THORNE AND HATFIELD MOORS: IMPLICATIONS OF LAND USE CHANGE FOR NATURE CONSERVATION

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BACKGROUND: THE PUBLISHED RECORD

This paper deals with the impact of human activity on the two Moors. It describes the aspects of historical and modern land use which are responsible for the range of present-day habitats; it also briefly characterises the wildlife of these habitats.

Gaunt (1987) and Limbert (1987a) give valuable accounts of aspects of the landscape history of Thorne Moors, and Limbert (1978) provides a brief account of the geomorphology of Hatfield Moors. The habitats on Thorne Moors are described generally by Limbert *et al* (1986), and the vegetation of Hatfield Moors as it was in 1978-79 by Eversham & Lynes (1980, 1981, 1983). Much of the vegetation information in this paper is taken from these sources; unpublished observations are the author's own.

Aspects of the human history of the area have also been documented. Drainage in the nineteenth century is described by Limbert (1990), whose research into the history of the peat industry are on-going; two papers already cover the industry on the two Moors in outline (Limbert, 1985, 1986), and a full collation of all available information is in preparation.

This paper considers the role of human activity in shaping wildlife habitats on and around the two Moors, and how technological changes now threaten those habitats. In the post-medieval period, three major human activities have affected the peatlands themselves and adjacent non-peat habitats:

reclamation, especially by warping
peat cutting
drainage

'Reclamation' has occasionally produced semi-natural non-peat habitats in place of peatlands, and drainage has often been linked with the other two processes.

The paper is in two parts, dealing first with the non-peat habitats, and then the peatlands themselves.

NON-PEAT HABITATS AND INFLUENCES

Fundamental to current vegetation on both Moors is the underlying geology (Limbert, 1978; Gaunt, 1987). Two aspects are of particular significance in providing non-peat habitats important for conservation: nutrient enrichment around the edges of Thorne Moors has produced fenland and brackish habitats; and the sand and gravel deposits underlying Hatfield Moors outcrop along the western and south-western edges, giving rise to heathland.

FENLAND AND WARPING

An intact raised mire is usually fringed with a belt of fen or carr, richer in nutrients than the acid mire. This narrow belt can be seen clearly along the southern and eastern edges of Hatfield Moors, and around most of Crowle Moors: in summer, it is recognisable by the distinctly grayish-green appearance of the willows and sallows, contrasting with the lush green of the birches growing on the peat. Around Thorne Moors, this narrow strip of non-peat habitats has been considerably enlarged in places by reclamation of peat and of other wetlands using a special technique : warping.

This involves laying mineral soil on top of the peat or other poor soil, either by digging topsoil from one area and carrying and tipping it ('cart warping' or 'dry warping'), or by controlled flooding from the nearby silt-laden tidal rivers ('wet warping'): if a tide is allowed in, then the sluice gates at the mouth of the Warping Drain closed, the silt settles out, leaving a thin (1-3 mm) layer. Opening the sluices at low tide allows the water to flow away, leaving the alluvium. The process is repeated daily over a period of months (usually Spring to mid-Autumn) until up to 0.3 m of silt had been laid down. The resulting farmland would be sown with grass or clover and grazed for a few years, to allow the salt to wash out, after which arable land of the highest quality results.

The first local warping was performed in 1730-1740 or earlier, and large-scale moorland 'reclamation' took place during the late eighteenth and early nineteenth centuries; by 1845, nearly 4,000 acres of land had been warped (Gaunt, 1987). Wet warping was possible over much of the area because it is very low-lying, at or below the high-tide level of the surrounding rivers. Additionally, a large proportion of the original peat area had been cut over before it was warped, making flooding easier still. Gaunt, 1987 shows the extent of warping around Thorne Moors, and the area of peatland which has been lost through warping. Around 50% of the original area of Thorne Moors peat has disappeared since 1800 under warpland (Gaunt, 1987), much of which is now highly productive arable land.

The only extensive cart (dry) warping in the area was on Hatfield Moors, over several decades in the nineteenth century (Limbert, 1985). Soil was excavated close to the eastern moor edge (forming what is now Lindholme Lake), and spread over the peat to create the arable fields in the northeast quadrant of the Moors.

A few areas near Thorne Moors which were warped (perhaps accidentally, or only thinly and ineffectively) were not subsequently cultivated, and have acquired elements of vegetation and fauna which would otherwise have been restricted to the fenland zone round the mire edge. Some of the uncultivated warpland has developed to willow/sallow woodland, but a little remains as more open fen grassland and reedbeds.

Two important areas of wooded warpland have long been noted for their Nightingales: Will Pits, adjacent to Swinefleet Warping Drain; and the belt of sallows and willows around the southern edge of Crowle Moors. They also support some scarce insects, such as the ground-beetle *Agonum livens.* The large willows host a range of corticolous lichens, including regional rarities such as *Usnea subfloridana* and *Cetraria chlorophylla* (Eversham, 1987).

The narrow carr fringe on the southern edge of Hatfield Moors, east of Ellerholme Farm, is more diverse, containing large bushes of Alder buckthorn *(Frangula alnus),* and its attendant Brimstone butterflies, and a few broad-crowned Black Poplar *(Populus nigra),* probably native trees at the northern limit of their range (Meikle, 1984). The poplars support several scarce leaf-hoppers *(Idiocerus* spp.), and their rot-holes have a good dipterous fauna, including the rare soldierflies *Solva marginata* and *Neopachygaster meromelaena.* So far, the carr and the nearby drains do not appear to have been affected adversely by pesticides or fertilizers used on the adjoining farmland.

Grassy clearings in carr or along the moor edge, and the more extensive area of unclutivated warpland kept open by grazing at Inkle Moor, support a specialised flora and fauna. Inkle Moor is the only local site for Marsh Pea *(Lathyrus palustris),* and the only locality in Britain where the ground-beetle *Dromius sigma* is found regularly (Shirt, 1987). The Red Data Book (RDB) amphibious snail *Lymnaea glabra,* flourishes at the western end of Inkle Moor, in shallow water among Reed Sweet-grass *(Glyceria maxima),* and at the edges of drains to the south of Crowle Moors and south-east of Hatfield. Lowland South Yorkshire is now its British headquarters; the snail is also a declining species "of special concern" throughout Europe (Wells & Chatfield, 1991). Drain banks on and near the Moors have also produced records of Fen Violet *(Viola persicifolia)* at irregular intervals, most recently on Hatfield in the 1960s and south of Thorne Moors in the mid-1970s (Eversham & Lynes, 1983).

A distinctive variant of fen-grassland on the more acid soils along the southern edge of Hatfield Moors is dominated by Purple Small-reed *(Calamagrostis canescens),* which supports its own specialised fauna. The rectangular strip of sallows on the south-west corner of Hatfield Moors has the most diverse assemblage of marsh- and spotted-orchids recorded in the area, including Common Spotted-orchid *(Dactylorhiza fuchsii),* Heath Spotted-orchid *(D. maculata* spp. *ericetorum),* Southern Marsh-orchid *(D. praetermissa),* and Northern Marsh-orchid *(D. purpurella),* together with several hybrids (Eversham & Lynes (1980) and unpublished data).

ESTUARINE INFLUENCES AT THORNE

One small part of the western edge of Thorne Moors has developed, very surprisingly, as salt-marsh. Its origins are uncertain. Warping of adjoining areas would provide some saline soils, and the tidal ingressions would probably bring plants and invertebrates with them: the Coole naturalist, H F Parsons, recorded Sea Aster *(Aster tripolium),* for instance, along river banks and warping drains in the l870s (Lees, 1888). Since the salt-marsh contains species not at present known from the Humber, it is reasonable to assume that it became established at Thorne before the main river was polluted or had its banks built upon and industrialised. There is some early faunal evidence: in 1837, J C Dale recorded the Short-winged Conehead *Conocephalus dorsalis* when he visited Thorne Moors (Skidmore *et al,* 1987). This bush-cricket is

very largely coastal in the north: Spurn Point is its classic Yorkshire site (Marshall & Haes, 1988).

However it came to be there, the salt-marsh associated with Bell's Pond has been maintained, and probably extended, this century by the 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. The water flowed through the halide belt which underlies the magnesian limestone, so the outpourings were highly saline. When sampled in 1977, parts of the Pit Dyke had a typical salinity of over 40 ppt, more saline that the North Sea (Eversham, 1977), and the dyke and ponds become saturated in hot weather. Although the colliery closed in 1956, pumping continues, in anticipation of possible re-opening.

The area of salt-marsh around Bell's Pond and the Pit Dyke, marked by large stands of sea aster, is the only Yorkshire locality for many insects, including the RDB soldierfly *Stratiomys singularior* (Eversham, 1983). The otherwise exclusively estuarine/coastal shorebug *Saldula pilosella* is sometimes abundant there. Extensive reed-beds *(Phragmites australis)* near Bell's Pond and at Inkle Moor support an important invertebrate community, including many species of wainscot moths, and scarce bugs such as the grassbug *Stenodema trispinosum* and several *Chloriona* leaf-hoppers. The beetles here include the RDB ground-beetle *Dromius longiceps* (Skidmore *et al,* 1987; Heaver & Eversham, 1991). The reeds also hold a large population of Harvest Mice.

FORMER EXTENT OF SANDY HEATHLANDS AROUND THE HUMBERHEAD LEVELS

Large areas of the wind-blown periglacial sands of Hatfield, Tudworth and much of north Lincolnshire could well have supported grass-heath long before peat formation began at Hatfield (c4,000 years BP) and Thorne Moors (c3,000 years BP), if grazing pressures were locally sufficient to prevent complete forest cover.

Although losses of peat-based habitats have been considerable, sandy heathlands in the region appear to have suffered even more (Webb, 1986). Almost all of the important sandy heaths and warrens to the north and west of Scunthorpe have been built over by industry or by housing; the last important remnant, Atkinson's Warren, was destroyed as recently as the late 1980s (R S Key, pers. comm.). Other areas of heathland are being quarried, for example Blaxton Common, just south of Hatfield Moors, and Messingham Heath and Brumby Warren to the east of the Trent (Gibbons, 1975). Over 80% of the formerly extensive heaths to the south of Scunthorpe have been lost under conifer plantation, including Laughton Common, some of Manton Warren, and much of Scotton Common. Parts of the latter are now protected as a Lincolnshire Trust reserve (Gibbons, 1975), and their flora appears to have much in common with Hatfield's. Other areas, such as most of Manton Warren, have been converted to low-grade arable land. To the north of Thorne, the lowland heaths and bogs in the Vale of York have also suffered from agricultural reclamation and afforestation (Sutton & Beaumont, 1989).
In the context of these losses, the surviving sandy heathland elements in the flora and fauna of Hatfield Moors take on a particular importance when assessing the Moors' regional conservation value.

SANDY HEATH AND WOODLAND AT HATFIELD MOORS

The western edge of Hatfield Moors has always had very shallow and discontinuous peat, with nutrient-poor periglacial sand breaking through in many places. The best example of this sandy-peaty heathland was immediately adjacent to Lindholme Airfield, but this is now being quarried for the sand and gravel. The other important glacial deposit is the 'island' moraine at Lindholme.

The significance of the sandy influence at Hatfield is twofold. First, it helps to explain the unusual insect fauna, which has affinities with East Anglian Breckland and with coastal sand-dunes, 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.

The wooded sandy fringes of Hatfield's western and north-western edges supported a kind of woodland not found elsewhere on the Moors, a mixture of sallow, birch, rowan and some oak, but lacking narrow-leaved willows. The ground flora was characterised by Climbing Corydalis *(Corydalis claviculata)* and Honeysuckle *(Lonicera periclymenum).* Several scarce moths have been found in this habitat, including the Speckled Yellow *(Pseudopanthera macularia)* at its only lowland Yorkshire locality: its nearest sites are in the Derbyshire Dales (Sutton & Beaumont, 1989). Nightingales bred here, too (Marshall *et al,* 1989*).*

More open areas of Hatfield's sandy margins supported grassland of Wavy Hair-grass *(Deschampsia flexuosa)* and Purple Moorgrass *(Holinia caerulea).* This habitat contained several species not known from Thorne Moors, such as Slender St John's-wort *(Hypericum pulchrum)* and the damsel-bug *Stalia boops,* with Heath Rush *(Juncus squarrosus)* in the wetter areas. It also held large numbers of Nightjars and Green Tiger-beetles *(Cicindela campestris).*

Almost all of these sandy wood-grassland-heath habitats were destroyed in the period 1983-1989, or are scheduled to be quarried for sand and gravel in the near future.

The 'sand' of Lindholme is possibly the most remarkable non-peat habitat of all. It is a mixed glacial moraine, probably the product of rock-laden ice, stranded on the edge of the glacial Lake Humber as the water receded and the ice melted. The moraine contains gritstone, magnesian limestone, quartz, chert and sandstone - a complete cross-section of Yorkshire geology - with an undulating cover of periglacial aeolian sands (Limbert, 1978). The resultant vegetation is a fine-scale mosaic of acid and basic grassland: sandy grassland species such as the ground-bug *Plinthisus brevipennis* living among *Deschampsia flexuosa* only a few metres away from Lady's Bedstraw *(Galium verum),* Field Mouse-ear *(Cerastium arvense)* and the richest grassland mollusc assemblage in Yorkshire away from the magnesian limestone belt. This includes obligate calcicoles such as *Vallonia costata* and *Vertigo pygmaea,* and the scarce and declining Heath snail, *Helicella itala.* The terricolous lichens are also important, with masses of large *Cladonia* species, and the only local site for *Coelocaulon aculeatum* (Eversham, 1987).

The island of Lindholme also has some fine parkland oaks, both at the Hall and in the grassland, which have a characteristic fauna, including beetles, such as *Orchesia undulata* indicative of old woodland, and the pseudoscorpion *Chernes cimicoides* at its northern limit in Britain (Legg, 1989).

THORNE COLLIERY

The spoil heap and winding gear of the colliery has been the most prominent feature of the western edge of Thorne Moors since the 1920s. Although the shales and silts of the spoil are an alien habitat in the Levels, they have been colonised by several scarce plants and animals. The flora includes plants such as Ploughman's Spikenard *(Inula conyza)* and Yellow-wort *(Blackstonia perfoliata)* which are otherwise not recorded away from the limestone. The ants *Formica fusca* and *Hyrmica sabuleti* are southern species associated with warm, south-facing slopes. Little Ringed Plover breeds in the open expanses and, most surprising of all, Sea Campion *(Silene maritima),* forms extensive carpets along the eastern slopes of the spoil heap.

The flat shale area, extending north from the colliery toward Inkle Moor, has a flora characteristic of intense disturbance, including melilots *(Helilotus* species) and Sticky Groundsel *(Senecio viscosus),* and a large population of the Mottled Grasshopper *(Hyrmeleotettix maculatus),* associated with bare ground. Among rough grass in this area in the 1970s, the Lesser Marsh Grasshopper *(Chorthippus albomarginatus)* was recorded, at the extreme northern limit of its British range (Marshall & Haes, 1988).

PEAT HABITATS

If the underlying deposits, and more recently overlain ones, are the key to understanding the non-peat habitats round the two Moors, human activity on the surface has determined the modern character of the peatlands themselves. Drainage in the nineteenth century modified the topography of the Moors, and probably caused the extinction of a few species associated with the very wettest parts of the mire (Limbert, 1990). Since then, peat extraction has been the dominant factor on the Moors.

ORIGINAL MIRE SURFACES

The extent and intensity of peat extraction on the two Moors has resulted in very little of the original mire surface vegetation surviving in the 1990s. Until only a few years ago, this was not the case on Hatfield Moors. Peat cutting on Hatfield had historically been concentrated on the northernmost areas, close to the mill. Although some drainage and agricultural reclamation occurred last century, perhaps 2,000 acres of intact mire surface survived in the early 1970s - the largest area of uncut lowland mire in England.

Peat extraction expanded rapidly in the 1970s and 1980s (as described and mapped below). However, the vegetation survey of 1978-79 (Eversham & Lynes, 1980, 1981) recorded large areas of valuable habitat. Some important bog plants, such as Bog-rosemary *(Andromeda polifo1ia),* Bog-myrtle *(Myrica* gale) and Cranberry *(Vaccinium oxycoccos),* and lichens such as *Cladonia portentosa* were more abundant on Hatfield than on any part of Thorne Moors. Several species were found which have never been recorded on Thorne, among them the conspicuous cup-fungus *Disciotis venosa,* the rare northern lichen *Cladonia sulphurina,* and mosses such as *Sphagnum tenellum.* It is possible that these were relics of the intact mire surface which have failed to colonise even the oldest of nineteenth century hand-gravings.

The area of peat vegetation on Hatfield Moors adjacent to the gravel workings on the south-west edge retains some of this flora, and several invertebrate species have

recently been recorded there which are not on the Thorne list. The fact that it is the only extensive area of uncut mire which retains a 'mire-like' flora and fauna anywhere in eastern England adds considerably to its conservation value.

No uncut mire surface at Thorne Moors now survives with its original vegetation intact. Small areas near the Moor's centre may possibly have never been cut, but are now too severely drained by modern peat workings to support mire communities: these raised baulks between cuttings (described by Smart et al 1986, and Holland 1990a, 1990b) tend to be dominated by Heather (Cal1una *vulgaris)* and Bracken *(Pteridium aqui1inum),* together with birch scrub if there has not been a recent fire.

Areas near the edge of Crowle Moors which have perhaps never been cut support birch woodland rather than open mire vegetation. A small area near the southern edge of Thorne Moors, at Casson's Garden, is probably original surface; most of it is now dominated by *Rhododendron.* However, it was in a small damp clearing among Cross-leaved Heath *(Erica tetralix)* here that the tiny shorebug *Micracanthia marginalis* was found in 1976 and 1977 (Crossley, 1977), its only known occurrence on the Moors.

DEVELOPMENT OF A PEAT EXTRACTION INDUSTRY

Peat cutting on the two Moors has been thoroughly documented by Limbert (1985, 1986); this account aims to assess the consequences of peat extraction for wildlife, rather than describing the industry *per* se. It draws heavily on Limbert's papers. The early history of the industry on Hatfield Moors is far less clear than on Thorne, so the account is based mainly on events on Thorne Moors, until the 1970s.

The following sections review the development of the peat industry relying on hand-digging, and illustrate the changing scales of its operations over time. The final sections describe the introduction of mechanical extraction, and the impact which this has had on the wildlife of the two Moors.

TECHNIQUES AND EXTENT OF HAND GRAVING

Peat digging by hand, known locally as 'graving', had begun on Thorne by the 14th century, and may well have impinged on the edges of Hatfield Moors for equally long, though records are fewer. Hand digging continued until the early 1960s. By the l820s, 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. Much of it, to the south-east of the present Thorne Moors, towards Medge Hall, was converted to arable land by warping in the nineteenth century (Gaunt, 1987).

Judging by the earliest detailed naturalists' accounts, dating back to the l820s, peat cutting before then had had relatively little effect on the flora and fauna. So, it seems reasonable to concentrate on the last 170 years of peat cutting; this is also the period for which fairly reliable information is available.

In the absence of ledgers and maps of workings, it is difficult to quantify the volume or area of peat cutting. Even in recent years, commercial confidentiality means that few figures have been published. Despite the problems, it is possible to identify the broad trends, as shown in Figure 1, which also shows the estimates of area and tonnage which it is possible to derive from statements in the literature.

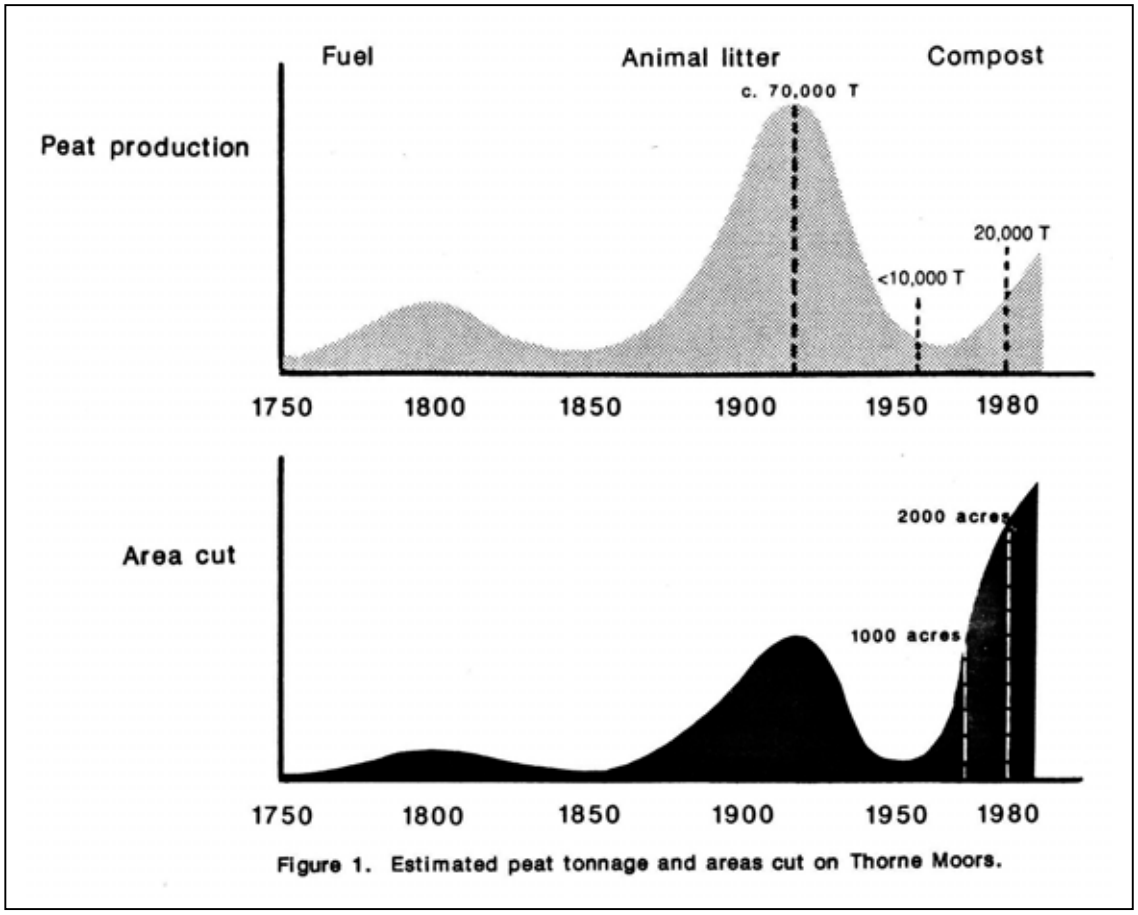


Figure 1. Estimated peat tonnage and areas cut on Thorne Moors.

Contrary to expectations, peat extraction has not increased steadily over time. Massive fluctuations in activity have followed market forces. The first half of the nineteenth century saw peat cutting mainly for fuel. A large number of small companies was involved at this time, including many names now preserved in the local landscape: Casson, Elmhirst, Gossip, Durham, and Creyke. William Casson appears to have been the first to appreciate the horticultural value of peat. But, rather than selling it as compost, in the l830s he established a market garden on the southern side of Thorne Moors (Limbert, in press). Here he grew and sold tens of thousands of *Rhododendron,* and a variety of other ericaceous shrubs, too. The *Rhododendron,* in particular, flourished and is now well-established on both Moors, though mainly south-western on Thorne Moors still. The only other peatland plant which is known to have survived to the present is the North American Sheep Laurel *Kalmia angustifolia,* which dominates an area about 15m square on the part of the Moors still known as "Casson's Garden".

Around 1850, the potential of peat as animal litter was noted. This business gathered momentum in the 1880s, a time when enormous numbers of horses and ponies were used in transport, and when the expansion of coal mining was ending the use of peat for fuel (Ensor, 1936; Matthew, 1984). A high proportion of London's trolley-bus horses were probably stabled On Thorne Moors peat at the turn of the century. The earliest diggings which have provided a vegetated modern surface probably date from about 1880.

In the late nineteenth and early twentieth century, two very different methods of hand graving were used extensively at Thorne. additionally, 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', which are deeper and different in character from the rest of the Moors.

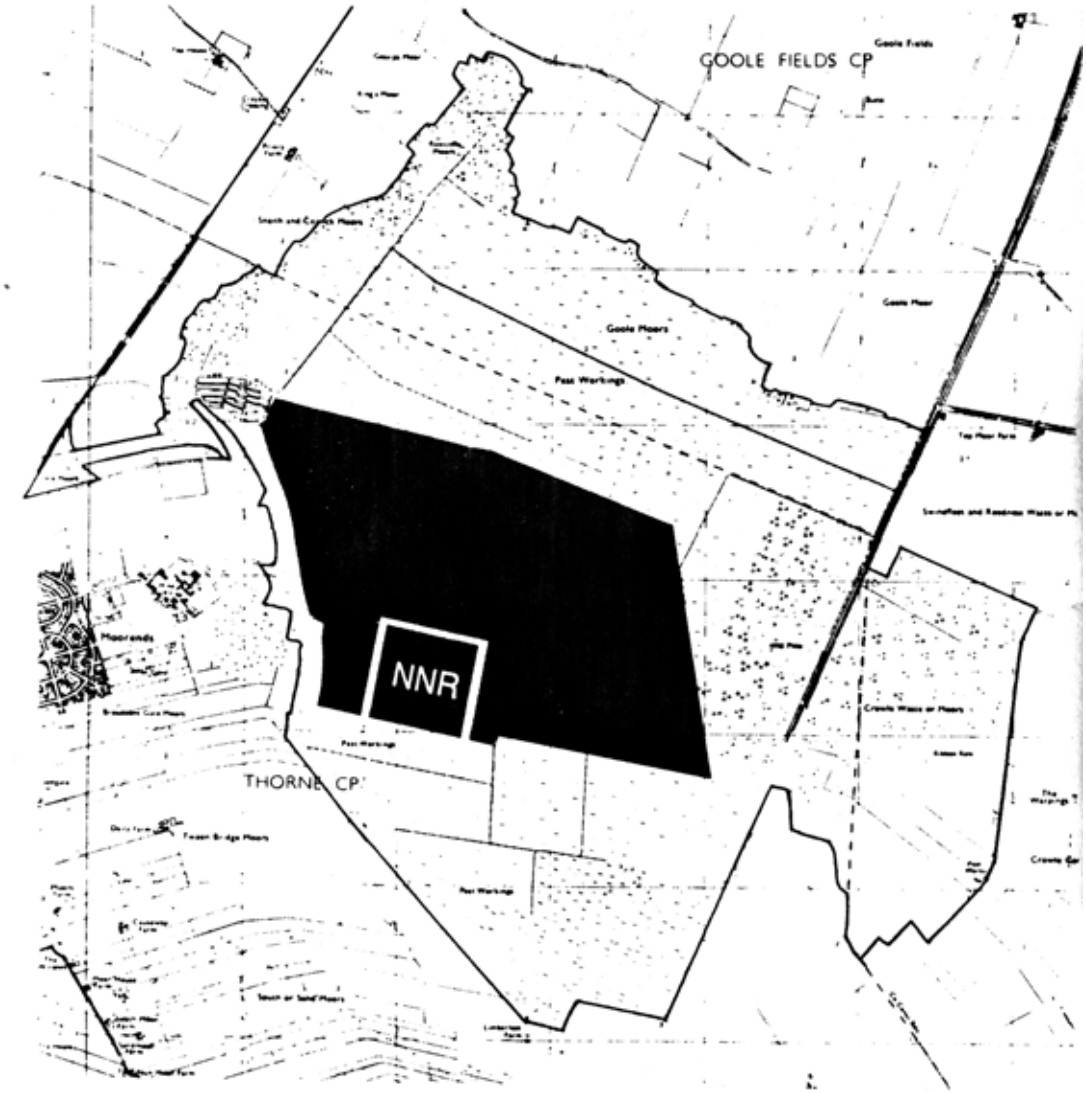
In 1894 (not in the 1870s, as recorded by Smart *et a1*, 1986), the first Dutch immigrant workers were brought to Thorne Moors, and settled in the terraced houses to the north of Moorends which are still known as 'Dutch Row'. They introduced a new extraction technique which came to be known, unsurprisingly, as 'Dutch graving'.

From 1894 until the 1930s, the two different techniques of hand graving were being used simultaneously On different parts of the Moors. Dutch graving produced wider, somewhat shallower cuttings, and occupied about 500 ha on the western side of Thorne Moors, as far east as Thousand Acre Drain (Figure 2), The best-known surviving feature of the Dutch peat industry on Thorne is the networks of canals in the NNR and the area to the north and east. These were used by horse-drawn barges, transporting peat to the Paraffin Mill, from 1895 until 1922. They now support vegetation and invertebrates with more of a fenland character than the cuttings themselves.

The southern series of canals may have been partly clay-lined, and the towpath of the long linking canal was well embanked with mineral soil. The central portion of this series is now within the NNR. and the towpath of the linking canal forms the Reserve's northern boundary. These canals now contain some fine wet peat habitats: large *Sphagnum* hummocks, expanses of sundew *(Drosera rotundifolia),* a few Royal Fern (*Osmunda regalls),* and in some years, carpets of bladderwort (*Utricularis vulgaris).*

Perhaps because of clay puddling in the bottom of some of the canals, combined with nutrient-rich (or even slightly brackish) water reaching them from the Moor edge, the southern canals contain a diverse range of rich and poor fen communities, as well as assemblages characteristic of acid mire. Plants such as Saw-sedge (Cladium *mariscus)* and Lesser Bulrush *(Typha angustlfolia)* survive in the canals, together with a few ca1cicole molluscs, such as *Vertigo pygmaea.* These species would probably have occurred on the margins of the intact mire before human interference, and their survival in a refugium such as the canals is important if the full range of mire habitats is eventually to develop agsin. The canals in this series which are still outside the NNR are also of considerable (and subtly different) botanical interest.

Figure 2. Area of 'Dutch' peat cutting c. 1894–1910 on Thorne Moors.

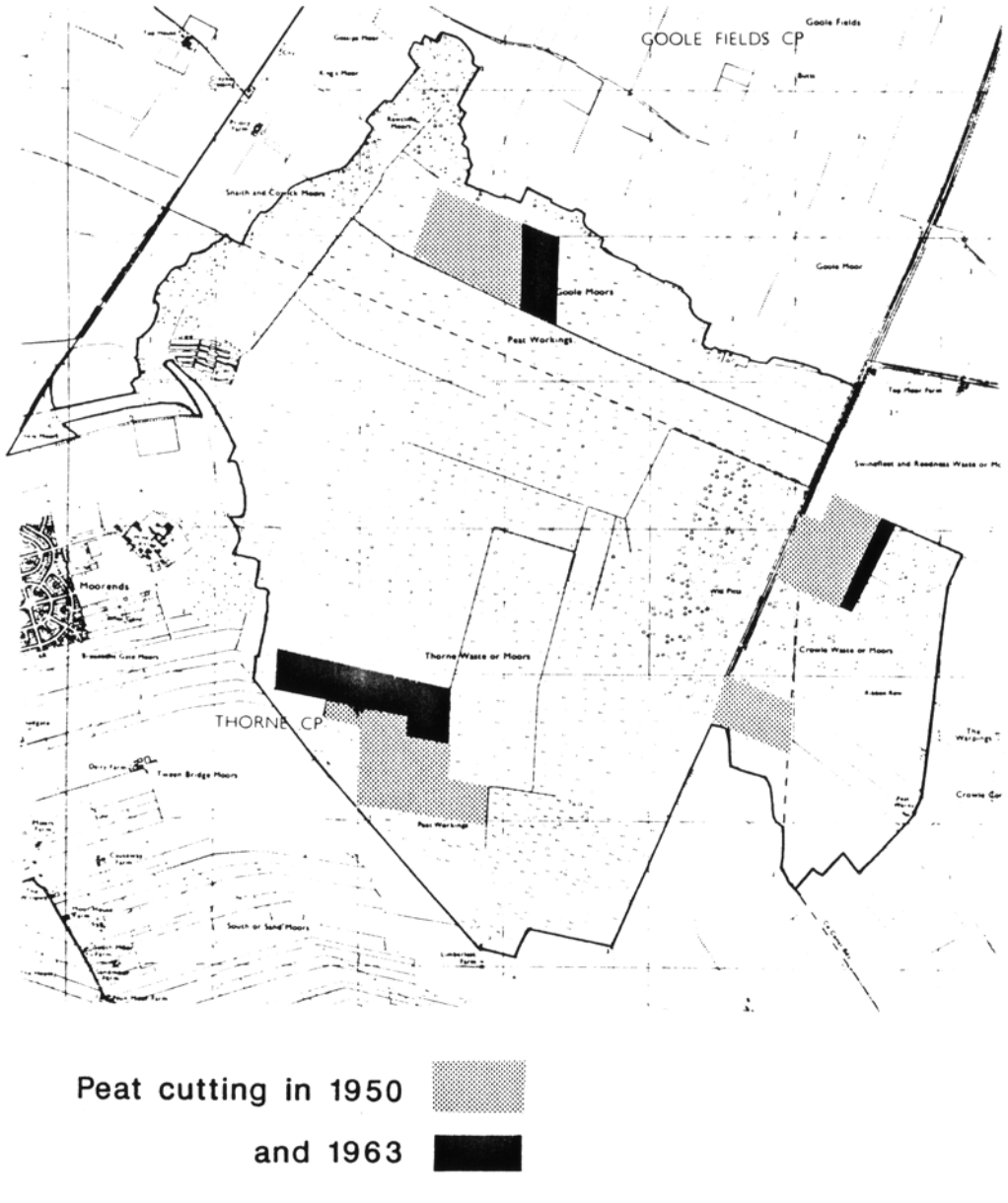


The northern canals, beyond the NNR boundary, were generally more acidic and less clay- or warp-influenced than the southern series. As such they supported, for example, the largest Royal Ferns seen on the Moors in recent years, and charophytes which have not been found elsewhere (Limbert, 1987b). The whole of this series of canals has recently been drained, beginning in the Spring of 1989; the vegetation has been damaged, but has not yet been removed.

While the large Dutch company, probably employing in excess of 300 people, worked a well-defined parcel of land, several smaller companies were operating on other parts of the Moors at the same time, mainly using the alternative method of digging, English hand graving. This produced rather narrower, deeper cuttings, and was the method used in the southern and south-eastern parts of Thorne, on Crowle Moors, and on Hatfield Moors. It is estimated that in 1905, a total of 70,000 tons of peat were removed from Thorne Moors (all dug by hand).

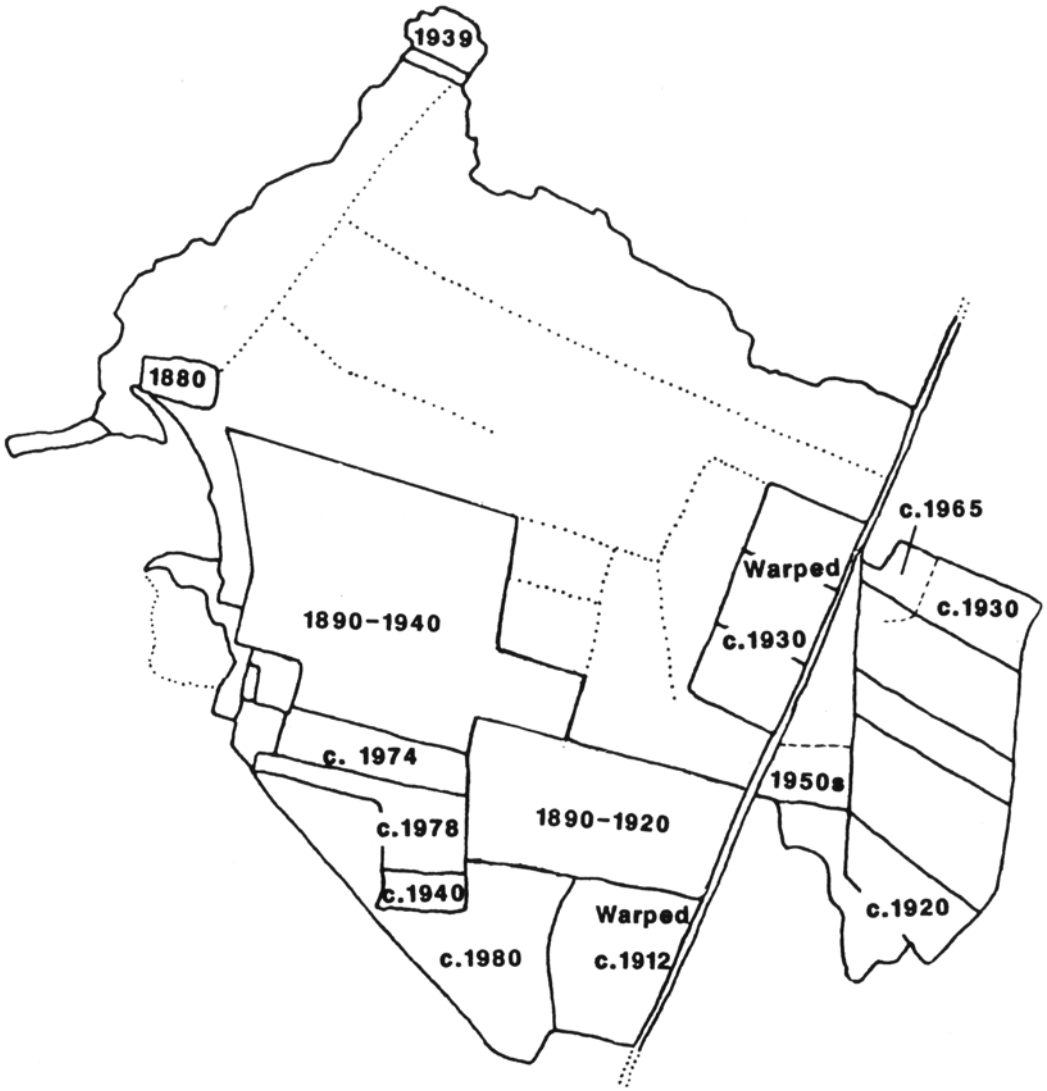
The two forms of graving are believed to have had different effects on the vegetation succession which developed in the cuttings. It is known that a high water table was maintained in the area of the canals (A J Eversham, pers. comm.). The Dutchmen may well have thrown the wettest vegetation into already-flooded cuttings; this may be why only the Dutch cuttings seem to have since developed multi-species *Sphagnum* hummocks. English gravers tended to make more use of the cut surface vegetation: when beginning to cut a new area of moor, a worker would first slice away the surface vegetation. However, providing there were no trees present, he would place this, living side up, next to his cutting, to form a cushion on which the cut turves would lie. Some plant and invertebrate species, perhaps those associated with intermediate wetness, would be expected to survive better in this cutting regime. Of the invertebrates, the Red Data Book reed-beetle *Donacia obscura*, and several rare spiders, including the raft spider, *Dolomedes fimbriatus* and a jumping spider, *Bianor aurocinctus*, are recorded only from the older English gravings.

Figure 3. Areas of peat cutting on Thorne Moors c. 1950 and in 1963.



Peat production on Thorne was probably greatest in tonnage and volume c19l0, after which horses began to be replaced by petrol engines and the market for litter for stabling declined. The canals were not used by barges after the 1920s, when a fire severely damaged the Paraffin Mill. Hand graving was the only method of peat-cutting on Thorne or Hatfield Moors until the 1960s; and until the 1950s, the waggons of peat were horse-drawn to the factories, and moved by manpower within the factory yard. Ironically, as diesel engines replaced horses for traction on the Moors in the 1950s, the change throughout British industry signalled the end of the market for peat as horse-litter. By the late 1950s, the whole extractive industry at Thorne and Hatfield had reduced to less than a tenth its maximum extent (Figure 3).

Figure 4. Last peat cutting dates for vegetated areas on Thorne Moors.



(After Heaver & Eversham, 1991, modified)

The period 1920 to 1965 (roughly the end of the hand graving era) produced a range of surface patterns, all of which left dry baulks standing between wet cuttings, but in various configurations and with subtly different effects on the flora and fauna. As well as 'Dutch' and 'English', a further variant appeared in the 1930s-l950s, when Irish

workers arrived and used their own modification of the Dutch method. Most post-1920 cuttings were doubtless second cuts over areas that had been drained and worked earlier. Despite these complications, it is possible to define the approximate date of last cutting for most of the currently vegetated parts of Thorne Moors: these are shown in Figure 4.

WILDLIFE RECOLONISATION DURING HAND-DIGGING

If so much of the Moors was being drained and cut over, how did so many of the Moors' plants and animals survive? Losses seem to have been confined to plants requiring deep water in bog pools, such as Rannoch-rush *(Scheuchzeria palustris)* and Bog Sedge *(Carex limosa)* (Limbert, 1990). A few species may have been quick to colonise the canals and the ditches which contained permanent standing water. The diversity of the *Sphagnum* bog-mosses in the canals suggests they colonised at a time when much of the Moors' surface had not been severely modified.

Figures 2, 3 and 5 show the total area of Thorne Moors being cut at different times over the past 90 years, and the amount of peat being removed is plotted in Figure 1. There are a few other measures of the scale of peat-digging operations which are useful when considering the likelihood of successful recolonisation by vegetation and fauna. During hand graving:

> The area of peat cut by a group of gravers working together would rarely be above 50-100 acres. The Moors were thus a patchwork of vegetation in different stages of recolonisation after cutting, and the individual blocks of uniform habitat would rarely be larger than 100 acres.
>
> The length of individual cuttings would rarely exceed 10 chains in length (cuttings can be regarded as linear features: workers were paid 'by the chain' (1 chain - 22 yards -20 m) even in the 1980s).
>
> The working method also meant that bare, de-vegetated peat would usually be within 5 m of living vegetation containing many of the typical moors plants and invertebrates.
>
> The rate of cutting was so slow that a patch of cut peat was seldom re-cut again in less than 10-20 years; hand graved once between 1900 and 1950 were not re-cut until the mechanised era.

These four measures of the impact of cutting methods are tabulated, for each of the major methods, in Figure 9. This shows clearly how hand graving left far more vegetation within cut-over areas, whereas later techniques exploited increasingly larger areas, removing the patchwork effect and leaving very much greater distances for plants and animals to cross if they were to recolonise.

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.

Fisons bought almost all of Thorne and Hatfield Moors, all the peat cutting planning permissions, and all the mills, for c£250,000 in 1963. Fisons developed the new

market for horticultural composts rapidly. Simultaneously, they began mechanising the cutting operation. At this rime, the Moors were opened up for cutting in small patches (1-200 acres), and cut in linear strips with vegetation left intact in between. The overall impression was of a green landscape with small temporary bare areas within it: the trenches of the machine cuttings themselves would be re-vegetated within 5-10 years. In the early 1970s, there were a few cuttings as long as 43 chains (865 m), but these were considered too long to be worked efficiently by the then current methods.

As mentioned above, 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, especially the cottongrasses *Eriophorum angustifolium* and *E. vaginatum,* growing in their wetter parts, and heather-dominated communities in the drier baulks. The area immediately south of the NNR is typical of 1970s' cuttings, in this case abandoned c1974.

During the 1970s, the horticultural market expanded gradually, and so did the area cut; but much vegetation still remained on both Moors.

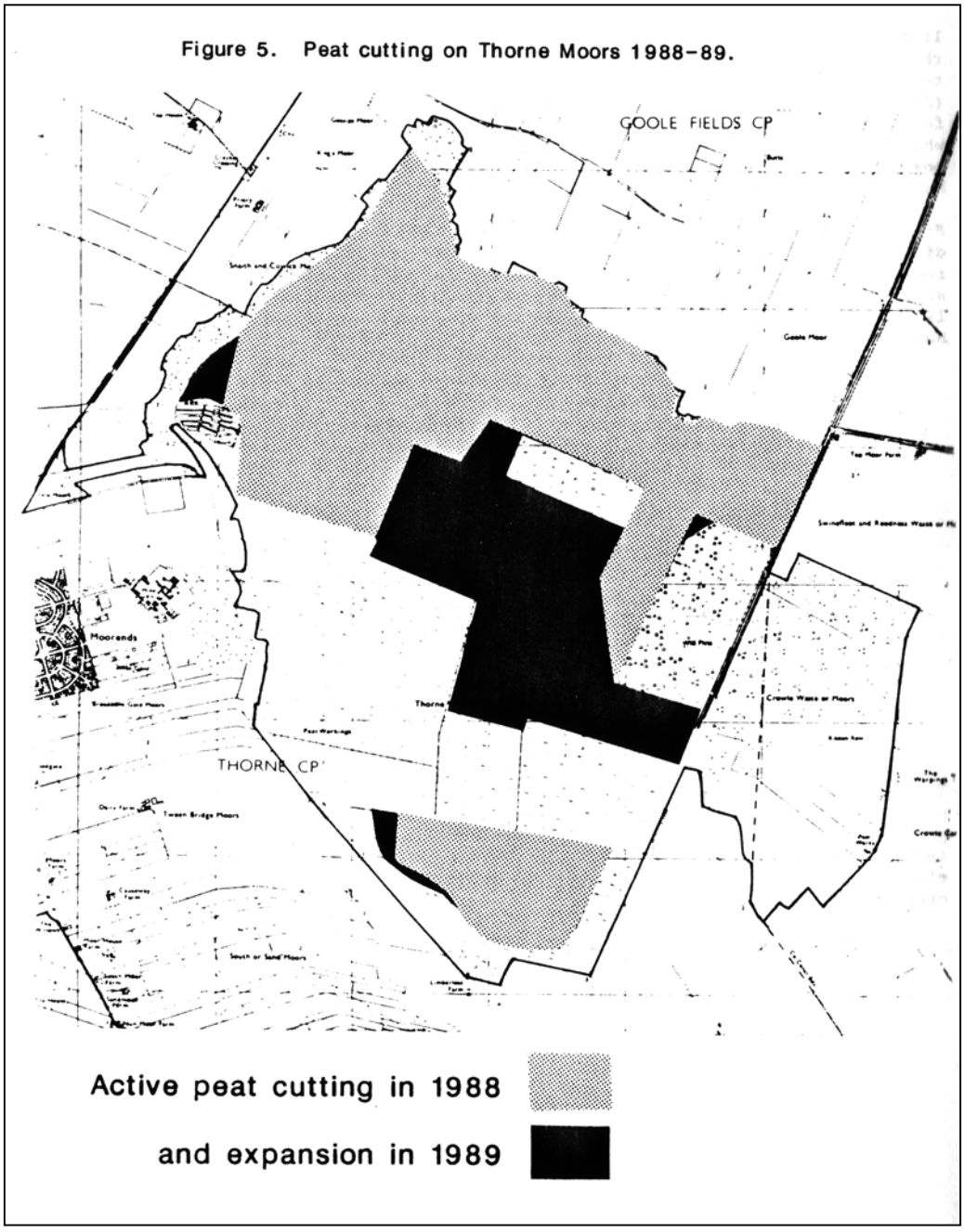
However, by 1978, the peat cutting landscape was changing. By slight modifications of the methods of moving peat across the Moors, longer cuttings became the norm: there were '60-chain flats' (1.2 km) on Thorne Moors, and the first block of '150-chain flats' (3 km) to the south of Lindholme Road on Hatfield. These extensive cuttings on Hatfield were also the first to be repeatedly re-cut on a short rotation, and kept 'tidy', without strips of vegetation between the cuttings. This tendency was one of the most damaging to wildlife: it resulted in the complete absence of all vegetation, even drought-tolerant species such as birch, between the cuttings. The loss of vegetation in turn reduced the breeding bird populations, even common species such as Pied Wagtails, Skylarks and Meadow Pipits being very sparse in the intensively worked areas: Goole Moors, in particular, had very little vegetation and. few birds remaining by 1982.

PEAT MILLING

At about the same time as the 'tidying up' of cuttings, peat milling was introduced, first on Hatfield, then about 1985 on Thorne Moors. Instead of periodically cutting trenches among an otherwise undisturbed peat surface, now the whole surface of an area was regularly skimmed, taking a depth of only 4-6 cm of peat each time, but repeating the process more often, routinely on a 3-6 week cycle, and in very dry weather, more than once a day. Milling also produces a completely flat, uniformly dry surface, lacking the 'baulks and bottoms' which had been a feature of the industry for the previous century.

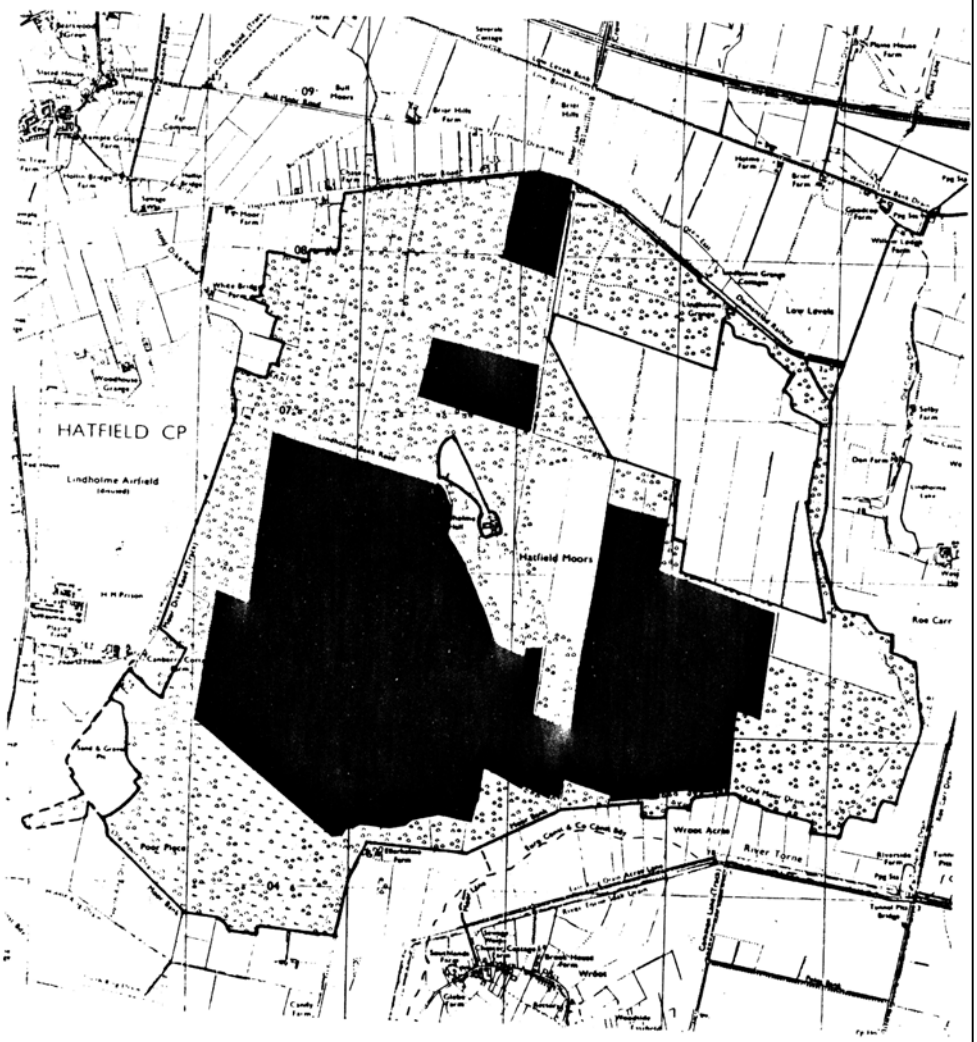
Having evaluated the milling process on Hatfield Moors, where the cut area increased considerably (Figure 6), milling was introduced to Thorne Moors. Goole Moors had, by the mid-1980s, been cut intensively and 'tidied up', so the introduction of milling was merely the final stage in stripping it completely. Major extensions of cutting took place in 1988 and 1989. Figure 5 shows the extent of cutting on Thorne in winter 1988-89, with the more recent clearances added to this.

Figure 5. Peat cutting on Thorne Moors 1988–89.



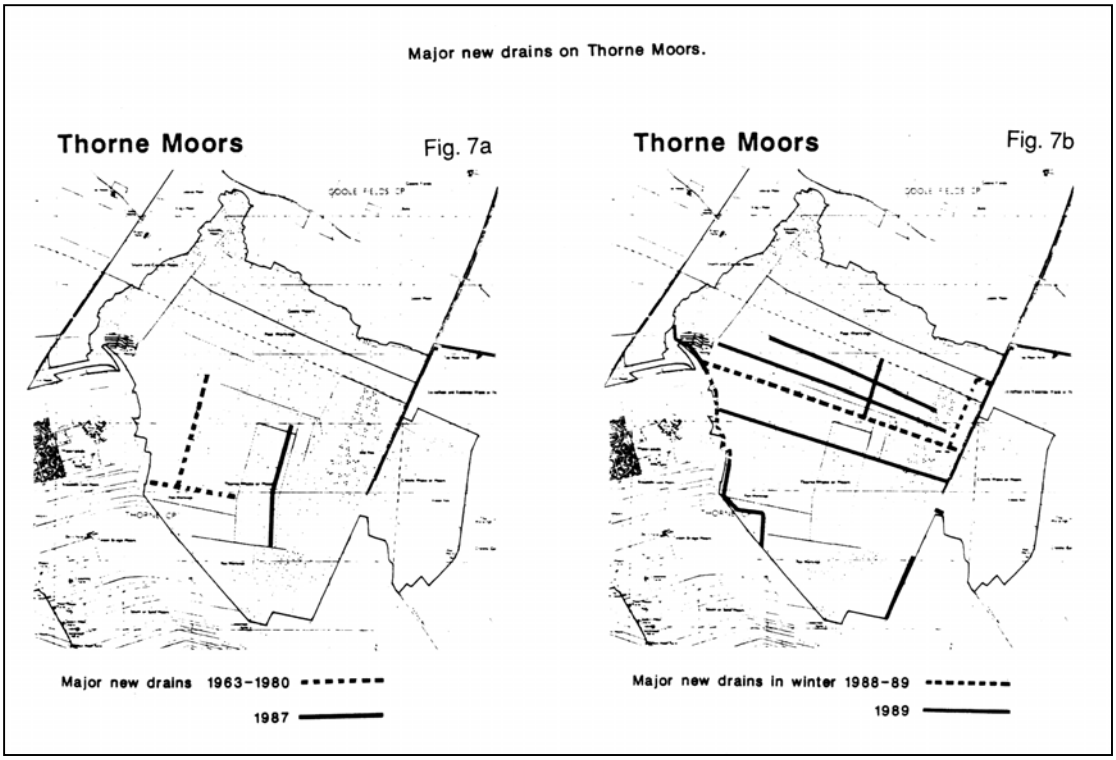
No areas of milled peat have yet been abandoned long enough for the vegetation succession to be studied, or for their colonisation by invertebrates to be commented

Figure 6. Peat cutting on Hatfield Moors in 1980.

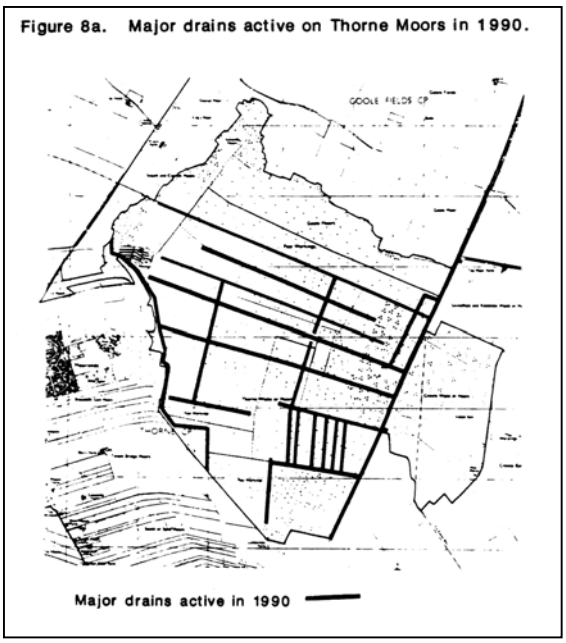


upon. The first area where such research could be carried out would be on Hatfield Moors north of Lindholme Bank Road, which has recently been set aside. It is understood that milling on the eastern part of Goole Moors will be completed in 1991. This also offers the chance to monitor the fate of a milled peat surface.

Drainage of the Moors keeps one step ahead of clearance and cutting. The recent expansions have been accompanied by the most active programme of ditch-digging in the last century. The new drains are larger than any which have been dug before, with the sole exception of the Warping Drains. They are up to 3 m wide and 2 m deep, and have shown themselves able to drain large areas which have been flooded and undisturbed for decades or centuries, such as Mill Drain Marsh and the Shoulder o' Mutton Well, in a matter of days. The series of maps in Figures 7 and 8 show the major new drains since 1970.



[Certain of the 'new' drains in the south-east of Thorne Moors are described by Fisons as 'opening up existing drains'. The linear channels in question date from the 1920s or earlier. They had contained 40 cm deep standing water with floating *Sphagnum* since at least the 1930s, and had not aided the movement of water since that time. It is a matter of semantics whether a 60-years-old trench containing species-rich mire vegetation is a 'drain' or a 'linear bog-pool'. The channels were deepened, and their vegetation scraped out by mechanical diggers, in February 1990, and it is agreed that the channels now function as drains.]



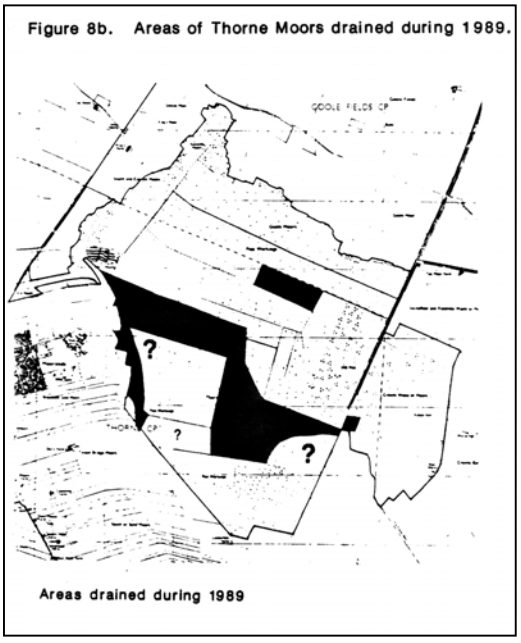


FIGURE 9

SCALE AND IMPACT OF DIFFERENT METHODS OF PEAT CUTTINGS

Technique	Area of patches (acres)	Length of cuttings (chains)	Distance of bare peat from intact vegetation	Mean time between re-cutting
Hand graving	50-100	< 10	5 m	10+ years
Pre-1975 machine	1-200	10-20	10-20 m	2 years
Post-1975 machine	up to 500	to 60 (T) to 150 (H)	100-200 m	1 year
Milling	500-1,000	50-160	500-2.000 m	1-2 months

CONCLUSIONS

Figure 8b shows the areas of the Moors currently being dried out by new drains, the areas cleared of vegetation, and the areas of active milling. Little of Thorne Moors, and still less of Hatfield, remains vegetated and wet. This paper is intended primarily to document the effects of changing land use on the wildlife of Thorne and Hatfield Moors, and not to evaluate what remains. However, it is hard to avoid the conclusion that the currently vegetated area of the Moors is of very considerable conservation value: this suggests that all which remains ought to be viewed as part of the minimum acceptable refugia. As each of the remaining areas is drained, more species will become extinct on the Moors; and some will thereby become extinct in the British Isles.

REFERENCES

Ball, S G (1986) Terrestrial and freshwater invertebrates with Red Data Book, Notable or Habitat Indicator status. *Invertebrate Site Register Report No.* 66. Peterborough: Nature Conservancy Council.

Collins, N M and Wells S M (1987) *Invertebrates in need of special protection in Europe.* Strasbourg: European Committee for the Conservation of Nature and Natural Resources.

Crossley, R (1977) *Report of an invertebrate* survey *of Thorne Moors.* Unpublished report to NCC.

Drake, C M *(Diptera* (in press). *Atlas* of *the horseflies, soldierflies and allies Brachycera)* of *the British Isles.* Huntingdon: ITE.

Ensor, R C K (1936) *England 1870-1914. (Oxford History* of *England, Vol. XIV)* Oxford: University Press.

Eversham, B C (1977) *Quantative analysis* of *water and sediment in drains adjacent to Thorne Moors.* Unpublished report.

Eversham, B C (1987) An annotated list of Thorne Moors lichens. *Thorne Moors Papers,* **1**, 77-85.

Eversham, B C (1983) *Stratiomys singularior* and S. *potamida* in Yorkshire. *Proc. Trans. Brit. Ent. nat. Hist. Soc.* **17**, 21.

Eversham, B C and Lynes, M (1980) A peat moor study: Hatfield Moors. Habitats. Part 1: Notes on significant species. *Lapwing,* **12**, 29-38.

Eversham, B C and Lynes, M (1981) A peat moor study: Hatfield Moors. Habitats. Part 2 : Vegetation survey. *Lapwing,* **13**, 23-46.

Eversham, B C and Lynes, M (1983) A peat moor study: Hatfield Moors. Habitats. Part 3 : Historical records. *Lapwing,* **14**, 26-38.

Fitter, A H and Smith, C J (1979) *A wood in Ascam.* York: Yorkshire Naturalists' Trust, Ebor Press.

Gaunt, G D (1987) The geology and landscape development of the area around Thorne Moors. *Thorne Moors Papers,* **1**, 6-30.

Gibbons, E J (1975) *The flora* of *Lincolnshire.* Lincoln: Lincolnshire Naturalists' Union.

Heaver, D J and Eversham, B C. *Thorne &Hatfield Moors Invertebrate* Survey *Report.* I: 86 pp + 51 Figures and Tables; II: Appendices, 146 pp. Unpublished report to Thorne &Hatfield Moors Conservation Forum.

Key, R S (1988) Peat-cutting and invertebrate fauna of lowland peatland, with particular reference to the Humberhead Levels mires of Thorne and Hatfield Moors,. in : Meade, Rand Fojt, W (eds.) *The ecology and conservation of cut-over raised mires.* Peterborough: Nature Conservancy Council

Lees, F A (1888) The flora of West Yorkshire. *Bot. Ser. Trans. YNU.,* **2**. London: Lovell, Reeve.

Legg, G and Jones, R E (1988) Pseudoscorpiones (Arthropoda, Arachnida). *Synopses Br. Fauna (New Ser.)* **40**. Leiden: Brill/Backhuys, for Linnean Society of London.

Limbert, M. (1978) A peat moor study: Hatfield Moors. Geology and geomorphology. *Lapwing,* **11,** 36-39.

Limbert, M (1985) An outline history of Hatfield Moors. *Old West Riding,* **5**, 1-6.

Limbert, M (1986) The exploitation of peat at Thorne. *Old West Riding,* **6**, 9-16.

Limbert, M (1987a) Some notes on the landscape history of Thorne Moors. *Thorne Moors Papers,* **1**, 31-43.

Limbert, M (1987b) Charophytes from Thorne Moors. *Thorne Moors Papers,* **1**, 86-87.

Limbert, M (1990) The drainage of Thorne Waste in the nineteenth century. *Thorne & dist. local Hist. Assoc., Occasional Paper,* **5**.

Limbert, M (in press) William Casson of Thorne. *Naturalist.*

Limbert, M, Mitchell, R D and Rhodes, R J (1986) *Thorne Moors: birds and men.* Doncaster: Doncaster &District Ornithological Society.

Marshall, J and Haes, E C M. (1988) *Grasshoppers, crickets, cockroaches and allied insects* of *the British Isles.* Colchester: Harley.

Marshall, R A, Lynes, M and Limbert, M (1989). The vertebrate fauna of Hatfield Moors. *Lapwing Special Ser.* **5**. Doncaster: Doncaster &District Ornithological Society.

Matthew, H C G (1984). The Liberal age (1851-1914). In: Morgan, K O (ed.). *Oxford history* of *Britain,* 518-581. Oxford: University Press.

Meikle, R D (1984). Willows and poplars. *BSBI Handbook No.4.* London: BSBI.

Ratcliffe, D A (ed.)(1977). A *Nature Conservation Review.* Cambridge: CUP.

Rogers, S A and Bellamy, D J (1972) Peat exploitation and conservation: a case study. *Proc. 4th Int. Peat Congr., Helsinki,* **1**, 291-233.

Shirt, D B (1987). *British Red Data Books,* **2** : *Insects.* Peterborough: NCC.

Skidmore, P, Limbert, M and Eversham, B C (1987) The insects of Thorne Moors. *Sorby Record,* **23**, (supplement), 89-153.

Smart, P J, Wheeler, B D and Willis A J (1986) Plants and peat cutting: historical ecology of a much-exploited peatland Thorne Waste, Yorkshire, UK. *New Phytol.* **104,** 731-748.

Smith, C J (1982) *Atlas of Yorkshire spiders.* York; privately published.

Sutton, S L and Beaumont, H E (eds.) (1989) *Butterflies and moths of Yorkshire: distribution and conservation* Leeds : Yorkshire Naturalists' Union.

Webb, N R (1986) *Heathlands.* 223 pp. London: Collins.

Wells, S M and Chatfield, J (1991) *Convention on the conservation of European wildlife and natural habitats: draft report on threatened non-marine molluscs of Europe.* Strasbourg; Council of Europe.