie in the area proposed for denotification from the SSSI.

The restoration of raised mire is the principle aim of EN's management plan for both sites, and the declared intent of the Board of EN. The exclusion of these key priority areas from the SSSI is thus surprising.

11.2 Depths of peat required for re-establishment

The areas proposed for denotification generally have the greatest depths of peat. Yet there is a consensus among mire ecologists that the prospects for restoration are greater, and the options for management are wider, the deeper the peat.

The depth of peat which is needed for mire regeneration has never been established. It is likely to depend on the physical nature of the peat, the quality and volume of water available for restoration, the surface topography of the site, and the availability of refugia of vegetation, or at least propagules of key plant species. EN's stance on the topic has been inconsistent. E. Idle, at a briefing for the PCC in January 1993, agreed that a *minimum of 1m* of peat was needed, and that this was the basis of EN negotiations with Fisons. Within 4 weeks, the first announcement of the Fisons/Levington/EN agreement appeared, and this had been reduced to an *average* of *0.5m.* The lowest 0.5m of peat in most areas is commercially worthless, since it contains a high proportion of timber and plant roots, and would be almost impossible to extract without including some of the underlying sand or clay. Indeed, it is unclear whether this woody material falls within a commercial definition of peat (which usually refers to *Sphagnum* peat in England), so that it should perhaps be excluded from the measurement. The average is to be measured within milling fields (which may be a little as 20m wide, but on Hatfield Moors extend to lengths in excess of 1km). Because the agreement is secret, it is unclear how this change of mind came about.

11.3 Site integrity

The arguments about maintaining site integrity during the phase of peat extraction (section 7) apply as strongly in the post-extraction stage, when re-establishment of mire and other semi-natural vegetation is the aim.

11.4 Refugia for recolonisation: sources of innocula

For mire vegetation to re-establish when the whole of both moors are under the conservation management of EN, it is crucial that all the key species (and preferably, the full range of species which have characterised the moors over the past millennia) survive on site, and within colonisation distance of the available land surfaces which have reached a suitable stage in succession to support them. Although the science of restoration ecology is still evolving, there is agreement that success is greatest when sources of inoculum are closest to the target areas. Refugia should thus ideally be distributed across the whole of the site.

11.4.1 Natural processes of recolonisation

The ideal future for plant and animal species on the moors is survival during the (hopefully brief) period of continuing drainage and peat milling, followed by a phase of gradually increasing areas of suitable habitat, which will be recolonised from the patches of habitat which survive on site through the present inhospitable phase.

11.4.2 Avoidance of the need for translocation or reintroduction

Although the scope for ecological investigations into the surviving flora of the two moors is immense, the most recent studies are concentrating on the recolonisation of stripped peat (B.D. Wheeler and R. Money, unpublished), and have involved the introduction of large volumes of plant material from as far away as Scotland. This may have been necessary, to provide an adequate supply of particular *Sphagnum* species which no longer survive in sufficient quantity at Thorne for experimentation. It is unfortunate that other species were transported to the moors accidentally: bog-asphodel (*Narthecium ossifragum*) has appeared in experimental pits on Crowle Moors after an absence of many decades. Several other plant species may likewise have been brought to the moors, but no monitoring has been carried out. Even more serious than the botanical accidents is the likelihood of translocation of invertebrate species, for which Thorne Moors is of unique biogeographic significance (Eversham *et al.* in press). No attempt has been made to monitor the sites of introduction, and no recording was done at the donor sites in Scotland: it is unfortunate that 'professional' ecological research is often so constrained by funding (in this case, from Fisons, the peat mining company) that it must focus on a narrow research objective, and cannot mitigate the incidental damage which it causes (R.S. Key, pers. comm.; Eversham, 1997). If any northern or montane plants or insects are added to the Thorne list in future, the possibility of casual importation cannot be ruled out. It is strongly urged that such long-distance translocations are avoided in future.

11.5 Site connectivity and species survival: metapopulations

Current ecological theory predicts that species living in a patchy environment will survive only if the patches are large enough, and/or sufficiently long-lived, and/or sufficiently well connected, to avoid chance local extinction through population fluctuations or natural disasters (Eversham, 1996).

Some theorists propose that a ‘classical metapopulation’ is untenable for the majority of species inmost landscapes. Instead, they resort to ‘island biogeography’ theory (McArthur & Wilson, 1968), which postulates the existence of a ‘mainland’, a habitat patch large enough that the population can survive indefinitely within it.

11.6 Size and hydrology of viable refugia

There is no agreement among conservationists as to what size of habitat patch or 'refugium' is large enough for a species to survive within. For some species, such as the large and mobile Northern Eggar moth *Lasiocampa quercus callunae*, NCC staff (A.E. Stubbs, pers. comm.) have suggested a minimum area of 100ha (1km x 1km). At the other extreme, consultants working for Fisons (P. Atkins, B.D. Wheeler) proposed refugia of 1ha (100m x 100m): this latter appeared in the recommendations at the end of some copies of Fojt & Meade (1989), but was removed after complaints from conservation scientists. The truth will vary from species to species, and is also time-dependent: if a species has to survive in an patch for only 2 or 3 years before it can begin to re-establish on surrounding habitats, a small patch may suffice; if it remains isolated for 20 or 30 years of intensive peat milling, even the largest remaining patches on the Humberhead Levels may be insufficient). Some small species, with low average mobility, and very limited feeding requirements, such as the bog-hog *Curimopsis nigrita*, may survive for several or many years in habitat patches of only 10m x 15m (the area available to the species at its third British site at Haxey Turbary (Eversham, 1996)), if the habitat is of adequate quality.

In any wetland, the maintenance of the hydrology is crucial to the long-term survival of species. Within peatlands, it is not yet clear which elements of the flora and fauna will be lost during brief periods of desiccation or drainage, nor which will be able to survive in patches of suboptimal habitats (such as most small refugia?) during a prolonged period of peat extraction.

11.7 Spatial distribution of refugia

If the range of patch sizes from 1ha to 100ha, deriving from the opinions of NCC staff and peat extractors' consultants, is considered an adequate 'best guess' for the range of species found on Thorne and Hatfield Moors, an interesting conclusion arises. Many of the areas proposed for denotification will contain several fragments of habitat which could serve as refugia during the milling phase. Further, the Peat Producers' Association code of practice requires that refugia be identified within each major milling area, so that plant and animal species can survive on site until peat extraction ceases. So, following Levingtons' own association, one concludes that the areas proposed for denotification *ought* to contain sufficient habitat to support the peatland flora and fauna. If they do not, one may conclude that the secret Levington/EN agreement is less strict than the PPA code.

As a working example of an apparently adequate refugium, one could examine the flora and fauna of the area of damp peat on the north-west end of the Lyons' property on Lindholme Island. This area of perhaps 30ha supports populations of many invertebrate species which have never been seen elsewhere on either moor, including some which have been found nowhere else in Britain (see section 5.4). The area has suffered drought stress for at least 10 years, during which time the health and abundance of the bog flora has declined, and the density and height of birches has increased. These processes seem to imply that such a refugium is not likely to survive indefinitely unless the adjoining habitat reverts to vegetation with a higher water table than peat milling permits (see 9.1.3). However, the timescale of observed survival is encouragingly similar to some predictions of the likely future of peat extraction at Thorne and Hatfield.

12. THE NEED FOR A COMPREHENSIVE REAPPRAISAL OF HUMBERHEAD PEATLAND SSSI BOUNDARIES

12.1 General observations on the current SSSI boundaries

Peatland scientists in the region, and the voluntary conservation bodies, have lobbied NCC and EN regarding the SSSI boundaries for over a decade. It has been pointed out that important areas of habitat have been excluded capriciously, almost appearing to be accidents of cartography rather than considered decisions based on a scientific case. Thus, a full review of the boundaries of the two sites is perhaps overdue. However, whereas the current proposal is for large-scale *denotification*, especially at Hatfield, but without any extensions to the SSSI, most of the arguments which have been put to NCC and EN since the late 1980s have concerned the need for *extensions* on both sites. The following presents the case for particular parts of the two sites.

12.2 The peat body

There is no logic to including parts of the peat body but excluding others, if this is not based on vegetation and other wildlife. On Hatfield Moors, a significant block of peatland, mostly with mire-edge ('rand') vegetation and birch woodland (see sections 12.3.3 and 12.5 for a discussion of the likely value of such habitats) has been left out of the SSSI. Following pressure from the Forum in 1990, a small-scale invertebrate survey was commissioned by EN (R. Crossley, unpublished). This was not satisfactory, however. The surveyor found it difficult to gain access to the land, then was unable to penetrate the more dense areas of woodland to assess the habitats lying within it. On most of his site visits, the weather was inclement, and he did not use any form of trapping: his report was based entirely on the species found during site visits, which previous studies (e.g. Heaver & Eversham, 1991) have shown can give a very poor indication of the species complement of an area. No recent information on the flora, vascular or lower plant, nor on the breeding birds of the area, has been considered by NCC or EN.

The area of deep peat on the south-eastern edge of Hatfield Moors, currently being worked by Mr J.T. Carr, is another part which was omitted from the SSSI for no obvious reason. (It may be no coincidence that the boundary of the SSSI follows the claimed land ownership of Fisons plc, and of their peat cutting planning permission; is it possible that an over-worked member of NCC staff failed to notice that there was a 100-300m strip of peat outside the boundary when the SSSI was extended in the 1980s.) It is no longer clear whether Mr Carr has the benefit of an extant planning permission for peat extraction, which makes the continued omission of this area from the SSSI even more surprising.

12.2.1 Habitat mosaics in peatlands

Certain aspects of habitat mosaics within the peatland are already recognised and valued by EN, and receive favourable treatment in recent EN site leaflets: the tramways (see 12.2). Within the peat body, fine-scale mosaics of different vegetation structures are likely to be of considerable importance in maintaining the full range of plant and animal species (Key, 1991).

The faunistic and floristic heterogeneity of areas of superficially similar vegetation can be very great (Eversham, 1997). A habitat classification is presented by Eversham & Swindlehurst (1992), but more detailed analyses allow a quantification of the variation within each broad habitat class. Only 3 of the 26 nationally rare species, and 12 of the 79 regionally scarce or local species, were trapped in all four of the distinct blocks of peatland vegetation identified by Heaver & Eversham (1991). Thus, superficially similar areas may support very different invertebrate faunas. The same may well be true for the fungi,

lichens and bryophytes, too, although they have not yet been the subject of comprehensive, well-localised recording.

Finally, a similar comparison may be made within a single microhabitat, *Sphagnum* bogmoss. The data again come from the 1990 pitfall trapping programme. Many pitfall traps were placed among *Sphagnum*, and the location of each trap was recorded in terms of *Sphagnum* 'topography'. Three positions were distinguished:

Sphagnum 'lawn' (flat, uniform surface)

Sphagnum hummock (on top of a mound)

Sphagnum hollow (at the base of mounds)

The trap catches in the three situations were very different. Only 79 of the 309 species trapped were found in all three *Sphagnum* formations. Only about half the *Sphagnum* associated species were found in the lawns (160 species). The overlap between hummocks and hollows was 116 out of 263 recorded species, even though they are two components of the same topography. Part of the divergence may be an effect of sample size (although, with a total of almost 400 pitfall traps, it was among the most thorough site surveys ever undertaken). But the message is clear: even within a seemingly narrow, species-poor community such as *Sphagnum*, a wide range of ecological conditions may be present, and only by maintaining the full range of this variation will the complete fauna have a chance to survive.

The same principle applies to the invertebrate fauna of bare or sparsely vegetated peat. From studies of recently abandoned peat workings on Thorne Moors (Heaver & Eversham, 1991), it is clear that an interesting and significant invertebrate fauna colonises within a few years of abandonment. This in turn can support insectivorous birds, such as nightjar, whinchat and skylark. But, whereas the avifauna will be species-poor and rather uniform, subtle variations in the floristic composition, and especially in the water table within the peat, can result in very different insect assemblages developing.

All of the above points suggest that fine-scale juxtaposition of vegetation types will enhance the value of an area for conservation. Thus, patches of neutral or calcareous grassland (such as tramways) are now seen as a beneficial feature of the moors, even though they are not a part of an intact raised mire system; if the plant communities were present at all, they would have been confined to the mire edges.

Similarly, it may be argued that patches of exposed sand, which, if undisturbed, will rapidly develop a heathland flora, are an asset. They may support an invertebrate fauna which is of considerable conservation value in its own right; the fauna is akin to that of the habitats which occurred along the western margins of Hatfield Moors and on wind-blown sands further west and south from the moors. (see section 12.4). Moorland fringes with birch scrub and woodland intergrading into peat-based habitats are a common feature, especially on Hatfield, and will be considered separately (section 12.3.2).

12.3 Non-peat habitats: general

Several non-peat habitats occur on and around the two moors, and their treatment in the current SSSI schedules and boundaries is very uneven. The proposed modifications do nothing to correct the oversights or misjudged inclusions.

12.3.1 Trams and paths

A diverse array of typical meadow flowers is found on Thorne's abandoned tramways and along the lanes across Hatfield Moors, the composition of the flora depending on soil chemistry (particularly, nutrient and base status), drainage, and disturbance. Recently disturbed areas, such as active trams, are colonised by a ruderal flora, including least toadflax (*Chaenorhinum minus*), thale-cress (*Arabidopsis thaliana*), sticky groundsel (*Senecio viscosus*), and a high proportion of aliens such as American

willowherb and Canadian fleabane. Sandy disturbed areas on and around Hatfield Moor support specialists seldom found elsewhere, such as corn-spurrey (*Spergula arvensis*) and common stork's-bill (*Erodium cicutarium*). More stable mesotrophic grassland on trams and lanes is characterised by common species such as selfheal (*Prunella vulgaris*), daisy (*Bellis perennis*) and smooth hawk's-beard (*Crepis capillaris*). Where the turf is long-established but not too rank, adder's-tongue fern (*Ophioglossum vulgatum*) may be found, along with twayblade (*Listera ovata*), and broad-leaved helleborine (*Epipactis helleborine*).

Two rare plant species found on tramways have already been mentioned: dune helleborine (*Epipactis leptochila dunensis*), and greater yellow-rattle (*Rhinanthus angustifolius*). Although not true peatland flora, they are seen high priorities by EN.

12.3.2 Scrub

Birch scrub has been encouraged by drainage and the earlier phases of peat cutting. Few flowering plants thrive among dense scrub, although much of the flora of open mire may survive among scrub for several years, or even decades. Thus, in the Poor Piece area of Hatfield Moors, bog-rosemary, common cottongrass, cross-leaved heath and cranberry still linger among dense birches. One of the few species which is characteristic of birch scrub on the moors is the climbing corydalis (*Ceratocapnos claviculata*), with distinctive pale-green leaves and creamy-white flowers. Birch scrub also supports a wide range of fungi, including the conspicuous red-and-white fly agaric (*Amanita muscaria*), which is involved in a mycorrhizal association with the roots of birches, and bracket fungi such as *Piptoporus betulinus* and *Fomes fomentarius* growing on the dead and dying trunks. Although seen as a threat to mire vegetation, and seldom as a conservation priority, by EN, it has been shown (Heaver & Eversham, 1991) that certain areas of scrub or birchwood support a very significant invertebrate fauna not found elsewhere on the moors.

12.3.3 Woodland

In parts of the moors, birch scrub on peat has developed into mature woodland. Such areas support an impoverished flora, composed mainly of grasses such as wavy hairgrass (*Deschampsia flexuosa*), sweet vernal-grass (*Anthoxanthum odoratum*) and creeping softgrass (*Holcus mollis*). Birch woods are botanically species-poor compared with woodland on warp, or on the lagg zone of the mire; these are also discussed in section 12.5.

The most extensive area of warp woodland is the willow and sallow carr at Will Pits on Thorne, but the same habitat occurs in patches around the fenny fringes of Thorne, Crowle and Hatfield Moors. The cool, damp shade of carr woodland is ideal for a range of ferns to grow. The buckler-ferns (*Dryopteris dilatata* and *D. carthusiana*) are abundant on both moors, and male-fern (*D. filix-mas*) and the more delicate pale-green lady fern (*Athyrium filix-femina*) are locally plentiful. Last century, this habitat was noted for crested buckler-fern (*Dryopteris cristata*), now a national rarity confined mainly to East Anglia. Fenland plants such as meadow-rue, yellow-loosestrife (*Lysimachia vulgaris*) and common valerian (*Valeriana officinalis*) are abundant in glades and rides in the carr. Parts of Will Pits, and the northern edge of Goole and Rawcliffe Moors, are now dominated by Himalayan balsam (*Impatiens glandulifera*), whose spread may need to be controlled in future.

A particularly species-rich and important open woodland occurs on Lindholme Island, and is discussed in section 12.7.2.

12.3.4 Habitats around Thorne Colliery

The spoil heap at the western side of Thorne Moors provides a hostile environment for plants. In summer, the base-rich slag is backed hard by the sun, and south-facing slopes can be especially hot and arid. Even so, it supports a variety of species, including the lime-loving yellow-wort (*Blackstonia perfoliata*) and kidney-vetch (*Anthyllis vulneraria*). Another plant on the spoil heap is of particular note: sea-campion (*Silene uniflora*). It usually grows on coastal shingle or on mountain-tops, and is otherwise absent from the district (Eversham, 1997). These mat-forming perennial plants are probably

important in providing shelter for ground-living invertebrates: many scarce, mainly southern, species are recorded , including seed-eating ground-beetles (Coleoptera: Carabidae) such as *Harpalus puncticeps* and numerous *Amara* species (Eversham *et al.* 1996), and a high diversity of lygaeid bugs (Crossley, 1977), as well as two ant species, *Formica fusca* and *Myrmica sabuleti*, near the northern limits of their range. Equally important are the annual and short-lived perennial plants which provide a rich seed source, such as the scentless mayweed (*Tripleurospermum inodorum*), and mouse-ear-hawkweeds (*Pilosella* species). The extensive areas of bare ground is also important for the maintenance of both invertebrate and ruderal plant assemblages (Eversham, 1997).

The saltmarsh at the foot of the spoil heap, around Bell's Pond, is sufficiently distinctive, and regionally important for its invertebrate fauna (Eversham *et al.*, 1996), that it is treated separately (section 12.6).

12.4 Dry heath elements at Hatfield Moors

The western edge of Hatfield Moors has always had very shallow and discontinuous peat, with nutrient-poor sand breaking through in many places. The best example of this sandy-peaty heathland was immediately adjacent to Lindholme Airfield (compartment H22 as defined by Heaver & Eversham (1991)), but is now being quarried for the sand and gravel.

The importance of the sandy influence at Hatfield is twofold. First, it helps to explain the unusual fauna of compartment H32, which has affinities with East Anglian Breckland and with coastal sand-dunes (including the only inland site in Britain for the small bee-fly *Phthiria pulicaria*), as well as with typical raised mire. Second, it highlights the potential for heathland establishment on the worked-out areas of the gravel pits on the moors edge, and the advantages of dry restoration as opposed to the usual flooding. This would also be a very valuable 'fall-back' for areas which failed to regenerate toward raised mire in the first decades of conservation afteruse (see section 10).

Not only are such dry-heath areas intrinsically interesting, and rich in rare species, they represent a resource which has declined in the region even more severely than has peatland (Eversham, 1991b; Webb, 1986). There is also fragmentary evidence (P. Skidmore, J.T. Burn and B.C. Eversham, unpublished) that sandy heathlands within 3km of the western edge of Hatfield Moors supported an invertebrate fauna which was as distinctive and significant as that of Lindholme Island (section 12.7); at least two species of beetle are believed to have occurred here and nowhere else in Britain: the ladybird *Exochomus nigrinus* and the seed-eating ground-beetle *Harpalus flavicornis*.

12.5 Fen fringes: vestiges of a *rand* vegetation and fauna

Historically, the *lagg* or *rand* zone round a raised mire, where acidic habitats abut nutrient-rich habitats off the peat, is likely to have supported fen vegetation. The draining of the mire, and the intensive farming of most of the land around the moors, has constricted the fen fringes from both sides. What remains is most often dominated by common reed (*Phragmites australis*), such as the reed-beds near Thorne Colliery, often supporting elements of a fen flora, such as purple loose-strife (*Lythrum salicaria*). The rich fen-meadow at Inkle Moor holds flowers such as ragged-robin *(Lychnis flos-cuculi*), meadow-rue (*Thalictrum flavum*) and the nationally scarce and declining Marsh Pea (*Lathyrus palustris*). Until at least the 1960s, fen habitats near the western edge of Thorne Moors, and near Lindholme, supported fen violet (*Viola persicifolia*). This Red Data plant is a priority in the national Biodiversity Action Plan, and is currently known from only one or two fens in Cambridgeshire, but might possibly survive near Thorne or Hatfield: at Woodwalton Fen, it reappeared after an apparent absence of 50 years when areas of peat were exposed, presumably disturbing dormant seeds; it is currently the subject of an EN Species Recovery Programme (Preston & Croft, 1996).

12.6 Saltmarsh: the flora and fauna of Bell's Pond

One small part of the western edge of Thorne Moors around Bell's Pond has developed, very surprisingly, as salt-marsh. The saline pools and ditches at Bell's Pond support several species of saltmarsh plants, including sea aster (*Aster tripolium*), sea clubrush (*Bolboschoenus maritimus*) and reflexed saltmarsh-grass (*Puccinellia distans*). There are records of brackish water-crowfoot (*Ranunculus baudotii*) from near Thorne Moors in the 1950s. The origins of the 'saltmarsh' are uncertain. Perhaps warping of adjoining areas provided some saline soils, and the tidal ingressions would probably bring plants and invertebrates with them. However, records of estuarine insects in the 1820s (listed in Skidmore *et al.* (1987)) suggest that the brackish element of the fauna pre-dates large-scale warping.

Whatever its origins, the salt-marsh associated with Bell's Pond has been maintained, and probably increased, this century through pumping of brackish water out of Thorne Colliery. Opened in the 1920s, the colliery soon suffered problems with flooding, and had to pump continuously during mining. As the water flowed through the halide belt which underlies the magnesian limestone, the outpourings were highly saline. When sampled in 1977, parts of the Pit Dyke had a typical salinity of over 4%, more saline than the North Sea (Eversham, 1977), and the dyke and ponds become saturated in hot weather. The colliery closed in 1959, but pumping continues, in anticipation of possible reopening. Although pumping may currently maintain the salinity at Bell's Pond, the similarity between the 'brackish' fauna and that of wet areas of isolated fen meadow, within the SSSI at Inkle Moor (Ball, 1992; Heaver &Eversham, 1991), suggests that elements may survive in the absence of pumping.

The insect fauna of the area contains many rare and scarce species (Eversham, 1983b; Skidmore, Limbert & Eversham, 1987; Heaver & Eversham, 1991). Based on recent surveys, it may rank as the most species-rich, and rarity-rich, saltmarsh in northern England.

A major concern is that crucial parts of the brackish habitat fall between the boundary of the current SSSI and that of the Site of Scientific Interest, as defined by ecologists at Doncaster Metropolitan Borough Council (C.A. Howes, pers. comm.). The land-owner, RJB Mining, have been informed of the conservation value of the area by the Forum, and have responded sympathetically. It seems likely that they would not object to an extension of the SSSI (which already includes some RJB land) to encompass the whole of the saltmarsh interest. Unfortunately, despite regular promptings since 1990, EN staff have so far made no progress in notifying the area; and it is not dealt with in the current proposal for boundary modification.

12.7 Lindholme Island

This elongate block of land, partly farmed, partly grassy and partly wooded, in the centre of Hatfield Moors represents a unique feature of the site. It is a glacial moraine, dating from the end of the last glaciation, when it marked the southern limit of proglacial Lake Humber, which formed when meltwaters backed up because of an ice dam across the mouth of the nascent River Humber. It is geologically complex (Limbert, 1978; Gaunt, 1994), containing a cross-section of northern English geology, including magnesian limestone, millstone grit, as well as reworked aeolian sands. Given such diverse soils, it is not surprising that it supports a range of semi-natural vegetation which are otherwise unrepresented in SSSIs in south Yorkshire or north Lincolnshire.

The case for including Lindholme Island in the SSSI has been put to NCC and EN repeatedly since 1987. The suggestion has never been pursued, initially because of the alleged complexity of extending an existing site, then because it was argued that any extension to an SSSI should be worthy of notification in its own right (this case could have been strongly argued, and written documentation was supplied to NCC; but apparently the file was lost). The following is a

restatement of the case; most of the arguments have been presented to EN previously, but apparently ignored.

12.7.1 A periglacial refugium?

Invertebrate survey and palaeoecological investigation in the past 5 years has confirmed what has long been argued. The moraine at Lindholme retains elements of a fauna which has been buffered from surrounding land use change by the barrier which a 3km circle of raised mire provided.

Several elements of the biota are especially note-worthy:

> *Miscodera arctica*: as its name suggests, this is a northern and montane cold-climate beetle, whose modern distribution is northern European, and in Britain is almost confined to upland and Scottish morainic sites. It was present at Lindholme at least 3000 years ago (along with other boreal species such as *Cymindis vaporariorum*), and its survival is almost unique in the lowland zone (Luff, in press).
>
> 'Endemic' species on the peatland adjoining the moraine: recent research by Peter Skidmore (unpublished) has identified several species new to Britain from the small area of damp peat which survives on the north-western end of the moraine, on land owned by the Lyon family, who also own the island. They have entered into a Section 39 Agreement with EN and the local authority to ensure appropriate management of the wildlife habitats). These species, which are not known from any other British sites, include *Pelina guttipennis* (Diptera: Ephydridae), *Siphona ingerae* (Diptera: Tachinidae) and *Cotyna wasmanni* (Diptera: Sciaridae), and hardly a year passes without additional species being found. The absence of these from the 'peatland proper' on Hatfield, and from any part of Thorne Moors, is highly suggestive of a link to the moraine. *P. guttipennis* is otherwise an arctic species. It is at least possible that these species represent relict populations which have been isolated at Lindholme for several thousand years.
>
> *Pterostichus angustatus:* a ground-beetle, which is abundant on and around the moraine. This species was until recently believed to be a colonist to Britain in the past 90 years (Lindroth, 1975), but a fragment has been found in Bronze Age deposits on Lindholme Bank Road (N.J. Whitehouse, pers. comm.; identification confirmed by B.C. Eversham). This raises the possibility that the Lindholme beetles may thus represent a relict population, and as such would be of considerable biogeographic and genetic interest, on a par with the peatland Red Data species *Bembidion humerale* and *Curimopsis nigrita*.

The sandy areas of Lindholme are thus very distinct from the superficially similar sandy grass heaths of north Lincolnshire (e.g. Risby Warren SSSI, Manton Warren SSSI), or from sites in East Anglia with which they might be compared (Telfer & Eversham, 1996).

12.7.2 Parkland oaks

The large oaks in the grassland on Lindholme Island have a saproxylic insect fauna similar to that of medieval parkland and pasture-woodlands in northern England (Harding & Rose, 1986). In addition to being a further indication of the importance of the Island as a surviving fragment of an ancient landscape, the parkland fauna has been specifically identified by JNCC as in need of better protection, and is intended to be covered by a future supplement to the *Guidelines on selection of biological SSSIs* (see Appendix 1, section A1.1).

12.7.3 Acid and calcareous grassland

The sandy grass-heath on the moraine at Lindholme supports a lichen-rich turf dominated by *Cladonia portentosa* and *Coelocaulon aculeatum* growing among red fescue (*Festuca rubra*) and heath bedstraw (*Galium saxatile*), with other flowering plants including heath speedwell (*Veronica officinalis*) and harebell (*Campanula rotundifolia*) (Eversham, 1997). Many of these species are otherwise unknown

from southern Yorkshire, and the assemblage is different from the lichen-rich grass-heaths of north Lincolnshire. One reason for the grassland's distinctiveness is the presence of 'outcrops' of magnesian limestone boulders in the moraine.

The invertebrate fauna of the grassland is more akin to the north Lincolnshire and Breckland heaths and dune-grasslands, with beetles such as the rabbit-associate *Laemostenus terricola*, and large populations of the nationally scarce *Amara fulva* and *A. praetermissa*.. Together with the nearby shallow peaty soil, Lindholme Island has a unique assemblage of fossorial ground-beetles: the juxtaposition of the montane *Miscodera arctica* with the coastal-dune specialist *Broscus cephalotes*.

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APPENDIX 1: BRIEF NOTES FOR A CRITIQUE OF THE JNCC REVISION OF SSSI GUIDELINES: BOGS

A1.1 Justification for revision

JNCC staff are charged with maintaining uniformity of standards across the country conservation agencies. This includes the preparation of guidelines for statutory activity such as the notification of SSSIs.

At a meeting of the Dragonfly Conservation Group in January 1995, senior staff of JNCC explained the main factors behind the proposed programme of revision of SSSI guidelines. It was expressed in terms of three main shortcomings of the existing guidelines:

- Inadequate attention paid to lower plants (lichens, fungi, bryophytes, charophytes etc.); the results of the Lower Plants Biodiversity Register should be reflected in site designation

- Inadequate attention paid to invertebrates; the work of the Invertebrate Site Register should be reflected in site designation

- There was a need to redress the balance in designation in favour of certain habitats whose existence or importance was unknown or poorly recognised at the time of the previous SSSI guidelines; examples cited included pingos and other periglacial features in the lowlands, parkland and pasture-woodland, i.e. sites where geomorphological and historical understanding has improved.

The following brief account assesses how well the revised bog SSSI guidelines correct these problems.

A1.2 Production of revised guidelines: timing and consultation

It was made clear at the Dragonfly Conservation Group meeting, and in subsequent informal discussion with the invertebrates and lower plants specialists in JNCC and in EN, that none had been consulted over the revision of the bog guidelines. They had been drafted and published at great speed, without any formal consultation within JNCC.

The production of the guidelines (December 1994) coincided with the appearance of two documents from Dept of the Environment: the draft *Mineral Planning Guidance: guidelines for peat provision in England* (September 1994), and *report of the Working Group on Peat Extraction and Related Matters* (August 1994).

A1.3 Zoological content

There is minimal account taken of either vertebrates (half of one sentence on birds; no reference to other vertebrates) and invertebrates (a handful of passing references, but no criteria for evaluation and no serious reference to species information). This is particularly surprising in view of the several major surveys of bog fauna in recent years which the conservation agencies commissioned or supported: the Welsh Peatland Invertebrate Survey, survey of Cumbrian Mosses, East Anglian Fens Survey (which also examined some bog sites), Thorne and Hatfield Moors surveys, and the intensive and wide-ranging work on the fauna of the Flowe Country.

A1.4 Lower plants content

No reference is made to the lichen, fungus or charophyte floras of bogs, despite the production of relevant atlases, new flora, and Red Data Book respectively, all with support of the agencies.

A1.5 Position of bogs in ecological/geographical units

The guidelines have a strong northern and north-western bias. Much of the description is based on microtopographic and macrotope, mesotope and microtope features. These are apparent on most bogs in high-rainfall areas, but have never been described from lowland eastern bogs; if such features were present historically, naturalists and early ecologists overlooked them. No adequate account is given of geographic variation in bog structure. It is quite likely that the surface topography of an intact 'continental' (eastern English) bog was entirely different, and that the guidelines would be completely inappropriate for intact bogs, let alone the damaged and degraded sites which provide the best available examples of such bogs.

A1.6 International context

The regional bias extends to a neglect of international views of British bogs. Although the Council of Europe, the Ramsar Bureau and the European Invertebrate Survey have all acknowledged the very great value of British bogs for their invertebrate fauna, there is no such recognition in the new guidelines; this despite the EU/Ramsar resolution passed at their conference on management of wetlands for invertebrates, in 1989.

APPENDIX 2: REPORT OF 1990 INVERTEBRATE SURVEY

The following is taken from Heaver & Eversham (1991):

DIGEST OF KEY CONCLUSIONS

Results:

Three of the species found are now known only from Thorne and Hatfield Moors in Britain. Two are also considered to be internationally endangered.

The survey has produced 14 Red Data Book species, 34 Nationally Scarce species, and dozens of regionally rare or local species. Many were new to northern England.

Habitats:

There are many species which are confined to one very specific type of microsite. The whole fauna can be conserved only by maintaining the full range of peat surfaces, in particular, the small-scale mosaic of bare peat, leaf litter, hare's-tail hummocks and the full range of Sphagnum microhabitats.

Numerous species are found only in areas which have been unworked for upwards of fifty years: they have not yet made the move of just a few metres into more recently vegetated areas that adjoin their habitat. These species are obviously unlikely to survive any attempt at translocation, and their only safe future is to continue to survive where they are already established.
Retaining as much of the long-abandoned wet peat surface as possible is an overriding priority for the survival of the Moors' invertebrates.

Management:

The top priority for management, on the NNR and elsewhere on the moors, must be to raise the water table, as a matter of urgency.

Evaluation:

The ranking of the four peatland vegetation blocks on Thorne Moors, both by the total of rare species, and by the number whose survival depends on the block, is:

T51-52-56: Crowle: T49-55-59: NNR

(See maps in Heaver & Eversham (1991) for explanation of the compartment numbering; none of these areas is included in the proposed denotification, but this is partly because of the restrictions placed on the 1990 survey by Fisons: actively worked areas had to be excluded from the survey)

A strong 'sandy heathland' element in the fauna of Hatfield Moors distinguishes it from all parts of Thorne Moors.

Restoration:

No areas of milled peat surface have yet been abandoned long enough for its colonisation to be monitored.

For the sand and gravel working adjoining Hatfield Moors, dry restoration to heathland is preferable to experimental wet restoration.

APPENDIX 3: RATCLIFFE'S (1977) CRITERIA FOR CONSERVATION EVALUATION

The formal criteria for acquiring reserves, for preferring one area over another, were first expounded in detail in Britain in the 1970s. These official criteria for the selection of national nature reserves were published by D.A. Ratcliffe in the *Nature Conservation Review* (1977). The first of Ratcliffe's two volumes was a discussion of he extent of the wildlife resource in Britain, a classification of habitats within which it could be assessed, and the detailed criteria which might be used. Volume 2 was a 'shopping list' of potential National Nature Reserves, and includes a favourable account of Thorne Moors. (Hatfield was overlooked, largely because it was not well known among naturalists in the 1970s, although it had been highly regarded in the 1940s, and was about to regain popular awareness (Eversham & Lynes, 1983).)

Ratcliffe's criteria were rapidly adopted as a framework for considering biodiversity and conservation, in Britain and elsewhere in the world (Margules & Usher 1982), and they remain the most widely used set of descriptors of conservation value. They lie at the heart of the main NCC guidelines for selecting SSSIs, although have been lost from the revision for bogs. The criteria are as follows (informal annotations are my own):

- **Size** Large reserves are better; species are more likely to survive if there is enough habitat to maintain large populations
- **Diversity** All other things being equal, more diversity (of habitats or species) is better; but some habitats are naturally species poor, and extra species would signal damage or decline. Increasing diversity on a reserve is usually at the expense of some existing feature, e.g. wet heath or seasonally-flooded grassland may support several very rare species, but digging a pond in it would support more, but commoner, species which may be less in need of conservation.
- **Naturalness** A good thing; opposite of disturbance or human interference.
- **Rarity** A good thing: often, the rarer species and habitats are most in need of conservation now (Eversham & Roy, in press, a), and commoner ones will survive longest without it. But don't rely on it: some of our rarest and fastest-declining wild flowers are arable weeds, which have almost vanished over 20-30 years.
- **Fragility** Habitats which are most easily damaged, and least easily rebuilt or created, are more valuable.
- **Typicalness** Almost the contradiction of rarity: nature reserves should represent the typical British countryside and wildlife, as well as the special.
- **Recorded history** Not really a pure conservation criterion: but better-known places may be more important for that reason. If a site has been studied carefully for many years, it seems a shame to stop the work now. Monitoring might make a reserve more valuable.
- **Position in ecological/geographic unit** Two separate ideas presented together. Need to protect examples of each habitat throughout its range - defending heathland in Dorset, woodland in Sussex and fens in Norfolk isn't enough if all these habitats disappear in South Yorkshire. And need to maintain the full range of conditions, e.g. succession from grassland to scrub, habitats at different altitudes, in different rainfall regimes, with different frequencies of flooding or waterlogging.
- **Potential value** Can we rebuild it? Is there scope for a damaged site to be rehabilitated, or for important habitats to be created? A criterion designed with cut-over raised mires in mind?
- **Intrinsic appeal** Do the general public, or VIPs, like the site? Is it 'pretty'? More a measure of how easy a place may be to defend than its real importance?

The above list was intended to be applied to drawing up a 'shopping list' for National Nature Reserves (vol. 2 of the *Nature Conservation Review*; vol. 1 provides a detailed description and evaluation of wildlife habitats in Britain). Certain important criteria which were left out, and which may be more important at a county and regional level, and to an individual land-owner:

- **Availability** Can the land be bought? How expensively? Is nature conservation its main use, or is it already important to the company for other activities?

- **Location** Is it near existing reserves? (Connectivity is discussed in section 10.5). Is it easy for people to visit?

- **Cost commitments, safety and other liabilities** Is it safe for visitors without a warden/guide? Is it a threat to other land-owners (through flooding, 'pest' populations etc.)? Does it contain buildings, roads etc. which need maintaining? How will this maintenance interact with conservation work? Is regular management needed? Will future management be expensive? If so, every year or only periodically?

The more biological of Ratcliffe's criteria can perhaps be simplified into three attributes:

Habitat quality Is it a good example of the habitat in the region? does it have the features and species we expect in the habitat?

Species diversity More species is better? Certainly, more species typical of the habitat(s) present is better.

Presence of rare species The more the better? A quick and easily used way of evaluating sites, but fraught with complications and dangers: more survey = more species and more rarities?

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