A contribution to the vegetation and land use history of the eastern-central north York Moors

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ABSTRACT OF THESIS.

The vegetation history of an area of 100km^2 in the eastern-central area of the North York Moors is studied by means of pollen diagrams from five contrasting sites. At two of these sites the peat began to form near the beginning of the Post-glacial period, while at the other three sites the deposits date from the first millenium B.C. Pollen analytical zones V to VIIb are distinguished on the diagrams (after Godwin), and for the post-Neolithic period a set of zones (A to G) is delimited, which are correlated between the diagrams.

Factors in the history of the vegetation are discussed, and in particular an attempt is made to assess the part played by Man in modifying the vegetation cover. Zones of clearance activity and woodland regeneration are distinguished. The first major clearance occurred in the Iron Age - Romano-British times, with others in the Viking - Medieval period and from the eighteenth century to the present day. Details of land use practices in these zones are discussed and an attempt is made to correlate these with the known archaeological and documentary evidence for the area.

A survey of the contemporary pollen allows some conclusion to be drawn about the dispersal and deposition of pollen within the study area. These results are applied to the sub-fossil pollen diagrams in an attempt to identify probable catchment areas and to seek out the limitations of each of the sites. In conclusion, the need for management and conservation of the vegetation cover in the future is stressed.

"A CONTRIBUTION TO THE VEGETATION AND LAND USE HISTORY OF THE EASTERN-CENTRAL NORTH YORK MOORS."

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Figure 1.

Photograph 1.

The escarpment of the Hambleton Hills from the Vale of York.

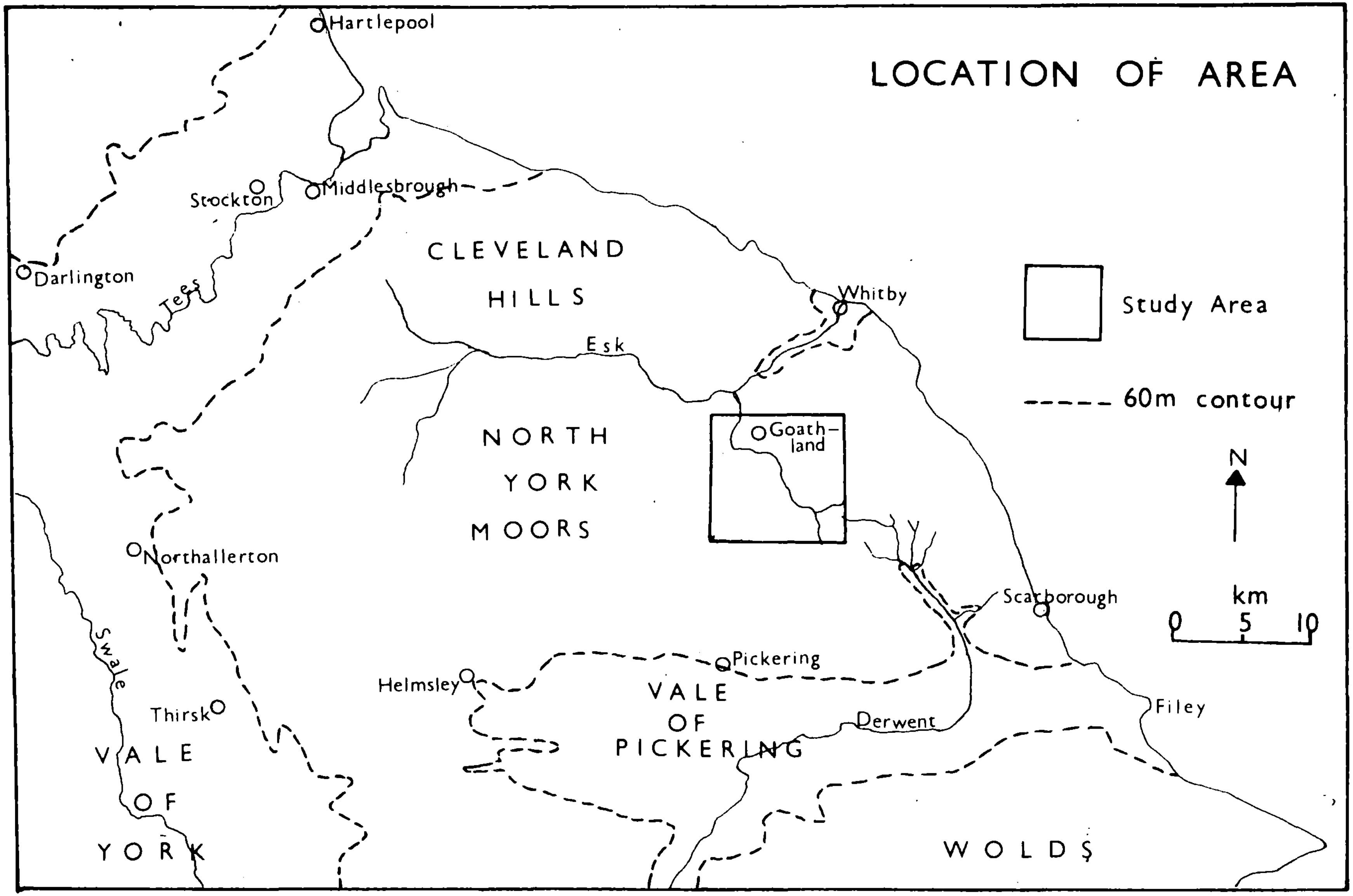
From 466816, looking ENE.

PART ONE. INTRODUCTORY.

CHAPTER 1. INTRODUCTION.

From the flat drift plain of the Vale of York, the Hambleton Hills rise in an impressive escarpment, isolating to the east of their summit line the upland island of the North York Moors. This block of Jurassic rocks is gently tilted towards the east, so that the crest line falls from 454m (1489') on Urra Moor in the west to 183m (600') at Ravenscar on the east coast, where it ends in a series of magnificent sea-cliffs, forming some of Yorkshire's most beautiful coastal scenery. The upland massif is bounded to the north by the faulted escarpment of the Cleveland Hills, overlooking the basin of the Tees lowlands. To the south, another fault raises the Tabular Hills 153m (500') above the level of the Vale of Pickering, thus making the North York Moors a clearly defined unit in the physical landscape.

Within the area so defined, settlement is confined to the margins and to the dales, which slash the Moors in a series of deeply dissected valleys and carry tongues of lowland deep into the heart of the upland. In the northern part of the area, the west-east valley of Eskdale detaches the Cleveland Hills from the main massif. To the south of the Esk valley, dales run north and south from the main watershed, from Bilsdale in the west to Newton Dale in the east. Here the main watershed is bisected by the combined valleys of Newton Dale to the south and the Eller Beck to the north. To the east of



Map 1.

Figure 2.

this line, the Moors are lower, reaching a maximum height of 292m (959') at Lilla Howe (890988), and no major dale interrupts the sweep of the moorlands towards the coast.

The eastern-central part of the North York Moors straddles the boundary between this lower eastern area and the main block to the west of Newton Dale. It can be defined as the area lying between eastings 80 and 90 and northings 93 and 03. Peat deposits at five sites within this area have been used in a study of the Post-glacial vegetation history. This work, together with that of Simmons (1969), Cundill (1971) and Jones (1971), forms part of a larger study of the Quaternary Ecology of the North York Moors as a whole. Some thirty sites to north and south of the Esk Valley now provide pollen diagrams covering the whole Post-glacial period, which allow a detailed picture to be constructed of the development and modification of the vegetation cover. In particular, this work will enable an assessment to be made of the importance of the anthropogenic factor in vegetation history - a task already undertaken by Dimbleby (1962).

As well as this general aim of contributing to knowledge of the ecological history of the whole region, this study has as its specific purpose the elucidation of the relationship between vegetation change and land use practice in the period from the Neolithic to the present. Sites have been chosen in both upland and lowland facets of the landscape, as land use must often have varied between the two. In addition, it is hoped that the detailed comparison of pollen diagrams from these sites in different topographic situations but in close

Figure 3.

Photograph 2.

Part of the eastern-central area of the North York Moors.

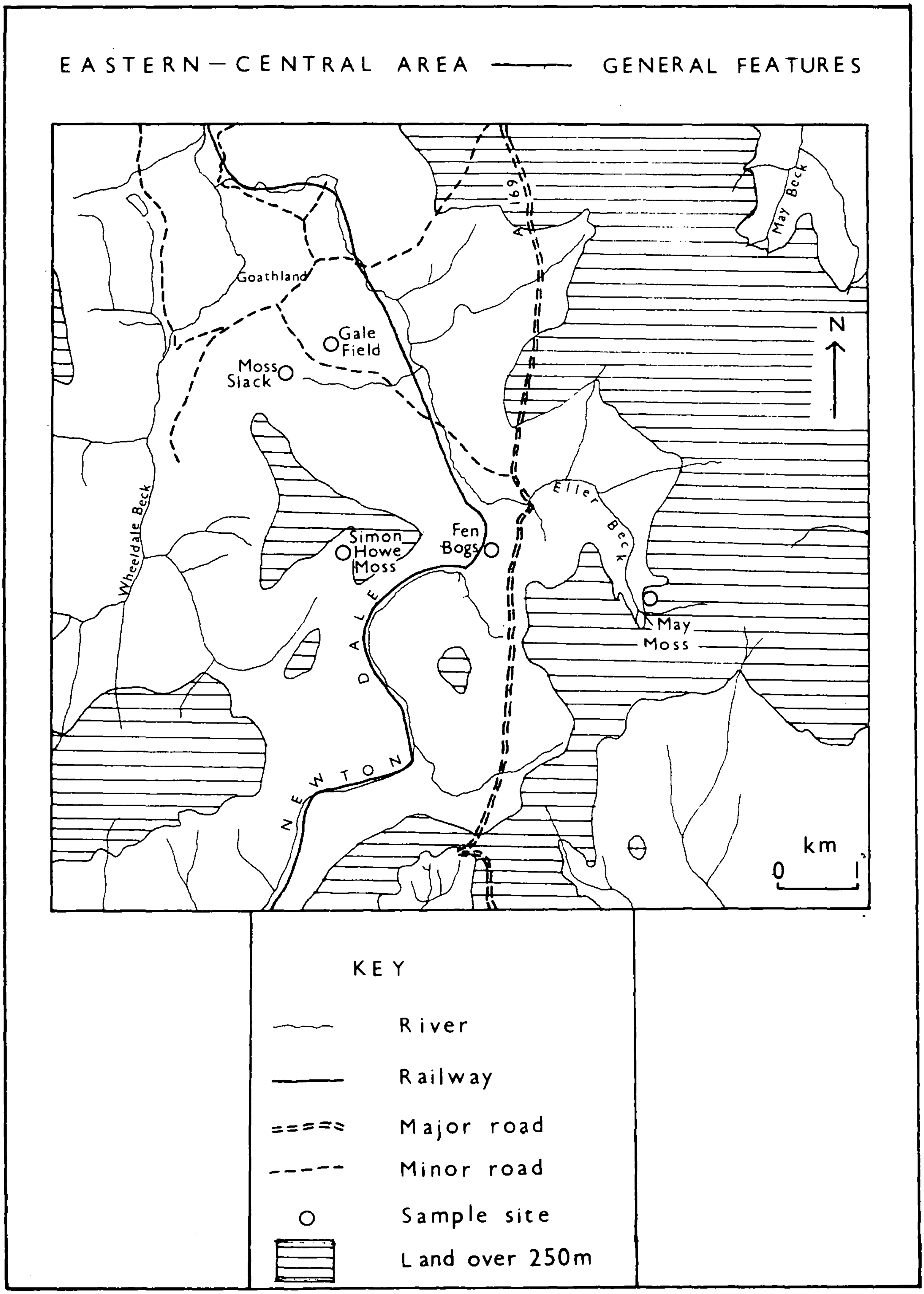
From Sil Howe (852028), looking SW.

In the foreground, a typical spread of Callunetum covers the higher ground, while the lower land around Goathland village (middle distance) is enclosed, mostly for pasture. The coniferous plantation surrounding Randay Mere reservoir (811019) can be seen on the right of the photograph, while on the higher ground on the horizon the moorland comes into view again.

proximity to one another, will allow some comments to be made on the interpretation of diagrams from different types of site.

The work will be presented in three sections. Firstly, the physical and cultural background to the study area will be described and the nature of the evidence for temporal changes will be discussed. Secondly, strat--igraphical and palynological evidence will be presented from five sites in the eastern-central area and the interpretation and correlation of this evidence will be discussed. In the third section, changes in the vegetation as revealed in the pollen diagrams will be interpreted in terms of several factors. Particular emphasis will be laid on the part played by changing land use practices, through the use of archaeological and historical evidence in conjunction with that from the pollen diagrams. Stress will be laid upon the nature of the evidence involved and the limitations of the techniques employed.

Map 2. Figure 4.



CHAPTER 2. THE PHYSICAL BACKGROUND.

2.1 Solid Geology.

The North York Moors are composed entirely of rocks of the Jurassic period, laid down some 135 - 180 million years ago. The general dip of the rocks is gently towards the south, which brings the younger strata to the surface in the south of the area and exposes the older ones only in the north. The complete series of beds from the Lower Lias to the Upper Calcareous Grit of the Corallian is represented in the region, which was the classic area for the study of the Jurassic period in Britain (Fox-Strangways, 1915).

Table 1 shows the stratigraphic sequence, and the surface distribution of the major groups of rocks is shown on map 3. It can be seen that whilst the Liassic rocks in the west and north of the area follow on in geological sequence from the Keuper Marl underlying the Vale of York and the Tees lowlands, there is an unconformity between the Kimmeridge Clay in the Vale of Pickering and the Chalk of the Wolds to the south.

The older Liassic rocks are exposed on the fringes of the area and as lozenge-shaped inliers in the dales of the main massif. They are most important in the Cleveland Hills, where they form prominent frontal benches on the fault escarpment and on the Eston and Upleatham outliers. The Middle Lias Ironstone Series was the basis of considerable mining activity in Cleveland last century, and there were more limited workings near Grosmont in Eskdale. This, with the South Durham coking coal, was the original basis of the iron and steel industry

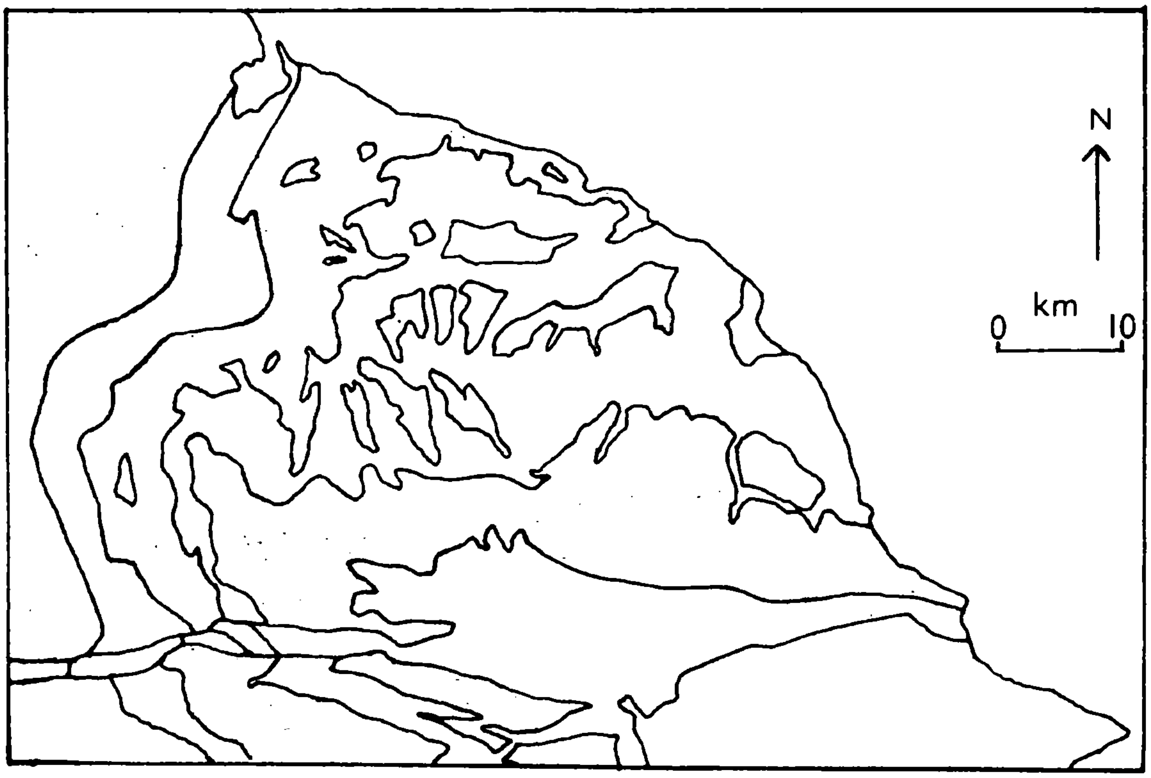
Table 1.

SIMPLIFIED GEOLOGICAL SEQUENCE.

RECENT	Peat Alluvium	
GLACIAL	Upper boulder-clay Sands and gravels Lower boulder-clay	
CRETACEOUS	Chalk	
UPPER JURASSIC	Portlandian Beds Kimmeridge Clay	
	Corallian	Upper Calcareous Grit Osmington Oolite Middle Calcareous Grit Hambleton Oolite Passage Beds Lower Calcareous Grit
	Oxford Clay Kellaways Rock Cornbrash	
MIDDLE JURASSIC	Upper Deltaic Beds (Moor Grit at base) Scarborough Beds Middle Deltaic Beds Millepore Bed Lower Deltaic Beds (with Eller Beck Bed) Dogger	
LOWER JURASSIC	Upper Lias	
	Middle Lias	Ironstone Series Sandy Series
	Lower Lias	
TRIASSIC	Keuper Marl Bunter Sandstone	

(After Geological Survey and Hemingway, 1968)

NORTH YORK MOORS — SOLID GEOLOGY



KEY

CHALK	LIAS
KIMMERIDGE CLAY	KEUPER MARL
CORALLIAN with OXFORD CLAY & KELLAWAYS ROCK	BUNTER SANDSTONE
DELTAIC SERIES	

of Teesside. The Upper Lias has also been of economic importance, in particular the Jet Rock and Alum Shales which helped to make Whitby famous.

The main part of the upland is formed of rocks of the Middle and Upper Jurassic, which in this part of the country are predominantly sandy with limestone playing a subordinate part. The bulk of the moorland is developed on the Estuarine or Deltaic[1] Series, which consists of clay and fine silts alternating with grey and yellow sandstones. The latter often form inland crags, but the Series as a whole is of low resistance, which leads to the formation of fairly flat slope facets of 1 to 2 degrees (Gregory, 1962a). Some thin seams of poor grade coal occur and have been worked at Lealholm (764078), Danby (708085), Rosedale (690010) and Collier Gill (799999). The other main economic use of the Series has been in the building trade, where brick clays and refractory clays have been worked at Commondale (662105) and Egton (809063), and building stone has been quarried near Aislaby (846086) and used for the piers at Whitby and the London Bridge which now resides in Texas.

Three thin marine beds interrupt the Deltaic Series:- the Dogger, a sandstone with some iron in it; the Eller Beck Bed, consisting of sandstones underlain by ferruginous shales and ironstones,which were worked in the Middle Ages and the nineteenth century near Goathland[2]; and the Millepore Bed, a hard calcareous sandstone separating

1 The latter name is preferred, as the beds are freshwater deposits of a deltaic nature (Hemingway, 1968).

2 As shown by the line of slag heaps (830009) known locally as Julian's line, from the popular belief that the Romans (Julius Caesar) were responsible for the mining.

Photograph 3. The Corallian escarpment.

From 855956, looking SE.

In the foreground is the Juncus swamp from which surface sample No.10 was taken. In the middle distance, the enclosed pasture land at the foot of the escarpment picks out the narrow band of Oxford Clay.

Photograph 4. Newton Dale.

From 830949, looking SE.

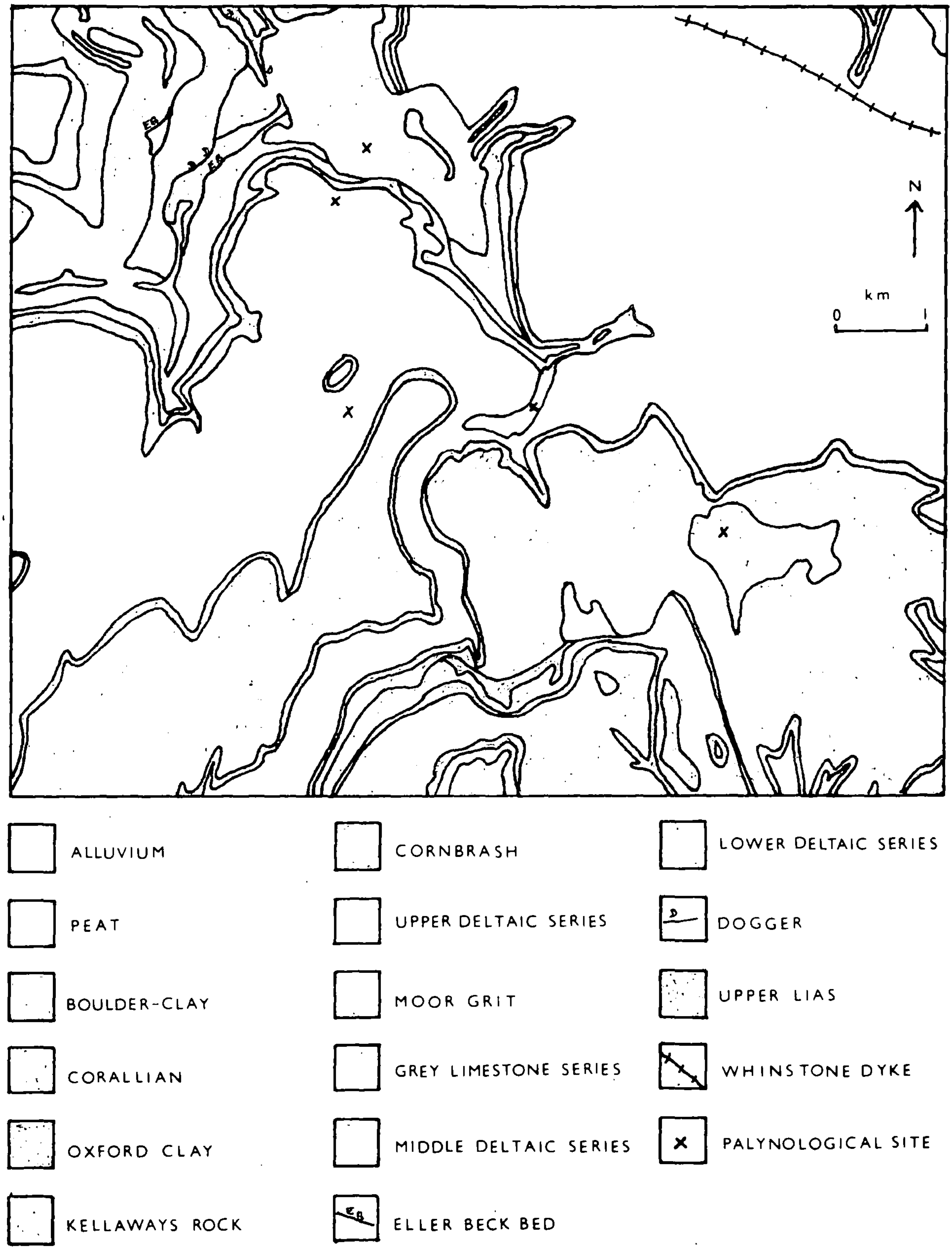
1. Corallian escarpment on Levisham Moor.
2. Massive slabs of Kellaways Rock form vertical cliff face with Cornbrash at base.
3. Upper Deltaic Series form gentler slope beneath, with deciduous woodland (Talbot Wood) clinging to slopes.
4. Mature stands of part of Pickering Forest.

the Lower from the Middle Deltaic Beds. The Middle and Upper Deltaics are separated by the Scarborough Beds (or the so-called Grey Limestone Series) which, in fact, consists mostly of shales with silty sandstones, impure limestones and ironstone nodules.

It will be apparent from the foregoing description that the rocks of the Middle Jurassic, although characterised by great diversity of detail, are basically variations on the same theme, i.e. that of alternating sandstones and shales. For this reason the large area of upland covered by these rocks is monotonous and subdued in appearance, the only striking contrasts being formed where erosion has exposed rocks of other periods.

The Middle Jurassic surface is capped in the central parts of the Cleveland Hills and the main massif by the brown marine sandstone of the Kellaways Rock, from which it is separated by a thin band of shales and sandy marl known as Cornbrash. Both these formations are more resistant than the Deltaic Series and form steeper slopes of 6½ to 9 degrees (Gregory, 1962a). To the south of the Kellaways Rock on the main massif, a narrow vale of Oxford Clay (mostly grey shales) lies at the foot of the Corallian escarpment, which is one of the most conspicuous features in the landscape of the North York Moors, (Illustrated in Photograph 3). The Corallian Series consists of calcareous grits alternating with thin limestone beds to form a gently rolling topography, which contrasts with the bleak, severe lines of the moorlands to the north. The "Limestone Hills", as the area of Corallian rocks is commonly called, terminate in a broken, faulted dip slope looking down on the Kimmeridge Clay of the

GEOLOGY OF THE EASTERN—CENTRAL NORTH YORK MOORS



Vale of Pickering, and beyond to the distant escarpment of the Chalk Wolds.

The geology of the eastern-central part of the North York Moors is shown on map 4. It will be noted that glacial deposits obscure the solid geology in the Eller Beck and Wheeldale valleys in the north-west of the area and it is on the boulder-clay here that the Gale Field site is situated. The main part of the area is developed on the monotonous surface of the Upper Deltaics, crossed by the Tertiary whinstone dyke in the north-east, marked on the ground by a line of old workings (846031). In the north-west the Middle Deltaic rocks are exposed beneath a thin outcrop of the Scarborough Beds, exposed,for instance, in the bed of the Eller Beck (856983). Above this the Moor Grit, the lowest bed of the Upper Deltaics, forms craggy outcrops, as, for example, at the northern end of the Fen Bogs site (854981). Where it crosses the channel of Newton Dale it forms a harder sill of rock, and perhaps it was the slightly greater resistance of this bed which prevented the Eller Beck from being captured by Newton Dale, as the former is only a few feet below the level of the latter at this point.

From Eller Beck bridge (859983) the A 169 road climbs southwards up the slope of the Cornbrash on to the Kellaways Rock, which forms the extensive area of moorland on which the May Moss site is situated (875960). To the west, the channel of Newton Dale cuts through the Kellaways Rock and Cornbrash to the Upper Deltaic Series below. The resistant Cornbrash forms steep rocky sides to the channel with the Kellaways Rock forming the tops (see photograph 4). The northern tip of the Kellaways Rock projects as Crag Stone Rigg (838978), while an outlier caps Simon Howe (831981). The Simon Howe Moss site lies in the slight basin of the Upper Deltaics between the two. In the extreme south of the area, the narrow vale of Oxford Clay at Saltersgate (852945) lies at the foot of the impressive Corallian escarpment (photograph 3). The northernmost part of the Corallian projects as Whinny Nab (867948), while Blakey Topping (872938) forms an outlier to the east of the escarpment.

2.2 Structure.

The structure of the area is relatively simple, its basic feature being the general easterly inclination, which is a continuation of the Pennine dip. The consequent streams developed on this surface flow towards the east and this drainage pattern is discordant with the underlying structure, which has led Gregory to suggest that it has been superimposed from an original Cretaceous cover (Gregory, 1962a). He also suggests the "proto-Esk" included what is now the upper Tees (not the upper Swale, as postulated by Versey, 1929). The capture of the upper part of the "proto-Esk" by the Tees detached the North York Moors from the main Pennine block and led to their subsequent development as an upland island.

The mid-Tertiary earth movements were responsible for the doming of the main anticline between the complementary synclinal troughs of the Tees to the north and the Vale of Pickering to the south, and the minor anticlinal roll of the Cleveland Hills to the north of Eskdale. Super--imposed upon this doming is a series of north-south folds, including the Robin Hood's Bay dome, the Sleights anticline and the Goathland syncline, which obliterate locally the effects of the major folds. As a result of these movements a radial drainage pattern was established on the main massif of the North York Moors and on the Cleveland Hills.

Gregory has recognised three major planation surfaces on the Moors, dating from erosion in the Tertiary period (Gregory, 1962a). The Summit Surface at and above 406m (1330') and the High Moor Surface at 351-393m (1150-1290') are characterised by gentle gradients, in contrast to the steeper slopes of the two partial peneplains which make up the Low Moor Surface at 290-335m (950-1100') and 235-284m (770-930'). Valley benches in the Esk valley correspond to each of these stages. Gregory recognises various changes in the drainage pattern associated with the end of the Low Moor Surface stage. This adaptation of drainage to structure consisted largely of the extension southwards of the Esk catchment area and the capture of streams such as Wheeldale Gill (780992), Blawath Beck (818970), Rutmoor Beck (790962), Little Eller Beck (875987) and Brocka Beck (855008), and the loss of the rivers Leven (600097) and Lounsdale (605110) in the west of Eskdale to the Tees system (wind gap at 635096).

The lower Esk itself changed course about the same time to take a more north-easterly direction from Grosmont (830052) to Whitby (900110). Gregory has correlated this change with the high sea level of the Calabrian transgression, when, he suggests, the sea approached the edge of the North York Moors and came partly up the Vale of York. This would have facilitated the drainage captures in the western part of Eskdale and would provide a possible explanation for the streams flowing south through the Corallian escarpment, such as the River Seven (747897) and the River Dove (688900).

2.3 Glacial and periglacial features.

The solid geology is obscured round the margins of the North York Moors by a mantle of glacial drift, which extends to 244m (800') above Stanghow in the north (678158), to 183m (600') up the slope of the Hambleton escarpment in the south-west, and to 320m (1050') in the Ingleby-Greenhow embayment in the north-west. In the east, the lower coastal plateau is covered with drift as far south as Ravenscar (987017) at a general level of 152-213m (500-700'). The drift continues further south at a lower level (30-90m, 100-300') and passes across the mouth of the Vale of Pickering as a narrow ridge.

The Scandinavian ice sheet which deposited this drift in the Weichselian period blocked the mouth of the Vale of Pickering, leading to the ponding back of the proto-Derwent and the formation of one of the most famous pro-glacial lakes. Lacustrine clays from this lake to a depth of 33m (107'), together with occasional delta deposits (e.g. at the mouth of Newton Dale near Pickering, 799849), and sands and gravels on the southern side obscure the Kimmeridge Clay over most of the Vale. Occasional islands of solid protrude above the general level, however, often providing settlement sites, e.g. Great Edstone (707841), or Great Barugh (748790). In addition, islands of boulder-clay are marked by the Geological Survey, e.g. near Wilton (860827), South Holme (700775), Salton (717795) and at 640830. These would suggest the presence of some ice in the area before the formation of the lake. Further north, in Eskdale, boulder-clay and outwash sands and gravel cover most of the ground below 183m (600'), while small amounts of drift provide fertile farming land in all the main dales except Bilsdale and Westerdale.

On the high moors there is little trace of drift. Both Elgee and Hemingway, however, refer to occasional erratic siliceous pebbles, e.g. on Wheeldale and Glaisdale Moors (Elgee, 1908, Hemingway, 1958). Further evidence for a possible ice-sheet covering the whole area is provided by Dimbleby, who describes ice-wedge deposits on the surface of the Lower Calcareous Grit of the Corallian to the east of Newton Dale. Large-scale features are described on Silpho, Suffield, Levisham and Lockton Low Moors, which show up from the air as a polygonal pattern of vegetation, with Eriophorum growing in the "cracks" and Calluna between them. Excavations in the infill of some of these wedges revealed a complex stratigraphy of boulder-clay and soil, which suggests a pre-Weichselian origin for the ice-wedges (Dimbleby, 1952a). This evidence leads to the tentative conclusion that an earlier glaciation affected the area, and to a higher level than was reached during the Weichselian. It would seem logical to correlate this earlier glaciation with the Gipping Maximum, but there is no evidence to support this.

The first detailed study of the Weichselian glacial features was undertaken by Kendall at the beginning of this century (Kendall, 1902). In a 100-page article he gave descriptions of glacial deposits and features over the whole area, recording every detail with painstaking accuracy. On the purely descriptive level his work remains of great value, although many of his conclusions have since been challenged (e.g. by Gregory, 1965). Kendall's hypothesis was that a series of lakes had been formed between the ice front and the main block of the Moors (which formed a nunatak). These lakes had been drained by a series of overflow channels which form conspicuous features in the landscape today. He listed the characteristics of these channels, which included their steep sides and flat floors, steeper gradients on the outside of meanders than on the inside, their usual lack of tributaries and the independence of the present drainage. Geomorphologists were quick to recognise similar features in other parts of the country and in some of these studies Kendall's ideas were mis-applied. Best (1954) extended Kendall's ideas to the rest of the Cleveland Hills and postulated two glacial episodes there, on the rather dubious evidence that the higher level channels had a more weathered appearance. Sewell (1903) claimed to have found a high-level overflow channel between Lake Wheeldale and Newton Dale at Slavey Slack (815950) at a height of 250m (820'). Gregory has since shown this to be a col formed by the capture of the Rutmoor Beck by the Wheeldale Beck in the Tertiary period (Gregory, 1962a).

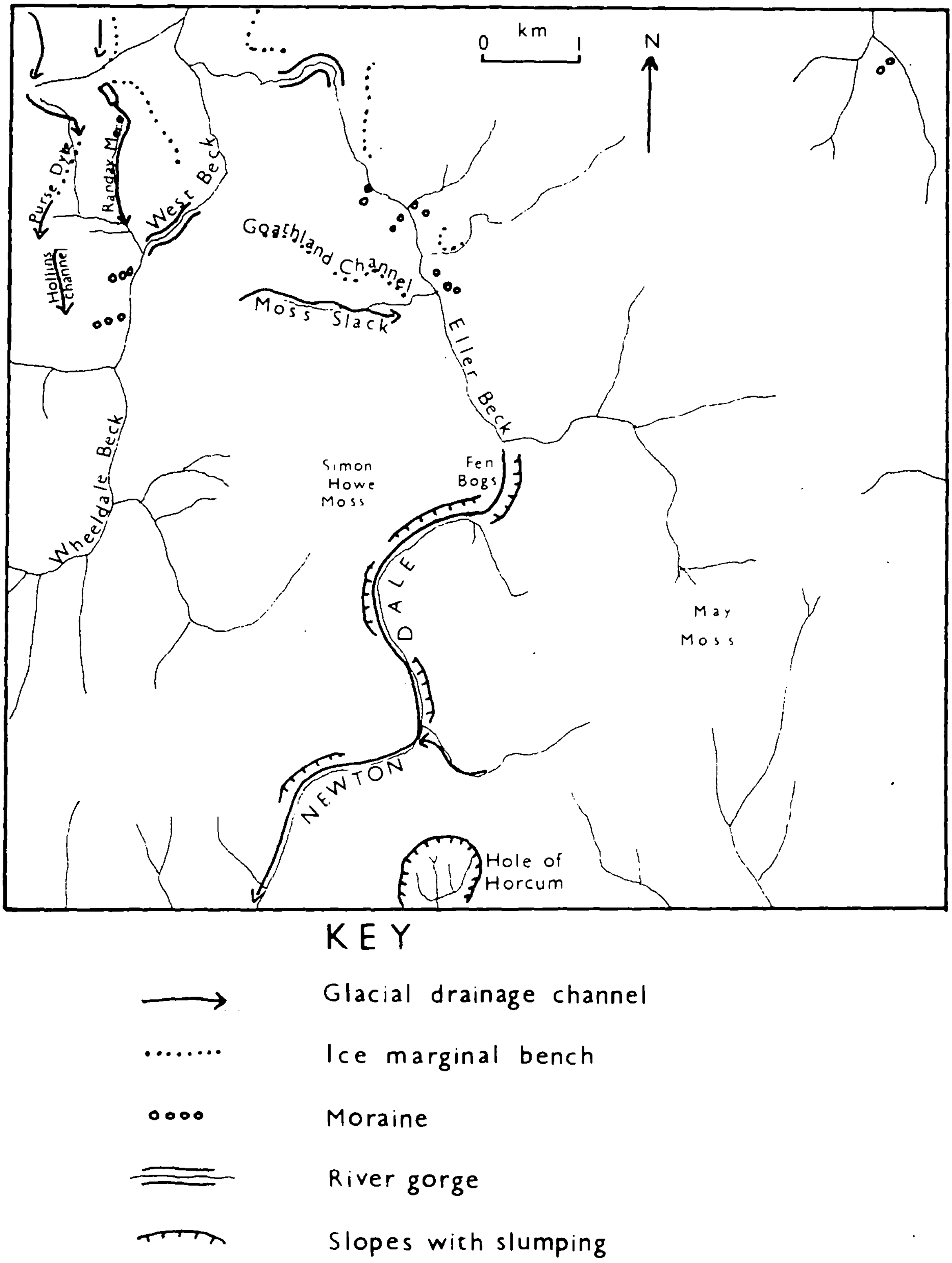
Sissons has criticised the too extensive application of Kendall's ideas and has suggested some alternative modes of formation for many of the channels, particularly as sub-glacial features (Sissons, 1960). He also notes the lack of evidence, such as strandlines, deltas or laminated clays, for the existence of many of the supposed lakes - a sentiment echoed by Peel (1956);

> "Thought has been perhaps unduly influenced by Kendall's concept of freely draining lakes, despite the common and disturbing lack of any independent direct evidence for such lakes."

Gregory has argued against the existence of a large lake in central Eskdale (Gregory, 1965). His theory was that ice entered Eskdale from the west and the east, possibly holding up a small temporary lake in between the two advancing ice fronts. Ice also over-rode the Cleveland watershed and coalesced with the Eskdale ice to form one sheet, including the frozen lake in the middle. The melting and down-wasting of this ice led to the formation of many stagnent ice features such as eskers and kame-terraces, which he has mapped. Sissons (1960) has also remarked on the implications of down-wasting rather than back-wasting of the ice, which would have resulted in ice occupying the very areas where Kendall's lakes were supposed to be. Gregory interprets most of the glacial drainage channels as marginal or sub-marginal features. Many of them appear to have had a complex history of sub-glacial and sub-aerial development at several different periods.

In the eastern-central area, Gregory distinguishes two main lines of marginal drainage, corresponding with positions of the ice-front marked by moraines in the

SOME GLACIAL AND PERIGLACIAL FEATURES IN THE STUDY AREA



After Gregory, modified.

Eller Beck and Wheeldale valleys (see map 5). The first used the channels of Lady Bridge Slack, Purse Dyke Slack and Hollins channel. These, having gradients of 0.7 to 1.5 per hundred are in the category of true marginal channels, with sub-glacial chutes between them. The second line, at a lower altitude, used Moss Swang, Castle Hill channel and Randay Mere. Ice marginal benches continue between them (these were cut when the angle of the hill slope exceeded 2.5 degrees). Both these lines of marginal drainage emptied into a lake in Wheeldale valley whose floor was at a height of 155m (510') and whose waters rose to 183-198m (600-650'). Drainage out of this lake was via two alternative channels into Newton Dale. The first to be used was Moss Slack, but later drainage was at a lower level via the Goathland Church channel, in which the peat of the Gale Field site has developed. After this, Newton Dale was abandoned altogether, as the ice was by now very fragmented and other outlets were available.

This explanation seems hardly adequate to account for the size of Newton Dale itself. The course of Newton Dale probably followed that of a pre-glacial valley; it has already been noted that Little Eller Beck was captured by the Murk Esk about the time of the Calabrian transgression, and Gregory has suggested that this stream and Sliving Sike (864993) formerly flowed through what is now Newton Dale. Straddling the main watershed of the Moors, Newton Dale appears to have a hump-backed profile at its northern end, which is difficult to explain except as a product of hydraulic pressure in a sub-glacial stream, (Gregory, 1962b). However, there is little evidence to suggest that the Weichselian ice margin came this far south, which raises the interesting question of whether it could have been a pre-Weichselian (Gipping?) channel used again in the Weichselian period.

After drainage from Lake Wheeldale had ceased, Newton Dale may still have had an important part to play in the disposal of snow-melt from the central part of the watershed. Recent work by McCann et al (1972) has emphasised the importance of ordinary fluvial processes in glacial and periglacial environments, and although the ice-sheet itself may not have extended south over the main watershed, the area must have been covered with snow and ice for a large part of the year. It seems probable that the glacial drainage channels played an important part in the transport of the annual snow-melt for many years after the retreat of the ice-sheet.

Gregory also describes many periglacial features dating from the Weichselian or Late-glacial, including asymmetrical valley slopes, altiplanation terraces, tors and land-slips. Asymmetry is characteristic of many valleys on the North York Moors and of slopes with several different aspects. The commonest aspect for the steeper slopes which Gregory found was west-facing, and he notes the possible association with the prevailing westerly winds during the Pleistocene, which might have led to more rapid melting of snow and therefore faster erosion on west-facing slopes.

Altiplanation terraces generally occur above the Weichselian snow-line, at heights of 244-335m (800-1100').

and they are most common on the Moor Grit and Grey Limestone outcrops. Palmer (1956) has recognised the Bridestones (875916) as tors, and Gregory finds other examples, such as the Raven Stones (783988), which are situated on an altiplanation terrace, and the Needle's Eye on the western side of Newton Dale (842953). Land-slips are of various kinds, the most common being the rotational slips, which usually involve the Alum Shales. Sometimes such land slips have accumulated peat deposits behind them, such as those studied by Cundill (1971) at St. Helena (685037) and Blakey (674996). Other types of mass movement include earth-flows and mass movements involving glacial deposits.

These features are very difficult to date, and the smaller-scale ones still occur today in conditions of excess precipitation (as, for instance, those studied by Gregory in 1960-61,(Gregory, 1962a)). Thus it is difficult to know whether the common features such as slumping seen in many valleys on the Moors (e.g. in the foreground in photograph 16) are attributable to present or past climatic regimes. Where they are associated with other features, such as solifluction deposits (e.g. at Fen Bogs), it seems likely that the main movements date from glacial or Late-glacial times; but minor movements may have continued with decreasing intensity towards the present at times of increased run-off, and some evidence for this may be afforded by stripes of mineral matter found within peat deposits at various sites.

Periglacial activity was probably responsible for the deepening of some valleys in the Corallian outcrop, beyond the ice-front. Many have coomb-like valley heads, such as that at the Hole of Horcum, where erosion nearly breached the escarpment at the Devil's Elbow (850940). The solifluction deposits referred to above are usually unstratified deposits of grey clay containing angular fragments of sandstone and representing hill-wash in a periglacial climate. Such deposits have been described from several channels on the North York Moors (e.g. Gregory 1962b) underlying Post-glacial peat deposits and probably referable to the Late-glacial period. Solifluction deposits occur in two of the sites in the eastern-central area, Moss Slack, Goathland, and Fen Bogs.

Various diversions in drainage occurred during the Weichselian, the most famous of which is probably the reversal of flow of the Derwent in the Vale of Pickering. In other cases, diversion was not so serious, resulting in shorter aberrations from the original course. Where the presence of moraine blocked the old path of a river, a new one was cut round or through the obstruction, as in the case of the gorges of the River Esk at East Arnecliff (790050) and Crunkly Gill (through the Lealholm moraine at 755071). The River Derwent cut the west-east valley (936950-942910) through the Corallian escarpment when its eastwards course from Harwood Dale to Cloughton was blocked by ice, and when this channel in turn was blocked, it cut the spectacular Forge Valley further south (983875-989854-photograph 5).

Pleistocene drainage diversions.

Photograph 5. Forge Valley.

From 981881, looking SSE.
The flat land in the foreground is part of the broad valley originally occupied by the R.Derwent and now occupied by the artificial sea cut. The steep sides of the gorge are clothed in mixed coniferous and deciduous woodland.

Photograph 6. The gorge of the West Beck.

From 815004, looking SE.
The steep sides of the gorge, cut into the Lower Deltaic Series, are covered in deciduous woodland with an understorey of Pteridium.

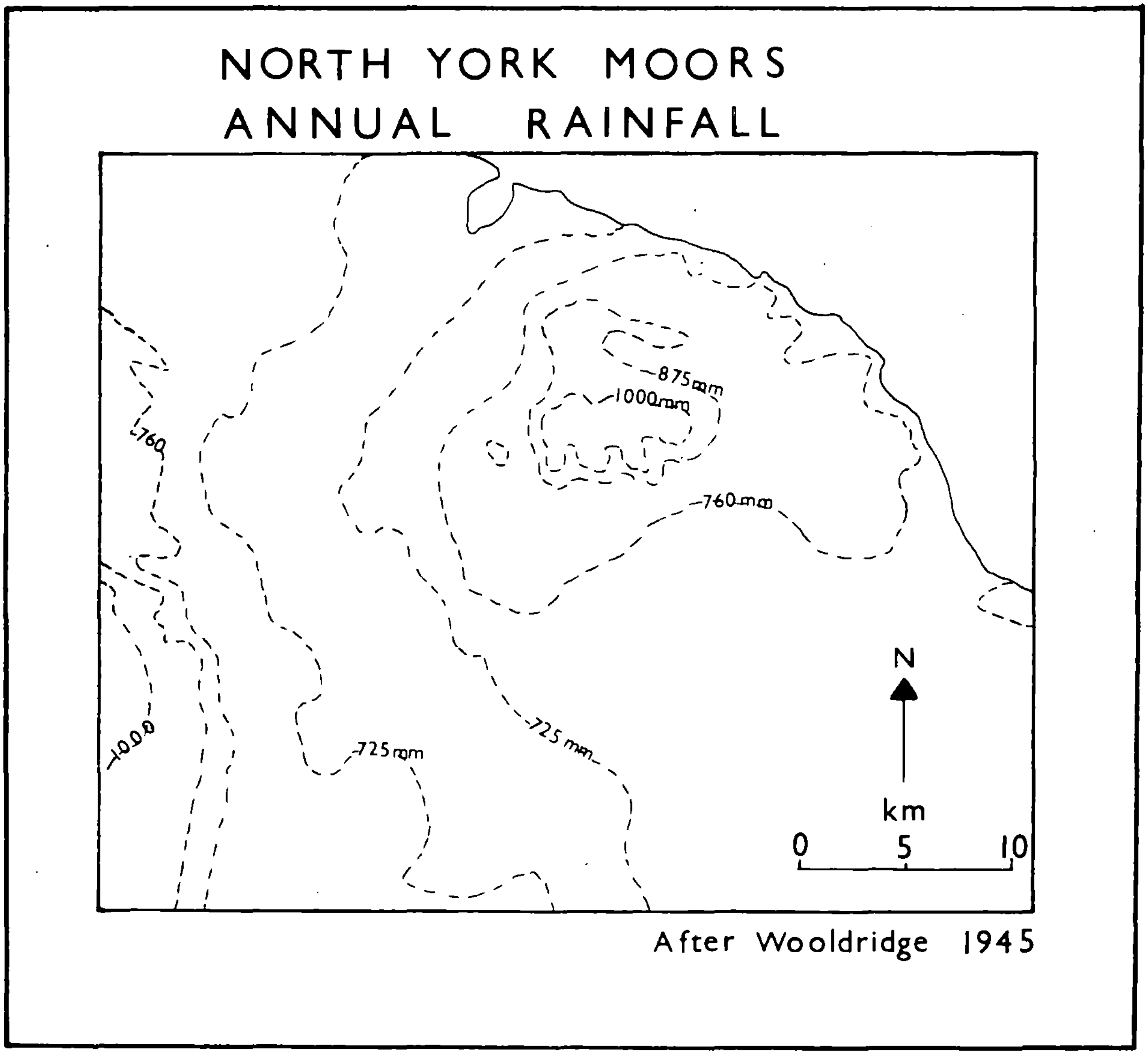
In the eastern-central area, the Eller Beck passes through a series of ravines between Goathland station (838013) and Beck Hole (835022), being diverted to the east of its former valley, now filled with boulder-clay. It falls 61m (200') in 1.5km in a series of waterfalls such as Walk Mill Force, Water Ark and Thomason Foss. Similarly, the Wheeldale Beck leaves its pre-glacial course at Nelly Ayre Foss (814997) and passes through a series of gorges as the West Beck for 2km to rejoin its old course near Beck Hole (photograph 6).

Changes in sea level associated with Pleistocene glaciations resulted in the cutting of channels graded to below present sea level, as for instance the buried channel at the mouth of the Esk at Whitby, which is 18m (40') below the present floor of the river. A similar buried channel marks the original eastward course of the Derwent in the east of the Vale of Pickering and is now filled with superficial deposits to a depth of 11m (35').

It will be apparent from the foregoing description that the Pleistocene period has had a profound effect upon the surface topography of the North York Moors. Deposits of boulder-clay in the lower areas provide some of the most fertile soils in the region; modifications to the drainage system provide some of the most spectacular inland scenery; whilst glacial drainage channels with no present-day drainage or small misfit streams have accumulated peat deposits, which make possible the reconstruction of the Post-glacial vegetation history of the area.

Map 6.

Figure 11.



2.4 Climate.

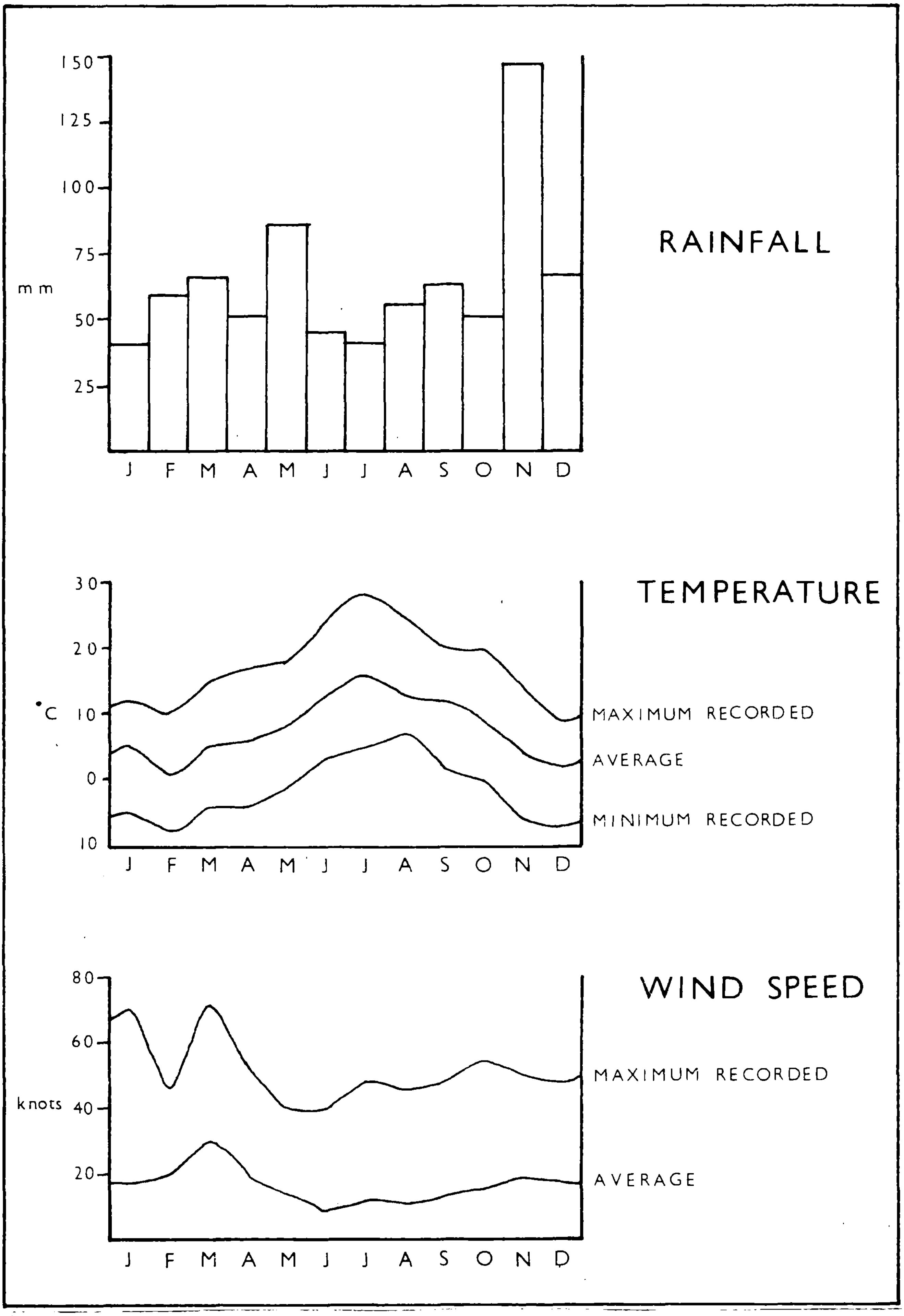
The climatic regime of the North York Moors is influenced by three main factors; its location to the east of the Pennine chain at latitude 54° - 54° 30' north; its maritime position; and the relief of the land. It is the particular combination of these three factors which causes the climate of this area to differ slightly from that of the rest of north-east England.

The proximity of the sea tempers the effects of the north-easterly position, so that extremes of temperature and rainfall are not felt, even on the high moors.. The cold easterly winds are somewhat compensated by the tendency to sea-frets and general mistiness which prevents excessive heat loss through outward radiation. This is particularly true in Spring or early Summer, when a low, formless cloud or sea-fret, sometimes known as the "haar", frequently shrouds the east coast in fog. This means that although snow may lie until well into April on the moorlands, temperatures are rarely far below zero. Conversely, summer visitors to the east coast resorts of Scarborough or Whitby will seldom find the weather more than "pleasantly warm". Compared with other parts of northern England, therefore, temperatures are fairly equable.

The main effect of the relief of the area is to limit the growing season, so that it comprises only c 33 weeks at heights of over 200m. This is particularly limiting for cereal cultivation. Another limiting factor for agriculture on the higher areas is exposure, which is accentuated by the general treeless nature of the vegetation. Shelter belts are common features, particularly on the Limestone Hills, and are generally planted to afford shelter

Figure 12.

METEOROLOGICAL DATA FROM FYLINGDALES EARLY WARNING STATION.



from the critical north-easterly winds blowing off the sea.

The Pennines cast a rain shadow over the area, so that the rainfall at sea level is only about 725mm (25 ") p.a. Relief is the controlling factor for rainfall and the isohyets follow the contours, as can be seen from map 6 (Fig. 11). The 760mm (30") isohyet circumscribes the Moors, while the 875mm (35") isohyet encloses the area over about 275m (900'). In the western part of the main watershed, the highest areas receive over 1000mm (40")p.a.

Climatic figures for the eastern-central area are available from the meteorological records kept at Fylingdales early warning station (866975). Summary graphs for temperature and rainfall are shown on Fig. 12, compiled from records for the years 1967-69. The lowest recorded temperature for the period was -8° C, but throughout the three years there was only one month with an average temperature below zero. Snow was recorded in six months in every year, and on two occasions in May. The highest recorded temperature was 28° C, but there was only one month in the period with an average temperature above 15° C.

To emphasise the factor of exposure, on several occasions wind speeds of up to 50 knots were recorded, and a speed of 72 knots was reached once. Winds are strongest in Spring, average speeds often exceeding 30 knots. Average rainfall for the three year period was 754mm, which is probably a rather low reading, as Fig. 11 would suggest that the area usually falls within the 760mm isohyet. A maximum is seen in November every year, with another in Spring or Summer.

2.5 Soils.

There is an overall correlation between geology and soils, most easily seen in the drift-free central parts of the area. The calcareous strata of the Corallian Series in the south provide the soils with the highest base-status and are covered for the most part with warm, well drained agricultural loams. On the real limestone beds Rendzinas may develop, although Brown Earths are the commoner natural soil type; while on the higher beds particularly on the Grits soils are more acid and usually podzolised. The Oxford Clay, which is particularly sandy in this area, carries a belt of Brown Earths and loams at the foot of the Corallian escarpment, but over most of the high moors to the north soils are more or less podzolised. The Kellaways Rock carries cold, wet podzolised soils, while the Deltaic Series provides soils of low but variable fertility and generally with peaty surface layers. Where sandstones predominate leaching is pronounced, whilst the shales tend to impede drainage and gleying occurs.

Where the Lias is exposed, for instance in the upper parts of Bilsdale and Farndale, soils are heavy and clayey, and the natural soil type is probably the Brown Earth under deciduous woodland. The soils of the boulder-clay areas are often relatively fertile, although as they are heavy and damp they tend to favour grassland rather than arable agriculture. In the Vale of Pickering true alluvial and warp soils are found, many of which have been successfully drained to give fertile soils for agriculture, especially towards the margins. The marginal belt between the Vale and the Limestone Hills has been an important area for settlement and agriculture at least since Anglian times. In the centre of the Vale, patches of lighter chalky and gravel soils occur on the islands of solid which protrude through the alluvium and drift.

Within this overall pattern, minor differences in soils often relate to drainage. On the high moors of the central watershed, for instance, the generally podzolised soils vary from peaty Podzols in freely drained situations to peaty gleys in areas of poor drainage and ground-water gleys in patches where drainage is very poor (Wood, 1970). All these soils are similar in the "A" horizons, with a raw humus layer above a bleached sandy horizon. Where drainage is impeded, gleying is marked in the "B" horizons, whereas under conditions of freer drainage a hard iron pan may be formed, which may itself cause some drainage impedance in the layers above it. The formation of this pan, however, depends on the amount of iron in the parent material, so that on the Moor Grit, for instance, iron pans are rare, but on the more ferruginous beds of the Upper Deltaics the whole "B" horizon may be orange in colour due to iron-staining.

Differences in drainage also result in differing depths of peat or raw humus in the surface layers. Cundill (1971) has mapped the depth of peat over the central water--shed. Over much of the higher area peat depth is in excess of 50cm, and in places it reaches 2m or more. The peat acts as a sponge, retaining moisture, and if it is removed soil erosion may follow. This has been described by Curtis from Levisham Moor (Curtis, unpublished), where both wind and water erosion are involved, after burning has destroyed the surface peat. Bolton (1965) described similar erosion on Fylingdales Moor, where tank damage in World War II has led to deflation of the surface soil in drier periods.

The apparently simple relationship between geology and soil, with minor differences due to drainage, led Jacks (1932) to suppose that the podzolised soils described above were the natural soils for the central area of the Moors. However, Dimbleby (1952c) has found buried Brown Earth soils under Bronze Age barrows on Silpho Moor on the Corallian outcrop, where the present surface soil is Podzol under Callunetum. Examination of soils under Betula plantations at sites on the Hackness outlier of the Corallian has shown that as the plantations mature the soils revert to Brown Earths. Under a sixty year old Betula plantation, no traces of the Podzol remained, although nearby soils under Callunetum were strongly podzolised. Dimbleby concludes that:

> "The podzol is seen as a secondary soil associated with a biotically controlled vegetation type, the heath, and is not maintained once the heath is superseded in a natural succession."
> (Dimbleby, 1952c)

Pollen analysis from sites further north on the Deltaic rocks (Cundill, 1971; Simmons, 1969; and below, chapter 5) shows that this area was once covered with deciduous woodland. It seems unlikely that this vegetation could have grown on podzolised soils, and therefore it is probable that Dimbleby's conclusions may be applied to most of the moorland area. Several writers have demonstrated the importance of the anthropogenic factor in the development of the heath vegetation (e.g. Dimbleby, 1952b; Simmons, 1969; Cundill, 1971), and it seems from this that Man has been a major factor in the evolution of soils, through his effects on the vegetation. The more fertile soils in the dales may be the result of later clearance of the woodland, as has been suggested by Anderson (1958).

Thus it appears that, while there is some overall correlation between geology and soil, the major factor in pedogenesis is probably vegetation, with drainage causing local variations. The environment must always have been marginal for the development of brown earths and deciduous woodland, and this marginality would have accentuated the effects of Man on the vegetation and soils.

2.6 Vegetation.

The diversity of geological detail of the Moors is belied by the monotony of the vegetation cover, which is, as Wooldridge has remarked,

> "singularly homogeneous in general type, presenting a number of slightly differing facies of *Calluna* heath."
>
> (Stamp, 1945)

Over the plateau surface, from the Cleveland escarpment in the north to the higher parts of the Corallian escarpment in the south, *Callunetum* is the dominant plant community, producing the effect of miles of purple heather which is one of the chief tourist attractions of the region (photograph 7).

The detailed variations of the *Callunetum* have been described by Elgee (1912), and practically all other writers on the area seem to have followed his descriptions. He divides the plateau vegetation into three main types; the mosses, the fat moors and the thin moors, according to the depth of peat on which they have developed. Thus there

Figure 13.

Moorland Vegetation.

Photograph 7.

From 857984, looking WNW.
The vegetation in the foreground is a virtual monoculture of Calluna vulgaris. In the background, patches of Polytrichum heath form a mosaic with the Callunetum on Two Howes Rigg. The sides of the Ellef Beck valley (middle distance) are covered in Pteridium and residual patches of deciduous woodland

Photograph 8.

From 891997, looking NE.
Eriophorum vaginatum dominates the wet flush of Green Swang at the head of Blea Hill Beck. Surface sample No.12 was taken from here.

is a high degree of correlation between the occurrence of these vegetation types and the depth of peat over the central watershed as mapped by Cundill (1971).

The mosses occur on the high axis of the central watershed between the dale heads on the deeper peat, and include such areas as Yarlsey Moss (755007), Pike Hill Moss (772010), and May Moss (897960). The Calluna is accompanied by Erica tetralix and Eriophorum vaginatum, with Sphagna in the wetter places. These other species may be locally dominant, as, for instance, Eriophorum vaginatum dominates Green Swang (892997) with a carpet of Sphagna in a wet flush at the head of a moorland stream (photograph 8).

The fat moors Elgee describes as areas developed on 30 to 120cm of peat, which remains damp even in the driest weather. Here the Calluna is accompanied by Erica tetralix, Vaccinium myrtillus and Eriophorum vaginatum in damper places. The wetter types of fat moor, as those developed on shales on Easington High Moor, Widow Howe Moor and Fylingdales Moor, grade into the mosses; while, at the other end of the scale,

> "insensible gradations connect the fat moor with the thin moor"
> (Elgee, 1912).

On the thin moors, the Callunetum is more varied and in places Nardus stricta and Scirpus caespitosus replace Calluna as the dominant species, with Eriophorum vaginatum, Molinia caerulea and Juncus squarrosus as subordinate species. The peat is shallower and forms a less continuous cover than under the fat moors, revealing patches of bare rock at the surface. This type of moorland is well developed on Kellaways Rock, for instance on Allerston High Moor surrounding May Moss.

Cundill (1971) has noted changes in vegetation in some places which have taken place since Elgee's day, and gives the example of Rosedale Head, where Eriophorum vaginatum was locally dominant in Elgee's time, but Calluna is more important now. Elgee also states that May Moss

> "is characterised by the great abundance of Erica tetralix in its surface vegetation. In fact, this species is here distinctly dominant, Eriophorum and Calluna being somewhat subordinate."
> (Elgee, 1912)

This is certainly not true today, and Calluna is much more abundant than Erica tetralix or any other species. This decrease in diversity of species is probably attributable to burning in connection with the management of the area for grouse-moor. The Callunetum is carefully managed sub-climax vegetation, which is regularly burned at approximately seven to ten year intervals in rotation, thus leaving some old heather to provide cover for nesting birds and some younger heather with tender shoots for the grouse to feed on.

Pearsall (1950) has stressed the artificiality of our present heather moorlands:

> "We do not really know what a natural heather moor looks like, but we know that on such a moor, left untreated, the heather would grow long and "leggy", leaving numerous openings in which other species could develop. Thus an unburnt or infrequently burnt heather moor tends to have a more varied flora than one which is burnt regularly, and burning is largely responsible for such uniformity as is found."

Tansley (1939) has described the colonisation of what he calls the "burn subsere" on grouse moors and the succession applies well to this area. The first colonisers, if burning was deep, are lichens and liverworts, e.g. Lophozia inflata, Webera nutans, Polytrichum spp., Ceratodon

Figure 14.

Photograph 9. Subseral stages of the Callunetum.

From 834000, looking SW.

1. In the foreground, old "leggy" *Calluna* in flower.
2. A patch burned two years before is still at an early stage of recolonisation.
3. In the background, the channel of Moss Slack Goathland.
4. Surface sample No.6 was taken from a polster of *Sphagnum* amongst the Callunetum.

purpureus and Cladonia spp. Sphagnum papillosum may colonise damper areas. These are succeeded by a turf of Calluna, Vaccinium myrtillus, Potentilla, Juncus squarrosus, Agrostis canina and Polytrichum. As the Calluna regains its dominance, the other species gradually die out, to leave almost a monoculture of Calluna. As the Calluna becomes old and "leggy", the centre of each clump becomes colonised by Hypnum and Cladonia spp., and Juncus squarrosus establishes itself too, before the moor is burned again and the cycle recommences. This rotational burning, together with local variations in drainage and slope, gives rise to a mosaic pattern of vegetation, with areas at different stages of succession, as seen in photograph 9 on Goathland Moor.

At the plateau edge, the Callunetum gives way to a more varied slope vegetation, with Vaccinium myrtillus and Pteridium aquilinum as major constituents with the Calluna. Pteridium is intolerant of very acid soils and likes well-drained situations. It has often been taken as an indicator of formerly wooded areas, and this is certainly true of the dale-sides where it flourishes today. Some patches of woodland remain in the dales, generally consisting of Quercus and Betula. Barry (1907) describes two or three patches in Jugger Howe Gill (940990) which he considers to be more or less natural. Newton Dale supports a scrubby woodland of Betula, Quercus, Sorbus aucuparia and Crataegus monogyna on the steep slopes, as seen in the foreground of photograph 16 (Figure 21).

The valley bottoms, especially the flat, boggy glacial drainage channels or "slacks", often support a mire vegetation, with Sphagnum and Carex spp. dominant and *Eriophorum*, *Calluna* and *Myrica gale* on the drier hummocks. At Fen Bogs, at the head of Newton Dale, *Phragmites communis* forms extensive reed beds with *Rhynchospora alba*, *Schoenus nigricans*, and *Salix* spp. forming a carr vegetation. Detailed descriptions of the vegetation of this and another glacial drainage channel, Moss Slack Goathland, will be given in chapter 4.

This chapter has dealt with the semi-natural vegetation only, as the plantations and agricultural vegetation are more properly described in the section on land use (chapter 3.4) . It will be seen that wherever possible the *Callunetum* is dominant on the Moors, only giving way to more varied types of vegetation where conditions of drainage or angle of slope force it to assume a more subordinate role. Remnants of deciduous woodland on the valley sides, together with the suggestion of its larger extent in the past from the distribution of *Pteridium*, intimate that the dales were formerly well-wooded. The part played by burning has been stressed in connection with the dominance of the *Callunetum*, which appears as a subclimax (or "plagioclimax", Eyre, 1968) type of vegetation.

The effect of the *Callunetum* on soils has already been discussed and it thus remains a distinct possibility that over much of the high moorland the natural climax vegetation was woodland over brown earths, rather than heath over podzols. Cundill (1971) has come to such a conclusion for the central watershed and Dimbleby has postulated the same for the Corallian Hills to the south. It is not possible, therefore, to agree with Elgee that

> "Moors are a natural plant community more or less untampered with."
>
> (Elgee, 1912).

CHAPTER 3. THE CULTURAL BACKGROUND.

3.1 Historical Background.

In this section a brief chronological survey will be made of the archaeological and documentary evidence which allows a reconstruction of the cultural background to the area.

The earliest settlers in the Post-glacial period have left little evidence on the Moors themselves, although the well-known site of Star Carr is situated in the eastern part of the Vale of Pickering (024812). This site has been dated by the radio-carbon method as mid-eighth millenium B.C. (9488 +/- 350 BP) and was thought to be a seasonally-occupied hunting camp (Clark, 1954). It has been described as Maglemosian in type, although Clark believed it to be earlier than the classic Danish sites, possibly an intermediate type between Upper Palaeolithic and later Mesolithic cultures.

Mesolithic sites on the Moors themselves are numerous, generally situated above 305m (1000') at the upper parts of the dales, eg. Farndale, Bilsdale, Westerdale, Commondale, Wheeldale. They are generally considered to be a regional variation of the Sauveterrian form (Radley, 1969). Like Star Carr, they show affinities to Upper Palaeolithic cultures, but the incorporation of Neolithic arrowheads at some sites suggests contact with later cultures also. Radley (1969) has interpreted the culture as a hybrid one, lasting well into the Neolithic until about 2000 B.C. Clark has argued for a similar overlap between the Mesolithic and Neolithic:

> "The Neolithic arts were diffused among the food-gathering peoples...peoples who neither vanished nor were extinguished, but who survived to form the human basis of the later civilisations....The survival of Tardenoisian* man in areas relatively undesirable to peoples with a different economy, can thus, be accepted on a priori grounds. The displacement of one culture by another is never achieved in an instant; in this particular case the overlap in time was probably a long one."
>
> (Clark, 1936)

The sites on the Moors are usually small and are characterised by their large quantities of waste flints. The main implements found are microliths. These were presumably mounted in rows on bone or wood, as is suggested by the arrangement of the six found at Sil Howe (Elgee, 1930). The microliths are found typically at the junction between the mineral soil and the overlying peat, and are found when the peat is removed, either by severe burning (as at Simon Howe, 830983, in 1947), or by preparation of the land for afforestation (as at Mauley Cross, 796945).

Few larger tools have been found at these sites, and Radley notes in particular the absence of axes or adzes suitable for felling trees. However, abundant charcoal remains at many sites point to the widespread use of fire, and Simmons and Cundill (1969) have stressed the probable influence on the environment. From the large number of sites (22 are known from the Ryedale area alone) a fairly substantial Mesolithic population is implied on

* The culture was thought originally to be Tardenoisian, although Clark later decided it was closer to the French Sauveterrian (Clark, 1955).

the high Moors, although except for White Gill (639026) the sites have not been interpreted as permanent camps. A ploughed out settlement site recently excavated at Upleatham (622200) suggests that more permanent settlements may have existed on the lower outliers to the north of the main uplands (Spratt, personal communication).

The distribution of Neolithic finds, in contrast to those of Mesolithic age, is very sparse on the high Moors. The main concentrations are further south, on the Wolds, with outliers on the Corallian outcrop in the south of the area. Polished axes have been found at Egton,(809063), Goathland, Allan Tofts (830028), Rosedale, Eston and Guisborough, and long-barrows have been found on the Limestone Hills to the south,e.g. at Kepwick (490902) (Longworth, 1965). Leaf-shaped arrowheads are not uncommon, but apart from these finds there is little indication of Neolithic settlement on the high Moors. The probable survival of late Mesolithic cultures into the Neolithic period has already been noted, and, indeed, these peoples may well have survived into the Bronze Age.

The Early Bronze Age has been described by Elgee (1930) as a period of invasion, firstly of the "Beaker" culture from Germany, Holland and Denmark, and secondly of the "Stone battle-axe" culture, based on a Danish culture. In Elgee's day only nine beakers were known from the area, but today the number stands at over fifty, many of them from the Windypits in Ryedale (McDonnell, 1963). Nevertheless, no very substantial population is indicated for this period, and most of the remains are concentrated on the Limestone Hills in the south of the area. The same holds true for the "food-vessel" culture, which resulted from the mingling of the above cultures with the Neolithic population. From these early Bronze Age cultures the Middle Bronze Age "urn" culture evolved, which was to be so important on the high moorlands, and which has been popularised, if not romanticised, by Elgee (1930).

Over ten thousand round barrows are estimated to be still standing on the North York Moors, most of which have been assigned to the Middle Bronze Age. Several of them, particularly the larger ones, have been found to contain collared-urns and cremated remains of this period, but the vast majority have been dated by association alone. This is particularly true of the smaller stoney cairns, often forming necropoles of hundreds, such as the cairn group of over three hundred cairns at Iron Howe described by Hayes (in McDonnell, 1963). Elgee interpreted these as the burial places of the lower classes of society, but, as Ashbee notes (1953):

> "The sepulchral character of many of these small mounds has never been proved."

None of them have revealed any grave-goods on excavation (Spratt, personal communication), and Elgee's suggestion that they covered inhumed remains which have rotted away entirely in the acid moorland soil is not convincing.

Some writers (e.g. Hayes, 1963; Fleming, 1971) have suggested that these cairnfields are the result of the clearing of stones from areas for cultivation. Fleming has explained the irregular lengths of walling associated with them in this way also. Hayes (1963) has described possible cultivation plots amongst walling and cairns at Struntry Carr (811025), and similar features are to be found on Allan Tofts, Goathland (830026). None of these sites has produced conclusive dating evidence, and Hayes suggests that they cover a longer period than the Middle Bronze Age, possibly extending into the Iron Age or beyond.

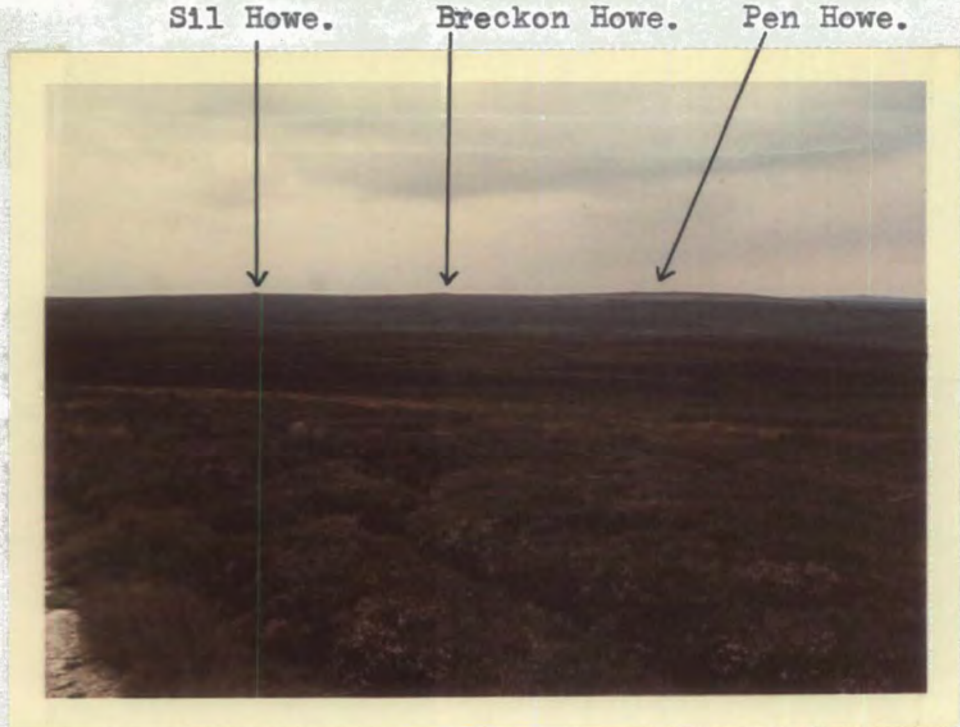
All writers have postulated a nomadic existence for the Bronze Age people, Fleming (1971) claiming that the emphasis was on cultivation rather than stock-raising. From the numbers of burials in the larger barrows and hypothetical rates at which land would be used by shifting cultivators, he worked out the total amount of land used and the total population. He concluded that the collared urn folk numbered under a thousand and were in the area for between one and five hundred years. Although not very conclusive results, these figures do illustrate that the Middle Bronze Age population was not so large as has sometimes been assumed. It seems probable that remains from a longer time-span have been included within the Middle Bronze Age period.

The cairnfields and their associated walling and enclosures have already been noted as examples of features which may date from a long period of time. The cross-ridge dykes and earthworks described by Elgee (1930) as part of settlement sites associated with the urn folk may be Iron Age as well as Bronze Age in date. The many hollow-ways or tracks described by Elgee as cattle droves may date from a variety of periods from Neolithic

Figure 15.

Bronze Age remains.

Photograph 10.



From 870019, looking NW.
Large Bronze Age barrows stand out against the skyline on the ridge top, which itself formed a prehistoric trackway and later part of Whitby Strand boundary.

Photograph 11. Foster Howes, 875009.

This pair of barrows, typical of the larger tumuli, lies on a continuation of the ridge in photograph 10, at an altitude of 300m O.D.

to Medieval, although some of them may well be Bronze Age. The cup and ring marked stones (e.g. one on Upleatham Moor,621200; three on Allan Tofts,830026) are probably Bronze Age, but not necessarily Middle Bronze Age in date. Finally, the tracks along the moorland ridges, often linking the larger barrows, may owe their existence to these barrows or may pre-date them. In any case, these ridges would form natural routeways, affording easier passage than the valley bottoms, whether or not they passed barrows on their way.

Thus it appears that whilst the Middle Bronze Age does represent a phase of considerable settlement on the Moors, its importance has probably been over-estimated by archaeologists..This is partly because of the conspicuous position of the larger barrows, which stand out in lines along the crests of the moorland ridges against the background of low-growing heather (photograph 10). Many of them have survived through the millenia because of their location in areas which have never attracted cultivation or settlement. The contrast between these remains and those of the Iron Age, for instance, is striking (photograph 12).

The Late Bronze Age, like the Early Bronze Age, is not well represented in this area. It represents another period of invasion, which continued into the Iron Age. Lines of penetration were probably the rivers and sea inlets, and the Vale of Pickering seems to have been one such route. Here lake-dwellings with Swiss affinities

IRON AGE EARTHWORKS, LEVISHAM MOOR

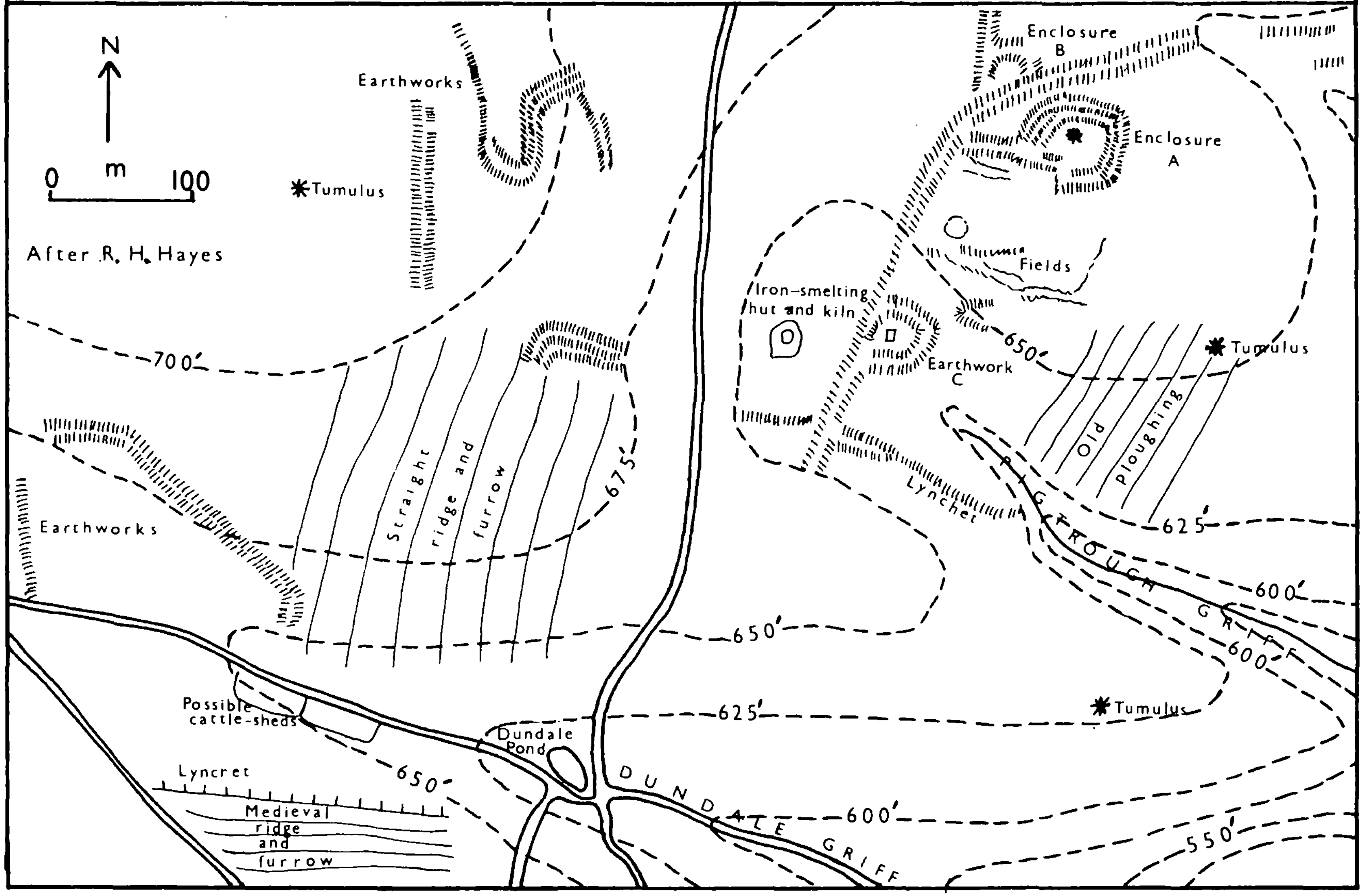


Figure 16.

(Elgee, 1930) have been discovered at Costa Beck (800763). Hoards of mass-produced weapons, including socketed axes and swords, have been found in various places on the fringe of the area, e.g. at Roseberry Topping (579127); but apart from one axe at Glaisdale (775053), there are no notable finds from the high moors.

The Iron Age period is one which is coming to assume greater importance in the history of north-east Yorkshire, largely thanks to the use of aerial photography. Much of the work on this period has been carried out in the last few years and is therefore unpublished, e.g. the excavations on Levisham Moor by the Scarborough Archaeological Society. In addition, certain earthworks which were formerly assigned to other periods have lately been reappraised as Iron Age in date, e.g. the hill-fort on Eston Nab (569184). This and other hill-forts seem to have been occupied as defensive positions by a feudal aristocracy (McDonnell, 1963). These sites were probably only used in times of attack in inter-tribal warfare, and do not represent the normal dwelling places of the populace. More typical of the period were the wooden farmsteads bounded by dykes and ramparts, such as those on Levisham Moor, and the lowlier huts, such as those on Percy Rigg (610111).

Other notable finds include the iron furnace from Levisham Moor enclosure B, accompanied by typical coarse Iron Age pottery and dated to the first century A.D. (Hayes, unpublished). The importation of the Belgic plough and the use of the animals' dung as manure allowed a more settled form of agriculture and opened up the heavier lowland soils for the first time. "Celtic fields" have been

Photograph 12. Iron Age earthworks on Levisham Moor.

From 832924, looking N.
The Calluna ridge in the foreground forms the southern wall of enclosure B; the two people are standing at the north-west and north-east corners. The enclosure contained remains of two hut circles near the north-western corner. The southern boundary of the enclosure forms part of a longer earthwork connecting several of the enclosure (see Figure 16.)

found in the area, such as those at Cold Cam (542814). These are larger and more regular than the earlier cultivation plots mentioned above in connection with the Bronze Age people, and they are more or less square, which indicates that they were cross-ploughed. These, together with finds of querns of various types, show that corn-growing was fairly extensive in this period. The Iron Age sites discovered so far are all on the margins of the high moors rather than on the higher parts of the watershed, but the next few years may well see the discovery of new sites testifying to a more widespread occupance than was formerly thought.

The arrival of the Romans was later in this area than in most of the country. It was not until A.D. 70 that Petilius Cerealis finally subdued the Brigantes, but the Romans never established a permanent station in the area, the nearest garrison town being Malton in the Vale of Pickering. The remains on the Moors can be assigned to two brief periods, the conquest of the area and the end of the fourth century A.D. From the first period (A.D. 80-120) date the practice camps at Cawthorn (785900) and the Roman road which crossed the Moors from Malton towards the coast at Goldsborough. This road was a purely military one for moving men and supplies up from Malton, but was probably instrumental in the pacification of the area. Sections of it are particularly well preserved on Wheeldale Moor (804976), where it is known locally as "Wade's Causeway", (photograph 14).

The only other notable Roman features from this area date from the second period and include the marching camp on Lease Rigg (815043) and the chain of signal stations along the coast from the mouth of the Tees to Filey, built at the end of the fourth century to give warning of Saxon raids. These were established at Huntcliff (687220), Goldsborough (835151), Ravenscar (980019), Scarborough, and probably Boulby (760190). The Goldsborough one went down fighting in the early fifth century; the Scarborough one was also destroyed by raiders later. The others decayed more slowly after the Roman withdrawal in 410 A.D. (Hayes, 1967).

During the Roman occupation, native farms flourished. The presence of the garrisons at Malton and York provided a market for food and clothes for the southern part of the area. A native farm has been excavated at Spaunton (725899) and a villa at Beadlam (655846), and several others near Malton and on the Howardian Hills. Sites at Flixton (400796) and Crossgates (029841) in the Vale of Pickering both show evidence for a peaceful, prosperous rural life in the third and fourth centuries A.D. (Rutter and Duke, 1958). Hayes has commented:

> "The Romanised way of life lasted longer in north-east Yorkshire than in other parts of Britain, probably owing to the isolation of the district and a lack of very large villas or towns. Also the coastal defences - small forts or signal stations, in conjunction with a fleet, helped to keep raiders down."
> (Hayes, 1967).

Further north, evidence of Romano-British sites in the moorland area is coming to light, e.g. the site at Newbiggin Hall (836073) and another at Briggswath (868082) dated by pottery and coins to the fourth century A.D. There is also the glass bangle from Stony Rigg (636032) and another from one of the Windypits, Ryedale. Hayes writes:

> "All these point to occupation, trading, and travellers in the dales and on the high moors. We are already coming to accept intensive

> Romano-British occupation on the Limestone Hills, therefore it is unlikely the dales remained uninhabited, for recent work in Kildale and Eskdale shows otherwise."
>
> (Hayes, 1967)

Perhaps in Romano-British times we have another period which has been underestimated by archaeologists in the past. There are certainly a number of "British" place-names for the high moors area: Elgee (1930) lists seventy. These mostly refer to rivers (e.g. Seven, Rye, Esk, Derwent) or to topographical features (e.g. Brown Hill, Pen Howe, Blue-man-i'-the-moss). Such names, however, may have been conferred as early as the Iron Age or after the Roman period, in the Dark Ages for which there is virtually no evidence. Some names point to a late occupancy of this area, at a time when the Angles were already established, such as Wardle Rigg (820950), the "wealh" element from the Anglian term for Britons. Smith (1928) has suggested that the Britons may have lived with the Angles, in subservience to them. One can imagine Anglian lords employing native shepherds, for instance, to tend their sheep on the high moors, which would be much better known to the Britons than to the Angles.

Both the archaeological evidence and the place-name evidence show sparse settlement by the Angles on the moorland area. However, some names may have been replaced by Scandinavian ones, and there are several instances of Old English personal names being combined with Scandinavian elements, e.g. Goathland ("Goda"), Fylingdales ("Fygela"), Lilla Howe, Hackness ("Hacca").

Further south, on the Limestone Hills, are plentiful Anglian place-names, e.g. Pickering ("Picer"), Levisham ("Leofgeat"), Lockton ("Loca"), and there are a few in the north-east of the area, e.g. Egton ("Ecga"), Streoneshalh (= Whitby Abbey). Anglian settlement at Whitby is well documented, since Oswy founded Streoneshalh Abbey there in 653 A.D. It was the seat of the well known Synod of Streoneshalh or Whitby in 664 A.D., which resolved many of the differences between the Roman church and its isolated British cousin. The Abbey was destroyed by Danes in c. 867 A.D. The founding of another Anglian monastery in c 659 A.D. by Cedd at Lastingham (730905) is recorded by Bede in his History of the English Church and People, and he gives a brief description of the surrounding countryside:

> "Cedd chose a site for the monastery among some high and remote hills, which seemed more suitable for the dens of robbers and haunts of wild beasts than for human habitation."
> (Bede, iii.23)

From this we may conclude that the high moors were not well populated at this time. This is in keeping with the scarcity of archaeological evidence for the period, which chiefly consists of cemeteries in the Vale of Pickering and at Robin Hood's Bay, and one Anglian bowl found near Goathland (Sheppard, 1941).

Evidence for the succeeding Scandinavian period is more abundant, including Norse crosses at Skelton (655188), and Thornaby (451176); Viking burials at Kildale (605095), and crosses with Irish ornamentation in Ryedale and Cleveland. Place-name evidence is also plentiful, especially on the Moors, e.g. Aislaby ("Asulf"), Biller Howe Dale ("Bili" or "Bil"), Whitby ("Hviti"), May Moss ("Magi"), and Sil Howe ("Sile"). (Smith, 1928).

Three main immigrations can be distinguished on the evidence of the place-names; firstly an immigration of Danes after 876 A.D., when Healfdene parcelled out the land into wapentakes to give to his followers. This was mainly the area of Pickering Lythe, the south of Ryedale, Bulmer and Hang East wapentakes (Victoria County History, 1914). In addition there were isolated settlements in Whitby Strand wapentake and in Eskdale and Cleveland, which Smith (1928) suggests were independent settlements made direct from the sea to the east. Typical place-names of this period bear the suffix -by, e.g. Whitby, Danby.

The second period of colonisation was of Norwegians from the sea to the Scarborough and Whitby districts. Typical place-name endings are gill, foss and slack. However, the tenth and eleventh century colonisation from Ireland and Cumberland was much more important, and among the names from this period are the common suffixes dale, moor, holm, thwaite and howe. This colonisation was probably not complete until the twelth century, and some names show a late connection with Scandinavia, e.g. Goathland has been influenced by the Old Norwegian change of "d" to "th", which occurred c. 1000 A.D. (Smith, 1928).

In general, the Danes were more important in the south of the area, while the Norwegians were more important in the north-east. Smith (1928) has commented on this distinction:

> "Whereas the Danes and Norwegians indifferently occupied districts already settled by Angles, the distribution of place-names suggests that the Norwegian settlers tended to avoid the districts occupied by the Danes in the previous century."

The distribution of place-names of Scandinavian origin today bears witness to the very thorough colonisation by these peoples in the centuries preceding the Norman conquest.

From Domesday Book we see that all the landowners in Edward's time were Scandinavian in this area. However, the conquest itself caused great changes in both land ownership and land value. Nearly all manors changed hands between Edward's time and the Domesday survey (1086 A.D.) and the King himself held fifty manors in the area at the latter date. A noticeable fact is the extremely low value of most manors and the decreases which had taken place since Edward's time. For example, the manor of Whitby had decreased from £112 to £3 and Pickering from £88 to 20/4d. Many manors were recorded as being of no value at all, being entirely "vasta". This was presumably due mainly to William's "harrying of the north" in 1069 - a reprisal against the rebellious northerners and a "scorched earth" policy in this area, lest the Danes should intervene with help from the sea. So thorough was this harrying that the only settlement left in the moorland area at Domesday was in Staintondale in the east, and there were a group of settlements in Eskdale, including Egton, Danby, Lealholm, Broca (lost) and Camisedale (lost). Most of these manors were wholly or partly waste; only one plough was left in the whole of Eskdale (at Crunkly) and no meadow was recorded.

It is doubtful whether William's men reached the high moors themselves, as the physical features would have been forbidding, especially for men unfamiliar with the terrain. However, it does seem likely that a redistribution of population took place from the uplands to the lowlands, leaving the main area of the Moors unpeopled. The settlement of Goathland is not mentioned in Domesday Book, but it seems likely from the place-name evidence that it existed. Buckley (1971) has suggested that it may have been included in Pickering, as it was part of Pickering parish.

Therefore, the period following the Norman conquest appears to have formed a hiatus in the development of the area, and subsequent settlement followed a different pattern. In the recolonisation of the North York Moors in the early Middle Ages, the great religious orders played a fundamental role. Houses of many orders were established, mostly within fifty years of Domesday. Whitby Abbey, refounded in 1078, was one of the most important Benedictine Houses in Yorkshire. Rievaulx and Byland were among the leading Cistercian ones, while Malton Priory was one of the wealthiest Gilbertine houses. Priories were also founded at Guisborough, Newburgh, Bridlington, Kirkham, Rosedale and elsewhere. Some villages, such as Griff and Stilton, became monastic granges. At other places vills were restored and granges established alongside them, as at Great Broughton and Wintringham. Malton Priory had a grange at Goathland at Morton Close (829035). Smaller religious establishments included the priory at Grosmont in Eskdale and the hermitage at Goathland granted by Henry I to Osmund the priest and a few brethren and later transferred to the Abbot of Whitby.

Waites (1967) has noted the close correlation between areas of waste in Domesday and monastic settlement. These areas provided the solitude required by the religious orders and were at the same time easy to acquire. Once established, the monasteries accumulated great wealth, by gifts of land from the laiety and by very efficient large-scale agricultural enterprises. The monks, with the use of lay-brothers as labourers, were able to organise their farming on a scale quite beyond the reach of any layman. They have been traditionally associated with sheep farming, but Waites has stressed the integration between pastoral and arable farming, which guaranteed their success. He has also suggested that in some areas iron-mining was their chief concern, e.g. Rosedale, Eskdale, (Waites, 1964).

Thus, in much of the area, the monks were pioneers in both settlement and agriculture. However, their influence was felt to a lesser extent in the eastern-central area. The lands of Whitby Abbey adjoined the area to the east as far as the Whitby Strand boundary, but most of the area was part of the Royal Forest of Pickering, which passed to the Duchy of Lancaster in 1285. In this area game was preserved, domesticated animals were allowed to graze only at certain times of the year, and no arable enclosures were allowed, although some were made. The Forest records form a rich source of information for this period (Turton 1894), giving us a detailed picture of population, farming and vegetation.

Other lay landowners apart from the Duchy of Lancaster were important in this area, for instance in the enclosure and farming of Allan Tofts (Hollings, 1971; Buckley, 1971). Further west, lay agriculture also became important after the Dissolution of the Monasteries in 1536-9.

The monastic lands were divided between lay owners; for example, a ranch of Rievaulx Abbey in Bilsdale was replaced by sixty-two small farms (Farra, 1961). Much land was obviously enclosed in the process and other enclosures were made direct from the moorland throughout the Medieval period and later. The eastern-central area particularly was never one of open-field agriculture; for instance, Goathland has no record of open-fields. By the latter eighteenth century, when land was enclosed by Act of Parliament, few areas on the North York Moors were affected.

The centuries between the Dissolution and the Industrial Revolution saw comparatively little change on the North York Moors. The pattern of settlement had been established by the early Middle Ages and in many cases went back to the Scandinavian colonisation or before. The high moors had always been an area of dispersed rather than nucleated settlement and of enclosed agriculture. The Limestone Hills to the south, by contrast, were a region of open-field agriculture until the mid-eighteenth century. Thus, the developments in agriculture of the eighteenth and nineteenth centuries which have sometimes been called the "Agrarian Revolution" had a far more pronounced effect upon the southern part of the area than they had on the high moors to the north.

From the writings of men such as Marshall (1788) and Tuke (1800), a fundamental contrast is apparent between the two areas. In the south, the Limestone Hills and the Vale of Pickering were characterised by large, newly enclosed fields with isolated farmhouses amongst them. Agricultural methods were relatively up to date and various improvements were in evidence. On the moors to the north, on the other hand, holdings were smaller and composed of small irregular fields won from the moorland at various periods; new buildings were uncommon and methods of farming were very conservative. Few attempts had been made to try out any of the improvements in agriculture, and consequently production was barely above subsistence level. Apart from fishing at several small villages on the coast (e.g. Robin Hood's Bay, Staithes) the only other economic activities of note were the mining of alum rock and the ship-building industry, both at Whitby. This port also enjoyed a short-lived prosperity in the late eighteenth/early nineteenth centuries when whaling became popular, and a maximum tonnage of 1181 tons of whale oil was exported in 1811 (Young, 1817).

The nineteenth century saw a change in the economy of the area, as improvements in transport led to increased contact with the outside world. The coming of the railways in particular gave a boost to agriculture and industry. Dodgson (1836) has described the effects of the opening of the Whitby and Pickering railway on the trade of Whitby. Another significant development was the growth of iron-mining, particularly in the Cleveland Hills but also at Grosmont in Eskdale, based on the exploitation of the ironstone series of the Middle Lias. This added to the landscape a number of new settlements, such as Esk Valley (822042), and led to the sudden expansion of others, such as Beck Hole (822022), where houses for 180 workmen were built and the remains of the slag heaps can still be seen near the old railway line. Further north, the landscape of much of the Cleveland Hills was altered by the addition of mining terraces and the scars of the iron-workings. Perhaps the most far-reaching change of the nineteenth century was the rapid growth of the industrial centre of Teesside. Middlesbrough docks were opened in 1842 and the growth of trade gradually led to the break-down of the traditional self-sufficiency of north-east Yorkshire. Teesside itself provided a nearby market for the agricultural products of the North York Moors.

The improvements in transport also opened up the area in another way, by making it accessible as an area for recreation. Whitby developed as a Georgian spa town and later as a major holiday resort in the Victorian era. Names such as George Street and Hudson Street in the Westcliff hotel and boarding-house area recall the connection between the tourist industry and the railways. Scarborough also developed further south, with railway connections to the west via the Vale of Pickering. Meanwhile, the high moors themselves were influenced by the growth of tourism, particularly the popular sport of grouse shooting. The effects of the management of the Moors for grouse on the vegetation cover have already been discussed (2.6).

Details of the present pattern of settlement and communications are discussed in the succeeding pages. The aim of this section has been to provide a summary of the main features of the human occupation of the area and to emphasise the most important periods of settlement and agriculture. This will provide a basis for the interpretation of the vegetation changes associated with Man's activities which will be revealed in the pollen diagrams.

3.2 Present-day settlement.

The evolution of the settlement pattern, as traced in the last chapter, has led to the existence of three major elements in the present distribution. Firstly, there are the coastal settlements to the north and east of the Moors. The lower, relatively fertile boulder-clay plateau supports a denser pattern of village settlement than is found in the interior of the region. Some of these villages have evolved as farming communities inland from the coast, e.g. Fylingthorpe (944050), Lythe (846130) and Cloughton (009945); others have grown up on the coast itself as fishing villages, e.g. Staithes (781183) and Robin Hood's Bay (951055). Many of the latter group have assumed a new role in recent years as centres for tourism. The picturesque groups of cottages nestling at the foot of the rocky cliffs have become local beauty spots - and bottle-necks. Guest-houses and restaurants have brought new, if seasonal, life to the coastal area, from Redcar and Whitby in the north to Scarborough in the south.

The second group of settlements comprises those on the inland margins of the area, including Teesside to the north, and the Vale of Pickering to the south. The effects of the recent growth of industry and population on Teesside have not been confined to the county borough itself. Many of the formerly small, agricultural villages in the Tees lowlands have become commuter villages for Teesside and have sprouted modern housing estates, e.g. Great Ayton (560110), Broughton (548062); and small market towns such as Guisborough (615160) and Stokesley (525085) have shared in this expansion. The links between these settlements and the North York Moors are becoming stronger, not only as more and more land is eaten away for building purposes in the north-west of the area, but also as the Moors serve as the natural "play area" for Teesside.

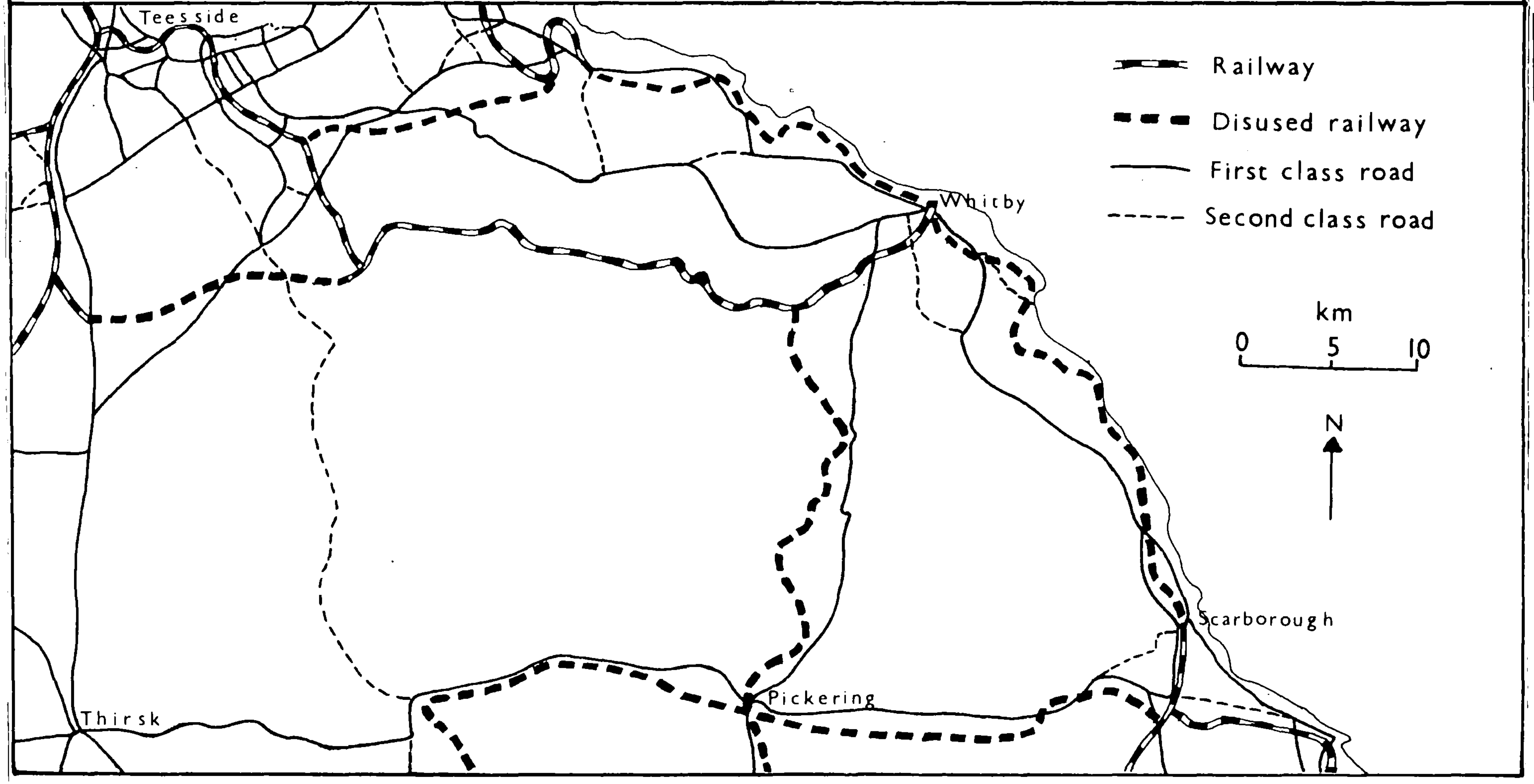
To the south, there has always been a close link between the settlements in the Vale of Pickering and those on the high moors, originally because much of the moorland, especially the Corallian outcrop, was used as rough grazing land for the settlements to the south. The series of agricultural villages, mostly of Anglian origin, on the northern margin of the Vale, between upland and lowland, has already been mentioned (3.1). Strip parishes associated with these settlements extended from the carrs or water-meadows of the Vale of Pickering across the rolling arable lands of the Corallian dip slope and on to the high moors beyond. Hence Levisham Moor, Lockton Low Moors, Allerston High Moor and Pickering Moor, all connected with settlements in the Vale of Pickering, cover parts of the eastern-central area of the North York Moors. As further proof of this strong relationship between the Vale and the Moors, Goathland was part of Pickering Parish until 1836.

The third group of settlements includes all settlements on the Moors themselves and in the Dales. Population is concentrated in Eskdale and in the dales running south from the main watershed. Nucleated settlements are few and small; within the eastern-central area, for instance, there are only two nucleations, Goathland village and the hamlet of Beck Hole, both in the valley of the Eller Beck. Eskdale contains several village settlements further north, e.g. Glaisdale (777053), Egton Bridge (805053) and Grosmont (829052). All these are small farming settlements, although one or two of them are becoming tourist attractions, such as Goathland, where the re-opening of the Whitby and Pickering railway by the North York Moors Railway Preservation Society is drawing many visitors in the summer. Apart from these villages, the only settlements in the moorland area are isolated farmsteads, usually in the valleys and generally below 183m (600'). Thus, large tracts of the central area are completely devoid of permanent population and have probably been so since Bronze Age times (vide supra, 3.1).

3.3 Communications.

The present pattern of communications is closely linked to the settlement pattern, and both are strongly influenced by relief. The only major roads skirt round the edges of the Moors, with major east-west routes running to the north of the Cleveland escarpment (A 171) and along the northern flank of the Vale of Pickering (A 170), joining up the series of villages mentioned in the last section. These link with north-south routes in the Vale of York to the west (A 19 and A 172) and along the coast in the east (A 171). The only major road to cross the moorland anticline is the A 169, which crosses the lower moors in the east and joins Pickering and Whitby. A second class road (B 1257) follows the valley of Bilsdale, which nearly cleaves the moorland in two in the west. Each dale has its own minor roads, some of which continue over the crest of the anticline and some of which end at the head of the dale, such as the road up Glaisdale, which stops short at 743028.

NORTH YORK MOORS — MAP TO SHOW MAJOR COMMUNICATIONS



Map 7.

Figure 18.

In the post-Beeching era, the roads are the only significant lines of communication in the area, but the railway network deserves mention as being of significance in the past and still a noticeable feature in the landscape. The area was one of the pioneering ones for railways, and the Whitby-Pickering line was opened as early as 1836. The original line was for horse-drawn coaches and included some quite steep gradients, such as the incline between Beck Hole and Goathland (823021 to 831017), which was 1 in 10, and up which coaches were pulled by a cable attached to a stationary engine (Joy, 1969; Potter, 1906). In 1865, this old line was abandoned and a new deviation line opened from Beck Hole to Goathland via Darnholm, joining up with the old line near the summit at Fen Bogs, (849985). The Whitby-Pickering line was later joined to an east-west line along the northern margin of the Vale of Pickering and the Esk valley line, which connected Whitby with Middlesbrough. Whitby was also linked to Scarb--orough by a line along the coast. The railways allowed Whitby to survive as a port at a time when its inaccessibility would otherwise have caused it to decline and it was a sad day for the town when the lines along the coast to Scarborough and to Pickering in the south were closed. The Vale of Pickering line suffered a similar fate, so that now only the Middlesbrough line remains open.

Smaller railways were important also, in connection with mineral workings, such as the line north along the coast to Sandsend, Hinderwell and Loftus from Whitby, and the line from Ingleby-Greenhow (581064) right along the crest of the watershed to Rosedale Head, (Hayes and Rutter, 1968). In their day, these railways played an essential role in the economic geography of the area; but today they serve as lines of communication only for the fell-walker and the industrial archaeologist.

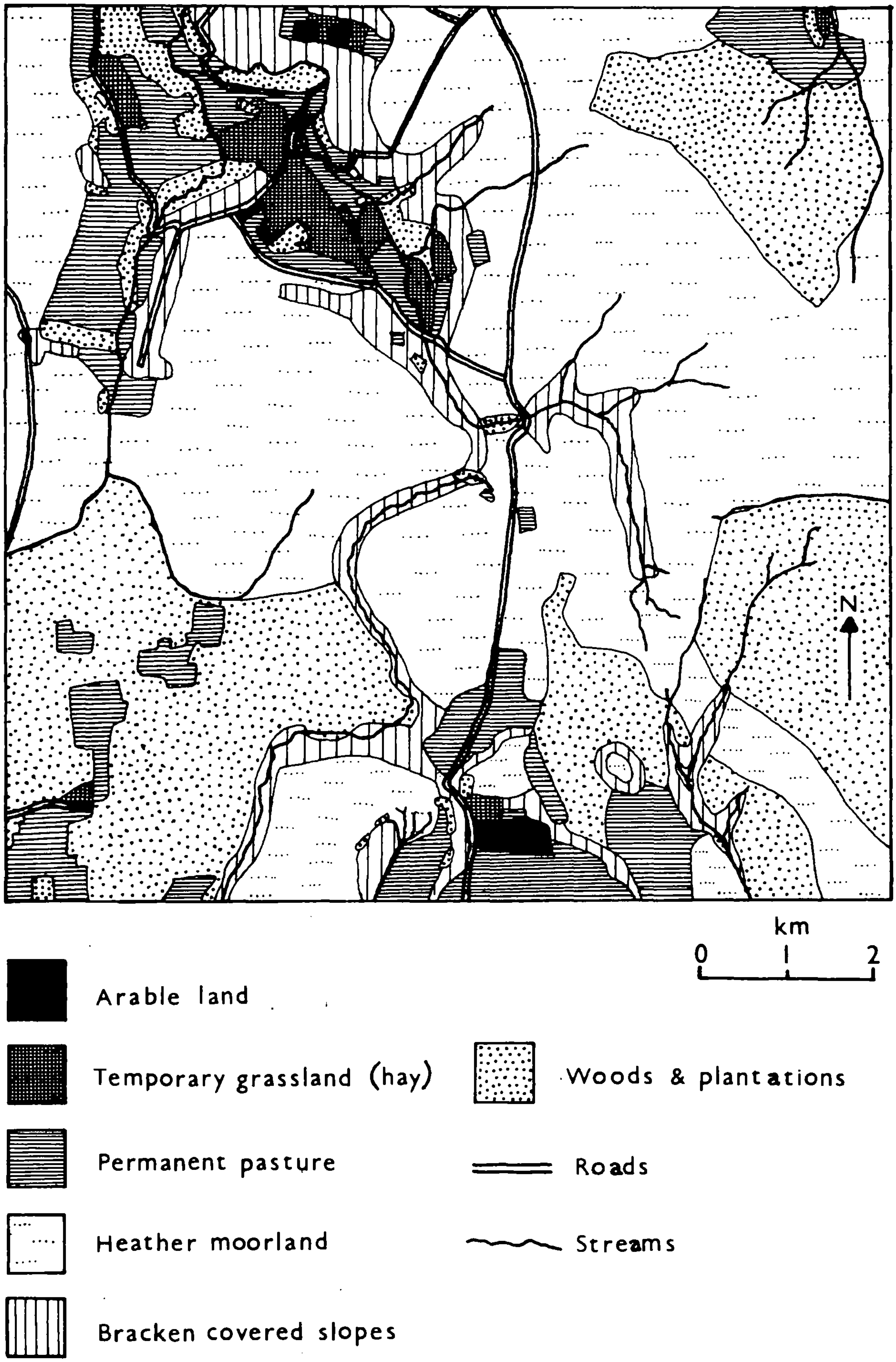
3.4 Land Use.

To conclude this introductory section, it will be appropriate to see how Man has responded to the varying physical conditions of the area by a survey of the different types of land use found at the present day. Four main categories of land use will be discussed: firstly, agriculture, both intensive and extensive; secondly, forestry; thirdly, recreation; and finally industrial and other minor uses of land.

Agriculture is by far the most important land use over the whole area of the North York Moors, but there are regional variations which deserve mention. Harwood Long (1969) has divided the area into three sub-regions for the purpose of discussion: firstly, the "Plateau Parishes", which comprise the area of the Corallian dip slope overlooking the Vale of Pickering; secondly, the "Dales Parishes" of the interior of the Moors; and thirdly the "Coastal Strip" on the boulder-clay plateau. The first and third groups are areas of mixed farming, with arable agriculture as an important element, whereas the "Dales Parishes" have a stronger emphasis on stock-raising.

The eastern-central area comes in the second region above, the "Dales Parishes". There is a clear distinction between intensive agriculture in the dales bottoms and the extensive grazings, often common, on the moorland. Traditionally this area was one of small,

LAND USE IN THE EASTERN-CENTRAL AREA IN 1971



self-contained holdings (vide supra, 3.1) and in many dales farms are still less than 100 acres and each farmer has "rights" over certain moorland grazings to augment his area for stock. Sheep farming was traditionally the chief occupation, with a little arable agriculture for subsistence on the enclosed lands in the dales.

Today, however, both arable agriculture and extensive moorland grazing are declining. There are several reasons for this, the most important of which is the rise of dairying, which, since the last war, has become the dominant activity in all the dales. Milk is exported to the industrial area of Teesside, to the seaside resorts of Whitby and Scarborough and to a food-producing firm in Driffield. This may be only a short-term trend, as several writers have noticed a slight shift in emphasis away from dairying towards beef cattle in the last few years (e.g. Long, 1969; Cowley,1972). This concentration on cattle led to an increase in barley and other fodder crops, but the cheap availability of ready-made cake has recently caused a decline in the acreage of arable in all the dales. Hay, by contrast, is becoming increasingly important and covers a large percentage of the enclosed land today, as is clearly seen on map 8 (figure 19) which shows the land use in the eastern-central area in 1971.

Sheep farming is far less lucrative than dairy or beef cattle, despite the annual subsidy of £1.50 per hill ewe, and about half the farmers in the "Dales Parishes" as a whole have relinquished their moor rights. The increasing hazards of motor traffic and accidental burning and the serious menace of bracken-poisoning (Emmerson, 1967) have added to the disadvantages of moorland grazing. There

Photograph 13. Land use on the Corallian dip-slope.

From 853939, looking SW.
Apart from the moorland on the right, most land is enclosed, much of it for arable cultivation. The field in the foreground had barley in it in 1971 (Map 8) but in 1972 has hay shelterin young trees of Pinus sylvestris.

Photograph 14. Newly reclaimed land on Wheeldale Moor.

From 805975, looking SE.
The land in the middle distance was ploughed up in 1972 and planted with grasses; an adjacent area was planted with root crops. In 1971 the area was Callunetum (Map 8), and vestiges of this remain beside the Roman road in the fore--ground. The surface sample No.19 was taken from a Sphagnum polster amongst this Callunetum.
In the back-ground, on the eastern side of Wheeldale Beck, are the northern-most plantations of Pickering Forest on Gale Hill Rigg.

are one or two of the larger sheep farms which are still profitable, such as the 3000 acres of Wheeldale and Goathland Moors which are grazed from Hunt House (815987) at a density of one sheep to three acres. However, the general trend in dales farming is towards larger units and increasing specialisation, and this specialisation is in most cases in dairy or beef cattle grazed intensively on lowland pastures.

The only contradictions to this trend away from the use of the high moors are the reclamation schemes in the south of the area. Near the Hole of Horcum, for instance, a Lincolnshire syndicate has reclaimed extensive tracts of moorland for arable agriculture (mainly cereals), part of which is seen in the foreground of Photograph 13. Such reclamation projects require considerable application of lime and fertilisers, but Anderson (1958) has demonstrated that good crops of grass, potatoes and autumn-sown rye and oats can be had up to 400m (1300'). Root crops are often chosen for the first crop, as, for example, on the area of Wheeldale Moor adjacent to the exposure of the Roman road (804976) which was ploughed for the first time in 1972. The profitability of such ventures may be a moot point in the long-run, while their desirability has been challenged by writers such as Cowley (1972).

The second major land use to be discussed is forestry. Most of the plantations on the Moors belong to the Forestry Commission, which started planting in 1921. Before this there were only about 10,000 acres of woodland, mostly on steeply sloping land in the Esk valley (Eyre, in Raistrick, 1966). The Forestry Commission plantations consist almost entirely of conifers, including the native Pinus sylvestris (Scots Pine) and introduced species such as Pinus contorta var. murrayana (Lodge-pole Pine), Picea abies (Norway Spruce), Picea sitchensis (Sitka Spruce), Pseudotsuga menziesii (Douglas Fir), Tsuga heterophylla (Western Hemlock), Larix decidua (European Larch) and Larix kaempferi (Japanese Larch). Vast areas of the Corallian outcrop in the south-east of the area are now covered by such trees, including Cropton, Staindale, Dalby, Bickley, Broxa and Wykeham Forests. The planted area is being extended further north on to the Kellaways Rock and Upper Deltaic beds in the eastern-central area, and Pickering Forest now extends north as far as Gale Hill Rigg (813968) and Wykeham Forest extends to High Woof Howe (894968), while Harwood Dale Forest in the east also extends on to the Upper Deltaics. In addition, the Forestry Commission had obtained the land on Lilla Rigg and Snod Hill which was purchased by compulsory order by the Ministry of Defence for Fylingdales early warning station, and when this land is returned to them it will be planted also, to join up with areas of Sneaton and Fylingdales High Moors which are now being planted. May Moss is surrounded by plantations to the west, south and east, and may well be drained and planted too when the M.O.D. land to its north is planted. It seems that towards the end of this century the whole of the eastern part of the Moors will be covered in forest, except for the boulder-clay areas near the coast and areas in the central part owned by the Duchy of Lancaster, such as Goathland Moor between Newton Dale and Wheeldale Beck, (the area on which Simon Howe Moss is situated).

Small patches of private woodland add to the acreage of forestry land, such as Brow House Wood, 13 acres of Picea sitchensis and Pinus mugo (Mountain Pine) planted in the 1920's, which covers the Gale Field site. Other small patches near Goathland include 45 acres at Crag Cliff Wood planted in between 1950 and 1962; 14 acres at Springwood planted in 1949, and 6 acres of deciduous woodland at Beck Hole Wood planted at the beginning of the century. These smaller woods cannot yield much profit to their owners, but the larger Forestry Commission plantations are now paying their way and also adding subst--antially to the employment in the area.

Many of the Forestry Commission plantations have a secondary function as recreational areas, and so come within the third major category of land use as well. Forest Trails have been organised at Newton Dale, Silpho, Sneverdale, Wykeham and Falling Foss; forest drives take visitors through the heart of Pickering and Dalby Forests; while a long-distance walk goes from Allerston (878826) to Reasty Hill (965945), passing through Dalby, Bickley and Langdale Forests. Outside the forests, other particularly well-known walks include the Lyke Wake Walk across the central watershed from Osmotherley (455972) to Ravenscar (980017), and the Cleveland Way, right along the coast. The proximity to Teesside makes the Moors a popular leisure area at weekends and most of it is within the National Park boundary. Recreation is becoming a large-scale land use over the whole area, including coast, moors and dales.

Apart from this general use of the whole area by the public at large, the most widespread recreational use is for grouse-shooting. This first became popular on a large scale in the nineteenth century after the railways opened up the area. Most of the high moors are managed as grouse moors and the rotational burning and Calluna monoculture described in 2.6 are largely the result of this type of land use. Sheep grazing is compatible with grouse-rearing and this dual-purpose use of the Callunetum for sheep and grouse accounts for the largest area of land on the North York Moors. This is seen clearly on map 8, for the eastern-central area, where moorland for grouse and sheep covers the biggest percentage of the area.

There are other smaller areas where recreation supersedes all other uses of land, notably the Nature Reserves owned by the Yorkshire Naturalists' Trust. Fen Bogs is one such reserve, while others include Hayburn Wyke (006971), Ellerburn Bank (853850), the Bride Stones (872905 and 865934), Hagg Wood Marsh (831893) and Little Beck Wood (879049). Farndale is a National Trust reserve, set up to preserve the wild daffodils along the banks of the River Dove.

The other uses of land on the Moors are confined to comparatively small areas. The M.O.D. area on which Fylingdales early warning station stands has already been mentioned. Mining was formerly important especially in Cleveland and near Grosmont, and the line of the Whinstone dyke is conspicuous across Sleights Moor and Sneaton High Moor by the line of old quarries along it. The only important modern mining activities are the recent potash exploits. Three companies have been involved in the search for potash, Cleveland Potash (ICI and Charter), Whitby Potash (Shell) and Yorkshire Potash (Rio Tinto Zinc), but so far only the first of these has sunk a mine, near Staithes. The iron works at Skinningrove on the coast (706196) are an outlier of the Teesside industrial complex which perhaps deserve mention, but industrial land uses are at a minimum in the area as a whole, and its designation as a National Park should ensure the maintenance of this position in the future.

Water resources may be an important future land use. Already there are reservoirs at Lock Wood Beck (670139), Scaling Dam (750128), Quarry Gate, near Osmotherley (465988), Oak Dale (470963) and Randay Mere (811019), as well as several smaller schemes, and Hull Corporation owns some land which it may use for water storage in the future. The recent proposal for a reservoir in Farndale hit the headlines, but the conservationists won for the time being. However, future conflicts between conservation and other land uses seem highly probable, as the area comes under the pressure of an ever-increasing population.

Fen Bogs, Newton Dale.

Photograph 15.

From 854978, looking SSW.

The main part of the valley mire is seen in the centre of the picture, with an isolated clump of Typha angustifolia in a wet hollow on an old track leading to the railway, 1.
2. The area dominated by Molinia to the west of the railway fence, with outliers of the carr vegetation along the drainage channels.
3. Surface sample No.9 was taken from the centre of the mire.

Photograph 16

From Northdale Scar (840975), E.

1. The drained pasture land to the south of Pickering Beck.
2. The small area of mire cut off to the west of the railway.
3. Reedswamp and carr vegetation beside the railway.
4. The slopes are covered with Pteridium and patches of deciduous woodland.
5. Fylingdales early warning station in background.

PART TWO. PRESENTATION OF DATA.

CHAPTER 4. SITE DETAILS.

The locations of the five sites studied are shown on map 2 (Figure 4). Each site will be described in turn in this chapter, and the physical features, the present vegetation and the field stratigraphy will be discussed.

4.1 Fen Bogs. 853977.

Fen Bogs is the deepest of the five sites and occupies a central position in the area under study. It is a valley mire, 1.5 km long and c. 200 m wide, occupying the watershed area at the head of Newton Dale at a height of 164m O.D. The site is owned by the Yorkshire Naturalists' Trust and managed by them as a Nature Reserve. Photographs 15 and 16 show the site from the north and south respectively, while map 9 shows the general features of the site.

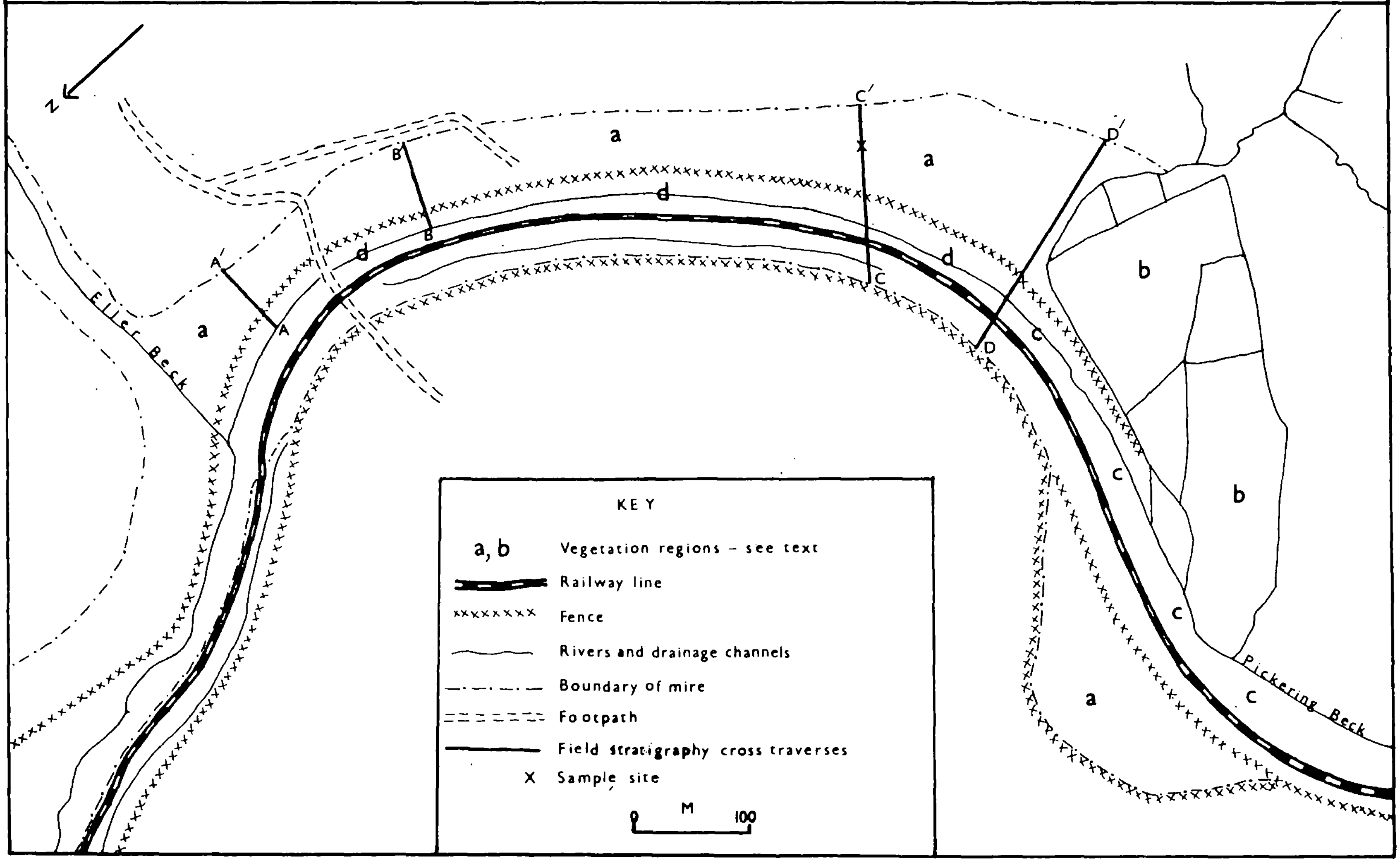
4.1.1 Physical features.

The formation of the glacial drainage channel of Newton Dale has already been discussed (vide supra, 2.3) and its relationship to other glacial features in the area can be seen on map 5 (Fig. 9). The northern boundary of the mire is formed by the Eller Beck valley, which flows westward as far as 852983 and then turns towards the north-north-west to join the Murk Esk and empty into the Eskdale drainage system. It has already been noted that the original course of the Eller Beck (and Sliving Sike and Little Eller Beck) was probably towards the south through what is now Newton Dale, and that sometime during the Tertiary, probably at the end of the Low Moor Surface stage, it was

Map 9.

Figure 22.

FEN BOGS — FEATURES OF THE SITE

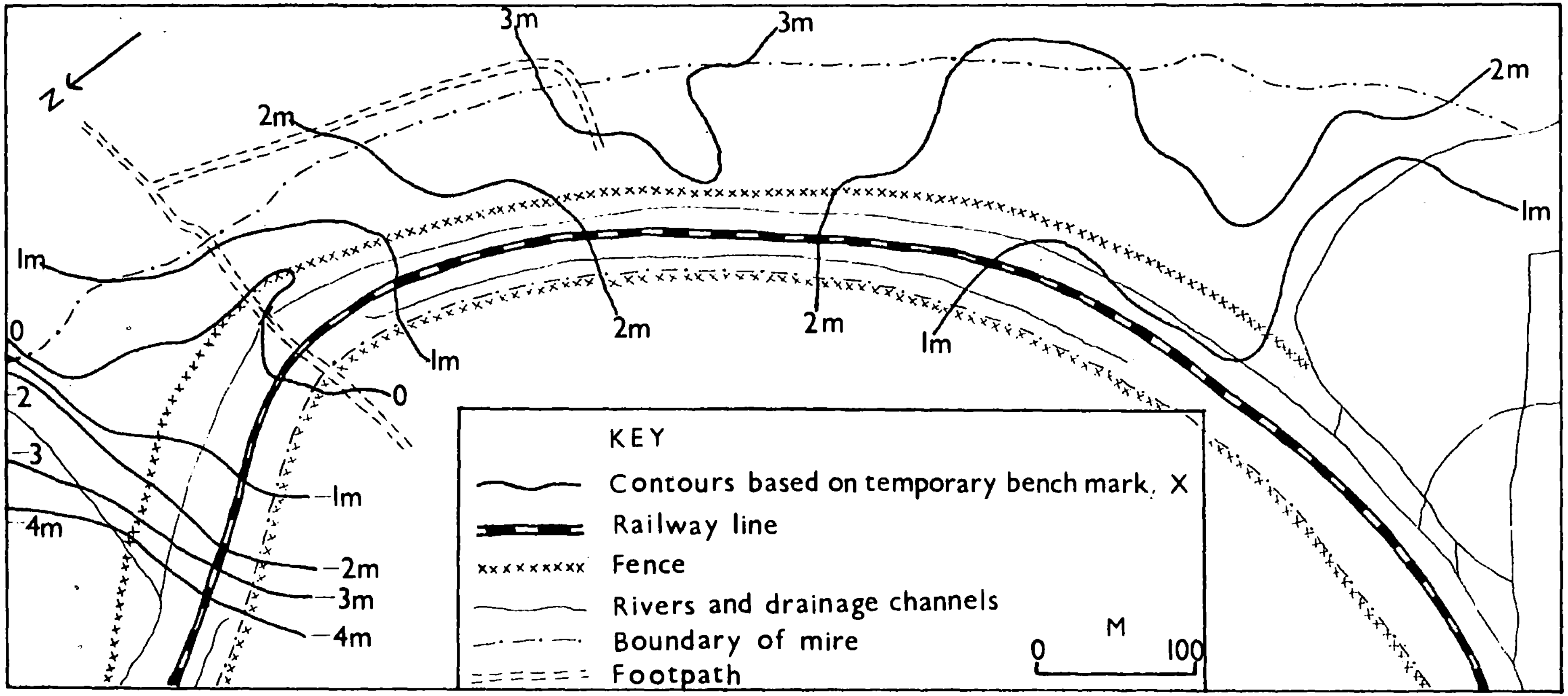


captured by the Murk Esk and its drainage diverted towards the north. (vide supra, 2.2). In the Pleistocene it was nearly recaptured by water flowing southwards down Newton Dale, and the Eller Beck is now only a few metres below the level of Newton Dale. The capture of the Eller Beck may have been prevented by the outcrop of the resistant band of Moor Grit, which forms a hard sill across the northern end of Newton Dale (map 4, figure 8).

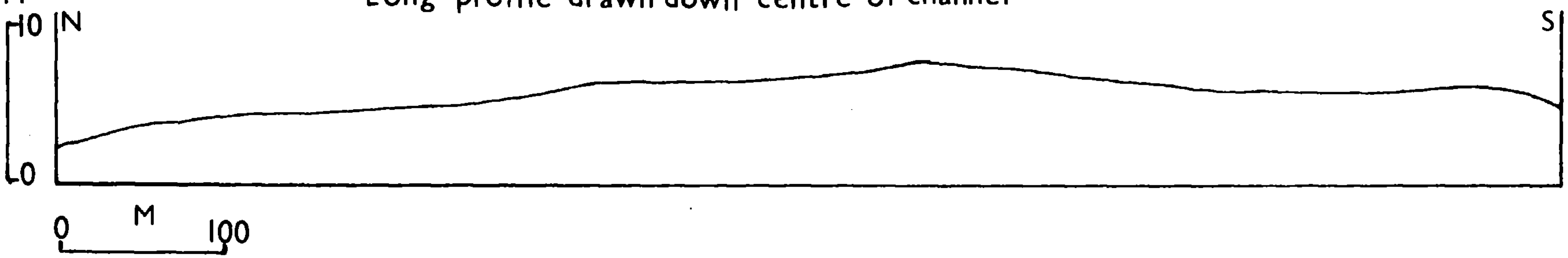
As can be seen from map 9, the main area of the mire is not drained by any stream at the present day, occupying the flat-floored area of the watershed between the Pickering Beck in the south and the Eller Beck in the north. The Pickering Beck seems to be aligned as if it once flowed northward as part of the Eller Beck system, for its upper portion flows north-westwards. However, on reaching Newton Dale (at 850974) it turns abruptly towards the west, aided by some artificial drainage channels, to flow through Newton Dale to join the Derwent drainage system in the Vale of Pickering. It would appear that the meltwater flowing down Newton Dale "captured" this upper part of the Eller Beck system but did not succeed in capturing the lower part, which still flowed towards the north. Had erosion proceeded a little further the original Tertiary line of drainage from Sliving Sike and Little Eller Beck through Newton Dale would probably have been re-established.

The "intake" of Newton Dale is thus at the southern edge of the Eller Beck valley, and there is a marked

FEN BOGS — SURFACE CONTOURS



Long profile drawn down centre of channel



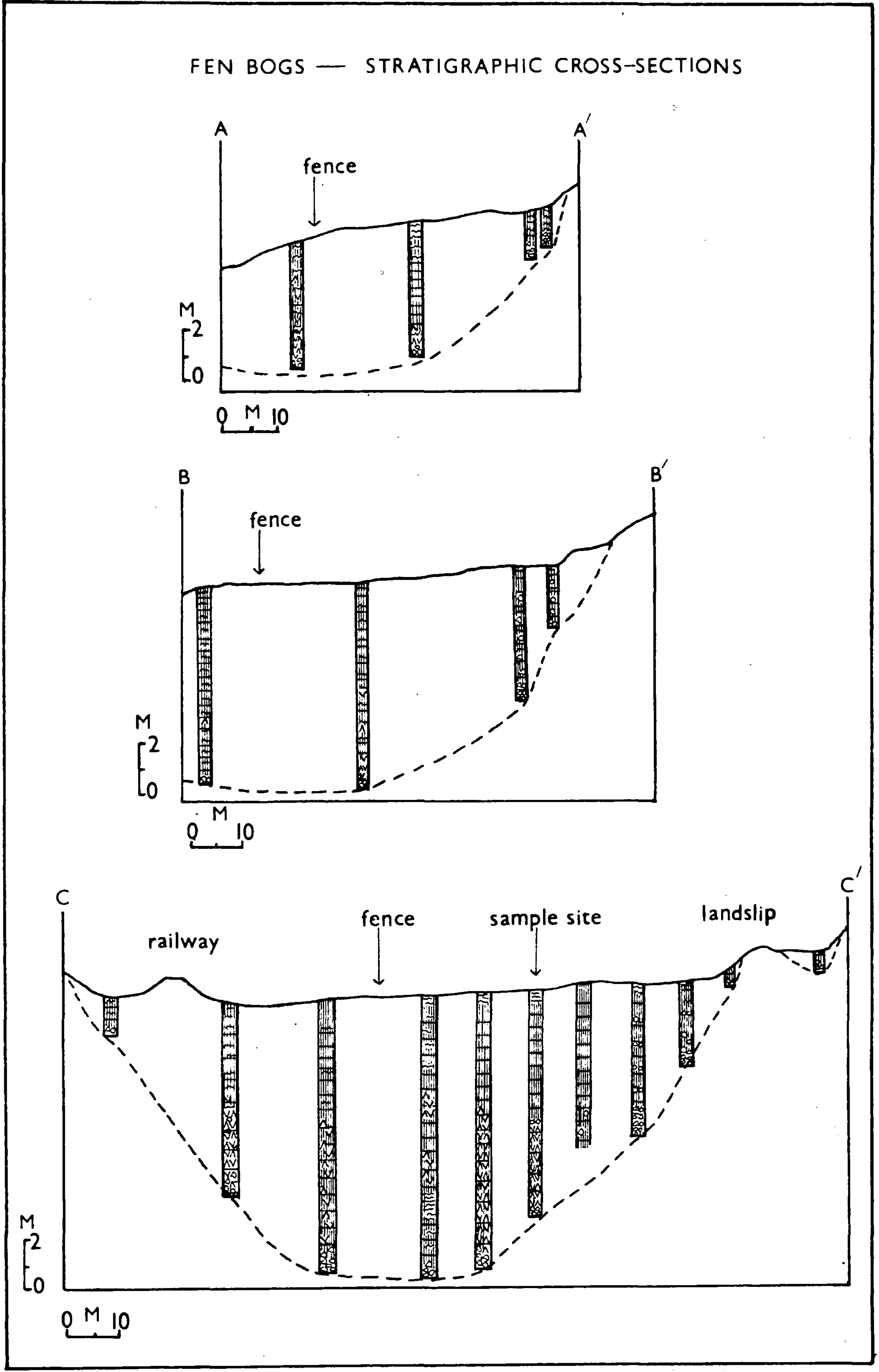
Map 10

Figure 23.

contrast between the cross-sections of the Eller Beck valley and Newton Dale. The former exhibits the features of a normal river valley and the latter bears the typical cross-section of a glacial drainage channel, with steep sides and a broad flat floor. Figure 25 shows the long profile of the upper part of Newton Dale at Fen Bogs and the surface contours of the site as compiled from a total of 92 readings and constructed from a base-line at a temporary bench mark at 853981. As can be seen, the surface of the channel today has a hump-backed profile rising from the intake towards the south and then falling again. This profile represents the surface of the peat and it is not clear whether this reflects an underlying hump profile in the rock itself (i.e. such as could have been formed by sub-glacial meltwater) or whether this simply reflects trends in the drainage at the present day in this watershed position. Gregory (1962b) assigned to Newton Dale a complex glacial history as a sub-glacial channel and later as a sub-aerial one. Because of the depth of the superficial deposits at Fen Bogs and the difficulty of engineering on a soft surface it has not proved possible so far to establish the shape of the long-profile of the underlying rock-cut channel.

Levelling along four cross transects revealed the cross-section of the channel, and the lines of these transects are indicated on map 9. As can be seen from the sections on figures 24 and 25, the surface of the mire is tilted gently towards the west with its lowest point just east of the line of the railway and not above the central

Figure 24.



FEN BOGS — STRATIGRAPHIC CROSS-SECTIONS
A
A'
fence
M
2
0
0 M 10
B
B'
fence
M
2
0
M
0 10
C
C'
railway
fence
sample site
landslip
M
2
0
0 M 10

part of the channel (or the deepest part, as indicated by the field stratigraphy borings). These surface contours are thought to relate to the drainage in connection with the railway. Channels are shown on map 9 and have drained the land to the west of the railway fence and produced obvious changes in the ecology. However, it is thought that this drainage (which must date from c. 1836 when the railway was opened) has affected a larger area of the mire, and some present day evidence for this is provided by observations made when the Lyke Wake Walk path crossing the mire in the north was drained in 1971. Ditches dug either side of the path carried water from as far as the eastern edge of the bog, where a drop in the water level was noted. Boatman (personal communication) believes that the lateral movement of water through the peat today is related to the drainage schemes associated with the railway.

Additional evidence for the effects of these drainage schemes is provided by the field stratigraphy, in which a change is noted within the top metre at all sites sampled from monocotyledonous peat rich in remains of *Phragmites communis*, to a more acid peat with more *Sphagnum* and no *Phragmites* remains. This would suggest a lowering of the water table and a change from topogenous to ombrogenous peat formation, such as could have been produced by artificial drainage.

4.1.2 Vegetation.

The present vegetation of the site can be divided into four major regions for purposes of discussion,

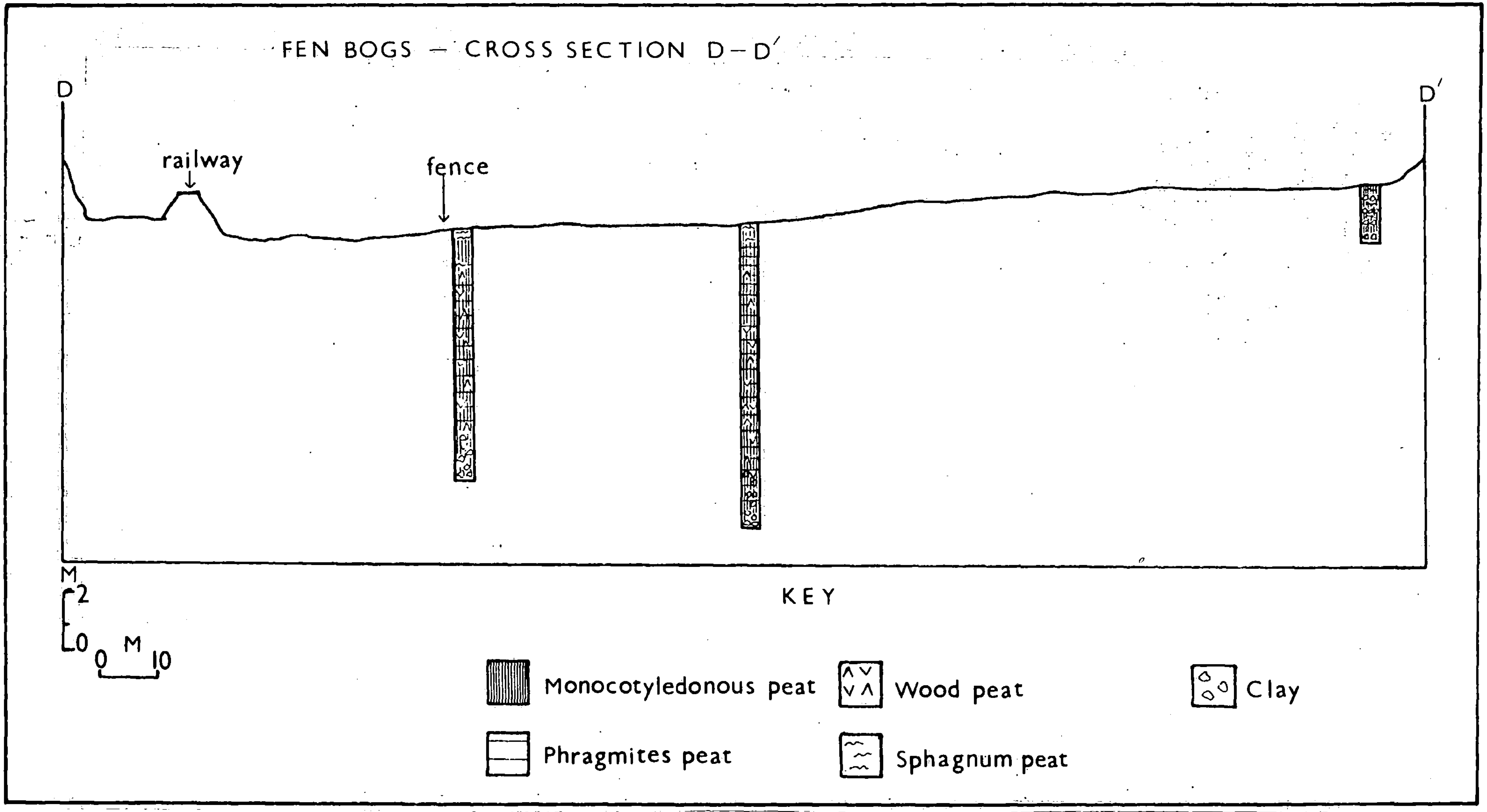

FEN BOGS — CROSS SECTION D–D′
D
D′
railway
fence
M
2
0
0 M 10
KEY
Monocotyledonous peat
Wood peat
Clay
Phragmites peat
Sphagnum peat

Figure 25.

and these regions are shown on map 9. The first region comprises the main part of the mire, i.e. to the east of the railway fence, to the south of Eller Beck and to the north of Pickering Beck. An outlier of this region lies to the west of the railway in the southern part of the area, as can be seen on photograph 16. Boatman (1972) has distinguished four major communities within this region, viz;-

1) A general community which covers the greater part of the area and of which Molinia caerulea, Myrica gale, Eriophorum angustifolium and Calluna vulgaris form the major components.

2) A community occupying the drier situations where Calluna vulgaris is dominant.

3) A community with Carex rostrata as its most conspicuous component. Free water occurs in this community throughout most of the year.

4) The community of the "soaks" - channels with free water.. Potamogeton polygonifolius is characteristic of this community and mosses characteristic of more nutrient-rich peats such as Scorpidium scorpioides and Drepanocladus revolvens also occur.

The most important factors in the distribution of these communities seem to be the amount of free water present and the acidity. Boatman writes:

> "The least acid and most nutrient-rich conditions occur in the soaks and open water areas (communities 4 and 3) where the pH is in the range 5.3 to 6.0. Along the edges of Community 3 particularly, carpets of bog mosses, especially Sphagnum papillosum can be found. The water in these carpets is much more acid with a pH of about 4.0. The water saturating the peat of Community 1 appears to be intermediate with a pH in the range 4.9 to 5.4 but where Sphagnum papillosum is an important constituent of this community, as at the northern end of the reserve, the pH is much lower (3.9 to 4.1)."
>
> (Boatman, 1972)

Thus the main part of the site is seen to be an acid mire forming a generally oligotrophic habitat, but with more eutrophic areas within it characterised by a

Photograph 17. Reedswamp vegetation at Fen Bogs.

From 850975, looking E

1. In the foreground, a dense stand of Phragmites communis colonises the area to the west of the railway fence.
2. Part of the main area of the mire (vegetation region "a").
3. Reclaimed pasture land of region "b."
4. The eastern slope is covered with Pteridium and Calluna.

Photograph 18. The southern end of the Fen Bogs site.

From 853975, looking WSW.

1. In the foreground, one of the mineral-rich soaks winds its way out over the main part of the mire (region "a").
2. Reclaimed pasture land to south of Pickering Beck ("b").
3. Carr-reedswamp vegetation forming region "c".
4. Molinia dominates region "d", to the west of the railway fence.
5. The western slope of Newton Dale in the distance shows evidence of slumping.

richer and more varied flora.

The second major area is that to the south of Pickering Beck (area b on map 9). Here the land has been drained and the ground is drier with no true bog plants. The area is dominated by Molinia caerulea with species such as Potentilla erecta, Ranunculaceae, Chenopodiaceae, and Rumex spp. It is crossed by a network of drainage channels, lined with Juncus spp. Both this area and the first one (the mire proper) are grazed by sheep. At the foot of the southern slope of the site a few Betula, Quercus and Alnus trees grow, while the slopes themselves are clothed with Pteridium aquilinum with an understorey of Calluna vulgaris and Vaccinium myrtillus.

The third major region is at the southern end of the site, where a dense stand of Phragmites communis forms one of the finest reed beds in Yorkshire (illustrated in photograph 17). Other plants include Typha angustifolia, Schoenus nigricans and Rhynchospora alba. Salix, Alnus and Betula form a carr vegetation fringing the reedswamp. The water table in this region is much higher than in the previous two and is maintained by the flow of drainage water from regions b and d. This drainage water is rich in mineral nutrients, which may explain the concentration of the Phragmites in this particular area, as Green and Pearson (1968) have noted that reedswamp communities in Cheshire are supported by more base-rich waters than are the Sphagnum areas.

The fourth region (d) lies to the west of the railway fence. Here Molinia caerulea is dominant, forming great tussocks, almost to the exclusion of other species.

This area is drained by channels on either side of the railway line, and remnants of the carr-reedswamp vegetation of region c straggle along these drainage channels. The region was burned regularly when the railway line was in use and this burning was probably responsible for the dominance of the Molinia. The sharp change in vegetation at the railway fence emphasises the artificiality of the boundary between this region and the mire proper. Like regions a and b, the area within the railway fence is grazed by sheep now that the railway line is closed. On the western side of the railway there is a narrow strip of mire similar to region a, beyond the western railway fence.

To examine the vegetation in more detail a belt transect one metre wide was taken across the mire from east to west along the line of cross-transect C (Fig. 21). 167 quadrats of 1 metre square were examined along this line and records were made for a total of 26 plant species. A product moment correlation coefficient was found for each pair of adjacent quadrats with the aid of a computer. From these statistics a cluster diagram was constructed, as shown in Appendix III, where the results are described in detail. The most marked changes (i.e. the lowest correlation coefficients) were found to occur on either side of the railway embankment, which is as we might expect, but the drainage ditches on the railway land are also seen to produce significant changes in vegetation. The junction between the mire and the drier slopes of the channel sides is seen clearly, but the change is more marked on the eastern side (r=0.4364) than on the west (r=0.7238). The wetter pool at the foot of the eastern slope appears to form a sub-region of the main part of the mire. This part receives the water from one or two of the soaks draining the slope, emphasising once again the importance of drainage and acidity in determining the vegetation.

Other significant factors in the distribution of the vegetation include the landslip on the eastern side of the mire, where the better drainage on the slightly higher ground produces a patch of almost pure Calluna, and the fence between the railway land and the mire proper, where both drainage and burning are important. More subtle changes are also highlighted in the figures, however, such as the patch of land on the western side of the railway where Scirpus caespitosus is locally important, and the drier part of the main mire dominated by Calluna, Myrica and Vaccinium oxicoccus as opposed to the slightly wetter part where Eriophorum and Sphagnum spp are dominant. Sometimes the boundary between these vegetation sub-regions is sharp, occurring in one quadrat, as between quadrats 5 and 6, and sometimes the change is more gradual and results in a run of low correlation coefficients, as across quadrats 97 to 100. (Appendix III).

The most significant changes in vegetation disting--uished by the computer agree well with those observed in the field; but a statistical measure of their significance has been obtained and also the computer has highlighted other more subtle changes which were not immediately apparent , but which on closer examination were seen to be significant. It is thought that this method compares well with others (usually more complex) used, for example, by

Dale and Walker (1970) or by Williams, Lance and Lambert (1966).

4.1.3 Field stratigraphy.

The superficial deposits were examined by a series of borings along the four transects across the mire shown on figures 21 and 22. The borings showed that the channel had a relatively flat floor, with its deepest part slightly west of centre, near the line of the railway fence. The deepest peat was found in transects C and D, reaching a maximum depth of 11.8m (38'). Below the peat at all sites was a deposit of whitish-grey clay, becoming bluer and stiffer after about a metre and impenetrable to a hand borer below this depth. Thus it was not possible to reach rock bottom at any of the sites and the broken line on the cross-sections represents the boundary between the peat and the clay and not the true base of the channel. The depth of this clay is unknown, but Kendall (1902) quotes a statement from a railwayman that when the railway was being built piles were driven in to a maximum depth of 60' (18m). Kendall interpreted this as the maximum depth of the peat, but the cross-sections prove this to be wrong. It may be a simple case of exaggeration on the part of the railwayman, but it is also possible that the figure of 60' represents the total depth of the superficial deposits, i.e. peat and clay, as with mechanical equipment the transition from peat to clay might not have been noticed. If this is so, it indicates a maximum depth of 6.2m for the clay.

The clay was found to be unstratified and to contain angular fragments of sandstone similar to that of the Deltaic Beds surrounding the site. It is very similar to the clay described by Gregory (1962a) from other sites and interpreted by him as a solifluction deposit. It was probably laid down in the severer periglacial climate of Late-glacial times, following the cessation of meltwater in the channel and preceeding the growth of the peat (the lowest peat has been dated by pollen analysis to the early Post-glacial period). One can envisage landslips on the sides of the channel and material slumping down and being washed out into the centre of the channel. The slopes of Newton Dale show much evidence of slumping, as can be seen in photograph 18 (Fig. 26). Some of these features may date back to Late-glacial times, but it has not been possible to date them. Similar features have been described from elsewhere on the Moors by Gregory (1962a) and generally assigned to the Late-glacial. A peat deposit has developed in the hollow behind a small landslip on traverse C, and samples from the base of the peat were examined by pollen analysis, but the peat appeared to be fairly recent and did not shed any light on the date of the landslip.

Other evidence of the instability of the slopes at the sides of the channel is provided by the inwash stripes which were encountered in several of the field stratigraphy profiles. These varied in their mineral content from almost pure clay to peaty horizons with some inorganic content. They were more common in the profiles close to the edge of the mire and died out towards the centre, suggesting that the mineral matter was derived from the sides of the channel. Today the small rivulets or "soaks" referred to above (4.1.2) flow down the eastern side of the channel and meander across the mire surface. These soaks are enriched with iron and carry mineral matter down from places where the bare soil has been exposed. At times of increased run-off a considerable amount of mineral material finds its way on to the mire surface, especially the finer particles of clay size. The soaks change course frequently and only affect a small area of the mire surface at a time. Therefore the mineral material deposited by them is very localised. It is envisaged that the inwash stripes observed in the profiles were formed in much the same way at various periods in the past. If so there is no reason to expect that an inwash stripe will be picked up on more than one profile in any transect, and consequently no attempt has been made in the field stratigraphy diagrams to join up the mineral horizons on adjacent profiles.

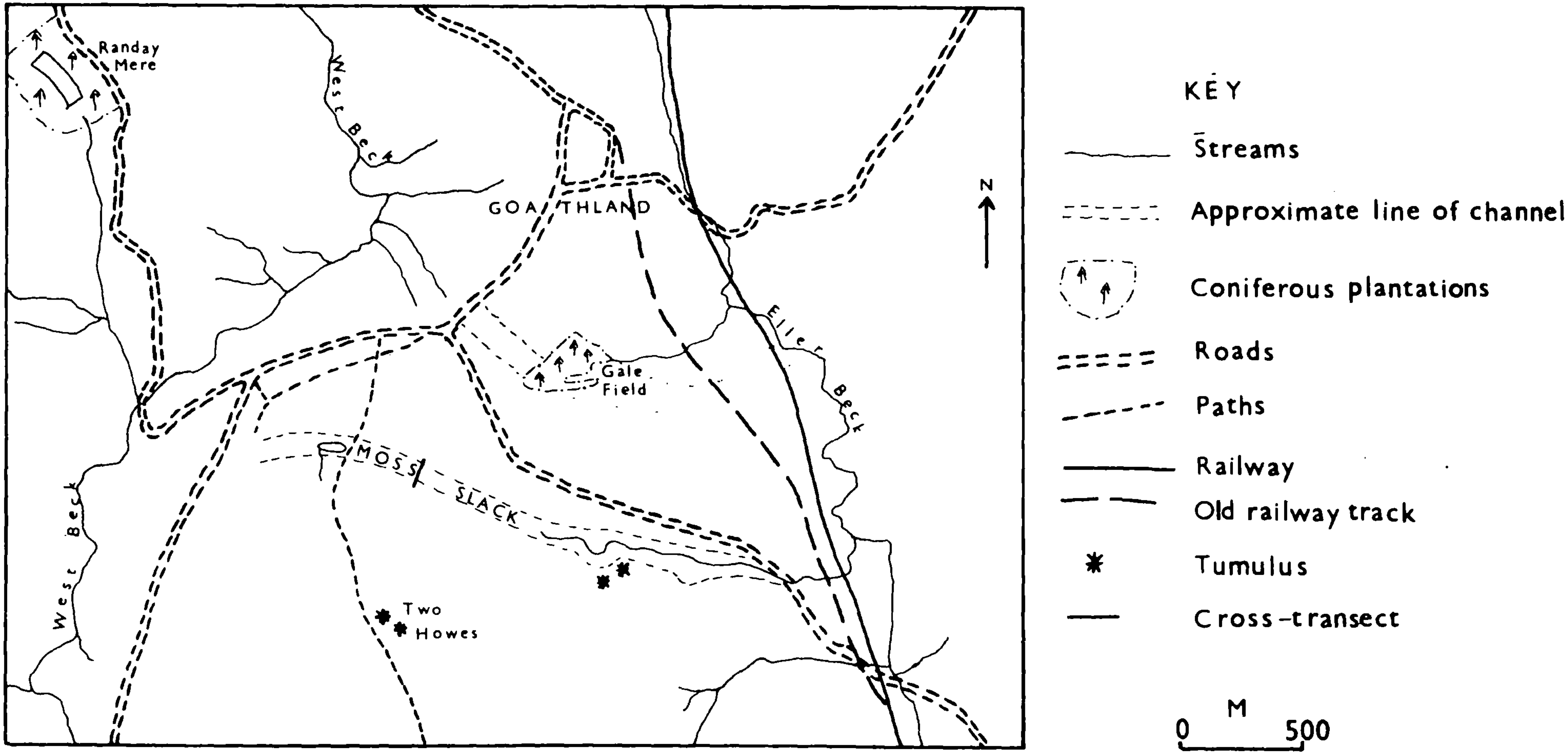
Similarly with the other stratigraphical changes in the peat, no attempt has been made to join up specific horizons as in most conventional stratigraphy diagrams (e.g. Faegri and Iversen, 1964). It was felt that the stratigraphic changes noted were not fundamental enough to be treated in this way. Such features as Sphagnum bands, while they may in some cases represent large-scale extensions of particular vegetation types, may in others be merely local features. The vegetation on the surface of the mire today displays a mosaic of patches of Sphagnum and other plants, and it is suggested that the field stratigraphy profiles record similar variations in the past, which are of no major significance.

The bulk of the peat in all profiles examined was a red-brown fibrous deposit with abundant monocotyled--onous remains, especially those of Phragmites communis. Occasional seeds of Menyanthes and Potamogeton were found and others which could only be identified as Cyperaceae. The type of community suggested by this peat is a reedswamp with grasses and sedges, i.e. one closer to the vegetation found at the southern end of the site today than to the present vegetation of the main part of the mire. It would appear that this reedswamp vegetation was formerly much more widespread, covering most of the site. Its restriction to the southern end today is probably related to the drainage schemes and the corresponding change in stratigraphy within the top metre of peat has already been mentioned.

The monocotyledonous peat continues to the base of most profiles, i.e. to the junction with the underlying clay, but in the lower parts wood remains are frequent. The upper limit of the woody peat is not found at a constant depth across the transects and no attempt has been made to join up this change in stratigraphy between profiles. Again, the occurrence of trees on the mire surface was probably a localised phenomenon relating to the distribution of drier hummocks. The relationship between woody peat and the inwash stripes is interesting. It will be seen from the diagrams that, excluding mineral layers at the bases of some profiles, all the stripes were found above the woody peat, suggesting an inverse correlation between the tree cover and run-off or soil erosion. The only point at which an inwash stripe can be dated is in the profile used for pollen analysis. Here there was only one inwash stripe at a depth of nearly 6m. Beneath this stripe the peat contained many wood remains (mostly Betula, but also Alnus and Salix), but above the stripe there was virtually no wood. From pollen analysis the stripe is known to lie just above the Ulmus decline, for which a radio-carbon date was obtained of 4720± 90 BP. This would suggest that the erosion indicated by the inwash stripe occurred within the period when Man is known to have been present in the area. It is tempting to postulate shifting agriculturalists clearing patches of woodland and exposing the soil to erosion. However, the evidence will not allow such a definite interpretation. One can only say that in the period after the tree cover in the immediate vicinity of the site had disappeared, there was a period when erosion caused mineral material from the sides of the channel to be washed down on to the surface of the mire, and that this occurred sometime during the Neolithic period.

The picture given by the field stratigraphy can be summarised briefly as follows. After the deposition, probably in the Late-glacial period, of a solifluction deposit, possibly to a depth of some six metres, Post-glacial peat began to accumulate in the waterlogged bottom of the channel at the watershed. The vegetation which formed this peat was a carr-reedswamp vegetation, with Betula, Salix and Alnus growing on drier ground amidst the Phragmites. After the beginning of the Neolithic cultural period, the trees on the mire began to die out, leaving the reedswamp with grasses and sedges. The reduction of woody vegetation caused instability on the slopes surrounding the mire, so that in periods of heavy rainfall mineral material was washed down from the sides and carried out on to the mire

THE MOSS SLACK AND GALE FIELD SITES.



Map 11.

Figure 27.

by soaks draining the slopes. Within the last 150 years, drainage schemes have lowered the water table and changed the mire from a topogenous to an ombrogenous one. This change has resulted in the extension of Sphagnum spp and the establishment of a more acid-tolerant flora on the main part of the mire, while the reedswamp community has become confined to the wetter and more base-rich environment of the drainage channels at the southern end of the mire.

4.2 Moss Slack, Goathland. 830000.

4.2.1 Physical features.

The second site, Moss Slack, Goathland, is also situated in a glacial drainage channel (Map 11). It has been described in 2.3 as a marginal channel, which carried water from Lake Wheeldale towards Newton Dale. Its intake, at 821001, forms a well-marked channel in the hillside at a height of c. 183m O.D. The floor of the channel rises from here towards the north-east for some 300m, where the highest point is 3m above the intake. A small reservoir has been created in this section of the channel with a turf wall at its western end. The channel is crossed at its highest and driest point by a trackway which descends from Simon Howe and Two Howes Rigg to Goathland village. According to Sewell (1923), this trackway is of some antiquity, dating back at least to the Medieval period.

From the trackway (824002) the channel turns south-east and falls towards its outfall at 842997, from which the stream draining it (Moss Dyke) descends steeply into the Eller Beck valley at 844997. The Eller Beck valley between here and the intake of Newton Dale is fairly broad

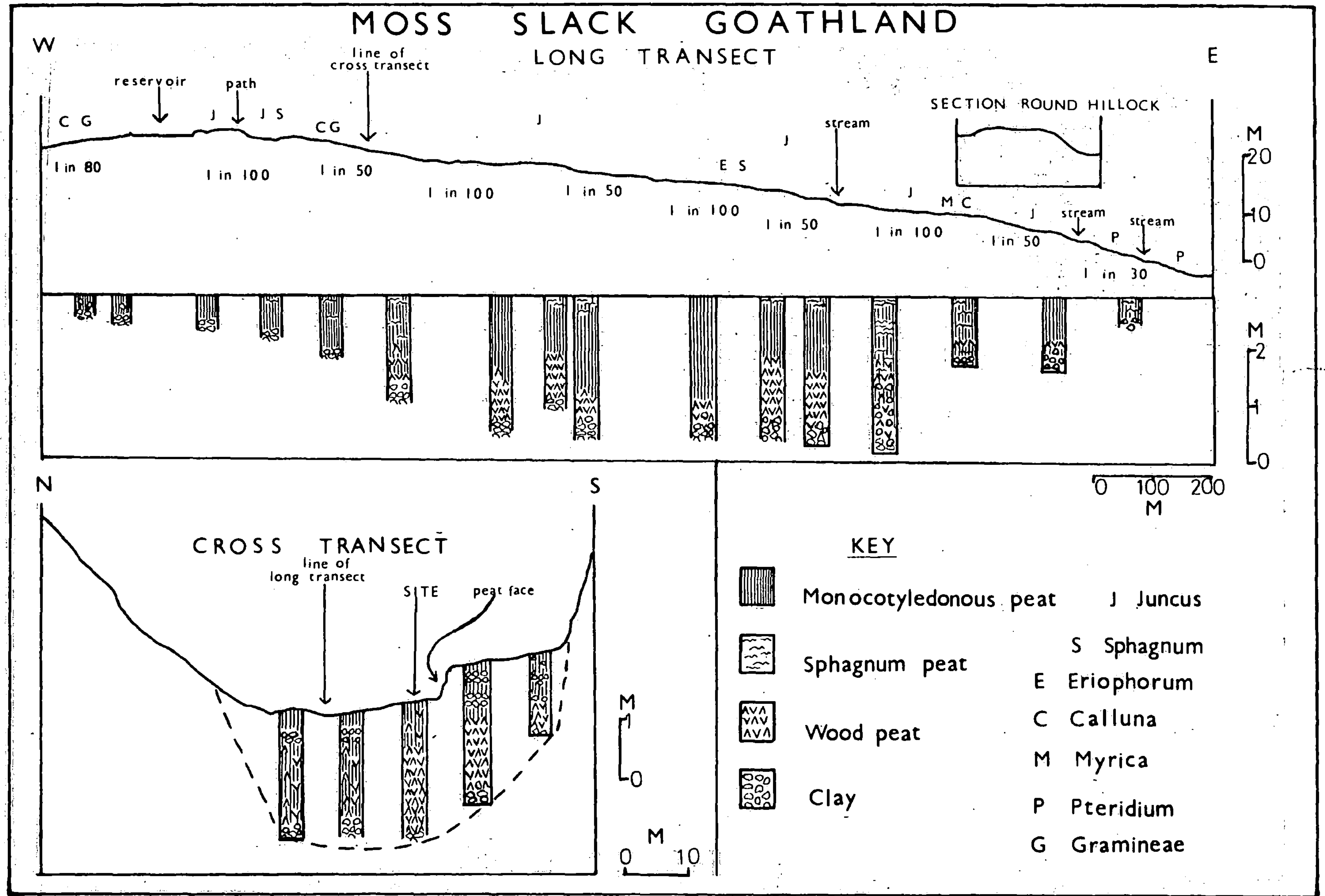

MOSS SLACK GOATHLAND
LONG TRANSECT
W
E
reservoir
path
line of cross transect
SECTION ROUND HILLOCK
stream
C G
J
J S
C G
E S
M C
P
1 in 80
1 in 100
1 in 50
1 in 100
1 in 50
1 in 100
1 in 50
1 in 100
1 in 50
1 in 30
M
20
10
0
M
2
1
0
0 100 200
M
N
S
CROSS TRANSECT
line of long transect
SITE
peat face
M
1
0
0 M 10
KEY
Monocotyledonous peat
Sphagnum peat
Wood peat
Clay
J Juncus
S Sphagnum
E Eriophorum
C Calluna
M Myrica
P Pteridium
G Gramineae

Figure 28.

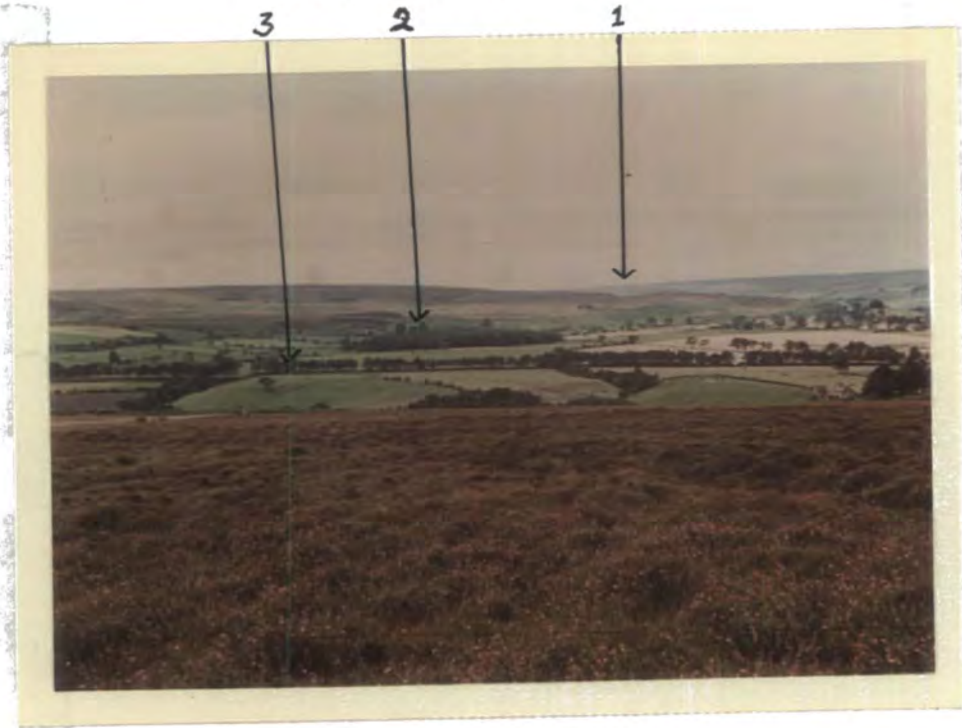
and steep-sided and has peat deposits in places on its flood-plain. Most of the drainage water from Moss Slack must have flowed along this section of the valley towards Newton Dale, but the greater width of Newton Dale at its intake and the more pronounced trough-shape of its cross-section suggest that at least some of the water flowed over or through the ice as far as Fen Bogs. This would require a lobe of ice projecting further south-east than was envisaged by Gregory (1965). A bench seems to continue along the hillside between the outfall of Moss Slack and the northern end of Fen Bogs, which might support the idea of a lobe of ice projecting to the south-east with drainage between the side of the hill and the ice.

The long profile of Moss Slack is illustrated on figure 28. The channel is incised round the spur of the hillside, forming a conspicuous notch in the skyline, (photograph 19). From its highest point it falls towards its outfall at an average surface gradient[1] of 1 in 68; but this generalised slope is made up of four relatively level areas (gradient 1 in 100 or less) separated by four steeper slopes (gradient 1 in 50), and ending in a slope of 1 in 30 immediately west of the outfall. Gregory (1962a) has noted this stepped effect in the long profile and gives his own sections to illustrate it. He notes two main flattenings of the long profile, which he links with various stages in the deglaciation of the area to the north.

1 The gradients refer to the surface of the superficial deposits and not to the rock floor, which it was not possible to reach on every boring with hand equipment.

Figure 29.

Photograph 19. The situation of the Moss Slack Goathland and Gale Field sites.



From 852028, looking SW.

The marginal drainage channel of Moss Slack is incised round the spur of Two Howes Rigg and appears as a notch in the skyline at the western end (1).

2. The Gale Field plantation.
3. The line of trees in the middle distance picks out the old course of the first railway line.

Photograph 20. Moss Slack Goathland.

From 828000, looking SE.

1. The steeper southern slope of the channel is covered with Pteridium, while the gentler northern one supports Callunetum (2).
3. The vegetation of the channel floor is a mosaic of drier patches dominated by Calluna and wetter areas dominated by Juncus spp..

Two subsidiary channels are cut round projecting spurs in the channel side, detaching small hillocks between themselves and the main channel. The long section round one of these is shown on figure 28 above the part of the main channel which it adjoins. The distinct hump-profile of this subsidiary channel is obvious at once. The features are difficult to explain in terms of marginal drainage. Kendall (1902) postulated a readvance of the ice blocking the main channel and causing the drainage water to cut a new one higher up the hillside which was abandoned when the old course was free of ice again. He called such features "in-and-out" channels. At other sites they have sometimes been explained as channels superimposed from streams flowing through the ice. In this case hydrostatic pressure might explain the hump-profiles.

The eastern part of the channel is drained by Moss Dyke, which follows an eccentric course around the subsidiary channel to the south of one of the hillocks mentioned above. Towards the eastern end of the channel it is incised into the floor of the channel forming a V-shaped notch in the flat floor, as is shown in Gregory's cross-sections. Gregory attributes this to Post-glacial erosion and there is no reason to postulate a Pre-glacial stream here.

4.2.2 Vegetation.

The surface vegetation of Moss Slack seems to be related chiefly to the drainage characteristics. The sides of the channel are better drained than its floor and carry only a thin cover of peat. The northern slope is covered by Callunetum and exhibits a patchwork of areas at different stages of subseral development after burning. The southern slope is steeper and clothed in Pteridium which gives way to Callunetum higher up towards Two Howes Rigg. The drier patches on the channel floor are dominated by Calluna vulgaris and Nardus stricta with Myrica gale and Erica tetralix, while other common species include Potentilla erecta and Polytrichum commune. This community colonises the areas of steeper gradient, as can be seen from the long section.

The flatter sections tend to be less well drained and are colonised by a community dominated by Juncus spp, Eriophorum angustifolium, and Sphagnum spp. The peat in some parts has been cut and the resulting depressions have filled with water and support open-water communities dominated by floating carpets of Sphagna. Thus the vegetation pattern of Moss Slack is a mosaic of communities adapted to poorly drained and better drained conditions, some of which may be seen in photograph 20.

4.2.3 Field stratigraphy.

A series of borings was made down the long profile in the centre of the channel to examine the stratigraphy. The profiles are illustrated on the long section at a larger scale, below the relevant points. The deepest peat encountered was 2.6m, at the sample site. In the middle section of the channel the peat was over two metres deep. Further west it thinned out to less than a metre at the intake of the channel. Similarly towards the outfall the peat thinned out to half a metre of less. In general the peat was deeper below the flatter sections of the channel and shallower where the gradient was steeper (see Fig. 28).

Beneath the peat at all sites whitish-grey clay was found, similar to that at Fen Bogs. This clay was also described by Gregory (1962a) and thought to be a solifluction deposit derived from the surrounding hillsides in the Late-glacial period. The cross-section of the channel is illustrated in Fig. 28. As can be seen from the section, the channel seems to be asymmetrical, with the deepest peat slightly north of centre. This asymmetry is seen in the cross-section of the exposed channel sides, the southern side being steeper than the northern one, and it is a result of the position of the channel around the spur of the hillside, cut along the line of the contours. The channel appears to have a flat bottom and fairly steep sides.. The borer hit the rock bottom at several sites, although at others the solifluction clay proved impenetrable. The depth of this clay was usually found to be less than 0.5m, although at one or two sites it was deeper, reaching a maximum depth of 0.8m.

Above the clay, a deposit of wood peat was found at most sites, mainly consisting of Betula remains. At some sites the wood remains were only detrital and were embedded in a matrix of clay - presumably twigs and other debris which fell into the channel from trees growing nearby while the solifluction deposit was accumulating. At others, massive chunks of wood and actual sections of tree trunk were encountered and the trees were obviously growing in the channel itself.

The wood peat begins to die out upwards between 1.8 and 0.8m and gives way to monocotyledonous peat with abundant *Eriophorum* fibres and occasional bands of *Sphagnum*, especially near the surface. The vegetation of which this peat was composed seemed to be similar to that growing on the site at the present day. At some sites, especially near the eastern end, the peat contained a certain amount of inorganic matter of a silty nature, containing reworked lumps of peat. This silty material may have been deposited by the stream draining the lower part of the channel.

A feature of the top half metre of some profiles was the occurrence of clay stripes, in some cases several centimetres deep, alternating with the peat. These clay stripes seem to be similar in composition to the clay underneath the peat and were presumably formed in a similar manner, i.e. by downwash of mineral material from the sides of the channel. Again, as at Fen Bogs, the clay stripes are found only after the wood remains have died out in the peat, and have been interpreted as indicating soil erosion in times of increased run-off and decreased vegetation cover on the sides of the channel.

The sequence of events indicated by the field stratigraphy can be summarised as follows. After drainage water had ceased to flow through the channel, a solifluction deposit of greyish-white clay was washed into the centre of the channel from the surrounding hillslopes. At some time after this, forest cover spread in the area and the channel was colonised by *Betula* woodland, probably forming a closed canopy over the site. Later this woodland began to die out and a vegetation similar to that of the present day took its place, consisting mainly of grasses and sedges, with *Eriophorum* as an important constituent, and occasional patches of *Sphagnum*. During this time erosion brought mineral material down from the sides of the channel periodically and the finer particles were washed into the centre of the channel and deposited as clay bands. Nearer the present, the cutting of peat in the floor of the channel has led to the formation of flooded areas and has resulted in the spread of *Sphagna* and open-water communities.

4.3 Gale Field. 832005.

4.3.1 Physical features.

The Gale Field site is a small peat deposit which has developed in another glacial drainage channel which carried drainage water between Lake Wheeldale and Newton Dale. (Map 11 and photograph 19). Gregory (1962a) has postulated that when the ice margin retreated towards the north, Moss Slack was abandoned and another channel was used at a lower level. On the hillside between the two channels are morainic mounds and debris which probably date from this deglaciation. The channel is less well developed than Moss Slack and was presumably used for only a short time. It is seen near Goathland Church (828007) flowing in a south-easterly direction and turning to the east-north-east at about Brow House Farm (832003) and finally back towards the south-east again to empty into the Eller Beck valley north of Saddler House (844000).

The channel is cut in boulder-clay deposited during the advance of the Weichselian ice. This boulder-clay was not easily penetrated by a hand borer. The only place where peat deposits have accumulated is in a depression in the centre of the channel to the north-east of Brow

Photograph 21. Gale Field.

From 820001, looking NE.
The plantation is surrounded by enclosed fields on the lower boulder-clay area around Goathland. The northern slope of Two Howes Rigg in the foreground is covered with Callunetum.

Photograph 22. The clearing in the plantation.

From 834004, looking W.
Pinus mugo and Picea sitchensis in the background are part of the plantation. The clearing, created by a fire, is dominat by tussocks of Eriophorum and Molinia. A few deciduous trees are colonising the clearing (Betula spp. and Crataegus monogyn The exposed peat face is just off the picture to the right. Surface sample No. 3 was taken from a Sphagnum polster amongst the Eriophorum in the foreground.

House Farm, in the area known as Gale Fields. The main deposit is about 400m east-west and 250m north-south and most of it has been planted with conifers, as seen in photograph 21. All around the plantation are cultivated fields, and where the peat deposit extends a short way into one of these to the east, it is clearly demarcated on the ground, as it has been left unploughed as waste land. A smaller patch of peat less than a metre deep occurs in the pasture field to the south-east of the main deposit and again no attempt has been made to improve the land (photograph 23).

4.3.2 Vegetation.

The Gale Field peat bog was first described by Elgee (1912) who said;

> "Its surface is now almost dry with much grass, occasional tufts of Cotton Sedge, and sporadic Sweet Gale."

After Elgee wrote, in the 1920's the main part of the deposit was afforested and has remained as a plantation since that time with little alteration. The main tree species are *Picea sitchensis* and *Pinus mugo* and these have apparently never been thinned. A very close canopy has been created and the forest floor lies in dense shade and is unvegetated except for patches of *Sphagnum* where fallen trees have created a temporary clearing.

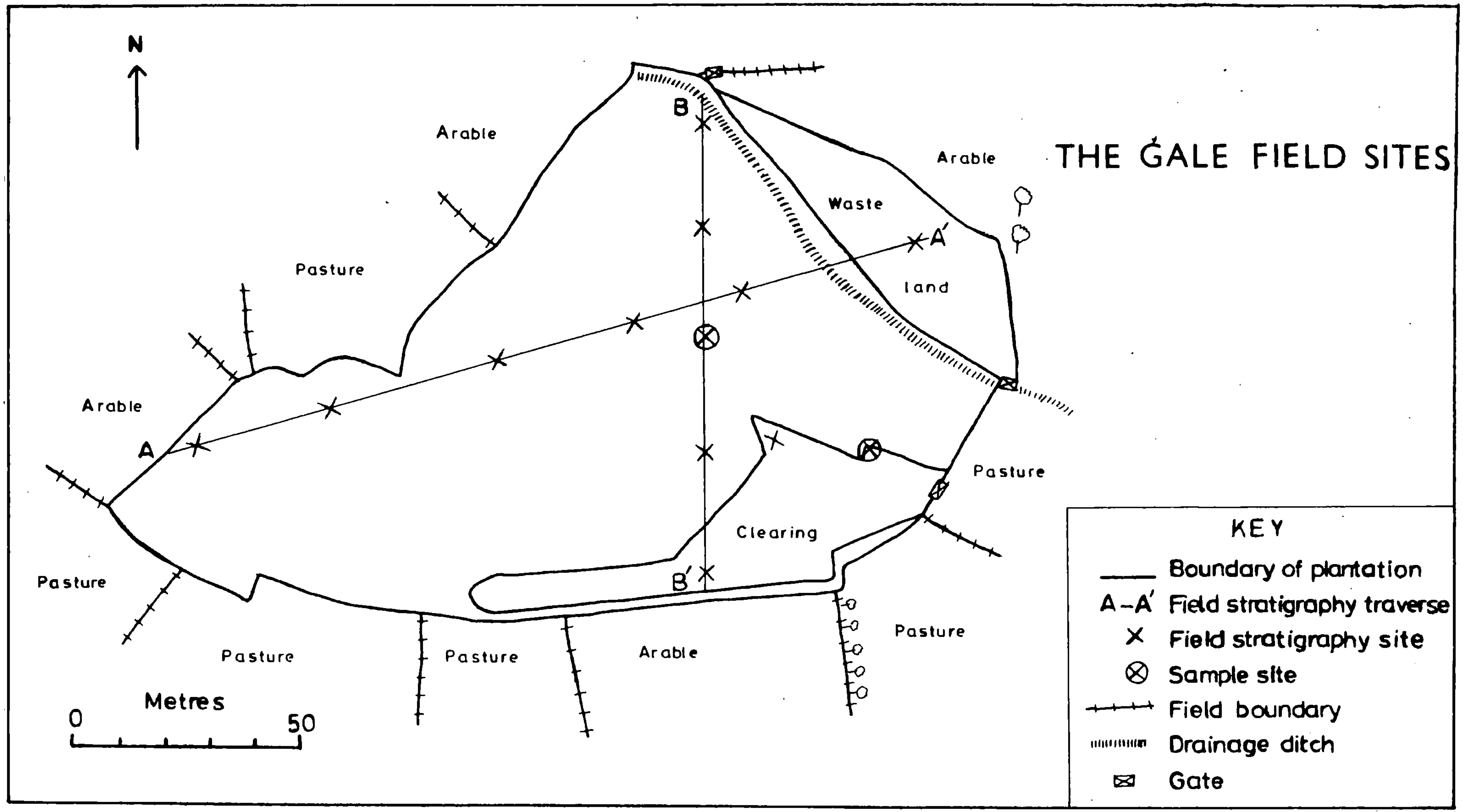
In the south-eastern corner of the plantation a fire has created a clearing nearly 300m long and 100m broad at its widest point, and this area is dominated by tussocks of *Molinia caerulea* and *Eriophorum vaginatum* with *Stellaria holostea* and *Myrica gale.* Some self-sown

Photograph 23.

From 834004, looking ESE.
A smaller patch of peat in the next field to the Gale Field plantation is dominated by Juncus spp. It is slightly higher in the centre than at the edges. The Gale Field site itself must have looked similar to this before the plantation was made. Surface sample No. 4 was taken from the middle of the bog.

deciduous trees add variety, mostly Betula, Sorbus aucuparia and Crataegus monogyna. (Photograph 22). A small portion of the main peat deposit is not planted (the waste land extending into the field to the east) and this supports a rich damp meadow flora, dominated by grasses such as Festuca ovina, Festuca arundinacea, Agropyron repens, Agrostis tenuis, Cynosorus cristatus, and Phleum pratense. Other plants include Filipendula ulmaria, Equisetum spp., Urtica dioica, Chamaenerion angustifolium, Linum catharticum, Lotus tenuis, Potentilla erecta, Polygonum persicaria, Rumex acetosa, Lychnis flos-cuculi, Vicia sativa, Cirsium spp., Campanula rotundifolia, Scutellaria galericulata, and Juncus articulatus.

The small patch of peat in the field to the south-east is dominated by Phleum pratense and Festuca ovina with Potentilla erecta, Filipendula ulmaria, Petasites hybridus, Succisa pratensis, Linum catharticum, Ranunculus acris, Cirsium spp., Trifolium campestre, and Leontodon hispidus. In the wetter areas Juncus articulatus is dominant with Equisetum spp., Sphagnum spp. and Hydrocotyle vulgaris. (Photograph 23). It is interesting that Myrica gale is only to be seen today in the clearing in the plantation, which is of recent origin, although it was obviously more common in the rest of the area at one time and was mentioned by Elgee.



Map 12.

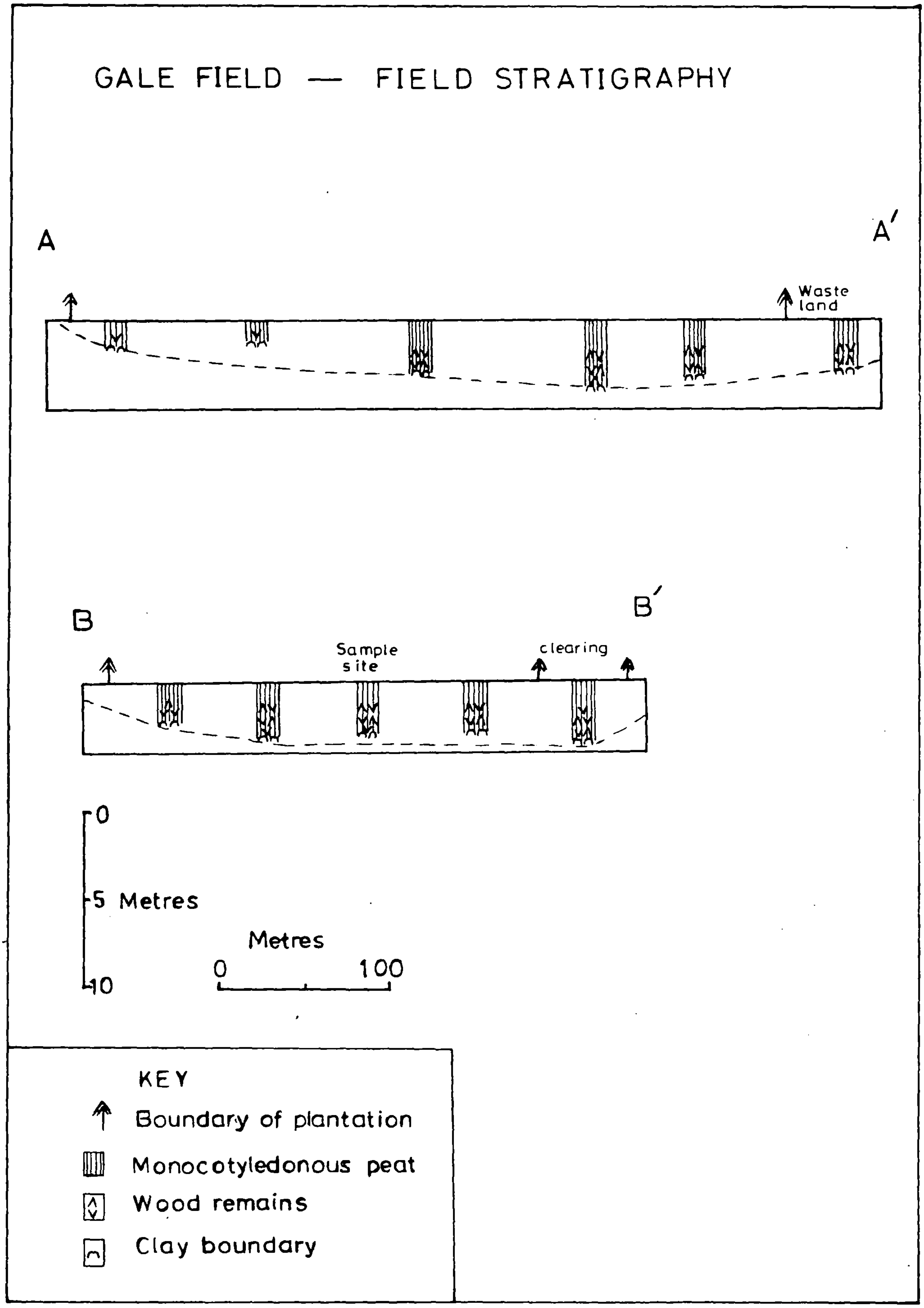
Figure 32.

4.3.3 Field stratigraphy.

Map 12 shows the general dimensions of the site and the field stratigraphy sampling points on two transects across the site. The transects were taken across the long axis of the site and the widest point of the short axis, at bearings of 255° and 0° respectively. These lines relate to the peat deposit itself and are not long- and cross-sections of the glacial drainage channel in which it is situated. Figure 33 shows the stratigraphy of the peat at the points marked. It was found to be impossible to take levelling readings across the site because of the close planting of the trees, but in any case the planting had disturbed the ground and altered the surface contours. Also there has been some peat cutting of the central part of the bog and a peat face has been created at the edge of the large clearing. Elgee (1912) described the deposit as saucer-shaped, higher in the centre than at the circumference, and this shape does seem to apply to the patch of peat in the next field (photograph 23) which has not been planted.

The maximum depth of peat found was 3.7m at a point near the centre of the site. The peat was found to be over 3m deep at several points in the centre. A site close to the centre was chosen for samples for pollen analysis, although the peat was slightly shallower (2.7m), as the particular spot was relatively easy to identify in contrast to most others in the centre of the plantation!

Beneath the peat at all sites a deposit of stiff grey clay was found with small gravel particles in it.


GALE FIELD — FIELD STRATIGRAPHY
A
A′
Waste land
B
B′
Sample site
clearing
0
5 Metres
10
Metres
0
100
KEY
Boundary of plantation
Monocotyledonous peat
Wood remains
Clay boundary

It was more finely-grained than the clay beneath the peat at Fen Bogs or Moss Slack and might represent a partially water-borne deposit rather than a solifluction deposit, especially as the channel is not very well marked and does not have steep sides which would be liable to slumping. The deposit, being only slightly stratified, did not resemble a true lacustrine deposit and is interpreted as a fluvio-glacial deposit laid down in a depression in the boulder-clay as the ice retreated. It is possible that a small temporary lake developed on the site and was filled in with sediment. Above the clay at some sites was a transition zone of inorganic material with organic remains becoming more frequent, and this might represent the infilling of the lakelet in the depression.

Above the fluvio-glacial clay at all sites was a deposit of wood peat, sometimes impenetrable locally, with remains of Betula, Salix, and Frangula alnus. The wood remains continued to within a metre or so of the surface at most sites, gradually dying out and embedded in a matrix of monocotyledonous peat. Occasional bands of Sphagnum occurred in the peat, which was dark brown in colour and became more humified towards the surface. In the top few centimetres were needles and twiglets of the litter from the modern conifers, except at two sites which were outside the planted area, where monocotyledonous peat extended to the surface.

The picture given by the field stratigraphy is one of a depression in the boulder-clay channel being filled in with fluvio-glacial deposits during the deglaciation

Photograph 24. May Moss.

From Whinny Nab (867949), looking N

1. Plantations in the northern part of Allerston Forest.
2. The darker area is May Moss, dominated by Calluna.
3. The interfluval ridge between the Eller Beck and Long Grain valleys.
4. In the distance, the plantations of Wykeham Forest can just be distinguished, on the western slope of the ridge on which High and Low Woof Howe stand.

of the area. Patches of open water remained in the bottom of the channel in depressions and were gradually infilled and supported a hydroseral vegetation. A carr woodland developed eventually on the site, consisting of Betula, Salix and Frangula alnus. Later on the trees began to die out and were replaced by grasses and sedges with Sphagna in the wetter patches. As the peat accumulated, the surface became gradually drier until by the beginning of this century it resembled a damp meadow. However, the ground was not suitable for cultivation, so in the 1920's most of the peat was planted with conifers.

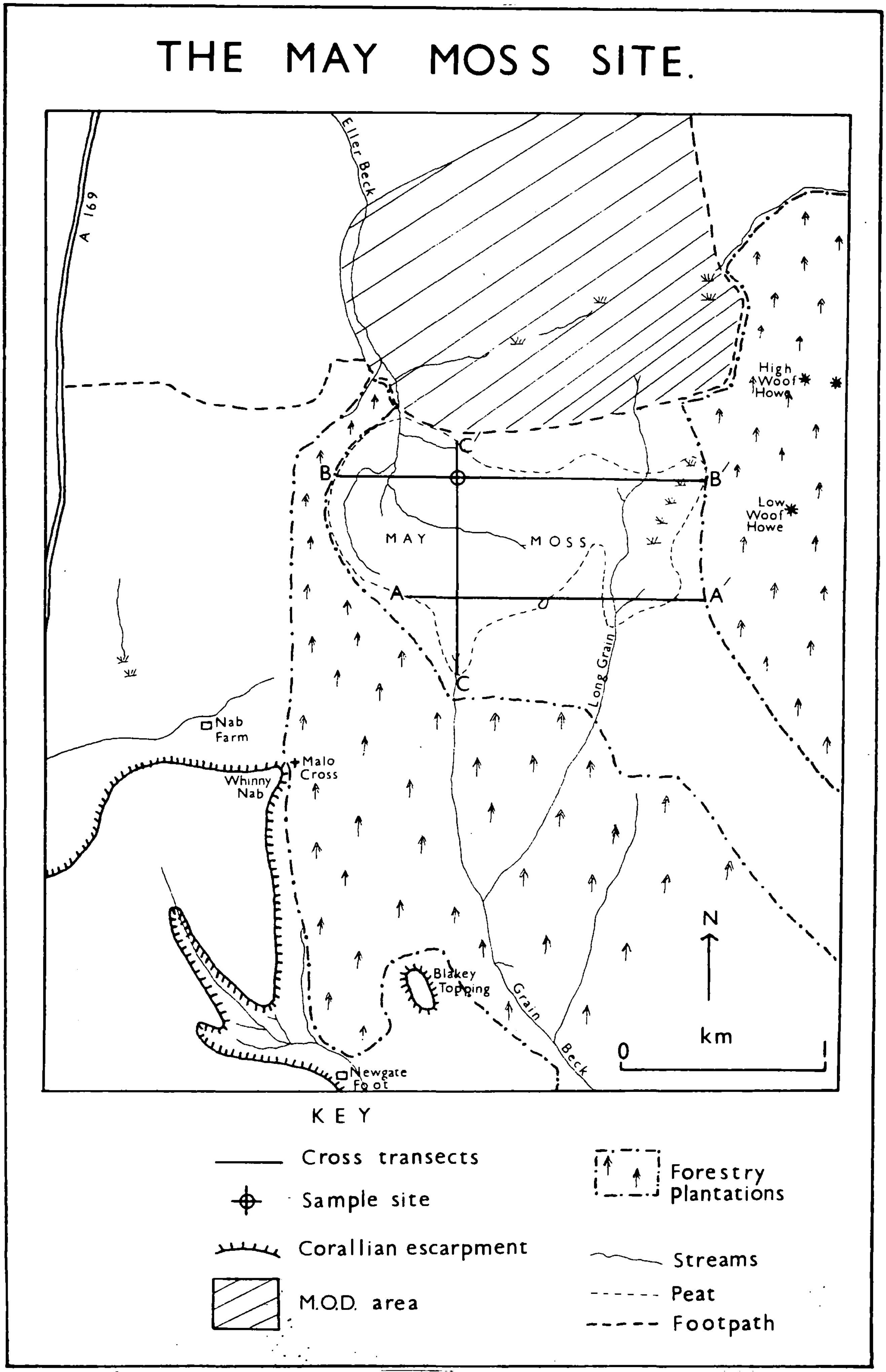
4.4 May Moss. 876960.

4.4.1 Physical features.

The fourth site, May Moss, is on the main watershed of the North York Moors, like Fen Bogs, but lies at a greater altitude than the latter, at approximately 244m O.D. (Photograph 24). Peat deposits have accumulated in two basins in the Kellaways Rock and have amalgamated to form a large area of peat 1.4km long and 1.1km wide. The watershed at this point has a "Simon's" effect, i.e. the source of the northward-flowing Eller Beck is further south than the source of the southward-flowing Long Grain, a tributary of Grain Beck and the River Derwent. The main features of the site are shown on map 13.

The Eller Beck rises from several headwaters in the north-west part of the site and flows northward in a broad open valley, as seen on cross-section B, figure 36. Flowing round in a broad sweep towards the north-west, it

Map 13. Figure 35.



is joined by Little Eller Beck and Sliving Sike before entering the eastern end of Fen Bogs, where its course has already been traced. (4.1.1) The headwaters of the Eller Beck are apparently more vigorous than those of Grain Beck, as is shown by figure 36. Sections B and C show the valley of Eller Beck at a lower level than Long Grain, which does not flow in a well-developed valley until several hundred metres south, as illustrated in section A. Other tributaries of the Derwent join with Grain Beck to flow eastwards along the northern foot of the Corallian escarpment as Crosscliff Beck and Black Beck before turning south-eastwards into the Langdale valley (map 13).

This upper section of the Derwent system would appear to be part of the original course, which flowed south-eastwards from Hackness to 980880 and then turned north-eastwards towards Scalby along the broad valley now occupied by the artificial sea-cut. Thus the Pleistocene diversions in the deep wooded gorges of the Upper Langdale valley and Forge Valley discussed in 2.3 do not appear to have affected the upper course of the Derwent. Therefore, May Moss has developed in a "normal" watershed situation, the morphology of which has not been noticeably affected by the events of the Pleistocene epoch.

4.4.2 Vegetation.

The vegetation of the surface of May Moss today is dominated by Calluna vulgaris, Eriophorum vaginatum and Nardus stricta. Erica tetralix is frequent and was apparently more so at the beginning of this century, as

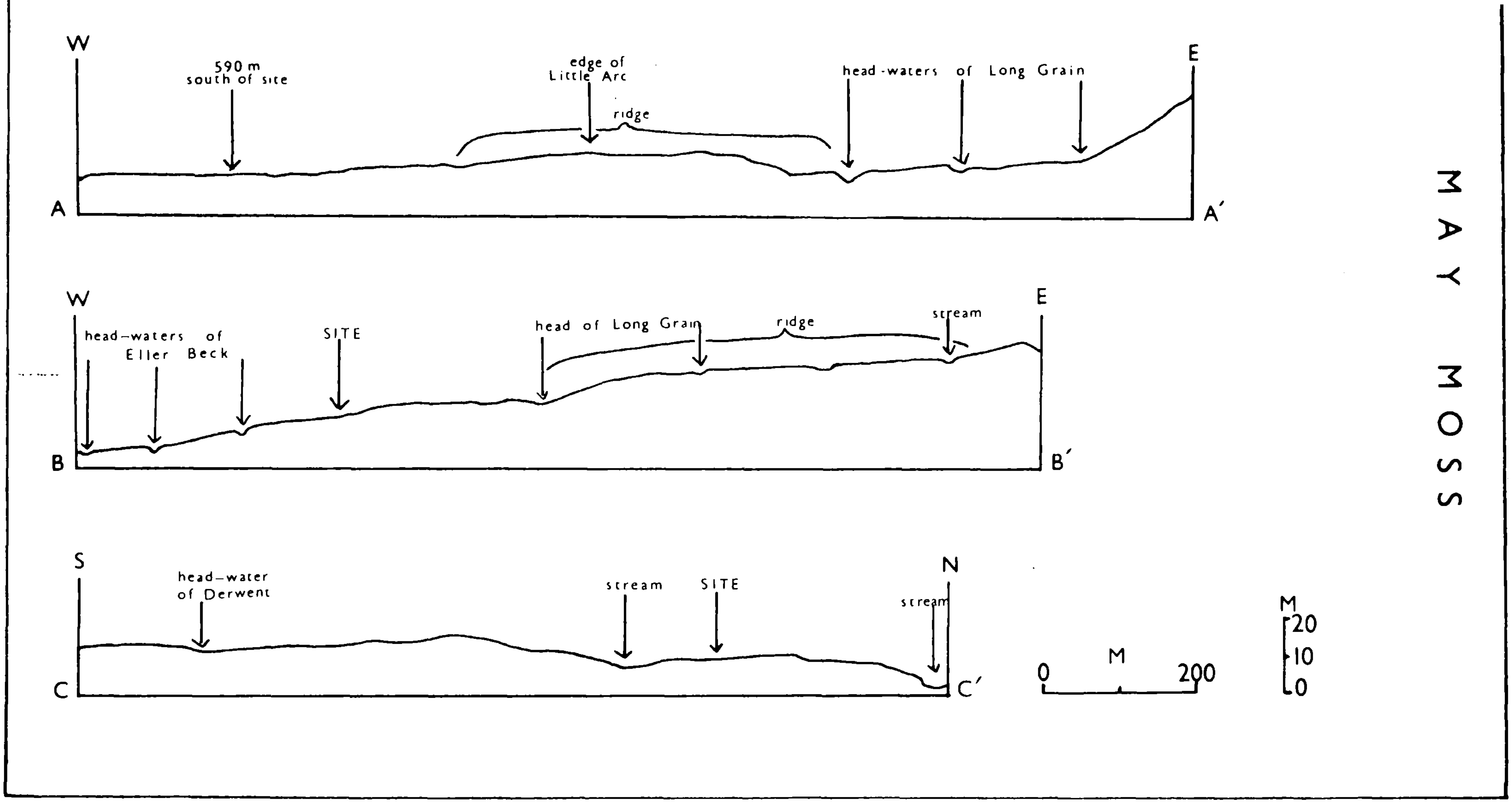

MAY MOSS
W
590 m
south of site
edge of
Little Arc
ridge
head-waters of Long Grain
E
A
A′
W
head-waters of
Eller Beck
SITE
head of Long Grain
ridge
stream
E
B
B′
S
head-water
of Derwent
stream
SITE
stream
N
C
C′
0
M
200
M
20
10
0

Figure 36.

Elgee (1912) said that it was more abundant then than Calluna:

> "Botanically, May Moss must be classed as a Tetralix moor, for the most abundant plant which grows upon it is the Pink Bell Heath (Erica tetralix). Heather and Cotton Grass (Eriophorum vaginatum) are much less numerous though otherwise fairly abundant...... Abundant as the Bell Heath is, it is not so gregarious as its allies, the plants are always more or less separated from one another by slight interspaces. Amidst these species and literally soaking wet, is a vast carpet of Sphagnum......"

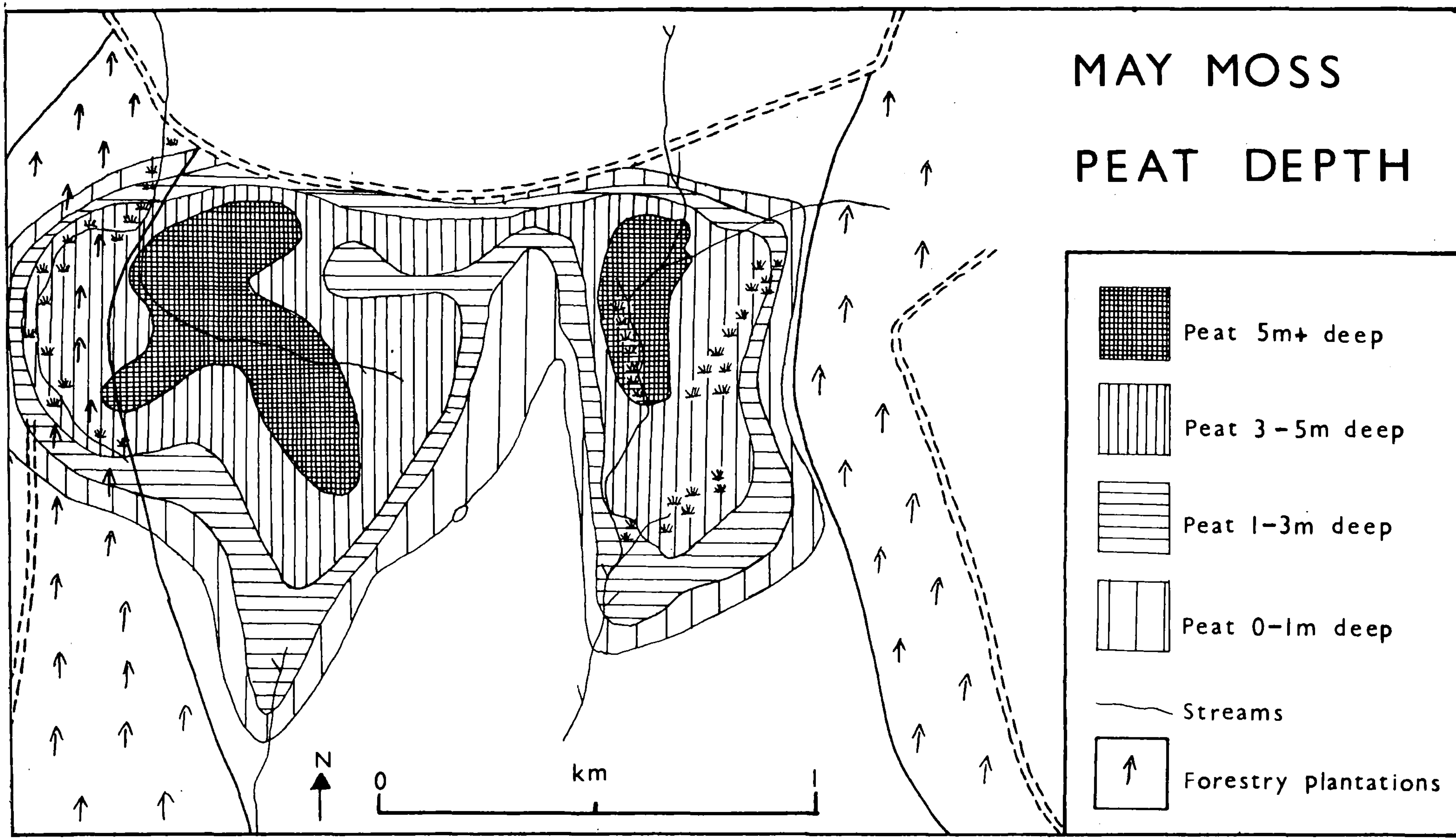
It is apparent from this description that the surface of May Moss has become drier during the last fifty years or so. The wettest parts today are found in small hollows formed by shell holes, as the area was used as a missile practice range during the second world war. One larger depression forms a small lake, at Little Ark (880958) and this is fringed by Juncus spp. The marshy upper courses of the moorland streams have carpets of Sphagna, but apart from this the flora is the typical Callunetum of much of the high moors.

One rare species in this area is Andromeda polyfolia, which was rediscovered at this site during the research. The moss is grazed by sheep, but not very intensively, as is shown by the profuse flowering of the Eriophorum. The relatively light grazing pressure in the central parts of the moss may be responsible for the survival of Andromeda. The interfluve between the headwaters of the Eller Beck and Long Grain has only a very thin cover of peat and in places the bare rock shows through. This ridge is dominated by Calluna with very few other species except for occasional clumps of Polytrichum commune.

To the east of May Moss the land rises gently from the Long Grain valley to form a north-west/south-east trending ridge surmounted by the barrows High and Low Woof Howe. This land has been planted by the Forestry Commission within the last few years as part of Langdale Forest. The land to the west of the Eller Beck valley has also been afforested. The peat cover was about half a metre deep here and the drainage ditches form a dense network of channels between the rows of young conifers.

To the north, the land which had not yet been planted was purchased by compulsory order for the Fylingdales early warning station and was not available for research. The land rises towards the boundary of the Ministry of Defence land in the north to form Worm Sike Rigg, as seen on section C, figure 36, and from the geological map it appears that the peat deposit dies out at approximately the line of the boundary fence. The peat extends to the head of the Eller Beck valley in the south-west and part way down the valley of Long Grain, but gradually thins out towards the south. When it is shallow enough to make drainage practicable the land is forested once again, so that May Moss is surrounded by plantations to the west, south and east, as is shown on map 13.

These plantations and their associated drainage schemes have probably had an effect on the deeper peat area of May Moss itself, as, from the field stratigraphy and Elgee's description, it seems that the moss was formerly much wetter than is its surface today. As at Fen Bogs and Gale Field, a comparatively recent change in the ecology



Map 14.

Figure 37.

has been brought about by drainage schemes in the surrounding area and the present vegetation communities have been established a comparatively short time.

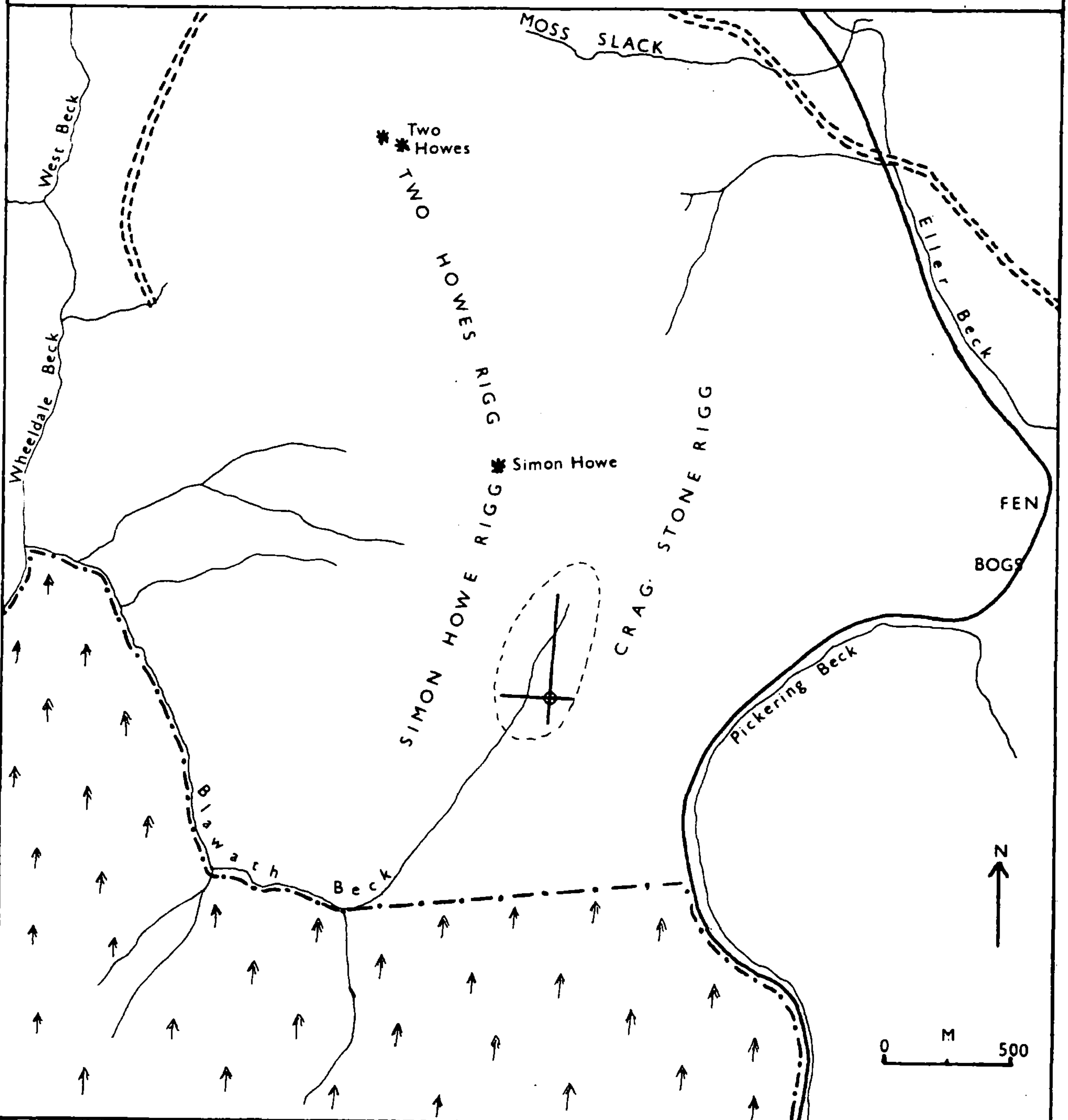
4.4.3 Field stratigraphy.

A total number of thirty borings was made to ascertain the depth of the peat cover at May Moss, and the results are shown in the form of a choropleth map on map 14. The map shows clearly how the peat has formed in two distinct basins, with the interfluval area between them hardly covered. The Eller Beck basin is the deeper of the two, and the peat reaches a maximum depth of 6.4m here at the point marked on the map between two of the headwaters of the Eller Beck. This deepest point was chosen as the sample site and a profile from here was used for pollen analysis. Sections B and C on figure 38 cross at this point, showing clearly its position in the Eller Beck basin.

The peat deposits preserved at May Moss proved to be homogeneous in character, being composed of alternating bands of *Sphagnum* and monocotyledonous peat with abundant *Eriophorum* fibres. Only right at the base of the peat were any wood remains found and these formed a detrital deposit with some charcoal present. The base of the peat was developed directly on to yellow weathered sandstone which could have been the lower horizon of a former soil. The boundary between the peat and the substratum was very sharp, and the latter was impenetrable below a few centimetres.

Map 15 Figure 38.

THE SIMON HOWE MOSS SITE.



KEY

Streams

Approximate area of peat

Railway

Roads

Field stratigraphy transects

Sample site

Forestry plantations

Much of the peat was very wet and very poorly humified, especially near the surface. The top few centimetres were much drier than the peat immediately below them, and the surface vegetation itself contained less Sphagnum and Eriophorum than the peat beneath it. This suggested a recent drying out of the moss surface, such as would be produced by drainage of the surrounding area. The probable effects of the afforestation of areas around the moss have already been discussed and seem adequate to explain this change in the stratigraphy.

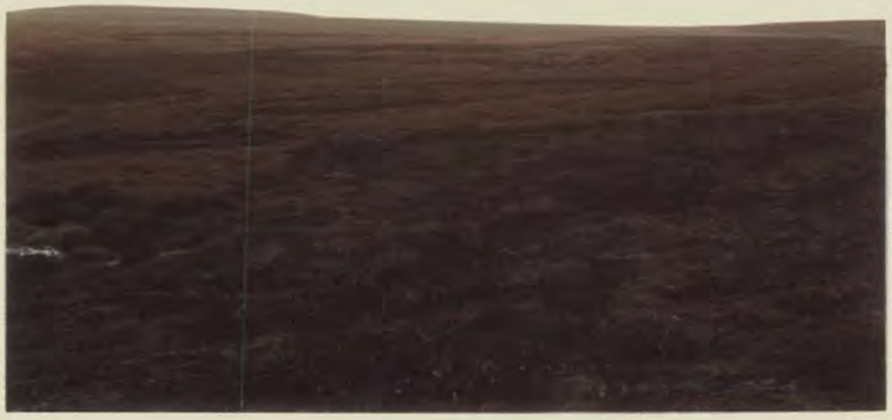
4.5 Simon Howe Moss. 834978.

4.5.1 Physical features.

The last of the five sites, Simon Howe Moss, is another upland site, lying above the Weichselian ice limit. The peat has developed at the head of a small moorland stream in the basin of Upper Deltaic rocks between the outlier of Kellaways Rock which caps Simon Howe and the main area of this rock to the south-east (see map 4). Photograph 25 shows the situation of Simon Howe Moss between Simon Howe Rigg and Crag Stone Rigg.

The moss is drained by the Blawath Beck, which flows south-westwards for 1.3km and then turns round in a broad sweep towards the north-west, being joined by several northward-flowing tributaries, to join the Wheeldale Beck at 811977 and empty ultimately into the Esk drainage system. The Blawath Beck has already been cited (2.2) as an example of river capture in the Tertiary. Its waters originally flowed south-eastwards to find their way down the pre-glacial

Photograph 25. Simon Howe Moss.



From 835976, looking NW.
The slopes in the foreground are dominated by Calluna and show obvious signs of fairly recent burning. Beyond this, the darker patches of vegetation represent the wetter parts of the site dominated by Juncus spp. On the skyline, the Simon Howe barrow caps the outlier of Kellaways Rock. A broad col of the Upper Deltaics separates this from the main outcrop of Kellaways Rock on Crag Stone Rigg, on the extreme right of the picture.

Photograph 26.

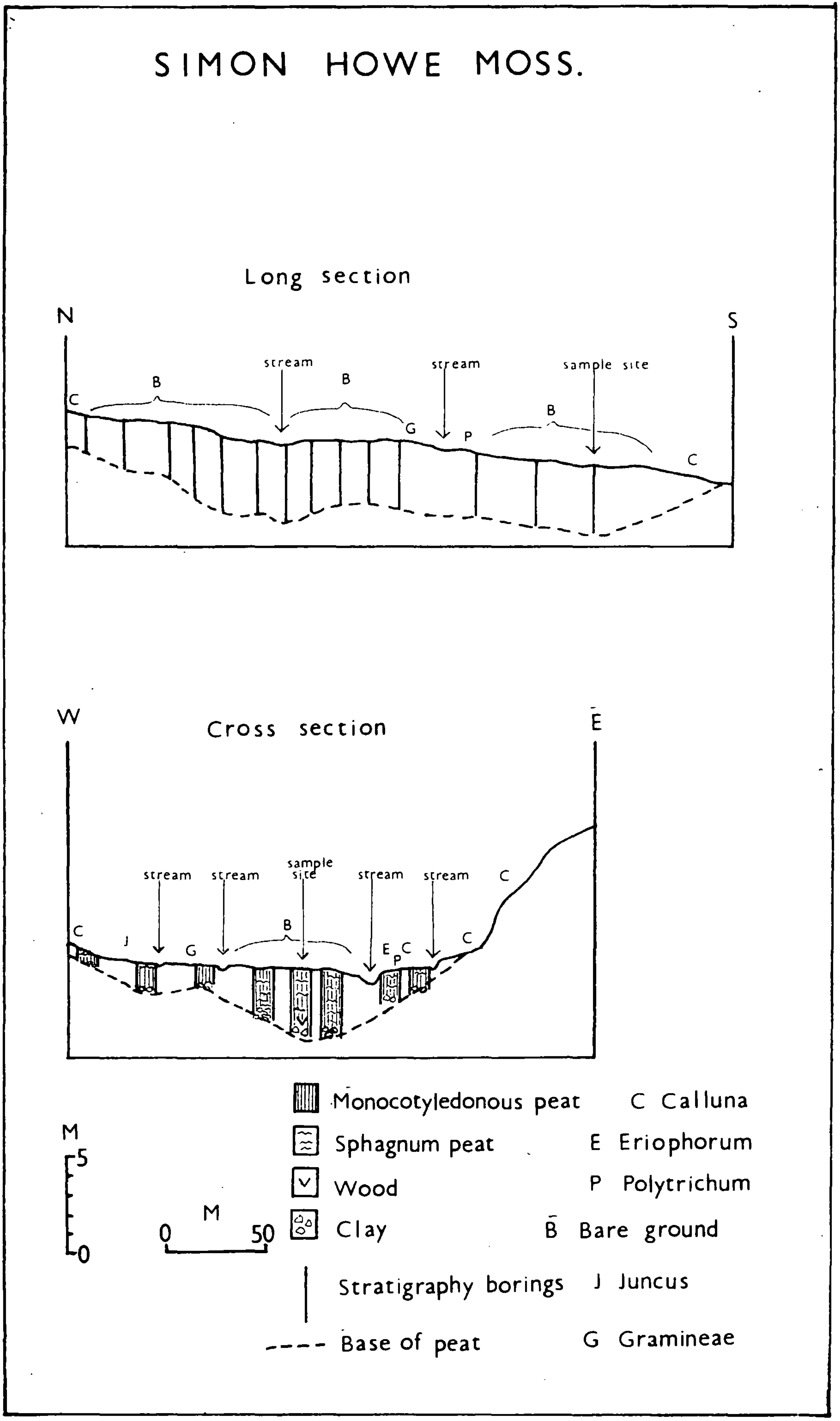
From 835976, looking W.
Parts of the site itself consist of areas of bare, eroding peat, perhaps the result of severe burning. The sample site was in the centre of the bare patch seen in this picture. In the background, Juncus spp. line the headwaters of Blawath Beck.

valley of Newton Dale and presumably to join the proto-Derwent drainage system in the south. The section of the stream flowing from Simon Howe Moss was a tributary of this original south-east flowing Blawath Beck. At the end of the Low Moor Surface stage (Gregory, 1962a) Blawath Beck was captured by Wheeldale Beck, leaving a wind-gap at 827957, and the tributary section from Simon Howe Moss to Wardle Green (825963), being more vigorous than the beheaded section from Wardle Green south-south-east, became the main stream.

Simon Howe Moss itself is an ill-defined area of peat which has grown up in the source area of the several small headwaters of the Blawath Beck. As can be seen from the long- and cross-sections (figure 40), the peat is deepest in the basins of the streamlets themselves and thinner over the interfluves. The whole basin area between the riggs of Kellaways Rock has a peat cover of half a metre or so, and hence it is difficult to draw an exact boundary round the moss itself. It seems to be lens-shaped, with its long axis north-east/south-west, following the direction of the stream, c. 400m long and 200m broad at its widest point.

4.5.2 Vegetation.

The area of Simon Howe Moss is grazed by sheep while the surrounding moorland is managed for grouse, as described in 2.6. Photograph 25 gives a general impression of the vegetation cover, which is devoid of trees except well down in the Blawath Beck valley and to the south of


SIMON HOWE MOSS.
Long section
N
S
stream
stream
sample site
B
B
B
C
G
P
C
Cross section
W
E
stream
stream
sample site
stream
stream
C
J
G
B
E
P
C
C
C
M
5
0
M
0
50
Monocotyledonous peat
Sphagnum peat
Wood
Clay
Stratigraphy borings
Base of peat
C Calluna
E Eriophorum
P Polytrichum
B Bare ground
J Juncus
G Gramineae

this, where the Forestry Commission have planted conifers. The peat itself seems to be eroding, as can be seen in photograph 26, and large patches of bare ground have been exposed with little or no surface vegetation. The area to the north of the moss near Simon Howe itself has a carpet of Polytrichum commune with few other species. It is not clear whether this erosion and paucity of surface vegetation is the result of over-grazing by the sheep or of too frequent burning of the moorland. The number of sheep involved makes the first alternative seem less likely than the second. The vegetation of the wetter peat areas may not be able to recolonise so easily after burning as the Callunetum of the drier areas surrounding the moss. It is known that a large fire in 1947 caused much damage near Simon Howe and it may be that such areas are unable to withstand severe or often repeated burning.

Where the peat does support a vegetation cover, it is composed mostly of Eriophorum vaginatum, Polytrichum commune, Sphagnum spp.,,and Nardus stricta, with Juncus spp. growing in the stream channels. On the drier areas near the edges, Calluna vulgaris is dominant. This lack of variety in the vegetation reflects the limiting nature of the habitat, especially under present management policies.

4.5.3 Field stratigraphy.

The long traverse (figure 40) shows the depth of the peat and the cross traverse reveals some of the details of its stratigraphy. The borer reached the underlying rock in several places and, as can be seen from the sections, the maximum depth of the overlying deposits was 3.75m. The relationship of the peat to the stream basins is obvious from the sections. In the bottom of the basins was a deposit of grey clay, to a depth of some 20cm at most sites. In some profiles fragments of yellow sandstone were noticed near the bottom and at several sites bright orange stripes were seen in the clay indicating iron-staining. It seems probable that the clay represents a solifluction deposit laid down by mass movement of material from the ridges of Kellaways Rock into the centre of the basin of Deltaic rocks in a severer climate, possibly Late-glacial. Despite their differing situations, the similarity of the clay in the glacial drainage channels of Fen Bogs and Moss Slack, Goathland to that in the upland basin of Simon Howe Moss is striking.

The upper boundary of the clay was not a sharp one and at most sites there was a transition zone several centimetres deep where organic and inorganic material were mixed together. At two sites a fragment of wood was found but there was no deposit of wood peat as found at the lower sites. The peat consisted of alternating bands of monocotyledonous peat, with Eriophorum as an important constituent, and Sphagnum peat. (c.f. May Moss). The vegetation of which the peat was composed appeared similar to that on the site at the present day, excepting the bare patches. So it would appear from the stratigraphy that Simon Howe Moss has supported a vegetation of sedges, Eriophorum and Sphagna throughout most of its history and that the only significant change in the stratigraphy of the peat is occurring at the present day in the form of surface erosion.

4.6 Comparison of the sites.

The five sites described in the foregoing sections are all within an area of 42 square km. Every site is within 3km of another one and the maximum distance between any two sites is 6km. Despite this close proximity, however, the sites differ markedly in the details of their location. Three of them are situated in glacial drainage channels, at altitudes of between 153m and 214m O.D. The other two sites are upland ones at altitudes of between 229m and 259m O.D. Thus both lowland and upland facets of the landscape are represented.

The sites differ in their size and shape. May Moss is an irregularly-shaped area of peat, 1.4km long and 1.1km wide. The other upland site, Simon Howe Moss, is lens-shaped and much smaller, with a maximum length of 400m and only 200 m wide. The Gale Field site is a comparable size to Simon Howe Moss but of an irregular shape. Moss Slack, Goathland and Fen Bogs are both elongated areas of peat. Moss Slack is nearly 1km in length but less than 100m broad, while Fen Bogs is 1.5km long and c.200m wide.

There is considerable variation in the aspect of the sites. May Moss has a fairly open aspect, but the other upland site, Simon Howe Moss, has a definite south-westerly aspect conferred on it by the upper part of the Blawath Beck valley. At Gale Field, the aspect would have been fairly open on all sides before the afforestation of the site, except to the south, in which direction it is sheltered by Two Howes Rigg. The other two sites are in more marked channels and have very definite linear aspects:- north-south in the case of Fen Bogs and east-west at Moss Slack, Goathland.

The depth of peat which has accumulated at the sites varies from less than 3m at Simon Howe Moss to over 10m at Fen Bogs. The nature of the superficial deposits also differs from site to site. The lowland sites all have abundant wood peat remains in their profiles, while the two upland sites were apparently never wooded. The present day vegetation of the sites and their surrounding areas shows some notable contrasts. The Gale Field site is afforested and set in the midst of enclosed agricultural land, while the other four sites are all surrounded by Callunetum. The May Moss site is surrounded further out by forestry plantations, and at Simon Howe Moss the Forestry Commission boundary extends as far north as the southern bank of the Blawath Beck. The other two sites are further away from large-scale forestry projects.

Thus, within a small area there are five sites which differ in their topographic situations, their aspects, their size and shape, the nature and depth of their peat deposits and their vegetation cover. Differences in the pollen diagrams between these five sites may be expected to reflect local differences in situation, aspect and vegetation, while similarities between them may arise because of the general similarity of their location. The aim of the analysis in the sections which follow is to compare and contrast the pollen records of these five sites so as not only to illuminate the general picture of vegetation change but also to highlight the details of the botanical landscape.

CHAPTER FIVE. THE POLLEN DIAGRAMS.

In this section, pollen diagrams from the five sites will be presented. The field and laboratory techniques involved in the preparation of the samples for pollen analysis are described in Appendix I. Macroscopic remains were inspected to elucidate the depositional context of the pollen, and the results have been incorporated in the descriptions of the profiles themselves. The pollen counts for each species have been expressed as a percentage of the total pollen sum, and the results are illustrated as bar graphs drawn on a logarithmic scale. The reader is referred to Appendix II for a discussion of the use of the logarithmic scale on the diagrams.

The diagrams for each site are presented in Figures 47 to 49. In this chapter the diagrams will be divided into zones for the purposes of description and the main vegetation changes seen on them will be summarised. The correlations between the diagrams and the dating of the various zones will be discussed in chapter 6. This section is intended to introduce the diagrams rather than to interpret them and will be purely descriptive.

5.1 Fen Bogs.

5.1.1 Profile details.

A profile for pollen analysis was taken from the site marked on cross-traverse C on figure 24 and on map 9. A central site was chosen within the main area of the mire, (i.e. to the east of the railway fence), so as to give as regional a diagram as possible. The peat was found to be 9.6m deep and details of the stratigraphy are given below:-

Figure 41.

FEN BOGS. POLLEN DIAGRAM I.

Surface vegetation: Dominant - *Molinia*, *Nardus*.
Abundant - *Calluna*, *Eriophorum vaginatum*, *Vaccinium oxicoccus*.
Frequent - *Sphagnum papillosum*.
Occasional - *Polytrichum*, *Myrica gale*, *Carex nigra*.

0 - 7cm	Very dark brown peat composed of rootlets of surface vegetation. Remains of grasses and sedges, *Calluna* and some *Sphagnum*. Charcoal fragments.
7 - 13cm	Dull, dark brown monocotyledonous peat with some *Sphagnum*..
13 - 16cm	*Sphagnum* layer with some monocotyledonous remains.
16 - 75cm	Dull brown monocotyledonous peat with occasional *Sphagnum* remains.
75 - 112cm	Monocotyledonous peat with remains of *Phragmites communis*. Small twig of *Betula* at 83-86cm. Some *Sphagnum*. Burnt *Calluna* fragments and *Eriophorum* spindles at 102cm.
112 - 591cm	Bright red-brown *Phragmites* peat with remains of grasses and sedges. *Eriophorum* spindles and fibres at 132cm. Charcoal at 172cm and 209cm. A little *Sphagnum*. *Calluna* remains at 277cm and 301cm. Becoming more humified with depth. Occasional seeds of *Cyperaceae*.
591 - 598cm	Inwash stripe of light grey clay.
598 - 600cm	Wood layer (*Betula*).
600 - 617cm	Well humified *Phragmites* peat.
617 - 626cm	Wood layer.
626 - 684cm	Well humified *Phragmites* peat with abundant wood remains (*Betula* and *Alnus*).
684 - 688cm	Wood layer.
688 - 813cm	Well humified *Phragmites* peat with wood remains (some *Salix*).
813 - 916cm	Wetter peat with fewer *Phragmites* remains. *Betula*, *Salix* and ?charcoal.
916 - 957cm	Transition. Peat with some inorganic material. Seed of *Carex* sp. at 954cm.
957cm	Boundary to whitish-grey clay with sandstone fragments and very few organic remains.

Samples were counted at a basic interval of 10cm, with closer sampling across the inwash stripe and in the top 2.5m. The pollen diagram will be described from the base upwards, i.e. in chronological order.

FEN BOGS. POLLEN DIAGRAM II.

5.1.2 The pollen diagram. (Figures 41 and 42)

The basal few samples, from c 900cm to the bottom, are characterised by high ratios of non-arboreal to arboreal pollen, the latter constituting between 20% and 30% of the total pollen. The arboreal pollen is dominated by Betula, which reaches 33.7% at 926cm, with some Pinus and very small amounts of Quercus and Ulmus. Shrub pollen comprises almost as much of the total pollen as does arboreal pollen, with Salix values reaching 1.83% at 936cm. Coryloid[1] values increase throughout the zone and reach over 30% by the top. The basic relationship between arboreal, shrub and non-arboreal pollen is best seen on the total pollen diagram at the end of figure 42.

The main constituents of the high non-arboreal pollen are Filipendula, Cyperaceae and the aquatics (Menyanthes and Potamogeton). Polypodium is conspicuous among the spores, reaching 9.9% at 926cm, and Filicales are also high, reaching 10% at 936cm, while some Sphagnum spores are recorded. These species were all probably part of the vegetation colonising the site itself, growing in hollows in the wet surface of the clay on the floor of the channel. The only other occurrences of non-arboreal pollen are insignificant amounts of Calluna and Gramineae and occasional records for members of the Ericaceae, Umbelliferae and Chenopodiaceae families. These show that there were some other open habitats in the vicinity, but that these were of limited importance. This zone may be compared with Zone V of Godwin (1940), and has been labelled as such on figures 41 and 42. The merits of the Godwin zonation

1 Coryloid = Corylus + Myrica. While it is believed that most of the fossil pollen is probably Corylus, it must be remembered that Myrica gale grows on the site today.

scheme for this work are discussed in 6.2.

From c.900cm to 810cm on the diagram a second zone may be delimited, the main feature of which is the change in dominance of the arboreal pollen from Betula to Pinus, which reaches a peak of 45.2% at 828cm. A clear reciprocal relationship is seen between the curves for Betula and Pinus, suggesting that Pinus was spreading largely at the expense of Betula. Other trees expand, however, including Ulmus and Quercus and later Alnus, which rises rapidly in the top part of the zone. Fraxinus and Tilia also make their appearance, while Salix and Coryloid values decline, along with those of Gramineae and Cyperaceae, indicating a decrease in the number of habitats available for shade-intolerant species.

Pteridium increases throughout the zone, probably occupying a niche at the edge of the expanding area of woodland. The presence of small amounts of herbaceous pollen indicates that open habitats were not entirely lacking, and both Filipendula and Melampyrum are present in notable amounts, whilst other plants recorded include Rumex acetosa, Artemisia, Sanguisorba officinalis, Rosaceae, Compositae, Umbelliferae, Chenopodiaceae, Cruciferae and Rubiaceae. The aquatic pollen has decreased, probably a result of local hydroseral development. This zone may be equated with Godwin's Zone VI, with the top part with the characteristic rise of Alnus representing Zone VIc. There does not seem to be enough evidence, however, to justify a three-fold division of the zone.

The subsequent zone VIIa may be drawn from 810cm to 612cm, and represents the climax of the Quercetum Mixtum, with maxima for Quercus, Ulmus and Tilia, and a rapid decline of Betula and Pinus. Fraxinus increases and Alnus rises to a peak of 9.7% at 779cm. Other woodland indicators include high values for Polypodium and Filicales and the records for Mercurialis. The zone sees the maximum development of woodland on the diagram and coincides with much wood in the stratigraphy, suggesting that at least parts of the site itself were wooded, and probably a closed canopy extended to the edges of the mire.

Non-arboreal pollen values are at a minimum, falling to 27% of total pollen at 779cm, and a marked decrease is seen in Calluna, Gramineae and Cyperaceae in the first part of the zone. Gramineae rise again from c. 760cm to 710cm, but this expansion is not seen in any of the other herbaceous species. The decline in arboreal pollen is registered on the total pollen diagram, but is partly the result of the decline of Pinus and Betula. From 710cm to the top of the zone, however, an expansion is seen in Calluna and Cyperaceae and higher values are noted for Succisa, Potentilla, Rosaceae, Sanguisorba officinalis, Artemisia, and Pteridium, suggesting an expansion of open habitats somewhere in the vicinity. The expansion is seen clearly on the total pollen diagram, but the increase of non-arboreal pollen is seen to be mainly at the expense of the shrubs rather than of the trees.

Sphagnum values rise in the early part of the zone and remain high, with a few short-term declines, from here to c. 260cm. There is no evidence from aquatic pollen to suggest an increase in wetness at this time, and the high values seem to correlate more closely with the development of the woodland itself. Some indirect factor seems the likely cause here - perhaps the quality of the run-off water from the deciduous woodland?

At 612cm, a sudden decrease is seen in the curve for Ulmus, which drops from 2.3% at 622cm to 0.49% at 612cm. At the same time there is a decrease in Tilia and a slight decrease in Quercus, while Betula, Alnus and Coryloid expand a little. This seems to be the appropriate place to draw the Zone VIIa/b boundary, following the Godwin zonation. A radiocarbon date was obtained for this level of 4720 ± 90 BP (for discussion of the radiocarbon dating, see 6.1). The first record for Plantago lanceolata is made at this point (except for one isolated record at 818cm). Increases in Calluna, Ericaceae and Gramineae are seen shortly afterwards, indicating the presence of more open ground. The inwash stripe comes just above this level in the profile and corresponds to a slight increase in Calluna and Plantago lanceolata. The inwash stripe itself suggests erosion, and in 4.1 it was suggested that this might be associated with deforestation of the slopes at the side of the channel, as wood remains die out in the peat at this point. This is consistent with the palynological evidence for a slight decrease in the woodland canopy at this stage, notably of Ulmus and Tilia.

From the Ulmus decline at 610cm to 480cm is a zone similar to that preceeding the Ulmus decline. Values for Quercus and Alnus are similar to those for Zone VIIa, while values for Betula, Fraxinus and Coryloid are somewhat higher. *Tilia* and *Ulmus* values fluctuate but are lower than in the preceeding zone. This suggests some opening up of the canopy, especially the decline of *Ulmus* and *Tilia*, which had recovered after the initial decline at 610cm, giving light-demanding trees such as *Betula* and *Fraxinus* a chance to expand.

Values for *Polypodium* and *Filicales* are lower in this zone, while those for *Calluna*, *Ericaceae* and *Gramineae* are higher, again suggesting more open ground. Other herbaceous species include most of those noted in Zone VIIa and also records for *Vicia*, *Polygonum bistorta*, *Polygala* and *Viola palustris* (no doubt local). A freak count at 563cm of 64.5% for *Melampyrum* causes the very marked fluctuation in the total pollen diagram and was probably the result of a fallen anther from a plant growing in the immediate vicinity of the site itself. *Pteridium* and *Cyperaceae* values are lower than in VIIa. Whatever short-term increases in non-arboreal pollen occur, the woodland seems to have recovered almost completely. This zone has been labelled Zone A on the diagrams.

From c. 480cm to 270cm, we can distinguish another zone (called Zone B) where the non-arboreal pollen is more frequent. The lower boundary of this zone is drawn at the point where *Tilia* declines to very low values and a slight decrease is seen in *Ulmus* too. Little effect is seen on the curves of the other trees, and the boundary is hardly registered on the total pollen diagram. *Fagus* appears in this zone and is present in small amounts throughout it.

The increase in non-arboreal pollen is seen in the curves for Cyperaceae and Plantago lanceolata particularly, but also in those for Gramineae, Calluna and Ericaceae, and other herbaceous present include Rumex acetosa, Filipendula, Potentilla, Rosaceae, Artemisia , Compositae, Umbelliferae, Chenopodiaceae, Cruciferae, Lychnis and Succisa . Records for Potamogeton and Menyanthes suggest a slightly wetter environment, but are probably local. Spore values for Pteridium are fluctuating but higher than in Zone A, as are those for Filicales , while Sphagnum remains very high. The combined effect of the non-arboreal species is seen on the total pollen diagram as a series of kinks in the curves. Thus the pollen record indicates a gradual but localised and short-lived increase in the openings in the woodland canopy.

This slow trend is suddenly accelerated at the opening of Zone C at 270cm. A sudden decrease in arboreal and shrub pollen is shown very clearly on the total pollen diagram and Fagus is the only tree to increase during this zone. Salix expands, but Coryloid pollen declines markedly. The decrease in arboreal pollen is compensated for by a vast increase in non-arboreal pollen, most marked in the curves for Gramineae, Cyperaceae and Plantago lanceolata, but also seen in those for Ericaceae, Plantago major/media, Rumex spp, Filipendula , Potentilla , Rosaceae, Artemisia , Compositae, Umbelliferae, Chenopodiaceae , Cruciferae, Rubiaceae, Ranunculaceae , Lychnis, Vicia, Succisa, Melampyrum, Polygala, Urticaceae et al. The appearance of Centaurea cyanus is noteworthy and cereal pollen is first recorded from this zone. Aquatic pollen is also high. Pteridium values are high, but Sphagnum and Filicales decline somewhat and Polypodium peters out. An opening up of the woodland is suggested on a scale far larger than anything seen hitherto on the diagram.

The non-arboreal pollen declines almost as suddenly as it rose at 160cm, the beginning of Zone D. A regeneration of the arboreal pollen is seen on the total pollen diagram. Betula, Coryloid and the other trees increase, except for Ulmus and Tilia. Fagus is still high, as is Salix, particularly at the beginning of the zone. Meanwhile, Gramineae, Cyperaceae, Calluna and nearly all the other herbaceous species decline, and Pteridium almost gives up altogether. Plantago lanceolata, however, retains its high values and Rumex acetosa only decreases temporarily, and although the non-arboreal pollen is much lower than in Zone C, it is more frequent than in Zone B.

At 110cm another major expansion of non-arboreal pollen is observed, lasting until c.60cm. Again the arboreal pollen declines, although not so markedly as in Zone C, and Coryloid values remain fairly high, while Ulmus actually increases. Calluna and Ericaceae expand at the beginning of the zone but decline sharply from 100cm upwards as first Cyperaceae and then Gramineae rise to a great peak. Pteridium suddenly increases again and some of the herbaceous species seen in Zone C show peaks, e.g. Filipendula, Potentilla, Rosaceae and Compositae. Others, however, show slight declines, e.g. Plantago lanceolata and Rumex spp. The details of these changes will be discussed in Chapter 8, but the general picture is of a renewed expansion of non-arboreal pollen and a reduction of woodland, although not on quite such a large scale as in Zone C.

From c.60cm to 30cm, another regeneration of arboreal pollen and especially of shrub pollen is seen, similar to that of Zone D, but shorter-lived. The main contributor to the increase in arboreal pollen is Betula, but Quercus, Alnus and Fraxinus also rise, although Fagus, Ulmus and Tilia decline. Coryloid pollen shows a very marked increase and is largely responsible for the big expansion of shrub pollen on the total pollen diagram. Gramineae and Pteridium gradually decline, but Calluna and Ericaceae increase, while Cerealia and Plantago lanceolata remain high. Other herbaceous species present a complex picture, some declining, e.g. Filipendula and Rosaceae, while others increase, e.g. Cruciferae, Compositae and Chenopodiaceae.

From 30cm to the top of the diagram Zone G sees another period of very high non-arboreal pollen. Arboreal and shrub pollen decline to minimal levels, but right at the top of the diagram (and including the surface sample) some species increase, no doubt owing to modern afforestation. This affects Pinus, Picea, Betula, Quercus, Ulmus, Fagus and Acer. The non-arboreal pollen is dominated by Calluna, and Ericaceae are also very high except right at the top. Gramineae and Cyperaceae are slightly lower than in Zone F, as is Plantago lanceolata. Records for other herbaceous species are numerous, including Rumex, Potentilla, Filipendula, Compositae, Lychnis, Cruciferae, and Cerealia which reach their highest value in the surface sample. Pteridium values are generally high, but reach their peak early in the zone. Another major phase of reduction of woodland and expansion of herbaceous vegetation is indicated. but throughout Zones E, F and G the vegetation changes are

Figure 43.

Photograph 27. Peat face at Moss Slack Goathland.

Depth of peat face - 50cm.

1. Litter layer.
2. Slightly darker mineral layer.
3. Clay band.
4. Black, peaty horizon.

For full profile description, see text.

very complex and will be discussed more thoroughly in Chapter 8 when land use changes are considered.

5.2 Moss Slack, Goathland.

5.2.1 Profile details.

The peat in Moss Slack has suffered a considerable amount of cutting, as was noted in 4.2. So, in order to obtain a complete profile, a site was chosen for pollen analysis where a spur of the uncut surface projected towards the centre of the channel, and samples were taken from both the cut face of the spur and the peat in the channel immediately below it. Photograph 27 shows the peat face; the stratigraphy of the combined profile is shown below:

Surface vegetation: Nardus, Galium saxatile, Festuca ovina, Calluna, Polytrichum commune.

0 - 5cm	Litter and roots of surface vegetation.
5 - 9cm	Slightly darker soil - "A" horizon? Few Juncus seeds.
9 - 11cm	Clay band. Very little organic matter.
11 - 24cm	Light greyish-brown clay with remains of Monocotyledonous plants. Ferruginous root channels. Few Juncus seeds.
24 - 26.5cm	Black peaty horizon.
26.5 - 34cm	Clay band.
34 - 36.5cm	Black peaty horizon.
36.5 - 43cm	Clay band. Some burnt plant remains.
43 - 50cm	Black, well-humified amorphous peat.
(samples from floor of channel beneath cut face)	
50 - 90cm	Rich brown Eriophorum peat with other monocotyledonous remains. Only partially humified. Wood layers at 57, 63 and 65cm. Betula twig at 89cm.
90 - 113.5cm	Monocotyledonous peat with Eriophorum and Polytrichum remains. Charcoal layer at 103cm. Scattered Betula twigs. Relatively unhumified.
113.5 - 180cm	Lighter coloured, better humified monocotyled--oneous peat with massive wood layers (Betula) Very wet. ?tree trunk from 156-180cm (impossible to sample).
180 - 202cm	Drier, well humified monocotyledonous peat with Betula twigs.

202 - 241cm	Lighter, mid-brown peat with less *Betula*. Some inorganic material. *Carex* seeds and many *Juncus* seeds.
241 - 248cm	Transition layer. Organic clay. *Juncus* seeds.
248 - 261cm	Clay with sandy partings.

Samples were prepared for pollen analysis as described in Appendix I. The sampling interval for this diagram was 10cm for the part between 1m and 2m; 5cm for the bottom part and from 1m to 0.5m; and 2cm for the top 0.5m (the exposed peat face). The pollen diagram is shown on Figure 44.

5.2.2 The pollen diagram.

The pollen diagram from Moss Slack Geathland presents a very different picture from the Fen Bogs diagram. The arboreal pollen curve exceeds 40% of the total pollen for most of the profile, reflecting the abundant wood remains in the field stratigraphy beneath c.1m. The shrub pollen curve is also relatively high. This woodland with its attendant shrub layer in the immediate vicinity of the site must have filtered out much of the regional pollen and contributed a great deal itself to the pollen record at the site. The wood remains begin to die out in the stratigraphy between 1m and 0.5m, and a big decrease is seen on the pollen diagram in the arboreal pollen curve from 1m upwards, which presumably reflects the disappearance of this local woodland. Below c.1m, therefore, we may expect to see a largely local picture in the pollen diagram and in this section there are only two zones which can be distinguished, both of them dominated by arboreal pollen.

Figure 44.

MOSS SLACK GOATHLAND. POLLEN DIAGRAM.

The first of these is from the bottom of the diagram to c. 2m, when the arboreal pollen is at its highest values, starting at 50% and reaching 72% at 225cm. The woodland supplying this pollen appears to have Betula, Quercus, and Alnus as its chief constituents with Ulmus and Tilia and a great deal of Corylus as an understorey. It also has a significant amount of Pinus in it and some Fraxinus, although no Fagus or Carpinus is recorded. The Salix seen in the diagram may have been growing in the damp channel itself. The non-arboreal pollen in this zone is composed mostly of Gramineae with some Calluna, Cyperaceae and small but significant amounts of other herbaceous species, e.g. Filipendula, Potentilla, Rosaceae, Ranunculaceae, Melampyrum and Succisa. Plantago lanceolata is recorded and some large grass/cereal pollen. It was not possible to determine definitely whether or not these grains were of cereal type, as their size was exactly on the boundary between grass and cereal.

The second zone distinguished is from 2m to 1m and represents a stable period on the diagram, although the curves may have been simplified by the wide sampling interval, as there is a gap in the sampling from 180cm to 156cm where the deposit proved impossible to sample (a tree trunk?). The arboreal pollen is lower than in the first zone, at values between 40 and 50% of total pollen. The composition of the woodland appears to be similar to that of the preceeding zone but with Ulmus, Tilia and Fraxinus relatively more important. The shrub pollen values are high, but mainly Coryloid, as Salix is unimportant in this zone.

Non-arboreal pollen is more important on the total pollen diagram, with *Calluna* and *Ericaceae* values much higher than in the preceeding zone. It is probable that this represents a spread of heath vegetation fairly close to the site, perhaps on Two Howes Rigg. *Gramineae* values are somewhat lower than in the first zone and no cereal pollen is recorded. *Cyperaceae* increase, but apart from this herbaceous pollen is not important, the only significant records being for *Potentilla*, *Chenopodiaceae*, *Ranunculaceae*, *Melampyrum* and *Succisa*. So, although the arboreal values are lower than in the first zone, there are fewer signs of open-habitat vegetation other than heathland in the pollen spectra. The two zones described so far are labelled C and D on Figure 40, but the reader is referred to Chapter 6 for details of the generalised zoning scheme and the correlations with other diagrams.

The top part of the diagram is much more complicated and has been sampled at a closer interval. From a peak of 60% at 1m, the arboreal pollen curve falls to a minimum of 28.6% at 70cm and then rises again to 59% at 65cm. The main trees concerned in this decrease and recovery are *Pinus*, *Betula* and *Quercus*. *Tilia* declines but does not increase again, but no effect is observed on the curves for *Ulmus*, *Alnus* or *Corylus*, while *Fraxinus* and *Salix* increase, perhaps in response to more light entering the woodland. *Hedera* is recorded several times. An isolated grain at 100cm shows *Fagus* was somewhere in the vicinity.

The pattern of the arboreal pollen curve is reversed by that of the non-arboreal pollen, with peaks of *Calluna*, *Ericaceae*, *Gramineae* and *Cyperaceae*. *Plantago* lanceolata really expands for the first time in this zone and reaches a peak of 1.8% at 85cm. Other notable herbaceous species include Filipendula, Potentilla, Rosaceae, Artemisia, Chenopodiaceae and Ranunculaceae, with records for Melampyrum, Scrophularia type and Succisa. Pteridium values are high and reach a peak of 9.2% of total pollen at 95cm. Polypodium and Filicales are much lower than in the previous zone, reflecting the decrease in the woodland.

At c.50cm, i.e. at the junction between the exposed face and the underlying peat, a further decline in the arboreal curve is observed to 13.5%, and the non-arboreal pollen increases to over 60%. Violent fluctuations are observed in the arboreal and shrub pollen just below this point and it is possible that the profile has been disturbed, e.g. by peat cutting. In the succeeding zone, shrubs are high, generally over 20% and composed mostly of Coryloid, with occasional records for Ilex, Hedera and Salix. The decline in the arboreal pollen is seen clearly on all the tree curves except Fagus, which expands, possibly taking advantage of the opening of the canopy. Tilia almost disappears at this point.

The increase in non-arboreal pollen consists of many species, including very high values for Calluna and Ericaceae, Gramineae, Cyperaceae and Plantago lanceolata and peaks of Plantago major/media, Filipendula, Potentilla, Artemisia, Compositae, Chenopodiaceae, Cruciferae, Rubiaceae and Ranunculaceae, and occasional records for many others. Pteridium values are high and Equisetum is recorded, both indicating woodland edge conditions. A few records of cereal pollen are from this zone and the identifications are more certain than in the earlier part of the diagram.

At c.21cm a further decline in the arboreal pollen reduces it to less than 5% of the total pollen. This time shrub pollen declines too, so that the non-arboreal pollen is contributing over 90% of the total. Again the decrease in the arboreal pollen is very sudden and this may represent a hiatus in the profile, as the samples at this point were from one of the clay bands (vide supra, 5.2.1). The main species involved in the increase of non-arboreal pollen seems to be Calluna (which reaches 86%) although peaks are noted in Filipendula, Compositae, Rubiaceae et al. It seems that most of the herbaceous plants remain as they were, while some decline, e.g. Gramineae, Plantago spp., Rumex spp., Chenopodiaceae and Ranunculaceae. Thus the increase seems to be mainly in heather moorland.

Within the top 7cm an increase in arboreal pollen and shrub pollen is observed, followed by a decrease. As this is only represented by four samples it is difficult to assess its significance, but most of the trees seem to be involved, including Betula, Quercus and Alnus, and Salix and Coryloid cause the very marked peak in shrub pollen of 28.9% at 5cm. There is a corresponding decrease in many of the herbaceous species, including Calluna, Rumex spp, Filipendula, Compositae and Chenopodiaceae. The surface sample has picked up the modern increase in Pinus pollen, as at Fen Bogs, and again an increase in Ulmus is noticed and also of Fagus. The surface sample also has by far the highest percentage of cereal pollen on the diagram. This is presumably coming from the cultivated area around the Gale Field site, just to the north.

However, there are some differences between the surface sample and that from 1cm which might suggest a break in deposition between the two, and this is not unlikely as the surface of the channel at this point was quite dry and the peat had evidently stopped growing sometime ago.

5.3 Gale Field.

5.3.1 Profile details.

A core was taken from the centre of the plantation in a small clearing between the trees. The stratigraphy was as follows:

Surface vegetation: Sphagnum colonising Picea needles.

0 - 4cm	Litter layer of Picea needles and Sphagnum.
4 - 11cm	Very dark brown, compact, well-humified peat with fragmented remains of monocotyledons and Sphagnum.
11 - 100cm	Slightly lighter, relatively unhumified, mid-brown peat with monocotyledonous remains. Some Sphagnum and occasional Eriophorum fibres.
100 - 165cm	Relatively unhumified fibrous mid to dark brown peat composed mainly of monocotyledons and occasional Sphagnum. Eriophorum fibres and fruiting head at 160cm. Juncus seeds frequent and occasional Potamogeton seeds. Scattered wood fragments from 125cm onwards.
165 - 266cm	Well humified mid-brown peat with monocotyledonous remains and abundant Juncus seeds. Occasional Potamogeton seeds. Wood remains throughout, mostly Betula, with large piece of Frangula alnus at 200-206cm and Salix at 245cm.
266 - 271cm	Transition zone of darker highly humified material with some inorganic matter. Monocotyledonous remains and Juncus seeds.
271cm	Boundary to stiff grey clay, fine-grained but with small gravel fragments. Very little organic matter.

Samples for pollen analysis were taken at 2cm intervals for the top 2m of the profile and below this at 5cm intervals, except for the bottom 15cm where a closer sampling interval was used again.

The level of the ground in the large clearing created by fire was seen to be a metre or so higher than that of the area under the trees. At the edge of the clearing is a peat face exposed by peat cutting early this century,according to local inhabitants. It was thought that this peat cutting might have been responsible for the removal of some of the peat from the centre of the site, accounting for the difference in level of the ground. Consequently, the profile described above may be truncated. In order to ensure that the top part of the peat was sampled, a series of samples was taken from the exposed peat face in the clearing, and the stratigraphy is described below:

Surface vegetation: _Nardus_, _Festuca_, _Molinia_ and _Myrica_.

0 - 18cm	Surface vegetation and roots.
18 - 36cm	Very dark brown well humified peat with many roots and remains of monocotyledons and _Sphagnum_.
36 - 48cm	Slightly lighter brown peat with monocotyledonous remains and roots and a few mineral fragments.
48 - 55cm	Darker band of _Eriophorum_ peat.
55 - 72cm	Mid-brown monocotyledonous peat.
72 - 124cm	Darker peat with monocotyledons, _Eriophorum_ and _Sphagnum_.
124cm downwards:	Lighter brown wood peat with massive chunks of _Betula_.

A comparison of these two profiles reveals several significant differences between them. Firstly, the depth of the litter layer is much greater under the grass in the clearing than under the plantation trees. This may simply reflect the differences between the two vegetation types, as much of the top 18cm of the profile in the clearing consisted of living vegetation - a tangled mass of grass stems and roots. Beneath this surface layer in both profiles is a layer of dark brown, well humified peat containing remains of monocotyledons and _Sphagnum_. In the site in the clearing this layer is 18cm deep, but at the site in the plantation it is only 7cm deep. Beneath this darker layer at both sites is a layer of lighter peat which is less well humified. This layer contains less *Sphagnum* than the layer above, but the main difference between the two is the degree of humification, which might indicate a change in environmental or local hydroseral conditions. If so, it would be reasonable to correlate this boundary on the two profiles, and if this were done it would indicate that the darker peat above was some 11cm deeper at the site in the clearing.

Bands of *Eriophorum*, *Sphagnum*, etc. obviously cannot be correlated between two sites 75m apart. The only other boundary in the stratigraphy which it may be possible to correlate is the top of the wood peat, which is very marked at the site in the clearing at a depth of 124cm, i.e. 88cm below the boundary between the darker and lighter peat. At the site in the plantation this boundary is less well marked, but the first wood remains in the profile are encountered at a depth of 100cm, i.e. 89cm below the other boundary. As the correspondence between the depth of the intervening peat at the two sites is so close, it would seem to confirm the correlation proposed above, but the two profiles cannot be correlated conclusively until the pollen diagrams have been compared.

5.3.2 The pollen diagrams. (Figures 45 and 46).

The pollen diagram from the main site in the wood will be considered first. Here, as at Moss Slack, the pollen spectrum is bound to have been influenced by the presence of woodland on the site itself, and we might

GALE FIELD. POLLEN DIAGRAM FROM SITE IN PLANTATION.

expect to find over-representation of this arboreal pollen. The wood remains start to die out in the stratigraphy at c. 1m and at this point a sudden decrease in arboreal pollen is seen on the total pollen diagram, which probably represents the clearing of this local woodland.

Dealing firstly with the period before this woodland was cleared, we can distinguish three main zones on the pollen diagram. The first is from the bottom of the diagram to c. 255cm, when arboreal pollen is between 50% and 65% of the total, with shrub pollen contributing c.30%. The woodland is dominated by Quercus and Alnus, with a notable amount of Pinus, and Ulmus and Tilia as important constituents. The high shrub pollen is almost all Coryloid. Non-arboreal pollen contributes less than 10% of the total, but there are significant amounts of Gramineae, Cyperaceae and Plantago lanceolata, with Calluna, Plantago major/media, Filipendula, Potentilla, Rosaceae, Ranunculaceae, Stellaria holostea, Melampyrum, Pteridium et al., which suggests a considerable amount of open ground, although perhaps not very close to the site itself. High values for Polypodium and Filicales at the bottom of the diagram probably represent local vegetation colonising the site itself. (This zone is labelled Zone C on the diagram, fig. 45.)

The second zone, from c.255cm to 200cm and labelled D on figure 45, sees an increase in arboreal pollen at the expense of shrub and non-arboreal pollen. The dominance of Quercus and Alnus among the trees is reduced and Betula plays a much more important part with Fraxinus coming in too. Although Coryloid declines, Salix appears and other shrubs, viz. Ilex, Hedera, Lonicera and Frangula. High values for Filicales and Polypodium reflect the woodland conditions still predominating in the local vegetation. A decrease is seen in non-arboreal pollen, on the other hand, clearly visible in the curves for Calluna, Gramineae, Cyperaceae, Plantago lanceolata and Pteridium spores. Most of the species noted in the first zone are recorded, but in smaller amounts.

At c. 200cm the arboreal and shrub pollen curves begin to decrease and the percentage of non-arboreal pollen rises to over 20% of the total pollen. This decrease in the canopy is seen most clearly in the Tilia curve and to a lesser extent in that for Ulmus. Fraxinus and the shrubs all expand, taking advantage of the increased light, and Fagus appears in the local woodland. A corresponding decrease is noted for Filicales, although Polypodium values stay much the same. Meanwhile, an increase is seen in the herbaceous pollen, particularly in Gramineae, Cyperaceae and Plantago lanceolata and more slowly in Calluna. Occasional grains of Cerealia are encountered and records for other non-arboreal species become more common, e.g. Plantago major/media, Rumex spp., Filipendula, Potentilla, Artemisia, Compositae, Umbelliferae, Chenopodiaceae, Cruciferae, Rubiaceae, Ranunculaceae, Succisa, Melampyrum and Urtica.

This picture is maintained until c. 130cm, when the curves for Gramineae, Cyperaceae and Plantago lanceolata show a decrease and records for other herbs also become less frequent, e.g. Rumex spp., Potentilla, Ranunculaceae. Temporary increases in arboreal species correspond to this, especially for Ulmus, Tilia, Alnus and Betula. This temporary regeneration of trees and shrubs lasts to c.100cm, when the woodland in the immediate vicinity of the site begins to disappear. This led to the reception of more regional pollen at the site, so that a very marked decrease is noted in trees such as Betula, Quercus, Alnus and Tilia, while a big increase is seen in heath species, together with Gramineae, Cerealia, Cyperaceae, Plantago lanceolata, Pteridium and Equisetum. Records for other herbaceous species become much more frequent, e.g. Rumex spp., Filipendula, Potentilla, Artemisia, Compositae, Umbelliferae, Chenopodiaceae and Ranunculaceae.

By c. 79cm, the trees have recovered somewhat and arboreal pollen has reached 20% again, but it never rises above this hereafter. Fagus takes the opportunity to expand, but Tilia does not return. Shrubs also make a comeback and values for Salix and Coryloid are only slightly lower than in the third zone. Meanwhile, a decrease in non-arboreal pollen is observed, seen in the curves for Plantago lanceolata, Pteridium spores, Compositae, Potentilla, Rumex spp and heath plants. However, little change is observed in other herbaceous species and the continued records for a wide range of plants suggests that the regeneration of trees and shrubs was of only local significance. Equisetum, however, is high in this zone, perhaps indicating the increased area of abandoned clearings or representing a local increase in abundance of this plant.

Another decrease in the woodland is indicated at 45cm, and arboreal pollen values decrease to under 10% again. This situation obtains until the top of the profile, but the surface sample is seen to be rather different. As might be expected, it contains a high percentage of Pinus and Picea pollen (22% and 14% respectively), and it also has much lower values for Coryloid, heath species,

Figure 46.

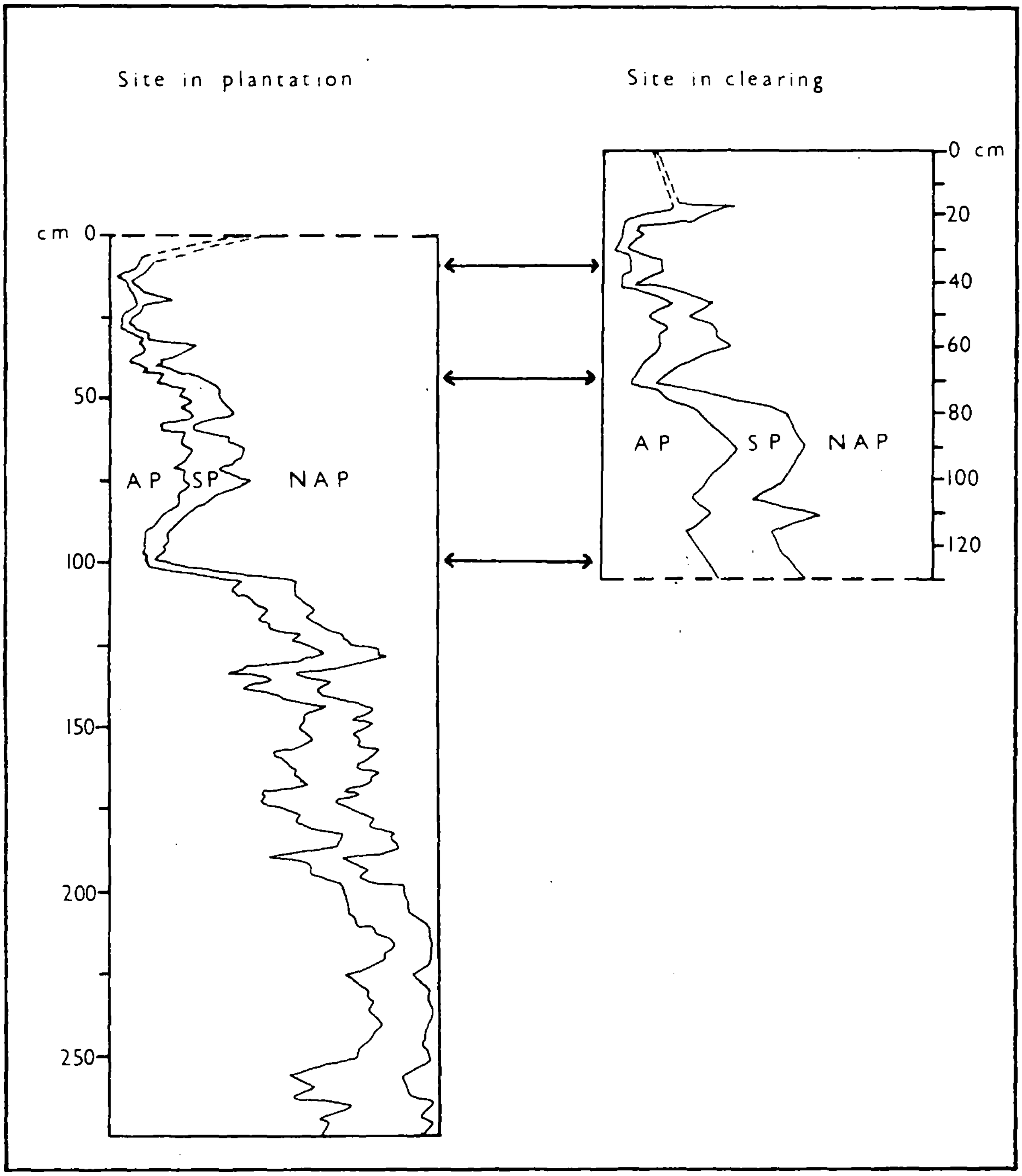
GALE FIELD.   POLLEN DIAGRAM FROM SITE IN CLEARING.

Cerealia and *Cyperaceae* than the sample from 8cm. It has already been suggested that the top part of this profile might be missing, so we must now turn to the profile from the clearing to test this hypothesis.

On this diagram (Fig. 46), the arboreal pollen values are over 25% until 70cm and shrub pollen values are over 20%. These values are lower than those which were observed on the main diagram prior to the major clearance of woodland starting at 1m, but are more in keeping with the values observed for the fifth zone (79 - 45cm). Between 80cm and 70cm an increase in non-arboreal pollen is seen and from here to c. 20cm the situation is similar to that seen in the sixth zone on the main diagram. If this change at c. 70cm is correlated with that seen on the longer one at 45cm, the amount of peat which has accumulated after this boundary in the profile from the clearing is 52cm, as compared with 41cm at the site in the wood, a difference of some 11cm.

If we return to the stratigraphy which was dis--cussed at the beginning of this section, it will be recalled that by correlating the top of the wood peat and the change in humification on both profiles there was an estimated 11cm more peat at the top of the deposit at the site in the clearing. Therefore, there seems to be good evidence from both the stratigraphy and the pollen diagrams for correlating these two profiles in such a way that the top 11cm of the profile in the clearing are missing from the profile in the wood, presumably because of peat cutting before the plantation was made (see Figure 47).

Correlation of the total pollen diagrams from the two Gale Field sites.



To complete our picture of the vegetation changes from the profile in the wood it is necessary to look at the top 11cm of the peat from the profile in the clearing. (N.B. This is not including the litter layer, so the total depth from the surface is 29cm.) Within this section of the peat the arboreal pollen increases steadily from 3.8% at 30cm to 21% at 15cm. It is slightly lower (15%) in the surface sample from this site. The shrub pollen increases up to 17cm but then decreases again to 3% in the sample from 15cm and is only 0.9% in the surface samples. Thus a gradual increase in woodland and shrubs is indicated reaching levels similar to those observed before 70cm on this diagram (45cm on the other one). Most of the tree species are involved in this increase, including Betula, Quercus, Alnus and Pinus, which increases dramatically in the sample from 15cm and remains high in the surface sample. The increase from 1.5% at 17cm to 15% at 15cm is so sudden that it must represent the first flowering of the trees planted on the site itself in the 1920's. However, this sample was from the bottom of the modern litter layer and it is possible that Pinus pollen has been washed down from the surface to this level. The amount of Pinus pollen in the surface sample is considerably less than in that for 15cm, which might indicate down-washing and accumulation of pollen. The 17cm sample, just at the boundary between peat and litter, does not seem to have been affected and appears to follow on smoothly from the 20cm sample.

There are several differences between the pollen spectra of the 17cm sample and the surface sample. Apart from the increase in Pinus and addition of Picea pollen in the surface sample, there is less Alnus, Coryloid and Calluna. This is probably because of the filtering effect of the surrounding plantation at the present day. (This point will be discussed in more detail in Chapter 9). The decrease in Cyperaceae may be accounted for by the drying out of the ground since planting, while the bulk of the Gramineae pollen is probably coming from the clearing itself. Other herbaceuus species probably originate in the cultivated fields around the site or on the waste land which is not planted in the next field, e.g. Rumex spp., Rubiaceae, Hypericum, Urtica and Vicia. The decrease in the diversity of non-arboreal species from 17cm to the surface sample suggests that most of this herb pollen is very local and again emphasises the filtering effect of the woodland canopy. It must be noted, however, that Elgee (1912) described the surface as quite dry, which suggests that the peat had stopped growing by the time that the site was afforested.

5.4 May Moss.

5.4.1 Profile details.

A core of peat 6.4m long was taken from the deepest part of the site as revealed by the field stratigraphy, (vide supra, 4.4.3). Details of this profile are shown overleaf:

Surface vegetation:	*Eriophorum vaginatum*, *Calluna vulgaris*, *Nardus stricta*, *Erica tetralix*,
0 - 5cm	Black, oxidised remains of surface vegetation.
5 - 13cm	*Sphagnum* peat, mostly consisting of *S.papillosum*, with remains of grasses and *Eriophorum*.
13 - 36cm	*Eriophorum* and *Sphagnum* peat.
36 - 47cm	*Sphagnum* band (*S.papillosum*) with *Calluna* remains.
47 - 150cm	*Eriophorum* and *Sphagnum* peat with a few remains of other grasses and sedges and *Calluna*. Carbonised plant fragments - burning? Very fresh, hardly humified, except for slightly more humified layers around 60cm, 120cm.
150 - 193cm	Very fresh *Sphagnum* peat, mostly *S.papillosum* with some *S.subsecundum*.
193 - 220cm	*Sphagnum* and monocotyledonous peat with *Eriophorum*. More humified than above and with carbonised plant fragments.
220 - 230cm	Monocotyledonuus peat, mostly composed of *Eriophorum* remains with occasional *Sphagnum*.
230 - 280cm	Poorly preserved monocotyledonous peat with abundant *Eriophorum* remains and much charcoal.
280 - 340cm	As above, plus occasional *Sphagnum*.
340 - 528cm	Monocotyledonous peat and charcoal. *Eriophorum* fibres at 490cm. Becoming more humified with depth.
528 - 534cm	As above, plus *Sphagnum*.
534 - 600cm	Monocotyledonous peat with a little charcoal.

Although the underlying weathered sandstone had not been picked up in the sample chamber, it was not possible to penetrate any further with the borer at this point. So another site was used, a few metres away, to collect the bottom samples, the stratigraphy of which is given below:

600 - 627.5cm	Dark chocolate brown monocotyledonous peat, almost completely humified, with a few pieces of charcoal.
627.5 - 638.5cm	Detrital deposit of well humified monocotyledonous remains and woody fragments, with occasional charcoal. Many *Juncus* seeds.
638.5cm	Sharp boundary to yellow weathered sandstone with few organic remains.

Figure 48.

MAY MOSS. POLLEN DIAGRAM.

Samples were prepared for pollen analysis at 10cm intervals from the first core and at closer intervals from the shorter basal core.

5.4.2 The pollen diagram.

The pollen diagram from May Moss is thus in two parts. These two diagrams have been adjoined in Figure 48, the break at 6m being indicated by the dashed line on the total pollen diagram. In fact, overlapping samples were counted down to 610cm on the main profile and up to 590cm on the basal sample and the two sets of count-sheets were compared to find the point where they corresponded most closely. This was found to be at c. 600cm on both profiles.

It may be convenient to start by considering the basal part of the combined diagram, below 600cm. From the total pollen diagram a 3-fold pattern is evident. Firstly, there is a period in the bottom few cm where non-arboreal pollen is c.40% of the total and shrub pollen is 30% - 40%. Then after 634cm there is a period when the shrub pollen expands dramatically to reach and maintain levels of between 60% and 74% of the total pollen, while arboreal pollen expands slightly and non-arboreal pollen is reduced to less than 5%. Thirdly, at c 605cm a change is noticed at the top of this basal section where the non-arboreal pollen increases again and the shrub pollen is reduced to under 50%. We may consider these three periods in more detail.

In the basal few cm of the deposit (spanning the peat-substratum boundary) there appear to be three main elements in the pollen. Firstly there are the local plants colonising the site itself, including several aquatics, vix. Sphagnum, Potamogeton,and ferns (Filicales, Polypodium, Lycopodium) and plants of damp habitats, e.g. Equisetum, Filipendula and Succisa. Secondly there are other herbaceous plants on the drier parts fairly close to the site, e.g. Melampyrum, Epilobium, Centaurea nigra, Lychnis, Artemisia, Potentilla and members of the Cruciferae, Rosaceae, Umbelliferae and Compositae families. Also within this category come the considerable values recorded for Gramineae and Cyperaceae, and the significant percentages of Calluna and other Ericales. In particular, a large number of grains of Erica tetralix type were found in this part of the diagram. From the evidence of this pollen it seems that there were a considerable number of open habitats available at the time when the peat started to accumulate.

The third element in the pollen record in the bottom few cm of the diagram is the regional pollen, which cannot have been derived from the site itself. This includes most of the arboreal pollen, as wood remains are scanty in the stratigraphy. There are, however, a few wood fragments in this part of the profile and trees like Betula and Salix may have been growing on the edges of the accumulating peat. Salix values reach 4.5% at 639.5cm and Betula values reach 21.4% at the same level. The rest of the arboreal pollen is presumably coming from further afield, consisting chiefly of Pinus with a little Quercus (less than 1%) and a trace of Ulmus. Coryloid values are under 50% but rising.

The second period in this basal section, from 634- 605cm, is a period of stability of the pollen curves. This period is dominated by shrub pollen, with Coryloid as its chief constituent, reaching 73% at 615cm. Salix values, by contrast, have dropped to less than 1%. The Coryloid peak is accompanied by a peak of Hedera. The tree pollen is still dominated by Betula and Pinus, but with increasing amounts of Ulmus and Quercus from 620cm onwards. Alnus makes its first appearance and begins to rise slowly. There is a proportional decrease in non-arboreal pollen so that low peaks are seen in Ericaceae, Gramineae and Cyperaceae, and the other herbs have also decreased since the first zone. Filicales, Sphagnum and Equisetum all decrease, probably because other plants have taken over their places in the succession as part of the normal hydroseral development. Thus it seems that a change has occurred in both the local and the regional vegetation from the first zone. Locally, the pioneer species which colonised the wet hollows have been replaced by others as the peat developes, and regionally the trees of the Quercetum Mixtum are beginning to assert their dominance, thereby decreasing the number of open habitats available for herbaceous plants.

In the top few cm of the basal diagram this latter trend is accentuated by the further increase of Quercus, Ulmus and particularly by the rapid rise of Alnus. Tilia is just beginning to appear in the pollen spectrum and Pinus is beginning its decline. Salix values become very low and a decrease is noted in Betula also, as these pioneer trees give way to the "climax" species of the Quercetum Mixtum. Coryloid values are still high (as indeed they are throughout almost all of the diagram) but are significantly lower than in the preceeding zone, indicating the relative decrease in the importance of this species as the forest closes in.

Polypodium begins to rise in this zone, presumably taking advantage of the woodland habitat, and Pteridium reaches a peak at the top of the second zone and in this third zone. After this it decreases again as the woodland area expands, so its peak may indicate a temporary flourishing at the woodland edge. As the woodland closed in, the "edge" habitat would be diminished. As in the second zone, most of the herbs which were so important in the first zone have disappeared. However, a significant increase is seen in the curves for Calluna, Ericaceae, Gramineae and Cyperaceae, although the last two do not reach high values. From here onwards the Calluna and Ericaceae curves are important constituents of the pollen spectrum and it is obvious that there were considerable areas of open ground occupied by these plants. So, although the closing in of the Quercetum Mixtum is clearly seen on the pollen diagram, it seems that there were still areas of open ground, probably quite close to the site itself.

On the pollen evidence presented above, the bottom few cm of the basal sample are assigned to the end of Zone V of the Godwin scheme. The second period, from 634cm to 605cm, is assigned to Zone VIa and b. It is not thought advisable to try and subdivide this section although it may be noted that the rise of Ulmus preceeds that of Quercus, as it does in southern England. From 605cm to the top of the basal sample is assigned to VIc, when Alnus values exceed 1% of total pollen. Therefore, the Boreal/Atlantic Transition comes at about the junction of the two profiles and thus can be placed only tentatively. However, it seems likely that this was a gradual change, and if the rise of Alnus is interpreted as a response to it, the change must have started in Zone VIc, so the actual place where the line is drawn is only an approximate one.

Considering from now on the longer profile, we may draw the boundaries of Zone VIIa at the bottom of the profile and at 490cm. This zone represents the "Atlantic" period, the climatic optimum of the Post-glacial and the maximum extension of the climatic climax vegetation, the Quercetum Mixtum. The woodland is dominated by Quercus and Alnus, with Ulmus and Tilia as important constituents and Betula colonising any clearings in the woods. Pinus declines slowly, but throughout this zone it is still present in significant amounts. A new arrival is Fraxinus, which is only recorded sporadically and in small amounts. Corylus declines gradually throughout the zone, but is still an important species, presumably as an understorey in the woods. As before, the Calluna and Ericaceae curves suggest some more open vegetation, probably of an acid heath type and possibly near the site itself. Occasional records for Drosera tie in with this. Values for Gramineae and Cyperaceae are relatively low and again this pollen is probably coming from close to the site itself, as the stratigraphy is composed of monocotyledonous remains with occasional Sphagnum bands. The curve for Sphagnum spores does not show any correspondence with the occurrence of these bands, but is slowly declining for most of this zone, although increasing again near the top. Filicales values are relatively high, as are those of Polypodium.

both taking advantage of the woodland habitat. Pteridium values, as was noted above, are lower than in the previous zone.

The only notable herbaceous species are occasional records for Filipendula, Rosaceae and Chenopodiaceae, and altogether the non-arboreal pollen is at its lowest on the whole of this main profile. This period must represent the maximum extension of woodland in the area, but the pollen evidence does not suggest a closed canopy over this site. It seems probable that there were considerable areas of open ground, probably with a heath vegetation, and it is interesting to note that Cundill (1971) also concluded that a closed canopy woodland did not extend over the higher parts of the watershed in the Post-glacial period.

The Zone VIIa/b boundary may safely be drawn at 490cm, as the Ulmus decline is clearer on this diagram than on that from Fen Bogs. It is accompanied by a temporary decline of Tilia and the first record of Plantago lanceolata. A slight rise of Coryloid presumably represents an expansion of the shrub into such clearings as may have been created, and Pteridium also increases steadily throughout the succeeding zone (A on Figure 48) taking advantage of the expansion of the woodland edge. However, it is interesting to note that Betula shows no such tendency and behaves rather as a forest tree, declining and then recovering again. There is no significant effect on the Quercus or Alnus curves and the Pinus curve continues its gradual decline. The curves for Filicales and Polypodium both reflect the woodland curve at this point.

On the total pollen diagram a period of relative stability follows the Ulmus decline to c.400cm, when a sustained increase in non-arboreal pollen is apparent. The intervening Zone A is one of very low herbaceous pollen. Coryloid values are high, but the pollen spectrum is still dominated by the arboreal pollen, with high Quercus, Alnus and Betula and values for Ulmus and Tilia recovering fairly quickly from the initial decline and then gradually decreasing again. This zone seems to show some temporary opening up of the Quercetum Mixtum, but no long-term vegetational change is suggested.

At c.400cm on the total pollen diagram an expansion of non-arboreal pollen reduces the shrub pollen to 17% and the arboreal pollen to 19%, bringing the non-arboreal pollen to over 50% of the total for the first time. Decreases are seen in the curves for all the main trees, being especially marked for Tilia and Pinus and a slight decrease in Corylus is observed also. These arboreal and shrub pollen levels are maintained, with minor fluctuations, until c. 270cm. The intervening zone is one in which herbaceous species are more important than before, with frequent records for Filipendula, Artemisia and Chenopodiaceae and occasional records for Plantago major/media, Rumex spp., Potentilla, Rosaceae, Compositae, Ranunculaceae, Umbelliferae and Urtica. The most notable change is in the curve for Plantago lanceolata, which rises rapidly to 1-2% of total pollen. Gramineae are at significantly higher values than in the preceeding zone, as Calluna is, but Ericaceae suffer a marked decline, the reason for which is not clear. Cyperaceae also increase substantially during this zone, so that it is clear that many new habitats for herbaceous species are being created. However, the continuing importance of the woodland is shown by the curves for Filicales and Polypodium, and a major clearance of the forest is not suggested by the pollen spectra. Rather the picture is one of temporary clearings in the woodland increasing in number of providing a greater diversity of habitat. Three main types of plant community are suggested: the woodland community ; an open herbaceous community, including the vegetation of the site itself; and a community at the woodland edge which fluctuates with the advances and retreats of the first-named community.

At c. 270cm a major change is clear from the total pollen diagram. A large-scale increase in non-arboreal pollen reaches a peak at c.250cm, when it comprises 70.2% of the total pollen, and then gradually declines again to 38.7% at 190cm. The pattern of this expansion and decline is followed by the curves for Plantago lanceolata and Rumex spp. and also by those for Artemisia, Plantago major/media and Filipendula, whilst other species which become important include Compositae, Umbelliferae, Chenopodiaceae, Cruciferae, Ranunculaceae and Urtica. The occurrence of cereal pollen from this zone onwards must be noted. Gramineae values are very high and also those for Cyperaceae and Calluna, and Equisetum expands rapidly.

Clearly, this zone saw a great expansion of the herbaceous community mentioned above. The woodland community was not doing so well and Tilia virtually dies out in this zone while Ulmus declines, as do Quercus and Alnus. This decline in the main trees of the Quercetum

Mixtum is mirrored by a decline in Filicales, Polypodium and Hedera. However, other species increase, notably Betula and Fraxinus, probably taking advantage of the extra light, while Fagus and Carpinus appear on the pollen diagram in significant amounts for the first time. Salix and Coryloid both expand, as is reflected in the increased width of the shrub pollen band on the total pollen diagram. Mercurialis reaches a peak and is probably taking advantage of the increased light on the forest floor. Pteridium expands at the beginning and end of the zone, and again it is thought that this is in response to the temporary extension of the woodland edge habitat at times of rapid advance and retreat of the forest.

From 190cm to 80cm a decrease in non-arboreal pollen is seen on the total pollen diagram, and significantly lower values are recorded for Gramineae, Calluna and Cyperaceae. Plantago lanceolata also declines as do species such as Ranunculaceae, Cruciferae, Chenopodiaceae and Potentilla. Others, however, increase, e.g. Artemisia, Centaurea cyanus, Centaurea nigra, Compositae, Umbelliferae, Rumex spp. and Cerealia. Thus this zone is one of reduced but still high herb pollen. A corresponding increase is observed in the arboreal pollen, notably for Quercus, Ulmus, Alnus and Fagus. Although Fagus seems to have first got a foothold in the woodland when clearings opened up the canopy, it seems to have behaved in a similar manner to the other forest trees once established.

As well as the increase in arboreal pollen, shrubs expand during this zone and increases are recorded for Salix and Coryloid. Pteridium expands and also Filicales, and these may be colonising habitats at the woodland edge.

Thus this zone sees a relative decrease in herbs and a resurgence of trees and especially shrubs and plants of the woodland edge community.

From c. 80cm to c. 30cm a short but notable increase in non-arboreal pollen is seen, with a corresponding decrease of trees (to 12%) and shrubs (to 7%). This is most clearly seen on the Ulmus curve, which seems to be very sensitive, and also on those for Betula, Quercus, Alnus, Fagus, Salix and Coryloid. Herbs show a marked increase, especially Cyperaceae, Cerealia and Ericaceae, but the Gramineae curve stays fairly stable. Ruderals increase, especially Plantago lanceolata, Rumex spp., Compositae, Chenopodiaceae, Cruciferae, Ranunculaceae and Urtica. Equisetum expands rapidly. There is some slight evidence for an increase in wet habitats provided by occasional records for Potamogeton and Typha spp.

The top two zones distinguished on this diagram are very short. From 30cm to 20cm a short but important regeneration of tree and shrub pollen is seen, reflected in the curves for Betula, Quercus, Ulmus, Salix and Coryloid. A corresponding low peak is seen in the curves for several herbaceous species, including Gramineae, Cyperaceae, Plantago lanceolata, Rumex spp., Artemisia and Ranunculaceae. This zone is marked Zone F on Figure 48.

This is followed by a zone from 20cm to the top of the diagram when herbaceous species expand again, as seen in the curves for Calluna, Gramineae, Rumex spp., Potentilla, Rubiaceae, Artemisia, Centaurea cyanus, Chenopodiaceae, Cruciferae, Ranunculaceae, Urtica et al. It must be noted, however, that this top zone (G on the diagram) is only represented by three samples, one from the surface, and some of the curves (e.g. Plantago lanceolata) show considerable fluctuations. It is partly on the basis of correlation with other sites, especially Fen Bogs, that Zones F and G have been separated.

5.5 Simon Howe Moss.

5.5.1 Profile details.

Samples for pollen analysis were taken from near the southern end of the site. The stratigraphy of the profile is given below:

Surface vegetation:	Polytrichum and Hypnum spp. colonising bare ground.
0 - 2cm	Dark, oxidised remains of surface vegetation. Sphagnum and Eriophorum remains and charcoal.
2 - 24cm	Mid-brown Eriophorum peat with remains of other monocotyledons and occasional Sphagnum.
24 - 92cm	Lighter-coloured Sphagnum and Eriophorum peat. Remains of other monocotyledons and Juncus seeds.
92 - 121cm	Monocotyledonous peat with abundant Eriophorum remains. Darker colour than above. Charcoal (?) at 107cm. Occasional Sphagnum.
121 - 141cm	c.f. 24 - 92cm.
141 - 162cm	Sphagnum peat with well-humified remains of Eriophorum and other monocotyledons.
162 - 258cm	Monocotyledonous peat with Eriophorum remains and Phragmites.
258 - 270cm	As above, plus Sphagnum.
270 - 288.5cm	As 162 - 258cm. Compact, well-humified.
288.5 - 309cm	Greyish deposit with some inorganic material. Fragment of wood at 297cm.
309 - 323.5cm	Slightly darker, more peaty deposit with less inorganic material. Very compact.
323.5cm	Abrupt boundary to stiff blue-grey clay with iron-staining. Borer on rock at 346cm.

Figure 49.

SIMON HOWE MOSS. POLLEN DIAGRAM.

5.5.2 <u>The pollen diagram</u>. (Fig. 49)

The pollen diagram from Simon Howe Moss is only half as long as that from May Moss, although they are from sites in similar situations. It spans a much shorter time period, as can be seen from the bottom of the diagram. When the peat started to form at Simon Howe Moss the <u>Quercetum Mixtum</u> was obviously well established, as substantial values are indicated for its constituents, in particular for <u>Tilia</u>. We may take the bottom part of the diagram as the first zone, from the base to c. 277cm. From the total pollen diagram it is apparent that arboreal pollen is very important in this zone, varying from 25% to 74% of total pollen. In the bottom two samples <u>Pinus</u> is very high, reaching 58% of the total pollen in the bottom sample (307cm). From 297cm to 277cm it is fairly steady at 3% - 6%.

The trees of the <u>Quercetum Mixtum</u> are dominant in all but the bottom two samples, with <u>Alnus</u> being particularly important. <u>Coryloid</u> values are high (7%-19%). The sample from 302cm has 2.8% <u>Salix</u> pollen. Values for <u>Gramineae</u> and <u>Cyperaceae</u> are relatively low but rising throughout the zone and there are many records of herbaceous species, e.g. <u>Filipendula</u>, <u>Rosaceae</u>, <u>Artemisia</u>, <u>Compositae</u>, <u>Rubiaceae</u> and <u>Caryophyllaceae</u>. <u>Scrophularia</u> type is recorded and could have been growing in the woods. However, the ruderals such as <u>Plantago lanceolata</u> and <u>Rumex</u> only just appear in the top of this zone.

It would appear, therefore, that this bottom zone represents a period when the woodland was well established and had some clearings in it. The bottom two samples are difficult to interpret because of the dominance of Pinus pollen. It is possible that these samples are much older than the ones above them, as both were in the part of the profile which had a fair amount of inorganic material in it, and there may have been a hiatus between this and the formation of the peat above it. Alternatively, Pinus could represent a local pollen source, as Pinus may have continued to grow in the higher areas after it had been succeeded at lower sites by the thermophilous trees. The woodland is accompanied by high values for Polypodium and Filicales, although these could represent local vegetation colonising the site itself. Pteridium is at its highest values during the whole profile and probably occupied a niche at the woodland edge. Indeed, the upper limit of woodland may have been near the site, as there is no evidence from the field stratigraphy to suggest that the highest areas were actually covered with closed canopy woodland. If so, many of the Pteridium spores may be of local origin.

At c. 277cm, a very marked change is seen on the total pollen diagram and a massive expansion of non-arboreal pollen is indicated and a contraction of the arboreal pollen. Shrub pollen is negligible from here up to 187cm, the end of the zone (marked as Zone C on Figure 49). The main constituents of this great increase in non-arboreal pollen are Gramineae and Cyperaceae, along with Plantago lanceolata, Rumex spp., Filipendula, Rosaceae, Rubiaceae, Ranunculaceae, Succisa et al. Calluna actually declines, so the expansion was evidently not of heath plants, but rather of grasses and ruderals.

Most of the tree species decline, especially Pinus and Ulmus, while Tilia dies out altogether. Fraxinus, however, expands, taking advantage of the increased light. Pteridium values are lower than in the last zone, although still relatively high, and this might be because the woodland edge was now further away from the site. Filicales and Polypodium decline with the woodland, while Equisetum expands. Potamogeton values are high, but probably relate to site vegetation, although this does suggest that conditions became rather wetter.

At the end of this zone the trees expand again to 14% of total pollen. All the Quercetum Mixtum species are involved, except Tilia, and Fagus and Carpinus are included. Salix and Coryloid also recover, as the Calluna and Ericaceae curves do too. A corresponding decrease is observed in values for Gramineae and Cyperaceae and for Rumex spp., Filipendula, Potentilla, Rosaceae, Umbelliferae and Chenopodiaceae, although the Plantago lanceolata curve is slower to react. It seems that the woodland and woodland edge communities have regenerated quite significantly after their very low values in the preceeding zone. Scrophularia type expands again, as do Filicales and Polypodium, all presumably associated with the woodland community. An increase in Equisetum may reflect the expansion of the woodland edge community, but Pteridium values do not show any real recovery. It may be that Pteridium is more closely associated with the contraction of the woodland edge and the colonisation of the relatively rich soils developed under the woodland than with the re-expansion of woodland on to abandoned clearings.

An increase in Sphagnum values is probably related to local vegetation, as Sphagnum becomes significant in the field stratigraphy a little higher up in the profile. This could indicate a gradual increase in wetness, as it is accompanied by records for Menyanthes and Hydrocotyle, but Potamogeton and Typha angustifolia have died out. Cereal pollen is present in this zone in increasing amounts. There was one earlier record of its presence near the top of the second zone, indicating that it may have been present earlier, probably at some distance from the site.

Between 67cm and 37cm another expansion of non-arboreal pollen and contraction of arboreal and shrub pollen takes place. An increase is seen in Cerealia, Plantago lanceolata, Rumex spp., Rosaceae and Compositae, and Humulus/Cannabis type pollen is recorded. A corresponding decrease is seen in the curves for Pinus, Betula, Quercus, Ulmus and Alnus, although it is not a very marked change. From 37cm to 17cm is a short-lived but marked regeneration of these tree species, but a decrease in the curves for herbaceous species can only be seen in Ranunculaceae, Rumex spp., Rosaceae, Compositae and Humulus type. This slight regeneration is followed by another contraction of trees and shrubs from 17cm to the top of the diagram, particularly marked on the curves for Betula, Quercus and Coryloid, and this is accompanied by a decrease in Cyperaceae, but an increase in other herbaceous species, including Rumex spp., Umbelliferae, Chenopodiaceae and Ranunculaceae. Cereal pollen decreases, except in the sample from 2cm.

In view of the few samples involved, it is difficult to be sure of the validity of the top three zones. Throughout the three, ruderals and other herbaceous species remain high, indicating that there was a considerable amount of open ground. The *Calluna* curve reaches high values and is accompanied by *Ericaceae*. It seems probable that heathland vegetation was dominant in the immediate vicinity of the site and that whatever changes were happening to the woodland edge were some distance away and hardly show up on the pollen diagram.

CHAPTER SIX. DATING AND CORRELATION OF ZONES.

There are two main types of method available for dating pollen diagrams - absolute and relative. In the former case an independent scheme of dating is employed, such as radiocarbon dating, and dates are obtained for key points in the profile. Interpretation is based on these known points and interpolation between them. Relative dating methods depend on the comparison of several diagrams and the correlation of similar features between them. Some of these features are in turn correlated to events of known date.

Both absolute and relative dating are combined in this chapter to give a chronological basis for the forthcoming discussion section of the work. Three main methods of approach are employed:- firstly some absolute dates have been obtained for one site, Fen Bogs, and these are presented and their implications discussed. Secondly, sites are dated relatively by comparison with sites outside the study area. This has been done according to the scheme proposed by Godwin (1940 and 1956) of eight major zones for the Late- and Post-glacial periods in Britain. These zones have been dated by absolute methods at many sites so that a generalised time-scale can be applied to any pollen diagram with a fair degree of confidence. This only applies where these zones are easily recognisable, however, and this method is of most use for the two longest diagrams, Fen Bogs and May Moss.

The third method employed is that of relative dating by the correlation of zones between the five diagrams under examination. Although this method is the most important one here, it derives its validity ultimately from the other two methods of dating, the radiocarbon dates and the Godwin zoning scheme. These three methods complement one another and are all used in conjunction to produce the scheme of zoning which is adopted for the diagrams for the rest of the work. The three methods will be discussed separately now, starting with absolute dating, and then the zoning scheme will be introduced.

6.1 Absolute dating.

Fen Bogs has been used as the pivot site throughout the work and all the radiocarbon dates are for this site. The other sites can only be dated relatively, by correlation with Fen Bogs. It was decided to have all the dates from this one site because it was felt that a set of six dates would give a fairly complete picture of vegetation change over a long time span. To a certain extent the dates would confirm one another, at least as far as chronological order was concerned, and it would be possible to estimate approximate rates of peat accumulation and this would aid interpretation of the diagram between the dated points. Six dates scattered between the five sites, on the other hand, might help to solve specific problems of interpretation, but would not provide such a complete chronological framework and it would not be possible to check the dates against one another.

Fen Bogs was chosen as the site for the dating as it was the longest and most complete profile and it was thought to be a fairly regional diagram, without too great a proportion of local pollen. Only the period from the Ulmus decline onwards was dated, as the part played by changing patterns of land-use was of particular interest. Dates are given in radiocarbon years BP (1950). Recent research using alternative methods of absolute dating, especially dendrochronology, has suggested that the relationship between the age of the sample in radiocarbon years and its true age is more complicated than was thought previously. More accurate measurements now place the half-life of C-14 at 5730 ± 30 years, rather than 5568 years, as calculated by Libby. (Stuiver and Suess, 1966). This discrepancy is negligible, however, when compared with the variations in atmospheric C-14 caused by variations in cosmic radiation and sunspot activity. A complex pattern is revealed whereby occasionally samples of several different true ages may have the same radiocarbon age. Stuiver and Suess (1966) give conversion tables for the period since 1000 AD, and Suess (1967) gives them for the period 4100 - 1500 BC, which enable a more accurate but still only approximate estimate of the true age of samples to be made. This is particularly useful for later historical time, although for the earlier periods many of the dates for cultural eras and events will have to be amended to fit in with these new ideas.

Details of sampling methods for radiocarbon dating are given in Appendix 2. A date was obtained for the *Ulmus* decline at Fen Bogs, which may be compared with many similar dates from this and other areas. In fact, the date of 4720 ± 90 BP (= 2770 BC unaltered, which is probably between 3650 and 3500 BC, Suess 1967) is younger than most, the average being around 4950 BP (3000 BC unaltered, which is probably nearer 3750 BC). If the *Ulmus* decline is taken to indicate human activity it would suggest the late arrival or lack of activity of Neolithic man in this area, which is in agreement with what is known of the Neolithic culture on the Moors (vide supra, 3.1).

A second date was obtained for the *Tilia* decline, which again may be compared with dates for a similar horizon at many other sites (e.g. Turner, 1965) and may help in the interpretation of other diagrams from the same area (for instance, Simmons 1969 recognises this horizon on his diagrams from further west on the Moors). This point is also the boundary between Zones A and B on the diagram and the date of 3400± 90 BP (= 1450 BC unaltered, which is probably c. 1770 BC) places this boundary near the beginning of the Middle Bronze Age in this area, for which there are prolific remains, as noted in 3.1.

Hereafter, dates were used to delimit phases of expansion and contraction of the woodland edge, and these boundaries form the basis of the zonation adopted. The opening of the first major clearance (Zone C) is dated to 2280 ± 120 BP (= 330 BC unaltered, which is probably slightly too young), which suggests Iron Age activity. The close of this zone and the opening of the next one is dated at 1530 ± 130 BP (= 420 BC unaltered and is probably 50-100 years too old). This suggests, therefore, a long period of clearance lasting from the Iron Age through to the end of the Roman occupation. This zone is succeeded by a period of woodland regeneration, which comes to an end at the opening of Zone E, dated to 1060 ± 160 BP. This date of 890 AD unaltered is probably a little too old and a date somewhere in the mid-tenth century would probably be nearer to the true date. The end of the clearance phase of Zone E has the last radiocarbon date, of 390 ± 100 BP, which is probably older than the unaltered date of 1560 AD would suggest and nearer 1470 AD. Therefore, it seems that the second major clearance on the diagram (Zone E) lasted from somewhere in the Viking period through to the end of the Medieval period. The upper boundary of Zone F was at a depth of 30 cm and it was felt that this was rather near the surface for accurate dating, as there was a risk of contamination by modern roots. So the boundary between Zones F and G can only be placed somewhere between the end of the fifteenth century and the present day.

From these dates an approximate rate of peat growth can be gained. From the Ulmus decline to the Tilia decline, i.e. Zone A, the average rate of peat growth was 1cm in 9.4 C-14 years. In Zone B this speeded up consid--erably to 1cm in 5.3 C-14 years. In Zone C the rate slowed down slightly to 1cm in 6.8 C-14 years, but it was not until Zone D that it returned to its original rate of 1cm in 9.4 C-14 years. In Zone E the accumulation rate was much slower, 1cm in 13.4 C-14 years, but in Zones F and G it speeded up to 1cm in 6.5 C-14 years.

This last rate may be inaccurate, as the lack of compression near the surface may give a false impression of faster peat accumulation than in the layers below. The possible reasons for these variations in growth rate will be discussed in detail in 7.1.

Thus the six radiocarbon dates give a set of absolute dates for the changes at one site and provide us with a firm chronological basis against which to set our correlations between sites.

6.2 Relative dating.

6.2.1 The Godwin scheme.

The second method of dating is that of correlation with the major climatic/vegetation zones delimited by Godwin (1940 and 1956). The first of these zones which is relevant is Zone V, to which the bases of the two longest profiles are assigned. In both cases the arboreal pollen is dominated by *Betula* and *Pinus* with only small amounts of *Quercus* and *Ulmus*. As at most sites in the north of England, *Betula* remains more important than *Pinus* throughout the zone. One of the definitive features of Zone V is the *Corylus* maximum, which is very marked on some diagrams, especially those from the north and west of England (e.g. Walker, 1965). It is not a very marked feature on either diagram from this area, as *Coryloid* values are high throughout most of the profiles, but values of over 70% of total pollen are reached at May Moss. At Fen Bogs, however, the maximum is 40%, a much lower figure.

The Zone V/VI boundary is drawn by Godwin at the point where the thermophilous trees start to expand

and replace the pioneer species. Betula is the first to suffer and Pinus actually increases to form the dominant species in Zone VI, the "Boreal". The V/VI boundary is generally dated to c 6800 BC. Erdtman (1927) has commented on the weakness of the Boreal Pinus maximum in this area. Values of 45% of total pollen at Fen Bogs and 17% at May Moss are the highest reached and these figures certainly do not show the marked dominance of Pinus seen in some other parts of the country. Oldfield (1965) has argued for a later Pinus maximum in the north and west of England than in the south and east, and if the maximum in this area was fairly late it would be at a time when the thermophilous trees were already well-established and therefore the impact of the Pinus maximum would be diminished. Bellamy et al (1966) also found a relatively low maximum for Pinus in Zone VI in the lower Tees basin, but Jones (1971) found Pinus comprising 80% of the tree pollen in Zone VI in Cleveland.

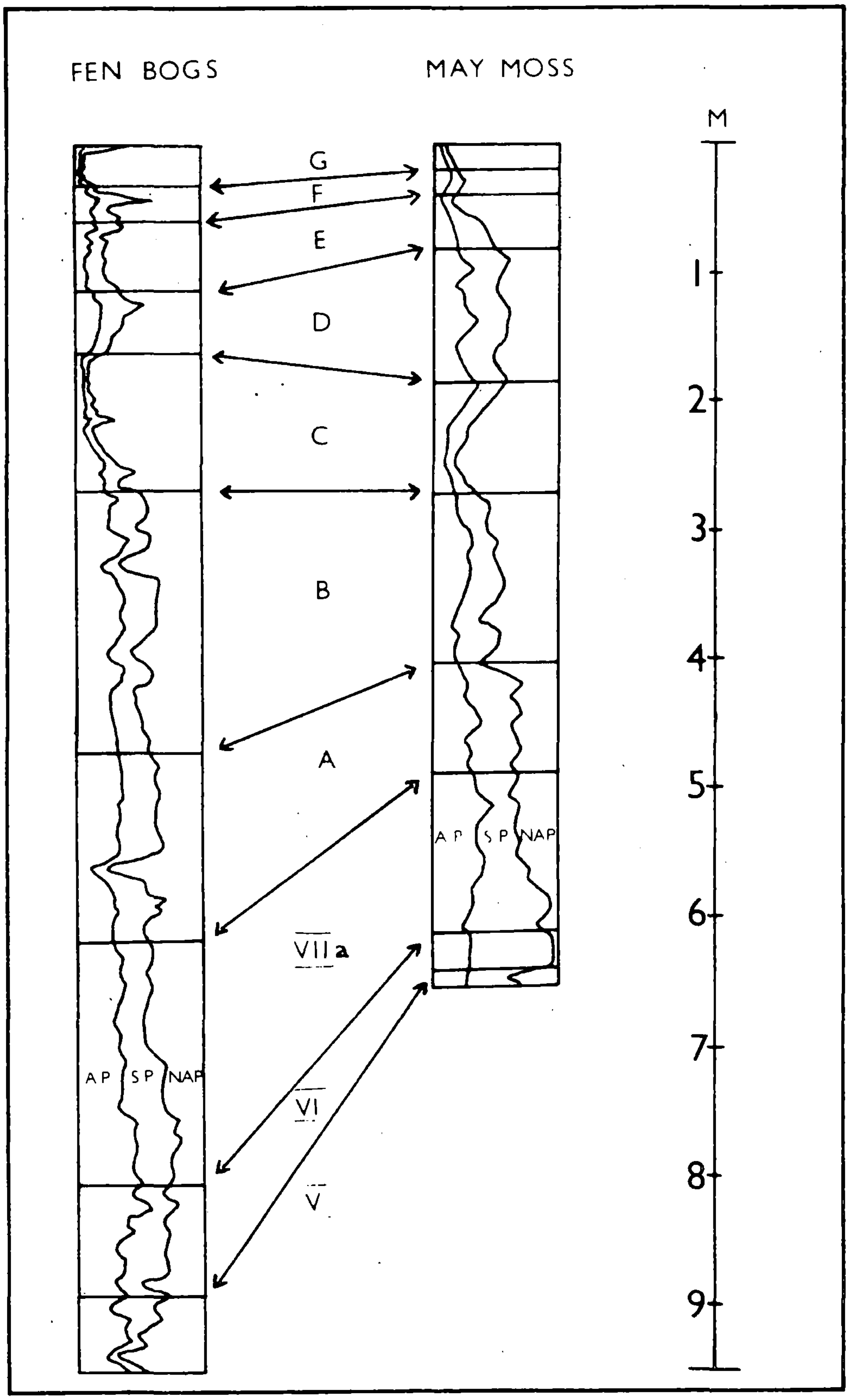
Zone VI has been subdivided in the south of England on the basis of the varying percentages of thermophilous trees. It is not proposed to attempt such a division here except to distinguish VIc on the basis of the Alnus curve, as described in 5.1 and 5.4 above. The VIc/VII boundary represents the Boreal-Atlantic Transition and C-14 dates for this span the centuries around 5500 to 5000 BC. Jones (1971) has a date of 6650 ± 290 BP for the Alnus maximum and Cundill (1971) has one of 6250 ± 220 BP from Glaisdale Moor. Both these dates are considerably later than those for the rest of the country and might be taken to indicate the later expansion of Alnus in this area. If we accept the more conventional date of c.5000 BC, this indicates that in the 1800 years or so spanned by Zone VI approximately 130cm of peat had accumulated at Fen Bogs and only 34cm at May Moss. This gives a slower rate of accumulation (1cm in 13.8 years) at Fen Bogs than was indicated by the C-14 dates for most of the later periods, and a very slow rate of 1cm in 53 years at May Moss. Thus, although there seemed to be a set of rapid changes at May Moss within the short basal sample, this is seen to represent a long period of time.

At both sites the forest in VIIa seems to be typical of the Quercetum Mixtum developed over most of the country at this time. The end of Zone VIIa is drawn by Godwin at the Ulmus decline, a feature seen in sites all over north-western Europe and which has aroused a great deal of controversy for many years. Dates from other sites seem to fall in the centuries around 3000 BC. Cundill (1971) has a date from St. Helena (685037) for just before the Ulmus decline of 5390 ± 220 BP (= 3440 BC unaltered). The date at Fen Bogs was 4720 ± 90 BP, which is rather late, but might be explained in terms of an anthropogenic change. If we accept this date, a total of 180cm of peat had formed at Fen Bogs in the 2230 years of VIIa and 110cm at May Moss. It appears, therefore, that the rate of accumulation at Fen Bogs has speeded up slightly to 1cm in 12.4 years, and at May Moss it has speeded up considerably to 1cm in 20.7 years. This might be taken to indicate an environmental change, but such interpretations must be made with caution, as variations in the rate of peat growth reflect primarily local conditions and cannot necessarily be correlated from one site to another.

Considerable variations are found between sites from Zone VIIb onwards and no typical pattern can usefully be described. In Godwin's scheme another boundary is identified falling at c.500 BC and corresponding with a change towards cooler,wetter conditions. Definitive features of Zone VIII include the presence of _Fagus_ and _Carpinus_ and the decline of _Tilia_. The validity of this boundary has been much in dispute for some time and many workers only recognise a combined Zone VIIb/VIII, e.g. Simmons, 1969. From the C-14 dates for the Fen Bogs diagram it can be seen that this boundary must fall somewhere about 3m down. _Fagus_ has been present for sometime before this, but at no point does it form a very substantial element in the vegetation. Thus it is thought to be a rather unreliable indicator. _Carpinus_ appears to be a better indicator, but the sporadic records for this species again make it unsatisfactory. _Tilia_ has declined long before this but remains in small amounts throughout the diagram. The possibilities of delimiting this boundary will be discussed in more detail in 7.1. Its usefulness for dating is very doubtful and far inferior to that of the C-14 dates.

So for the period prior to the _Ulmus_ decline relative dating can be used by correlation with the zoning scheme developed for other parts of the country. For the period from the Ulmus decline onwards there is a set of C-14 dates to provide the chronological background. Both these methods can be used for interpreting the diagram from Fen Bogs and the first can be used for the May Moss diagram also. For the other three diagrams, however, we must turn to the correlations with those from Fen Bogs and May Moss.

Correlation of total pollen diagrams from Fen Bogs and May Moss.



6.2.2 Correlation between the diagrams.

Having already correlated the lower parts of the diagrams from Fen Bogs and May Moss by applying the Godwin scheme, we may conveniently start by correlating the rest of these diagrams with each other. The total pollen diagrams have been correlated on figure 50. Zones up to the Ulmus decline have been denoted by their Godwin numbers and those after the Ulmus decline have been given a simple alphabetical sequence. A considerable degree of correlation is evident between the two diagrams. In both there is a zone following the Ulmus decline when arboreal pollen has decreased a little but a closed forest is still indicated. Non-arboreal pollen is generally low, but a series of minor expansions of the curves is seen in the diagram from May Moss and one larger one is observed at Fen Bogs. Temporary openings of the canopy are indicated, probably of a very local nature.

The Zone A/B boundary is placed at the first significant decline of Tilia. In Zone B on both diagrams the openings of the canopy are of increased importance and last somewhat longer than in Zone A. Fagus is first encountered in this zone. Shrubs are less important, especially at May Moss. At c.270cm on both diagrams a massive expansion of non-arboreal pollen and contraction of both arboreal and shrub pollen are noticed. On both diagrams, the openings of Zone C is one of the most noticeable features on the whole diagram. A further decline in the Tilia curve reduces it to minimal values at this point and a notable expansion of Fagus is observed.

Following this, Zone D sees some regeneration of trees and particularly of shrubs, while Zone E represents another phase of expansion of non-arboreal pollen, which is shorter and not so intense as that of Zone C. Then another regeneration phase follows at both sites, of about the same intensity as Zone D at Fen Bogs but less important at May Moss. Finally, the top zone on both diagrams represents another decrease of trees and shrubs, a trend which is continued in the surface sample at both sites.

These two sequences of events are so similar that it is proposed to correlate the zones between the two diagrams. If we do this and accept the C-14 dates for Fen Bogs as applying approximately to both diagrams, some remarks can be made about the relative rates of peat growth at the two sites. As already observed, May Moss gets off to a much slower start than Fen Bogs, and in Zone A the rate of peat growth is still almost twice as slow as that of Fen Bogs. Both sites seem to speed up in Zone B and then slow down again through the next two zones, but in Zone D the rate of growth at May Moss is much faster than that at Fen Bogs. This is rather difficult to explain unless we suppose that the D/E boundary is not synchronous at the two sites, i.e. that the opening of Zone E was earlier at Fen Bogs than at May Moss. Accumulation in Zone E is much slower than in D and averages 1cm in 13.4 years at both sites. The growth rate at May Moss is much the same in the top two zones, but it speeds up at Fen Bogs. As has already been noted, there may be an additional factor at Fen Bogs of lack of compression of the peat, which might cause the growth rate to seem faster near the top. At May

Moss, on the other hand, the surface layers of peat are much drier and seem more compressed, if anything, than the underlying layers, which might explain their relatively slow growth rate.

It may be best to consider the other diagram from an upland site next and to compare it with the May Moss diagram. The Simon Howe Moss diagram does not go back further than Zone VIIb. Values for Ulmus are low throughout the diagram, except right at the top and there is very little Tilia recorded. This is similar to the situation found by Cundill (1971) at his sites at Howdale Hill (646021) and Pike Hill Moss (758013).

A very marked expansion of non-arboreal pollen to over 90% of total pollen is seen at 277cm on the diagram. Such a large-scale and long-term change is indicated that the conclusion seems inescapable that this correlates with Zone C on the other diagrams. Tilia declines from nearly 1% at the bottom of the diagram to disappear temporarily, again reminiscent of the other two diagrams. Fagus, however, is not present at the bottom of the diagram, but does appear and expand in this zone.

It is probable that this represents the clearance of the woodland very close to the site, probably further down the Blawath Beck valley; but it is clear from both the pollen diagram and the field stratigraphy that there was never a closed canopy woodland over the site itself, and Fagus in particular may not have grown very close to the site. The close correspondence of the depth of this clearance at Simon Howe Moss and May Moss may reflect their similar situations and environmental conditions, but the fact that it occurs at the same depth at Fen Bogs too must be a remarkable coincidence.

At 187cm the arboreal pollen and shrub pollen expand again on the Simon Howe Moss diagram and remain fairly stable until 67cm, when they begin to decrease. This zone presumably corresponds to Zone D at May Moss. Another zone of high non-arboreal pollen from 67 to 37cm can be correlated with Zone E at May Moss and this is followed by a regeneration which can be correlated to Zone F and a short zone at the top which seems to fit with Zone G. If we accept these correlations, the amounts of peat which accumulated in Zones C to G at Simon Howe Moss and May Moss are shown below:

Zone.	Simon Howe Moss.	May Moss.
G F	37cm	30cm
E	30cm	50cm
D	120cm	110cm
C	90cm	80cm

There is a close degree of comparison between these two sites which have developed in broadly similar situations. As at May Moss, the only boundary at Simon Howe Moss which may not correlate with that at Fen Bogs is the D/E one. This would give a very fast rate of peat growth in Zone D, which seems unlikely.

Therefore, it is concluded that the diagrams from May Moss and Simon Howe Moss correlate closely with one another and with the diagram from Fen Bogs.

The two remaining sites are ones which were wooded for much of their history and where the local pollen predominates over the regional on the diagrams. We may start by comparing the two diagrams, which are from sites only 800m apart. On both these diagrams the point where the local woodland was cleared is fairly obvious and corresponds to the disappearance of wood remains from the stratigraphy. At Moss Slack Goathland this occurred at c.50cm and at Gale Field at c.100cm.

Dealing firstly with the period before the local woodland was cleared, on both diagrams there is a zone at the base of the profile where <u>Gramineae</u>, <u>Pteridium</u> and <u>Plantago lanceolata</u> values indicate an expansion of cleared land somewhere in the vicinity. At Moss Slack there are some possible cereal grains recorded as well. This is followed by a zone in which these species decrease at both sites, but at Moss Slack an expansion of heath species causes the non-arboreal pollen curve to expand rather than decline. At Gale Field, however, non-arboreal pollen declines and a marked regeneration of trees is seen. It seems that as the open ground cleared in the first zone was abandoned trees regenerated on the lower ground around the Gale Field site, but heath vegetation took over on the higher ground, probably to the south of Moss Slack on Two Howes Rigg.

The third zone is one of renewed high values for <u>Gramineae</u>, <u>Pteridium</u> and <u>Plantago lanceolata</u> at both sites and a decrease in arboreal pollen. Heath species are relatively less important, especially at Moss Slack, where a reciprocal relationship is seen between the curves for Gramineae and Calluna. Between 130cm and 100cm on the Gale Field diagram and from 70cm to 50cm on the Moss Slack one, a short-lived regeneration of the arboreal pollen is seen and a decrease in the herb pollen, before the clearance of the woodland on the sites at 100cm and 50cm respectively. Up to this point the diagrams are so similar that it is suggested that the clearance of the local woodland took place at about the same time at both sites.

After the sudden decrease in arboreal pollen and expansion of non-arboreal pollen which marks this local change, the arboreal and shrub pollen curves are fairly quick to recover at both sites. This recovery, however, is to levels much lower than those prior to the clearance. On the Moss Slack diagram this part of the diagram may be compressed as there are one or two places within the upper 50cm of the diagram where a hiatus is suspected. A comparison of the top parts of the two diagrams shows that at Moss Slack the changes are much more sudden than at Gale Field, which suggests that the latter diagram is the more complete.

Another zone of decreased woodland is seen on both diagrams within the top 45cm at Gale Field and the top 20cm at Moss Slack, when arboreal pollen is reduced to under 10% of the total and shrub pollen suffers a great decline. At Gale Field an oscillation is noticed in the middle of this zone, which shows up on the total pollen diagram from the site in the clearing between c.70cm and 45cm. At the top of the diagrams a slight regeneration of arboreal and shrub pollen is noticed, which may be correlated between the two diagrams. In both cases there is a significant difference between the surface sample and the top of the peat, which suggests that the peat had stopped growing sometime before the present day.

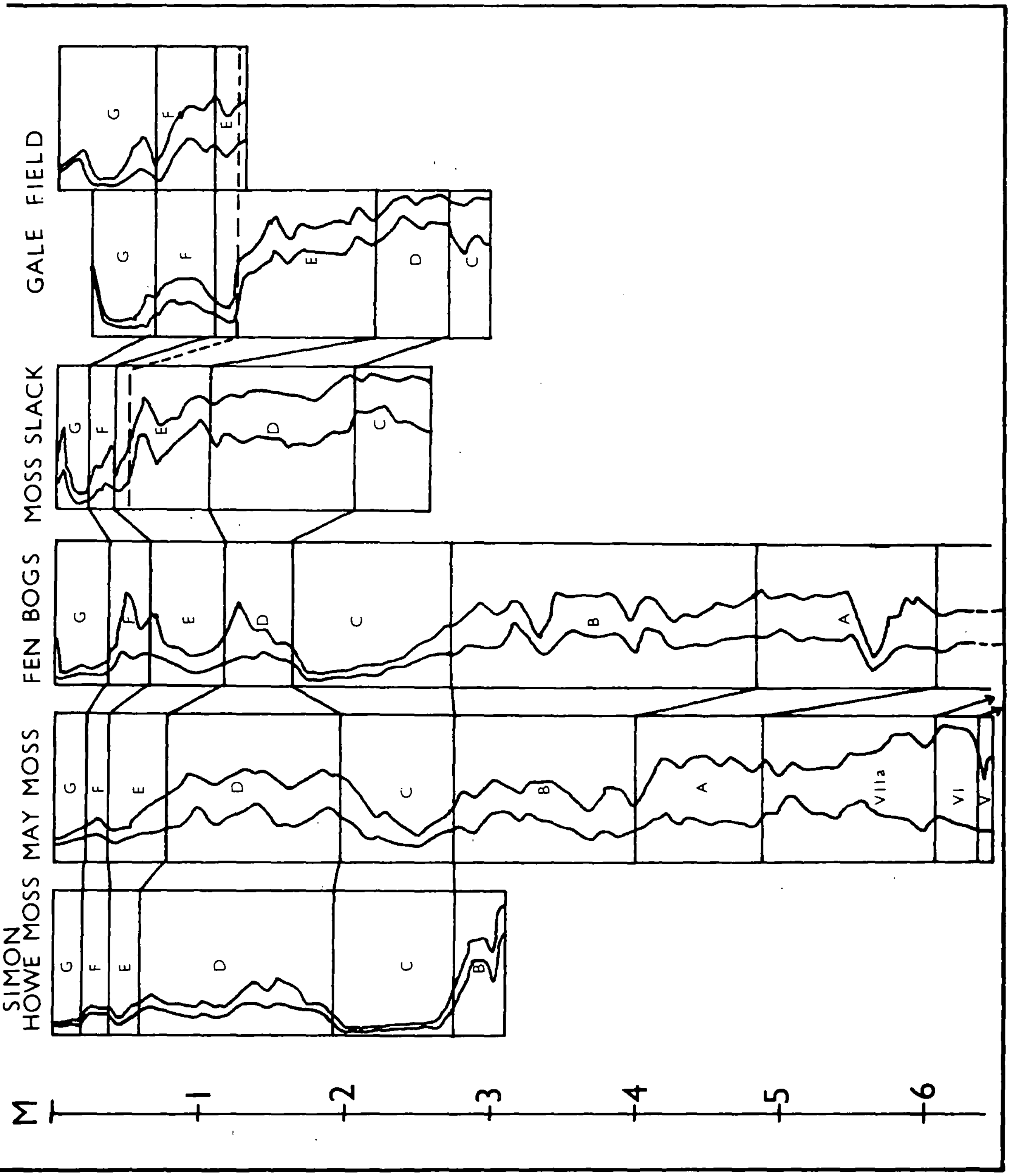
Thus there is a considerable degree of correlation between these two diagrams, from sites very close together, and because of this it is thought that they have had a similar history of vegetation change. It remains to correlate the changes observed on these diagrams with those on the other three.

For the more regional diagrams from Fen Bogs, May Moss and Simon Howe Moss changes in the tree pollen curves were often useful indicators, for instance the decline of Tilia and first appearance of Fagus, and the second decline of Tilia and expansion of Fagus, which marked the A/B and B/C boundaries respectively. On the diagrams from Moss Slack and Gale Field the first of these points is found at the beginning of the third zone and the second at the opening of the fourth. This, however, coincides with the clearance of the local woodland and we might expect Tilia to decline at this point. If there was still a closed canopy woodland over the sites before this, Fagus would be unable to establish itself in the vicinity, even though it might have gained a foothold elsewhere in the region. It is felt, therefore, that changes in the arboreal pollen will relate to the local vegetation at these two sites and it may not be possible to correlate them with the changes seen on the more regional diagrams.

The most useful way of comparing the diagrams seems to be in terms of clearance zones, such as Zones C, E and G on the other three diagrams. At Moss Slack and Gale Field, even if a closed canopy existed, some indication of these clearances might be expected to show up on the diagrams. Thus although the non-arboreal pollen is only comprising c.10% of the total pollen, a definite increase is seen in Gramineae, Plantago lanceolata and Pteridium in the first zone on both diagrams, which could be the result of one of these large-scale clearance phases. At Moss Slack some possible cereal pollen is recorded, but not at Gale Field. The Calluna curve is not very high yet and Calluna suffers a decrease during this clearance, reminiscent of the effect observed at Simon Howe Moss during Zone C.

Similarly, in the third zone, a more impressive clearance is indicated, which reduces the canopy somewhat and then begins to regenerate before the clearance of the woodland at the sites themselves in the next zone. These two zones may be part of the same clearance, with the local clearance causing the sudden increase in non-arboreal pollen observed on the diagrams. Very little cereal pollen is recorded up to this point on the diagrams, but after the woodland is cleared it increases, and in the next two zones considerable amounts are found. At Fen Bogs, moderate amounts of cereals are recorded in Zone E, with high amounts in Zones F and G. If the clearance of the woodland at the sites of Gale Field and Moss Slack was during Zone E, the regeneration of woodland following this might correspond to Zone F and the clearance above it to Zone G.

Correlation of total pollen diagrams from all five sites.



The minor increase in trees and shrubs at the top of the diagrams is probably the result of relatively modern afforestation schemes. Other points of similarity between the top of these two diagrams and Zones F and G on the others include the decreasing values for Alnus and Coryloid pollen in Zone G and the dominance of Calluna and Ericaceae among the non-arboreal pollen from Zone F onwards.

Further evidence for these correlations will be discussed in Chapter 8 when the evidence for the indicators of land use change is discussed. For now, it is proposed to correlate the two diagrams under discussion with the other three in such a way that the bottom zone is equivalent to Zone C. This suggests that the peat at these sites began to form near the beginning of the Iron Age by comparison with the C-14 date from Fen Bogs. If so, the incipience of peat growth might be due to the increase in wetness associated with the opening of the "Sub-Atlantic" zone, which will be discussed in detail in the next chapter. After this, the second zone corresponds to Zone D and the next two to Zone E, during which the woodland near the sites themselves was cleared. Zone F corresponds to the regeneration of trees and shrubs observed above this and Zone G to the top clearance.

These correlations are shown on Figure 51. As the sites are thought to have stopped growing by the beginning of the twentieth century, the top parts may not be complete; but the surface samples record the modern afforestation projects. As a slight increase in arboreal and shrub pollen is seen in the top samples from the peat it is thought that the cessation of peat growth was comp--aratively recent.

6.3 Summary.

The correlations shown on Figure 51 can be summarised as follows. In the early Post-glacial period (Zone V) peat started to accumulate at two sites in the eastern-central area of the North York Moors, Fen Bogs and May Moss, the one in the glacial drainage channel of Newton Dale at 164m O.D., the other at the head of the Eller Beck and Long Grain valleys at 244m O.D. and both on the main watershed of the Moors. The pollen record indicates a development of Quercetum Mixtum in the vicinity of these sites typical of that which covered much of Britain until the Neolithic period. A closed canopy woodland extended over all the lower ground, but thinned out on the higher areas, so that open ground colonised by heath vegetation was a feature of the regional vegetation right from the start.

A fairly well-marked decrease in Ulmus is dated at Fen Bogs to 4720 ± 90 BP and compares with other dates for this horizon for other parts of the country. It was followed by a period in which the woodland retained its dominance in the area, but some small-scale openings in the canopy were made locally. This is called Zone A on the diagrams. At the end of this zone Tilia began to decline in importance in the region and Fagus appeared in the woodland in small amounts. In Zone B the temporary openings of the woodland canopy increased in frequency and intensity, and as the A/B boundary is dated to 3400 ± 90 BP at Fen Bogs, it seems probable that they were at least partly the result of activity by middle Bronze Age folk. In the latter part of this period, peat started to grow at Simon Howe

Moss, and at several other sites further west on the watershed (Cundill, 1971).

The beginning of the Iron Age saw a large-scale clearance which caused a decrease in the arboreal and shrub components of the vegetation in the region, especially in the south near Simon Howe Moss. The clearance lasted until the end of the Roman occupation, in the early fifth century A.D. In the latter part of this Zone C, peat started to form at two other sites, Moss Slack Goathland and Gale Field, both in glacial drainage channels in the north of the area. The peat at these sites was surrounded by closed canopy woodland.

Activity in the region died down after the departure of the Romans and did not resume until Viking times, in the tenth century. Meanwhile, some of the woodland which had been cleared regenerated, while the higher areas remained open and heath vegetation expanded. In the Viking period, much of this scrub woodland was cleared once more, resulting in the renewed expansion of grasses and ruderals. A temporary diminution of clearance activity, possibly in the early Medieval period, gave way to a renewed attack on the woodland in the "High Middle Ages", during which the woods surrounding the peat at Moss Slack and Gale Field were cleared.

At about the end of the fifteenth century the clearance activity lessened in intensity and some of the trees and shrubs were able to regenerate, although not to values comparable with those before Zone E. This regeneration of Zone F gave way in turn to another phase of woodland clearance and expansion of herbs, but the main change was in the extension of heather moorland on the higher areas.

Nearer the present day, afforestation projects led to an increase in certain trees and shrubs in the region, culminating in the large-scale plantations of conifers of the twentieth century of which the Gale Field plantation is one.

PART THREE. DISCUSSION.

CHAPTER SEVEN. FACTORS IN THE DEVELOPMENT OF THE VEGETATION.

7.1 The Climatic Factor.

The two longer diagrams have been zoned according to the Godwin scheme (6.2.1). This scheme is based on the assumption that major changes in the vegetation were the result of large-scale climatic changes, and Godwin's Zones IV to VIII fit in with the five main climatic periods for the Post-glacial, viz. the Pre-Boreal, Boreal, Atlantic, Sub-Boreal and Sub-Atlantic, as proposed by Blytt and Sernander (West, 1968). The dating of pollen diagrams by the use of this zoning scheme is based on the assumption of synchronous climatic changes in north-western Europe, and, indeed, Godwin reiterated in 1966 that radiocarbon dates for the vegetation zones between 8000 BC and 3000 BC indicated that these zones were synchronous over large areas (Royal Meteorological Society, 1966).

One of the major problems with palaeoclimatology is that much of the evidence for past changes in climate has been inferred from vegetation changes and there is rarely any independent evidence for climatic change. For the more recent historic period there is additional documentary evidence, such as records of bad harvests, ship log-books, and the abandonment of marginal settlements. Such evidence has been used to delimit climatic oscillations such as the "Little Ice Age" from c. 1550 to 1700 AD (Lamb, 1966). However, many of the vegetation changes from the prehistoric period are susceptible of more than one interpretation and their climatic causation is open to dispute. It is in the context of a growing disatisfaction with Godwin's idea of synchronous climatic/vegetation zones that the evidence for climatic change on the pollen diagrams presented in this study is discussed.

7.1.1 The Pre-Boreal and Boreal Periods.

The period prior to the establishment of the "climax" Quercetum Mixtum is of little significance on the diagrams presently under discussion. The immigration of the thermophilous trees must have required temperatures not much lower than those of today, but these were probably reached early in the Post-glacial and the amelioration of climate after c.8300 BC was probably a fairly rapid one (Pennington, 1969). Even at the base of the Fen Bogs and May Moss diagrams, some pollen of Quercus, Alnus and Ulmus is encountered, although Tilia, the most thermophilous of our native trees, does not enter until the beginning of Zone VI.

Apart from this, the appearance of the different trees probably reflects their rates of immigration, as, for example, the slightly earlier appearance of Ulmus than that of Quercus in the Fen Bogs diagram (cf. Zone VIa in the south of England). The late arrival of Fagus and Carpinus may be generally taken as an indication of their slow immigration and their increased difficulty in finding a niche once a closed forest was established. Corylus is seen to play a slightly more important role before the Quercetum Mixtum becomes established on both diagrams, and this is probably a simple case of succession by the "high forest trees". Betula and Salix behave in a similar fashion, for these are both pioneer species. Corylus continues to play an important part throughout both profiles which would suggest that the forest did not form a closed canopy over the whole area.

The maximum of Pinus in Zone VI has been mentioned already as being less marked than in some other areas (vide supra, 5.1). It comes at a time when the thermophilous trees were already present and were rapidly establishing themselves, and so the area might be described as intermedâate between the south of England, where Pinus expands before the thermophilous trees, and the north-west, where Oldfield (1965) found Pinus coming into the established deciduous forest. In the south and east, the Pinus maximum corresponds with a dry phase of climate, but in the north and west it corresponds with a wetter one, and Oldfield has suggested that the maximum could be 700 to 1500 years later in the latter parts of the country than in the former.

We must look to the aquatic pollen for indications of whether the Pinus maximum preceeded or coincided with a wetter phase in this area. At Fen Bogs there are several records for Potamogeton throughout Zones V and VI and one record for Typha, while Menyanthes forms a peak near the top of Zone V corresponding with peaks of Polypodium and Filicales. At May Moss Potamogeton is important at the base of the profile, but dies out before the end of Zone VI. Most of this aquatic pollen is probably associated with local hydroseral development, but at Fen Bogs the Pinus maximum seems to come after the aquatic peak in Zone V and just before the set of Potamogeton records in the latter part of Zone VI, which suggests that it might have corresponded with a slightly drier phase. Whatever the environmental conditions pertaining at the time, it seems very doubtful whether the Pinus maximum can be considered indicative of a particular climatic phase which could be correlated with similar maxima in other parts of the country.

7.1.2 The Boreal-Atlantic Transition.

The Boreal-Atlantic Transition falls at about the place where the two profiles join on the May Moss diagram. Various changes are observed; the expansion of Alnus is well marked, and this is generally attributed to an increase in wetness, although the concurrent decline of Salix is difficult to reconcile with this explanation. However, Fraxinus appears at this stage and Tilia expands, so Salix may have suffered from shading in the closed canopy forest, as it is not recorded from the macro-remains at the site itself. The same thing is observed at Fen Bogs, but here the rise of Alnus is earlier, before the expansion of Tilia and Fraxinus and the decrease of Salix mirrors it very closely. It is possible that Alnus was colonising the same areas as Salix and that it was the Alnus itself which shaded the Salix out, causing it to form an understorey and possibly preventing its pollen from reaching the site. There is no very strong evidence for an increase in the number of wet habitats available, and the expansion of Alnus is more easily seen as a successional phase following relatively slow immigration. Godwin (1940) claimed that Alnus was present in southern England in low amounts for some time before it expanded, which he cited as evidence for a climatic change at its expansion. In this area, however, the rise of Alnus is seen to be a steady and rapid one from its first appearance.

There is little other evidence for an increase in wetness at the Boreal-Atlantic Transition from these diagrams, or on those of Simmons (1969) or of Cundill (1971). At Fen Bogs and May Moss the aquatic pollen dies out and at the latter Sphagnum values are also fairly low. At Fen Bogs, however, very high Sphagnum values are found throughout Zone VIIa and the local Zones A and B which follow it, i.e. corresponding with the maximum extension of the woodland. They decrease again later, when the climatic deterioration of the Sub-Atlantic might be expected to cause them to increase, as happens at May Moss. It seems probable that the Sphagnum curve at Fen Bogs is responding to some other factor, for example the nutrient supply in the ground-water.

There is some evidence for an increase in warmth in Zone VIIa from the records for Hedera at both sites, although these begin in the middle of Zone VI in both cases.[1] Tilia reaches its greatest expansion in VIIa, which may be taken as an indication of a higher temperature, according to most authorities, 2-3°C higher than at present. However, there is nothing in either diagram which provides conclusive evidence of a climatic change at the Boreal-Atlantic Transition, so presumably no threshold was crossed in this area. Zone VIIa does coincide with the maximum development of the Quercetum Mixtum and represents the climax of this vegetation type in the area.

1 Troels-Smith (1960) discusses the use of Hedera as a climatic indicator.

7.1.3 The Ulmus Decline.

The Zone VIIa/b boundary has long been the subject of dispute, especially the decline of Ulmus itself. The widespread nature of this decline (reported by Frenzel, 1966, even from areas like the central German mountains where he considers an anthropogenic explanation unlikely) and the relative synchroneity of the radiocarbon dates does suggest that some sort of climatic change was involved. However, there is little evidence for change in species other than Ulmus, except the appearance of certain cultural indicators such as Plantago lanceolata. Records for Hedera at Fen Bogs are too sporadic to allow any conclusions to be drawn from the curve, but at May Moss slightly more Hedera is recorded in VIIb than in VIIa. Tauber (Royal Meteorological Society, 1966) suggests that the increased Hedera in these latitudes meant that it was benefitting from the warmer summers which an increase in continentality would bring, whereas in Denmark, for example, it declined because of the colder winters.

The association of the Ulmus decline with a clearance phase (see chapter 8) casts doubt on the theory that it was caused by a climatic change. There is little additional evidence from the diagrams under discussion, such as significant changes in other tree species, to lend support to the theory. Therefore, it must be concluded that, as at the Boreal-Atlantic Transition, no climatic threshold was crossed in this particular area.

7.1.4 The Sub-Boreal/Sub-Atlantic boundary.

The aquatics start to reappear in the pollen record at Feh Bogs from Zone B onwards, the beginning of which is dated to 3400 ± 90 BP. Peaks of both *Menyanthes* and *Potamogeton* and occasional records for *Typha* and *Nuphar* are recorded from the end of Zone B and Zone C. The field stratigraphy does not suggest that these changes can be related to hydroseral development on the site itself, so it seems likely that a gradual increase in wetness occurred. This change, which may have covered a period of several centuries, may be associated with the deterioration of climate at the Sub-Boreal/Sub-Atlantic boundary, Godwin's Zone VIIb/VIII boundary.

At May Moss, *Typha* records are frequent in Zone C and aquatic pollen is recorded sporadically throughout the profile above this. As was mentioned before, *Sphagnum* levels increase markedly in Zone C and remain high hereafter. The same thing is observed at Simon Howe Moss, where, however, the rise in *Sphagnum* is rather later in Zone C. The *Potamogeton* peak, however, is earlier, near the beginning of Zone C and records for other aquatic species occur in late C or early D.

Peat at the two northern sites, Moss Slack Goathland and Gale Field, is thought to have started to accumulate early in Zone C. If this is correct, it suggests that the initiation of peat growth at these sites was associated with the Sub-Boreal/Sub-Atlantic transition. The peat at Simon Howe Moss appears to have started to accumulate shortly before the beginning of Zone C, i.e.

earlier than at Moss Slack Goathland and Gale Field. If a deterioration in climate at the Sub-Boreal/Sub-Atlantic boundary was responsible for the initiation of peat growth in all three cases, it must have been a gradual deterioration which was felt first on the higher areas and sometime later in the lowlands. Thus there would seem to be fairly convincing evidence for some sort of climatic change at this boundary, probably an increase in wetness.

7.1.5 Changes since the beginning of the Sub-Atlantic.

There are few other signs of climatic change on the diagrams, although the slowing down of peat formation at Fen Bogs in Zone E (dated to between 1060 ± 160 and 390 ± 100 BP) might be connected with the warm epoch of 1150-1300 AD mentioned by Lamb (1966). Periods of increased agricultural activity may well reflect ameliorating climatic conditions, allowing more marginal land to come into cultivation, but it is difficult to tell this from the diagrams. It must be noted that the latter part of the Zone E clearance phase corresponds approximately to the "Little Optimum", while the decrease in clearance activity in Zone F at Fen Bogs could reflect the colder spell known as the "Little Ice Age". Evidence will be presented below (chapter 8) to suggest that Zone F corresponded to a phase of arable cultivation concentrated on the lower ground during which some pastoral activity on the higher areas was abandoned. It is interesting to ponder the possible effect of the climatic deterioration of the "Little Ice Age" on farming in the marginal upland areas. It may be noted, too, that some of the pastoral activity was apparently resumed in Zone G, after the cold spell.

Conversely, it must be remembered that human interference can alter the micro-climate in a number of ways, and there are many examples on the diagrams of micro-climatic changes caused by human activity, which themselves caused changes in the vegetation. An example is an expansion of *Fagus*, *Betula* or *Corylus* after clearance, as these species respond to the increased light. Similarly, many of the herbaceous species which were common in the Late-glacial period, before the development of closed forest conditions, were able to re-establish themselves after deforestation by Man's activities. These species were simply responding to the changed micro-climate, which had been brought about through human interference.

To conclude, it seems that there is significant evidence for the climatic factor in vegetation development for the early part of the Post-glacial and for the Sub-Boreal/Sub-Atlantic boundary. Evidence for the Boreal-Atlantic Transition and for the Atlantic/Sub-Boreal boundary is scanty on these diagrams. As has been noted by Manley (1951) and many others, once a closed forest was established it would be able to maintain itself despite short-term or minor fluctuations in climate, and this may explain why these boundaries are not easily seen on the diagrams.
It is noted that the effects of Man often initiate climatic changes and in particular alter the micro-climate, but it becomes increasingly difficult to separate the effects of Man from those of climate as human interference becomes more intensive.

7.2 The Edaphic Factor.

7.2.1 General Discussion.

The relationship between vegetation and soil is dynamic and hence changes in the one will affect the other to a greater or lesser extent. The nutrient levels required by certain plants are such as to make associations between particular soil and vegetation types unlikely. For example, deciduous woodland requires a fairly nutrient-rich soil and is not usually found on very acid soils. The present soils of the North York Moors (vide supra, 2.5) are nearly all more or less podzolised, especially those developed over the Deltaic rocks. Yet pollen analysis suggests that most of these areas were covered with deciduous woodland in the Atlantic and Sub-Boreal periods, so the soils must then have been of a different type.

Dimbleby (1962) has presented evidence from sites on the Tabular Hills and also on the main watershed, where Brown Forest soils were discovered buried under Bronze Age barrows. The pollen spectra from these buried soils show that the landscape was largely wooded at this time, with a fairly high percentage of _Tilia_, so this presumably represents the climax forest of Zone VIIa. The podzols of the soils surrounding these barrows were observed to go over the tops of the mounds, suggesting that podzolisation post-dated the erection of the barrows. If there has been a change in soil type it is possible that this would have caused a change in the vegetation towards more acid-tolerant species.

The podzolisation of the soils must have been caused by increased leaching, removing mineral nutrients to the lower layers where they are unavailable to plants. Pearsall (1950) has suggested that the increased rainfall at the Sub-Atlantic boundary might have brought about increased leaching, which in a marginal environment like that of the North York Moors might be sufficient to initiate a soil change, which would in turn lead to changes in the vegetation, such as the spread of Calluna.

This view is rejected by Dimbleby (1962) who claims that the dominance of Calluna is the "end-point" of the sequence from Brown Earth to Podzol, but neither the cause nor even an essential requirement for the change. He proposes instead that forest clearance was the prime cause, exposing the soil to the full force of the rainfall, from which it had been protected by the closed canopy forest, and removing the vegetation which "pumped" nutrients up from the lower layers of the soil. This idea is based on the assumption that the whole watershed area was covered with closed canopy forest in the Atlantic, a conclusion not upheld by Cundill (1971) or by this work. However, there is good reason for agreeing with Dimbleby that the onset of podzolisation often followed forest clearance by Man. No direct measure of the podzolisation of the soils can be obtained; nevertheless, the relationship between Callunetum and Podzol appears close enough to make a study of the former a reliable guide to changes in the latter.

7.2.2 Evidence from the pollen diagrams.

There are considerable differences between the Calluna curves on the pollen diagrams in this study, which suggest that there were variations within the area in the date of the onset of podzolisation. At May Moss the Calluna curve is high from Zone VI onwards, which indicates some areas of heathland vegetation and podzolised soils dating from before the Atlantic. The Ericaceae curve is also notably high in the part of the diagram prior to the Ulmus decline. In Zones A, B and C, the Calluna values are very high, but they decline again after this and do not regain their high values even at the top of the diagram. The apparently lower values recorded from Zone D onwards may be a result of the percentage basis of the diagram. As other non-arboreal species increased in importance the relative position of Calluna may have declined, although its absolute values may not have decreased. At any rate, it seems that there is good evidence from this site to suggest that the podzolisation of soils and dominance of heath vegetation were features of the higher parts of the watershed from Boreal times onwards and that deciduous forest and its associated Brown Earth soil did not cover all areas even during the maximum extension of the Quercetum Mixtum.

At Fen Bogs, the rise of Calluna is somewhat later than at May Moss, but again preceeds the mid-Bronze Age, and values for Zone B (mid- and late-Bronze Age) are not appreciably higher than those for Zone A (Neolithic and early-Bronze Age). This does not lend support for Dimbleby's theory that the clearance of the forest which initiated the trend towards podzolisation was mid-Bronze Age in date and attributable to the Collared Urn culture. (Dimbleby, 1962). At Fen Bogs, Simon Howe Moss and Moss Slack Goathland, an important increase in heath species is seen at the end of Zone C, corresponding with a phase of woodland regeneration. At these sites Calluna does not behave like Gramineae or any of the major clearance phenomena but expands when these decline. This strongly suggests the spread of heath vegetation on to soils which had deteriorated after the abandonment of agricultural activity. On the lower areas, however, the woodland was able to regenerate, as is shown by the Gale Field diagram where the Calluna curve remains low throughout Zone D and the expansion is in Zone E, when the local woodland was cleared.

On the diagram from Fen Bogs a decline in the Calluna and Ericaceae curves is seen in the latter part of Zone E which corresponds to a clearance phase. At the end of this phase the Calluna curve rises again and reaches very high values which are maintained throughout Zones F and G. A similar effect is seen on the diagrams from Moss Slack and Simon Howe Moss. This suggests that the trend towards podzolisation and heath vegetation in Zone D was at least partially reversed in Zone E, and that the present day dominance of Callunetum on podzolised soils dates from the end of the Middle Ages.

7.2.3 Conclusions.

Thus the evidence from these pollen diagrams is not explained by Dimbleby's idea of podzolisation of soils dating from mid-Bronze Age times. There is seen to be considerable variation in the date of the onset of podzolisation; some areas appear to have had a heathland flora and podzolised soils from the early Post-glacial, whereas in parts of the lowlands heath vegetation was unimportant until the last millenium. In all cases the association with forest clearance seems evident, in accordance with the main part of Dimbleby's theory. Where a closed canopy forest never existed, Brown Earth soils would not have developed. Where deciduous woodland was established Brown Earth soils were maintained until a period of extensive deforestation allowed the process of leaching to operate for a long period of time undisturbed. This happened in Zone C (Iron Age/Roman times) in some areas and in Zone E (Middle Ages) in others. In both cases when the clearance was over and agricultural pressure decreased heath vegetation established itself on the impoverished soils.

Thus the essential requirement for the change in soils seems to be a long period of deforestation, as postulated by Dimbleby. However, this in itself suggests that the small-scale, temporary clearances of the mid-Bronze Age would not be sufficient to lead to the widespread podzolisation of soils. Even after the lengthy clearance of Zone C the changes in soils and vegetation were not irreversible, as in Zone E the heath species decline again.. Dimbleby (1952c) has suggested that the present podzolised soils can be reconverted to Brown Forest soils within sixty years when ploughed and planted with Betula, so even the very extensive spread of heath vegetation and podzols from Zone F onwards may not be permanent.

7.3 The Anthropogenic factor.

Although in the previous two sections evidence has been cited for the part played by environmental factors in the development of the vegetation cover, it is clear that Man must be regarded as another potent factor. Since Neolithic times, at least, Man has been the potentially dominant influence on the vegetation, his effects increasing in extent and intensity with time. No palynologist today would deny the importance of the anthropogenic factor in vegetation history, yet it has proved just as difficult to assess in detail as have the environmental factors.

In the past much attention has been given to the problem of the causes of vegetational changes. Often this has involved the reinterpretation of changes formerly attributed to climatic events as changes caused by Man; for example, the Tilia decline (Turner, 1962); the VIIb/VIII boundary, where the expansion of Fagus and Carpinus is now thought to have been influenced by Man's opening up of the forests; and the Ulmus decline, whose cause has occasioned much controversy and which has its climatic and its anthropogenic proponents. Determinists would argue for the influence of climatic change on Man's activities; on the other hand, Man's actions often initiate changes in micro-climate or soils, as was noted in the previous sections. Thus there is a very close link between the environmental and anthropogenic factors.

7.3.1 Evidence from the pollen diagrams.

The recognition of the anthropogenic factor in pollen diagrams is based on two main criteria; changes in the arboreal/non-arboreal pollen ratio which cannot be explained adequately by environmental changes alone; and the presence of certain species commonly associated with Man and known as "cultural indicators". These include both indigenous species which were present in small numbers throughout the Post-glacial period and benefitted from human activity (e.g. Plantago lanceolata, Rumex spp., Artemisia, Centaurea cyanus), and also exotic species introduced by Man (e.g. Cerealia, Humulus/Cannabis, Abies, Picea). Either one of these major criteria may be used to indicate anthropogenic influence, but in most cases both are found together.

Turner (1964) has distinguished three main types of change on pollen diagrams which may be classed as anthropogenic..Firstly there is a set of changes in the arboreal pollen with no related changes in the non-arboreal pollen. Such a situation, Turner believes, is typical when Man's activities are confined to using the natural products of the forests. Secondly there are more marked changes in the arboreal pollen and small scale increases in herbaceous pollen, such as are found when Man begins to control the natural vegetation for his own purposes without actually introducing new species. Thirdly there are large-scale decreases in arboreal pollen and increases in non-arboreal pollen associated with the agricultural use of land and the replacement of natural vegetation with species planted by Man.

Turner claims that:

> "Any one of these changes would be sufficient to indicate the presence of prehistoric cultures in an area and the absence of the increases in the herbaceous pollen types commonly regarded as agricultural weeds cannot necessarily be regarded as a serious argument against an anthropogenic interpretation of changes in the tree pollen frequencies."
>
> (Turner, 1964).

Following this, Smith (1970) has described changes in arboreal and shrub pollen values which are tentatively assigned to Man's influence; these include the rise of *Alnus* in the latter part of Zone VI and the *Corylus* maximum in Zone V.

However, it is impossible to be sure of the presence of the anthropogenic factor when neither of the two criteria discussed above is found. In the absence of definite cultural indicators, changes in the arboreal pollen curves cannot be assigned conclusively to the agency of Man, and no such features are recognised on the diagrams from Fen Bogs and May Moss as indicative of the anthropogenic factor. Nevertheless, there are signs of Man's activity before the *Ulmus* decline on both diagrams, and these are described in detail elsewhere (chapter 8). In every case, the anthropogenic interpretation is based upon changes in the non-arboreal pollen and in the earlier phases at Fen Bogs such changes are not accompanied by any significant changes in the arboreal pollen spectra. Therefore, we might add a fourth category to Turner's list, where the effects of early Man are seen in an expansion of some herbaceous species which does not depend upon any marked change in the forest canopy. Similar features have been noted by other writers, e.g. Simmons (1964) in his diagrams from Dartmoor.

This might be seen as an alternative to Turner's first category and more applicable in upland areas where closed canopy woodland was not established everywhere. In such situations the effect of Mesolithic man might well have been to enlarge natural clearings, probably for hunting purposes, rather than to crop the forest trees. Associated gathering activities might have cropped the trees, but with minimal effect on the vegetation pattern.

All the other changes on the pollen diagrams in which an anthropogenic factor has been recognised fall into one or other of Turner's second two categories. In a subsequent paper (1965) Turner distinguished three main categories of woodland clearance produced by these changes..The first type she called "small temporary clearances", in which Gramineae pollen reached 20% of arboreal pollen. By very close sampling (½ inch) and radiocarbon dates, Turner established that these clearances lasted approximately fifty years. The second type she called "extensive clearances", which were much larger-scale features, lasting several hundred years,and in which Gramineae pollen reached 100% of arboreal pollen. Thirdly she distinguished "complete clearances", which had remained open until the present day and which generally dated from the last few hundred years. In these Gramineae values exceeded 200% of arboreal pollen.

On the diagrams in this study a number of small temporary clearances are seen throughout Zones A and B. In Zone A they are relatively rare and small-scale, but in Zone B they result in larger fluctuations on the total pollen diagrams and a generally higher level of non-arboreal pollen. The difference between Zones A and B is well seen on the total pollen diagram from May Moss where the amplitude of the fluctuations in the curves is seen to be larger in Zone B than in Zone A, and non-arboreal pollen is c.30% and 50% in Zones A and B respectively. The time-scale involved can only be guessed, but it seems that Turner's fifty years is only an average figure, as clearly there are great differences in scale between the clearances in Zone A and those in Zone B at May Moss. In all cases these small temporary clearances are seen on the diagrams as both changes in the arboreal/non-arboreal pollen ratio and also records for cultural indicators which are indigenous species, e.g. Plantago lanceolata and Rumex spp.

Although there are size variations in the small temporary clearances, there does seem to be a significant difference in size between the largest of these and the "extensive clearances" described by Turner. In the extensive clearances, in addition to the indigenous cultural indicators, exotic species are recorded, the most significant of which is Cerealia. This suggests that a basic difference in activity was involved, a point which will be discussed further below (chapter 8). The extensive clearances have been used as the basis of the zoning from Zone C onwards. The first of these (Zone C itself) involves a much more substantial decrease in the shrub and arboreal pollen curves than did any of the small temporary clearances, and non-arboreal pollen values reach to over 95% of total pollen by the end of the clearance at Simon Howe Moss, while Gramineae values exceed 100% of arboreal pollen.

At Fen Bogs the boundaries of the clearance are dated and it is seen that it covered a time span of some 750 years. Zones E and G exhibit similar features and in both cases the evidence of changes in the arboreal/non-arboreal pollen ratio is supplemented by abundant records for cultural indicators. There can be no doubt that the anthropogenic factor was paramount in producing these changes.

It is difficult to distinguish on these diagrams between Turner's "extensive" and "complete" clearances. Even the last extensive clearance of Zone G cannot be regarded as being complete, since the surface samples show that modern afforestation is reversing the trend of the clearance. On the diagrams from May Moss and Simon Howe Moss the last clearance is not so intensive as the earlier ones, but on the Fen Bogs diagram the intensity of the Zone G clearance does seem to exceed that of the extensive clearances of Zones C and E by a narrow margin. This is not because of an increase in Gramineae values, however, as these are lower in the final clearance than in the other extensive clearances. Gramineae values cannot be used in the way Turner suggested on these diagrams, as the Zone C and E clearances both have Gramineae values exceeding 200% of arboreal pollen at Fen Bogs. A figure such as the 200% must be regarded as an arbitrary one which may not apply to diagrams from all regions. A more applicable feature by which the final clearance might be distinguished in this particular case is the dominance of the Callunetum ; but while this is marked at some sites, such as Fen Bogs, it is less marked at others, such as Simon Howe Moss. It would seem that there is no satisfactory way of distinguishing between the extensive and complete clearances on these diagrams.

To summarise, the anthropogenic factor has been recognised on these diagrams by the presence of both fluctuations in the arboreal/non-arboreal pollen ratio and also cultural indicators. It has been seen as an element in the small-scale expansion of certain herbaceous species within a generally wooded environment prior to the Ulmus decline; as the initiating factor in a series of changes involving small temporary openings of the woodland canopy; and as an essential factor in the creation of large-scale clearings lasting for several centuries. Thus the anthropogenic factor is seen to have been a very important one in the vegetation history of the area, but its inter-relationship with the environmental factors must be stressed.

CHAPTER EIGHT. CHANGES IN LAND USE.

In this chapter it is proposed to examine in more detail the clearances mentioned in the last chapter and attributed to the hand of Man. In particular, attention will be paid to the land use types indicated, and attempts will be made to link these to the archaeological and documentary evidence for the different periods.

8.1 The period prior to the Ulmus decline.

At Fen Bogs, although some herbaceous species indicate open ground in the vicinity right from the start, there are certain periods within the part of the diagram before the *Ulmus* decline when definite openings of the canopy are suggested. Thus it was noted at Simon Howe Moss that the curves for *Calluna* and *Gramineae* seemed to have a reciprocal relationship in the early part of the diagram, and the same phenomenon can be observed at Fen Bogs. *Calluna* starts at values of over 2%, suggesting that there were small areas of heath even in Zone V. From the field stratigraphy it seems unlikely that these were on the site itself and so they probably relate to the higher ground in the region. The *Calluna* curve falls, however, together with that for *Cyperaceae*, when a small peak of *Gramineae* occurs at c. 900cm. This is accompanied by the first *Pteridium* on the diagram and is the start of a period of frequent *Melampyrum* records. The aquatics disappear temporarily, so it is possible that this represents a spread of grasses on to an area near the site itself, but there is also a record for *Rumex acetosa* and for *Artemisia*, *Umbelliferae* and *Cruciferae*. The effect on the Calluna curve is seen to mirror that of Gramineae and the other herbs mentioned above, and once Gramineae decrease again Calluna expands once more, suggesting that the grasses had replaced heath vegetation which was re-established after the clearance phase.

Another expansion of Gramineae occurs with a peak at c.830cm, and again causes a decrease in the curves for Calluna and Cyperaceae. This time there is an isolated record for Plantago lanceolata (810cm) and a small peak of Compositae just before that of Gramineae, and the Melampyrum values culminate in a peak at c.820cm. No effect is noted on the total pollen diagram, and again it is suggested that the expansion of grasses and herbs was at the expense of the heath vegetation on the higher parts..

From 750cm to 710cm, a similar but larger-scale sequence of events is seen. The peak of Gramineae is more noticeable this time and the recovery of Calluna and Cyperaceae at 710cm is very marked. Other herbaceous species associated with the Gramineae peak include Rubiaceae, Cruciferae and Succisa, but Melampyrum and Filipendula decline. This time the total pollen diagram records the changes and a decrease in both arboreal and shrub pollen is seen at 750cm. Ulmus suffers most and Alnus decreases too, but Betula, Fraxinus and Salix increase. Evidently this was a more important expansion of grasses, affecting not only the heath and sedge vegetation of the higher ground but also parts of the tree and shrub layers.

At c.700cm another expansion of non-arboreal pollen is seen on the total pollen diagram, this time mostly at the expense of shrubs. Gramineae rise more slowly than in the previous episodes, to reach a peak at about the Ulmus decline. The Calluna and Cyperaceae curves decline and expand again to reciprocate this pattern. Pteridium values are very high, and Melampyrum has a small peak at c.700cm and a bigger one at the Ulmus decline. Other herbaceous species with high values include Potentilla, Rosaceae, Succisa and Filipendula, and there are records for Sanguisorba officinalis, Artemisia, Compositae, Umbelliferae, Chenopodiaceae, Cruciferae, Lychnis, Rumex acetosa, and for Plantago lanceolata from the Ulmus decline onwards. Fraxinus and Salix expand again, although Corylus does not rise until after the Ulmus decline. The whole episode seems to last from c.700cm to c.590cm.

The foregoing changes seem to have been fairly similar, but each one has been more marked than the last. In each case an expansion of grasses is primarily responsible for the change and some other herbaceous species also benefit. This suggests clearings, firstly on the higher ground where the forest thinned out but later also on the lower areas, at the expense of the shrubs and even of the forest itself.

The May Moss diagram does not record a similar picture, and here, although there is a definite rise of Gramineae before the Ulmus decline, no reciprocal relationship is seen with the curves for Calluna and Cyperaceae, although the Ericaceae curve shows a suggestion of such an effect. At this site heath vegetation was a more prominent component of the vegetation from the Boreal-Atlantic Transition onwards than it was at Fen Bogs and the increase in grasses was evidently not at the expense of these species. The total pollen diagram indicates a decrease in shrub pollen from c.530cm onwards, and this is seen in the Coryloid curve, which decreases as Gramineae expand. It appears that the clearing was in the area of shrub vegetation, probably at the woodland edge, and this and the fact that it immediately preceeds the Ulmus decline suggests that this corresponds most closely to the last of the clearings noticed at Fen Bogs. There are very few herbaceous species other than Gramineae involved here, the only significant records being occasional ones for Artemisia, Compositae and Chenopodiaceae. Fraxinus and Betula follow a similar pattern to the Gramineae curve, apparently taking advantage of the increased light to spread into the clearings.

The Ulmus decline is very sudden at May Moss, but, as at Fen Bogs, is seen to be at the culmination of a long period of clearing and is not an isolated event. Simmons (1969) finds a suggestion of clearance just before the Ulmus decline at his sites a little further west on the North York Moors, so it could be a regional phenomenon. All these clearings could have been made by fire, so lightning cannot be ruled out as a possible cause, especially for the earlier ones at Fen Bogs on the higher ground. However, the later ones are too long to have been caused by lightning alone and the conclusion seems inescapable that these were at least partly the work of Man. There are no signs of cultivation at either site, so some association with animals seems likely, to produce succulent grazing either as bait for game animals or as fodder for domestic herds.

The effect of Mesolithic man on his environment has long been a point of controversy. The traditional passive role assigned to him by writers such as Clark (1936) and Godwin (1965) has been challenged recently by others, e.g. Smith (1970), Dimbleby (1961) and Simmons (1968). Both records of non-arboreal pollen, e.g. of Plantago lanceolata before the Ulmus decline, and changes in the arboreal pollen have been cited as evidence for anthropogenic change. In particular, an increase in Corylus has been suggested as a probable effect of human activity, although no such effect is indicated on the diagrams presented here.

Most writers stress the part played by fire, and Durno and McVean (1959) find evidence for the destruction of several forests in the Atlantic period in Scotland. Dimbleby (1961) points out that if Mesolithic man used fire to drive game the effects on the vegetation could have been out of all proportion to his numbers. Conclusions about Mesolithic clearances must be only tentative, however, and at many of the upland sites the peat does not go back far enough for reliable dating of the changes.

The abundant archaeological remains of Mesolithic man in this area have been described in an earlier chapter (3.1). It will be recalled that there were sites very close to the study area, a particularly large one being at Simon Howe, to the west of Fen Bogs. Sites to the east are fewer and the main concentration seems to have been on the higher parts of the main watershed. Activity on Simon Howe Rigg and Cragstone Rigg might well explain the noticeable clearance episodes at Fen Bogs, while the less marked effects at May Moss are in keeping with the lack of archaeological evidence further east.

The culture, as described by Radley (1962) et al, seems to have been a hunting one rather than a herding one, as no remains of domesticated animals have been found. It has already been assigned to the later Mesolithic period and it has been suggested that it may have continued into the Neolithic time-period, possibly incorporating some of the Neolithic arts from immigrants of this culture. Indeed, Smith (1970) claims that the use of the terms 'Mesolithic' and 'Neolithic' cloud the real issues. If Mesolithic man did continue to live a basically hunting existence on the higher ground until after 3000 BC in this area, this would explain the relatively long clearance phase from c.700cm to 590cm at Fen Bogs and from c.530cm to 480cm at May Moss, incorporating within it at both sites the Ulmus decline, which is dated at Fen Bogs to 4720 ± 90 BP. If the Ulmus decline itself is to be attributed to Neolithic man, this point could represent the incorporation of Neolithic practices into the Mesolithic culture.

The earlier episodes at Fen Bogs are more difficult to explain. They do not involve any reduction in the woodland cover but simply concern changes in the relative abundance of Calluna and Gramineae on the higher ground. If their anthropogenic nature is accepted it suggests Mesolithic activity earlier than the cultures described so far from this area. They are presented here simply as changes on the pollen diagrams which claim our attention, although their cause is not at all clear.

8.2 The clearances of Zone A.

The *Ulmus* decline has probably received too much rather than too little attention from palynologists, and it has been suggested above that here it represents the culmination of a longer period of human activity. However, the evidence for climatic change has been described in the last chapter and cannot be dismissed. Smith (1970) sums up the situation when he suggests that:

> "at the Atlantic-Sub-Boreal transition we are dealing with a complex of effects and that, in different areas, different factors or combinations of factors may have been critical for the vegetation. The demonstration of a brief late Atlantic clearance in County Antrim (Newferry and Ballyscullion) allows of the conjecture that the landnam phase might be one of a series of such clearances and that during the landnam phase the vegetational changes are intensified because of a synergistic climatic effect."

After the *Ulmus* decline, however, the effects on the vegetation may have been rather different, as agriculture and not merely hunting was involved. We may consider first the clearances of Zone A at Fen Bogs and May Moss and then compare them to those prior to the *Ulmus* decline.

Shortly after the *Ulmus* decline at Fen Bogs an inwash stripe was encountered in the profile. This has been explained (4.1.3)as the result of erosion of material from the sides of Newton Dale and deposition on the mire surface by one of the soaks. As it comes so soon after the *Ulmus* decline, the possibility of human clearance of woodland causing this erosion cannot be ruled out. Sampling was carried out at a closer interval across the inwash stripe itself and a very rapid succession of changes was noted. The Gramineae curve is at high then low values and the Calluna curve has the opposite pattern of low then high values. The arboreal pollen behaves in a strange way, with low then high Pinus, Ulmus and Tilia, and a pattern of low-high-low for Betula. Values for Plantago lanceolata are high and those for Filipendula and Melampyrum are still high from the clearance phase during and before the Ulmus decline. Records for aquatics and fern spores probably relate to local vegetation at the site. It seems likely that there is a bigger time gap between the bottom and top of the inwash stripe than its width would suggest, and that a hiatus occurs at this level. From the samples from the stripe itself it appears that after the end of the clearance phase a recession of the Gramineae curve took place and a corresponding expansion of the Calluna curve and regeneration of most of the forest trees.

The inwash stripe is followed by a larger clearance seen on the total pollen diagram from c.580cm to 555cm, with a very marked peak of non-arboreal pollen caused by a freak count for Melampyrum. Again Ulmus suffers most markedly, but all the other trees except Fraxinus decrease too, as do the shrubs. High Gramineae values are accompanied by records for Filipendula, Potentilla, Rosaceae, Rumex spp., Artemisia, and others. Plantago lanceolata, however, is hardly recorded, and there are no cereal pollen grains. There does not seem to be much difference between this clearance and those described before, and there is nothing to suggest either selective felling of Ulmus (as postulated by Troels-Smith, 1953) or cultivation, as in the classic landnam clearances (Iversen, 1949). There are no more definite signs of clearance on this diagram until the A/B boundary, for which a date in the middle Bronze Age is available (3400 ± 90 BP). Therefore, the diagram indicates a continuation of small-scale clearings in association with hunting or herding rather than cultivation, similar to those made before the Ulmus decline, throughout the Neolithic period and probably the early Bronze Age.

At May Moss the Ulmus decline is more dramatic and shows up clearly on the logarithmic scale at 490cm. It is followed by a recovery of arboreal pollen and Ulmus in particular, and then a gradual decline to the A/B boundary. In the intervening Zone A Gramineae values are high in the latter part, reaching their peak at the A/B boundary, but no clearances can be seen before this except a small Gramineae peak between 470cm and 460cm. Pteridium follows a similar pattern of a gradual increase in the latter part of the zone, as does Plantago lanceolata. Records for other herbaceous species are not very frequent, consisting of occasional ones for Filipendula, Artemisia, Umbelliferae and Urtica.

Thus on the evidence of these two sites it seems that Neolithic and early Bronze Age people did not have a very significant effect on the vegetation in this area. It will be recalled (3.1) that the archaeological evidence for these people is mainly confined to the area to the south of the Moors. Mesolithic people, on the other hand, probably remained in the area well into the Neolithic, if not into the Bronze Age time-period, presumably practising a hunting economy, although possibly with some embellishments from their Neolithic neighbours to the south.

8.3 <u>The clearances of Zone B.</u>

Zone B opens with the clearance at the A/B boundary noted above. At Fen Bogs this is dated to 3400 ± 90 BP, and the end of the zone and opening of Zone C has a date of 2280 ± 120 BP. Thus Zone B is seen to span the mid- and late-Bronze Age, for which there is much archaeological material to aid the interpretation of the pollen diagrams. Right at the top of the zone is the beginning of the Iron Age, and an examination of the total pollen diagram reveals that the expansion of non-arboreal pollen which defines Zone C begins somewhat before the top of Zone B, at c.275cm. In this very top section of the zone cereal pollen is recorded, and for this and other reasons it is suggested that the radiocarbon date is a little above the B/C boundary.

Thus in Zone B at Fen Bogs there is no cereal pollen, but other herbaceous species are more common, particularly <u>Plantago lanceolata</u>, <u>Filipendula</u>, <u>Potentilla</u>, <u>Rosaceae</u> and <u>Artemisia</u>, and also <u>Rumex acetosa</u>, <u>Compositae</u>, <u>Umbelliferae</u>, <u>Chenopodiaceae</u>, <u>Cruciferae</u> and <u>Lychnis</u>. Godwin (1968) has distinguished <u>Plantago lanceolata</u>, <u>Rumex</u>, <u>Artemisia</u> and <u>Ranunculaceae</u> as indicators of pastoral agriculture ; and <u>Cerealia</u>, <u>Compositae</u>, <u>Chenopodiaceae</u>, <u>Cruciferae</u>, <u>Centaurea cyanus</u> and others as indicators of arable agriculture. These species can only be used as guides, however, as some of them, e.g. <u>Compositae</u>, may be found under both systems, and intensive grazing may prevent the flowering of plants such as *Plantago.*

It can be seen that there are more of the pastoral indicators in the Zone B clearances at Fen Bogs and none of the definite arable ones, e.g. *Cerealia* or *Centaurea cyanus.* Turner (1964) has devised an arable/pastoral index which is calculated by expressing *Plantago lanceolata* as a percentage of the total of *Plantago* spp., *Compositae*, *Cerealia*, *Cruciferae*, *Artemisia*, and *Chenopodiaceae*. If this value is less than 15% Turner suggests it indicates predominantly arable farming, whereas if it exceeds 50% it indicates pastoralism. Within Zone B there are three main clearances on the total pollen diagram at Fen Bogs, with peaks at 420cm, 390cm and 330cm. The arable/pastoral indices for each of these peaks have been calculated and are as follows: 80%, 85%, and 85%. All three figures are well over the percentage which indicates pastoralism according to Turner. The *Plantago lanceolata* curve is indeed a conspicuous feature of Zone B, but none of the other herbaceous species typical of human activity is prominent.

We may compare the situation at Fen Bogs in Zone B with that at May Moss. A gradual increase in clearance phenomena was noted at the latter site in the top part of Zone A, and this trend is continued over the A/B boundary, reaching its peak at 410cm. Another increase in *Gramineae* reaches a peak at 370cm and another at 320cm, both seen clearly on the total pollen diagram. Similar peaks are observed in *Plantago lanceolata.* Other herbaceous species recorded include *Plantago major/media*, *Rumex*, *Filipendula*, *Artemisia*, *Compositae*, *Chenopodiaceae*, *Urtica* and *Ranunculaceae*. *Pteridium* expands just after each of these clearances. Decreases are seen in the forest trees corresponding with these peaks. All the trees of the Quercetum Mixtum are involved and Corylus, although Fraxinus and Betula increase throughout the zone. At May Moss, as at Fen Bogs, no cereal pollen is recorded until the B/C boundary. If the arable/pastoral indices are calculated for the peaks of the three clearances the figures are 86%, 87% and 95%. Again, these figures indicate pastoralism and there are no indications from the pollen diagrams of any arable farming.

In an earlier section (3.1) it was noted that the main culture from the mid-Bronze Age in this area was the Collared Urn culture. Although much is known of the burial customs of these people, comparatively little is known of their way of life. The so-called settlement sites of Elgee (1930) have often turned out to be something else, sometimes Iron Age earthworks, so it is not certain whether they lived on the higher ground, where their barrows are found, or lower down, on the upper slopes of the dales. The densely wooded valley bottoms would have been unattractive settlement sites at this time.

Pollen analyses from the floors of Bronze Age barrows on the Hackness outlier of the Corallian outcrop were claimed by Dimbleby (1952c) to provide evidence about the vegetation at the time when the barrows were constructed. When these figures are compared with those from the Fen Bogs and May Moss diagrams, it is seen that they show a greater similarity to Zone A than Zone B, i.e. they can be referred to the Neolithic or early Bronze Age at the latest. Non-arboreal pollen comprises 38% of the total pollen, which compares with the situation in Zone A; but it is over 50% in Zone B. Among the arboreal pollen _Ulmus_ is low, but _Tilia_ is high, comprising 4.3% of the total pollen, which shows that this must be prior to the _Tilia_ decline at the A/B boundary.

There is little other evidence about the vegetational context of the mid-Bronze Age culture, but there are some archaeological clues to the land use practices. The stone walling and irregular plots noted by Hayes (1963) in the area (e.g. near Struntry Carr, 811025) were mentioned above (3.1) and the idea that many of the so-called cairnfields represent clearing of plots for cultivation has received some support in recent years, for example from Fleming (1971). The dating of these features is very tentative and largely by association, e.g. with grave-goods in the barrows within the walling, and it has been noted on several occasions that later archaeological features such as Iron Age earthworks often enclose remains of an earlier date.

Fleming postulated a shifting cultivation type of land use during the mid-Bronze Age for the whole of the North York Moors, particularly the higher parts, in which cereal cultivation was the prime aim and grazing of animals was a secondary although probably important consideration. He produced arguments and hypothetical figures for the feasibility of this pattern of land use rather than evidence to prove that it did occur. He argued that cereal grains had not been picked up by Dimbleby because his sites (e.g. Burton Howes) were at too great an altitude, and he thought that later pollen analysis would reveal their presence at other sites. The Fen Bogs site is at an altitude of 164m OD and recorded cereal grains from the Iron Age onwards, but none from this period. The May Moss site, although at a greater altitude, may have received a more regional pollen rain at this time (infra, chapter 9), as the surrounding woodland was probably thinner, but again no cereal pollen is found until the Iron Age.

Cereal cultivation was being practised elsewhere at this time and cannot have been unknown in the area (cf. the impressions of cereal grains at three barrow sites in the area, quoted by Fleming (1971) from Longworth's work.) There is evidence of cereal cultivation from the Eston outlier in the north of the area (Sockett, 1971) and Spratt (personal communication) found a fragment of a saddle quern in a Bronze Age barrow in the same area. It is quite possible that the "cultivation plots" associated with the cairnfields represent arable agriculture in association with settlement sites, as it is difficult to believe that the middle Bronze Age people did not practise some cultivation for food. If this is correct, it suggests that they lived on the lower slopes, between the higher interfluval ridges and the dale bottoms. This would be the most sensible area to choose for occupation sites and there is no need to postulate a retreat from exhausted areas higher up and a last attempt at shifting cultivation, as did Fleming, to explain the position.

Thus the findings from this study are not in accord with Fleming's ideas, suggesting rather that the dominant land use on the higher areas during this period was pastoralism. This resulted in the clearance of areas within the woodland and the expansion of grasses and ruderals, especially Plantago lanceolata. The mechanism for this clearance is not known. Dimbleby (1962) thought that fire was probably involved, and this might well have been the most effective way of creating clearings for grazing. On the other hand, Fleming has argued against the necessity for the deliberate creation of clearings for grazing animals and has suggested that the woodland itself would have been more suitable. If he is correct in his reasoning it may be the grazing itself which created the effects seen on the pollen diagrams. To whatever extent it was deliberate, a vegetation change was involved in the spread of this pastoralism, which can be distinguished from the earlier Meso-Neolithic clearances by the generally lower values for arboreal pollen on the diagrams and the higher values for Plantago lanceolata.

8.4 The extensive clearance of Zone C.

At c. 270cm on the Fen Bogs, May Moss and Simon Howe Moss diagrams, a sudden very marked clearance is seen, reducing the arboreal and shrub pollen values to much lower levels than those of Zone B. A point just above the start of this zone has been dated on the Fen Bogs diagram to 2280 ± 120 BP, which suggests a date in the early Iron Age for the beginning of the clearance of Zone C; and a date of 1530 ± 130 BP suggests that it ended at about the end of the Roman occupation. This clearance is one of the most marked features on all three diagrams, especially on the Simon Howe Moss one, where it has been suggested above (5.5) that this may represent the clearance of woodland close to the site, further down the Blawath Beck valley. It has been suggested (6.3) that the lower parts of the Gale Field and Moss Slack Goathland diagrams might be correlated with Zone C, but on these diagrams it is not a very marked phase. Although the filtering effect of the woodland may be held to be chiefly responsible for this, it does not seem likely that the clearance was very close to these sites and this suggests that it was to the south rather than to the north of the study area.

We may examine the features of this clearance in more detail. At Fen Bogs, two periods are seen when the Plantago lanceolata values are very high; one from the beginning of the zone to c. 230cm (with peaks at 269cm and 233cm) and the other from c.190cm to 170cm, with a period of lower values in between. The Gramineae curve displays the same effect except that it remains high for longer after the earlier peak. Other species which show a similar pattern include Plantago major/media, Rumex, Ranunculaceae, Artemisia, Rosaceae and Chenopodiaceae, most of which are amongst Godwin's pastoral indicators. The arable/pastoral indices (Turner, 1964) for the two peaks in the first period are 87% and 81%, and that for the second high period (187cm) is 87% also, confirming the impression that the emphasis was on pastoralism rather than cultivation. However, the records for cereal grains from the first period and of Centaurea cyanus for the second, show that some arable agriculture was being carried on as well.

The middle period of the zone is characterised by lower Plantago lanceolata values and peaks for Cerealia, Vicia, Melampyrum, Polygonum and Cruciferae. The arable/pastoral index for this period is 69%, which suggests a greater emphasis on arable agriculture, although it must be noted that the figure is well above that considered by Turner to indicate a predominantly pastoral land use.

As the clearance progresses the non-arboreal pollen gradually expands and a wider range of herbaceous species is recorded, with taxa like <u>Centaurea nigra</u>, <u>Cirsium</u>, <u>Hypericum</u> and <u>Lotus</u> making their first appearances. As the area of woodland was reduced new habitats would have been created for herbaceous species, and Godwin (1967) has noted that many Late-glacial species made their return when the forest cover was opened up through human activity. Also, the reduced woodland would lead to an increase in the pollen catchment area of the sites and some of the species mentioned above may have been growing some distance away and not have been recorded before because of the filtering effect of the woodland.

It is interesting that the period in the middle of the zone when there was more arable agriculture coincides with slightly more arboreal pollen, or conversely, the low peaks in the arboreal pollen curve coincide with the high peaks in the <u>Plantago lanceolata</u> and <u>Gramineae</u> curves. This suggests that the slightly greater emphasis on arable cultivation was accompanied by a reduction in the grazing pressure in other areas which allowed some local regeneration of trees and shrubs. This is consistent with the general rule that arable agriculture is a more intensive activity than pastoralism, and so the peaks of non-arboreal pollen on the diagram do not necessarily represent peaks of population or human activity, but a greater emphasis on grazing, affecting a larger area of land. Some rough calculations show that, assuming the peat in this zone to have grown at an even rate, the first (pastoral) period lasted c.270 years, as did the succeeding more arable phase. This would suggest a date in the first century BC for the beginning of the arable phase.

The reduction of the woodland affects all the tree species except Fagus, which first becomes a significant element in the arboreal pollen in this zone. Carpinus and Acer are recorded also. Salix expands, but other light-demanding trees and shrubs, such as Betula and Corylus decline, presumably because they were growing in the areas used for agriculture. This raises the interesting question of where Fagus was growing if it was not affected; but the answer could be that it was some distance away and its pollen began to reach the sites in greater quantities once the local woodland was reduced. Tauber (1965) has noted that Fagus pollen grains are particularly susceptible to filtering.

We may look now at the other two diagrams which record Zone C clearly. At both of these a three-fold pattern can be distinguished. At May Moss, there is a peak of Cerealia near the beginning of the zone, which lasts to c.250cm. The arable/pastoral index for 250cm is 84%. After this, peaks are observed at c.220cm for Plantago lanceolata, Rumex, Ranunculaceae, Umbelliferae, Compositae, Chenopodiaceae, Cruciferae et al and the arable/pastoral index falls to 78%. In the next period, from c.210cm to 190cm, Cerealia are important again, and Plantago, Rumex and others decrease a little, but the arable/pastoral index for 200cm is 81%. Thus, although the cereal curve seems to suggest the opposite, a slightly greater emphasis on arable agriculture is suggested in the central period of the zone, as at Fen Bogs.

At Simon Howe Moss, cereal pollen is only recorded once, near the top of the zone. The Plantago lanceolata curve shows a marked decrease in the middle and a recovery to lower values than in the first period. The arable/pastoral indices for 267cm, 237cm and 217cm respectively are 91%, 50% and 67%. This seems to indicate that the arable phase was more marked at this site and lasted longer. This could be because the arable area was closer to the site or because the arable pollen was coming from farther afield and was picked up on this diagram as part of the regional component. From the aspect of the site it is possible that much of the pollen was coming from the south-west and could have originated on the more fertile areas of the Corallian outcrop to the south, which is a more likely area for arable cultivation than the high moors of the eastern-central area.

Although the other two sites hardly show the clearance of Zone C, the Moss Slack diagram must be mentioned because of the possible records of cereal pollen. No three-fold division of the zone can be attempted; indeed, the boundaries of it are hard to place, but there is a marked peak of cereals (1.27%) at 230cm. The Gale Field site has no records of cereal pollen from this zone, but there are marked peaks of Gramineae and Plantago lanceolata and records for other weeds which show that signs of this clearance had reached the site. As the clearance is so marked at Simon Howe Moss and arable agriculture was evidently fairly important within the pollen catchment area of this site, it is tentatively suggested that the cereal pollen on all these diagrams was coming mainly from the south-west, probably from the Limestone Hills, and not from within the eastern-central area itself. The main attack on the woodland was evidently not within the northern part of this area, as is shown by the closed canopy remaining over the Moss Slack Goathland and Gale Field sites, and the relatively insignificant appearance of this clearance on these diagrams is consistent with the idea of activity further south.

To summarise Zone C as seen on these diagrams, we can say that near the beginning of the Iron Age period an onslaught on the woodland reduced the forested area in such a way that it never recovered fully afterwards. A long period of predominantly pastoral activity was the cause of this change in the vegetation, but there are signs, particularly from the middle of the period, of arable agriculture as well. It is thought that the area of arable agriculture was to the south or south-west of the study area, and that the northern parts of the region were not greatly affected by the clearance activity.

The lack of archaeological remains from this period (vide supra, 3.1) led most writers, until recently, to believe that there was little settlement in this area. Consequently, most pollen analysts have assumed, in the absence of radiocarbon dates, that the major clearance is to be attributed to the middle Bronze Age people, whose remains are so plentiful in this region, rather than to the Iron Age folk.

Dimbleby, from his work on buried soils under Bronze Age barrows mentioned earlier, suggested that the woodland on the upper parts of the Moors was cleared during the middle Bronze Age, but the evidence he presented was not conclusive. He noted the higher arboreal pollen values in the buried soils which showed that the area was wooded prior to the Bronze Age, although it has already been suggested that the pollen spectrum in question was from Zone A, i.e. Neolithic or early Bronze Age, not mid-Bronze Age. He compared these values with those from the raw humus above the mineral soil outside the barrow and found a picture which, in terms of the present work, post-dates Zone C. Dimbleby noted that the barrow was constructed in a clearing and assumed that it was this and similar clearings of mid-Bronze Age date which were responsible for the great decrease in arboreal pollen seen in the raw humus. However, there is no way of telling how great a lapse of time there was between the deposition of the pollen in the mineral soil and that in the raw humus.

Although Dimbleby's interpretation is questioned, there is nothing in his results which conflicts with the findings of this work that the major clearance was Iron Age in date and not Bronze Age.

Simmons (1969) reached conclusions similar to those of Dimbleby from his sites in the central area of the Moors. On his diagrams, two from glacial drainage channels and two from upland sites, he recognises the primary Ulmus decline, a second Ulmus decline and a "TF" horizon,"where Tilia finally declines and before the entry of Fagus". No second Ulmus decline is recognised on the diagrams in this work, but Ulmus does tend to decline at the end of Zone A, the Tilia decline. Zone B usually correspannds to the first appearance of Fagus, and at the final decline of Tilia, Fagus expands, but it has been present for some time before this. As has already been discussed, changes in trees such as Tilia and Fagus are not thought to be very good features for correlating diagrams because of their local nature at wooded sites. Certain other features may be correlated between the diagrams in this study and those of Simmons, viz. the main clearance (of Zone C in this work) and the first record of cereal pollen.

At Simmons' sites, Cerealia pollen is recorded from his Zone C or just before. At the two upland sites this coincides with the major clearance on the diagrams, and Zone C is a period of high clearance phenomena. At the channel sites, the major clearance does not occur until much later, in his Zone D, and after the first records of cereals. This fits in with the findings of this work, where at the upland sites the main clearance was during the period of first cereal records, but at the lowland sites the local woodland persisted until well after this. Simmons has no radiocarbon dates for his diagrams, but suggests that the major clearance of his Zone C, "might relate to the Middle Bronze Age Urn Folk whose burial sites and settlements are plentifully scattered over the surrounding moorlands." From the diagrams presented in this work it seems more likely that the middle Bronze Age falls within his Zone B, which corresponds to a moderate to high clearance phase at Lady Bridge Slack, or Zone A, which is also a period of moderate clearance activity. Simmons goes on to dismiss the idea of Iron Age clearance with the words, "Late Bronze Age and Iron Age occupation seems to have been lacking." This has been shown to be an erroneous conclusion by recent archaeological research. As with Dimbleby's work, there is nothing in Simmons' data which conflicts with the conclusions reached in this study, and in the absence of dating evidence his conclusions were only tentative.

The idea that the peak of prehistoric activity in this area was middle Bronze Age has been reiterated by most other writers, e.g. Cundill (1971) and Jones (1971). None of these writers has radiocarbon dates for the period in question and they all rely on correlations with the known archaeological evidence. The Iron Age discoveries are all fairly recent so that the only writer who mentions them is Jones (1971). It is suggested that the conclusions of many of these workers need reappraisal in the light of this recent archaeological research and the findings of this study.

An Iron Age date for the main clearance would be in keeping with the findings for many other areas, e.g. Turner (1964) for mid-Wales and Phillips (1969) for north Derbyshire. Turner found a long period of pastoral agriculture from 404 BC on at Tregaron Moss. Phillips found an extensive clearance starting at 340 ± 90 BC at Leash Fen, which began as mainly pastoral but had more arable cultivation towards the end. Turner (1964) comments on the difference that the discovery of iron must have made to Man's potential to clear the woodlands, as in its cheapness and general availability it contrasted with the bronze and copper of previous periods. We must note also the advances in agriculture which the Iron Age settlers brought with thmm, e.g. the mould-board plough which enabled them to tackle the heavier lowland soils, and the practices of manuring and crop rotation which allowed a more permanent type of farming. Indeed, the basis of the Medieval open-field system was probably laid in the Iron Age, and a basic change in the whole organisation of agriculture took place from that of the Bronze Age.

Although Fleming's idea of shifting cultivation in the Bronze Age has been rejected for this area, the pastoral agriculture practised may have involved a semi-nomadic way of life, and it is probable that the cultivation plots associated with the settlement sites had fairly short lives. Very little is known about the organisation of Bronze Age society, but it is possible that the economic unit was something akin to the extended family group, as compared with the tribal organisation of society practised by the Iron Age people and described by Caesar in "De Bello Gallico". It is possible that the Bronze Age-Iron Age transition represented a fundamental change in the organisation of society and its economic appraisal of the landscape, in its way almost as significant as those associated with the Neolithic and Industrial Revolutions.

If the general effect of this change is well-known, its details are still obscure. Although both arable and pastoral agriculture must have been involved, the relative importance of them in particular areas is not known. For the North York Moors there are the "Celtic fields" (3.1), but these are not so well defined as those at Malham , Grassington or Weardale. Some of the stone walling and cultivation plots mentioned before may date from the Iron Age, but dating evidence is lacking in most cases. It seems likely that the settlement sites noted above (3.1) would have had cultivation plots associated with them in the same way that the Bronze Age sites probably did, and the Percy Rigg sites are associated with a rectangular field (Spratt, personal communication). In many cases, however, the areas cultivated in the Iron Age must have been the same as those used in later periods and all trace of the earlier agriculture has disappeared. Most of the Iron Age sites discovered to date are marginal to the high moors, so it seems probable that the arable agriculture was confined to these surrounding areas and the main use of the high moors was as grazing land. The closest settlement site to the eastern-central area is the complex on Levisham Moor (3.1). This probably represented several farmsteads, but it may have been occupied on more than one occasion, as pottery found there goes through to the second century A.D. Some of the enclosures are thought to be for cattle (Figure 16) but the full findings are not available yet. The pollen diagrams discussed in the present work indicate a phase of pastoral agriculture in the early part of Zone C, which would fit in with the idea of the North York Moors as a cattle-rearing area.

One interesting find was the discovery of the iron forge mentioned in 3.1, dated to the Iron Age C period and built on top of remains of two other forges. This is particularly significant in view of the large quantity of charcoal which it must have required and the effect this must have had upon the surrounding woods. At the Simon Howe Moss site, in particular, the opening of Zone C is very sudden and might be explained more easily in terms of large-scale clearance of woodland for charcoal than of long-term grazing pressure. Simon Howe Moss is the nearest site to these remains on Levisham Moor and probably would have recorded the changes more accurately than the other sites. The very low values to which arboreal pollen is reduced in Zone C here suggest that the iron smelters may have gone as far afield as Blawath Beck for their charcoal; if, indeed, there were not other bloomeries in the same area.

The Pre-Roman Iron Age lasted in this area until AD 70, and it was not until the end of the first century that a Romanised way of life began to affect the local population. There was no permanent military presence in the area, the nearest garrison town being Malton, so we are dealing with native farms rather than Roman villas. The greatest effects were felt in the south of the region, on the Limestone Hills, where the demand for consumer goods from the Romans stationed at Malton and York stimulated arable farming on country estates like those discovered at Spaunton, Beadlam, Gillamoor and elsewhere. Meat and dairy products would also be in demand and it seems likely that the higher land would have been used as grazing for cattle and sheep and pigs. A Roman pottery kiln found in a wood at Cold Cam (542814) reminds us that industry would have been stimulated by the Roman presence as well as agriculture.

On the high moors few Romano-British remains have come to light so far. As remarked above, the settlement at Levisham Moor spanned a long period of time, from the Iron Age through to the Romano-British period, indicating continuity of native settlement rather than Roman colonisation. Although the Britons must have learned a great deal from the Romans it is the flowering of British agriculture which we see and not the imposition of an alien system of farming. Thus a long stable and prosperous period is indicated from the Iron Age through to the end of the Roman occupation and beyond, and it is this long phase which is seen in Zone C on the pollen diagrams. As has been noted above, the emphasis was on pastoral agriculture all the way through the zone, but there is some evidence to suggest that arable farming was important especially in the middle of the period and probably to the south of the study area. This middle period may be correlated with the extension of arable agriculture on the Limestone Hills during the Roman period in association with the native farms.. The relatively small impact of the period on the diagrams from the northern sites is consistent with the lack of archaeological evidence for settlements on the Moors south of Eskdale. Caesar wrote that the Britons of the highland zone lived on milk and meat, which again suggests a basically pastoral economy for most of the area.

The identification of cereal pollen grains is very difficult and the identifications presented here are only tentative. At Fen Bogs grains of <u>Hordeum</u> and <u>Triticum monococcum</u> and <u>Secale</u> type were identified from this period; while at Moss Slack Goathland most of the grains seemed to be of Hordeum type. Most of our common cereals were grown from Roman times onwards, but the records for Secale confirm the post-Iron Age date and those for Triticum monococcum suggest a prehistoric or early historic date.

8.5 Zone D.

The reasons for the departure of the Roman legions in 410 AD are well known, but the effect on agriculture in this country is not so easily ascertained. As this was an area of native farming rather than Roman colonisation, the effects were probably less drastic here than elsewhere, but the loss of the Roman market for agricultural products may have led to a recession in agriculture, and the uncertainty caused by the removal of the Roman protection may have been another factor in the gradual run-down of the large villa-estates in the south of the area. The lack of evidence for the Dark Ages themselves suggests a period of uncertainty and lack of cultural activity which probably implies the decay of large-scale organised agriculture.

However, the survival of the fairly large British population in the area means that agricultural activity of some kind must have continued, even if organised on a smaller scale and purely for the needs of the resident native population. Thus we might expect to find a recession in arable agriculture at the end of the Roman period but a continuation of activity in the area. Phillips (1969) found such a decline at 420 ± 90 AD at Leash Fen, and the date for the end of Zone C at Fen Bogs is also 420 AD unaltered (= 1530 $\pm$ 130 BP), just ten years after the departure of the Romans.

A more sudden regeneration than might have been expected is found at the beginning of Zone D, seen well in the arboreal pollen curves, especially Betula, which was probably an important recoloniser. Quercus and Alnus also show a marked comeback at Fen Bogs, but Ulmus and Tilia do not. Fagus and Fraxinus expand, and very marked expansions are noted for Salix and Coryloid pollen. This is consistent with the idea that the light-loving species were first to take advantage of the diminution of agricultural activity.

A corresponding recession is seen in the clearance phenomena, especially Gramineae and Pteridium, but not in heath species, which are particularly high at the beginning and end of Zone D. This suggests that where heath vegetation had established itself during Zone C it was not succeeded by woodland again when the clearance ended. This accords with Dimbleby's idea that the establishment of heath vegetation indicates podzolisation of the soils (vide supra, chapter 7).

Zone D is one of a reduction of clearance indicators, but this concerns some species more than others. Plantago spp, for example, remain high, especially in the middle of the zone, and are accompanied by a peak of Rumex acetosa and Melampyrum. Breaks are seen in the records for other species, however, e.g. Compositae, Cruciferae, Rubiaceae, Ranunculaceae, Chenopodiaceae, Umbelliferae, Filipendula, Potentilla, Rosaceae and

Artemisia all decline in the middle of the zone. *Cerealia* are not recorded except from the top of the Zone, near the D/E boundary. The arable/pastoral index for the period before cereals are recorded (169cm-132cm) is 86%.

At May Moss a similar pattern is observed for the earlier part of Zone D, with a peak of *Plantago lanceolata* corresponding with an absence of cereal pollen at 170cm. The arable/pastoral index for this sample is 75%, and at this site a greater variety of weed pollen is recorded in Zone D than at Fen Bogs. This probably reflects a more regional pollen rain, and the weed species pollen may be coming from some distance away. It seems that the higher areas remained open after the Zone C clearance, and the May Moss site has probably picked up signs of continuing arable agriculture from areas further afield, while at Fen Bogs the regeneration of trees and shrubs has resulted in a more local picture in the pollen record. This is confirmed by the arboreal pollen which shows a less marked increase at May Moss than at Fen Bogs. The increase in shrub pollen is more noticeable, again indicating that the vegetation remained fairly open after Zone C.

At Simon Howe Moss the regeneration of arboreal pollen and shrub pollen is more marked, and perhaps this suggests a regeneration of woodland in the Blawath Beck and Wheeldale valleys. Here a definite increase in *Plantago lanceolata* is seen at the C/D boundary, suggesting an increase in agricultural activity rather than a decrease. The arable/pastoral index for 157cm is 77%. If the woodland clearance had been largely for charcoal for iron smelting the end of the clearance might coincide with the abandonment of this activity and an increase in the relative importance of pastoralism. Thus the general picture for the Dark Ages is one of a decrease in the importance of arable agriculture but a continuance of the traditional way of life from Iron Age times, with an emphasis on pastoralism and a few crops grown as well. Where these people were living is not known, but the arable indicators seem to be coming from some distance away, so it is probable that their settlements were on the Limestone Hills to the south or in the dales and that their chief use for the upland was as a grazing area. A decrease in iron smelting and other activities led to the regeneration of woodland in the valleys, e.g. on the sides of Newton Dale, surrounding Fen Bogs; but the higher areas remained open, with heath vegetation expanding on the impoverished soils.

The radiocarbon dates for Fen Bogs suggest that the Anglian period also falls within Zone D. From what little is known of the Anglian period the main distribution seems to be on the Limestone Hills and along the coast (e.g. the cemetery at Robin Hood's Bay). Excavations at Anglian sites in the Vale of Pickering have found bones of domesticated animals which tentatively suggest that the economy was biassed towards pastoralism. It was noted in a previous section (3.1) that there is some evidence from place-names for Britons living alongside the Angles, probably in subservience to them, and they may well have been employed as herdsmen to tend the flocks grazing on the Moors. Therefore, the area was probably controlled but not colonised by Angles, and in terms of land use practice and vegetation the period probably saw little change.

8.6 <u>The beginning of the Zone E clearance</u>.

At Fen Bogs the radiocarbon date for the D/E boundary is apparently from the Viking period (6.1). It is interesting that Phillips (1969) also has a clearance phase beginning in the Viking period in North Derbyshire, (dated to 965 AD, but thought to be earlier). At Fen Bogs a long period of low arboreal pollen is seen but with shrub pollen more important than in Zone C. The general impression of the clearance from the total pollen diagram and the arboreal pollen curves is that it was not so intensive as that of Zone C. The radiocarbon date for 60cm, the E/F boundary, is 390 $\pm$ 100 BP, which suggests a date about the end of the Medieval period for the end of the clearance phase.

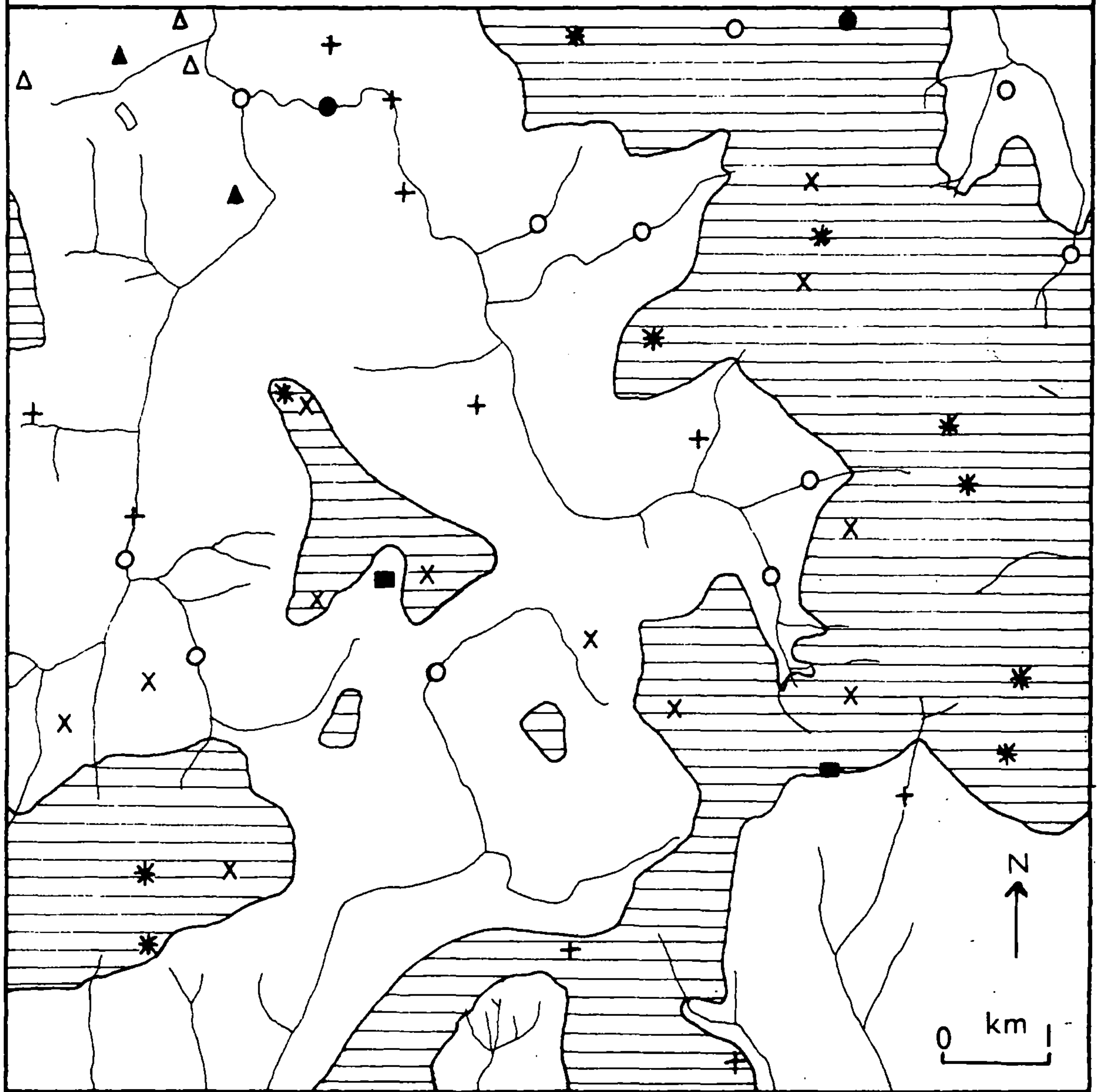
Although arboreal pollen is low throughout the zone at Fen Bogs, the herbaceous pollen curves suggest two main periods within it. The first of these is charact--erised by low <u>Gramineae</u> values and high values for heath species and the second by very high <u>Gramineae</u> values and a decline in heath species. There is a short transitional zone between these two periods, at c.90cm. The reciprocity between the <u>Gramineae</u> and <u>Calluna</u> curves suggests that in the latter part of the zone <u>Gramineae</u> were expanding on to areas which had been colonised by heath species, probably on the higher ground. If the peat from this zone grew at an even rate, a date near the end of the twelth century would be suggested for the beginning of the second part of the zone.

In the first period, when Gramineae values are low, Pteridium values are also relatively low. Plantago lanceolata and Cerealia both have a peak near the D/E boundary, as do Rumex spp., Filipendula, Rosaceae, Artemisia, Compositae, Umbelliferae, Chenopodiaceae, Cruciferae and Urtica. This is followed by a period when these taxa are nearly all less frequent, although there are some others which increase, e.g. Ranunculaceae. The arable/pastoral index for 118cm-106cm, spanning the D/E boundary, is 67%, a much lower figure than for the pastoral period before and indicating a significant increase in arable activity within the area. Assuming the average rate of peat growth for Zone E applies, this period lasted for approximately 160 years, and probably extended from the last part of the ninth century to the early eleventh century A.D.

We shall search in vain for documentary or archaeological evidence to support this theory of a period of mixed agriculture in the Viking era, but we may note the possibility of such a phase from the evidence of Viking settlement in the area. The most useful source of evidence is that of place names. There are abundant examples of both Danish and Norse place names on the Moors (vide supra, 3.1). Many of the common names for features of the landscape are Viking, especially Norse, e.g. howe, gill, dale, rigg. This suggests that the Norse settlers were conversant with the whole area, which immediately suggests pastoral agriculture. Although the arable/pastoral index suggests a significant amount of arable agriculture, it is still within the limits for pastoralism as the dominant activity, and it is to be

Map 16. Figure 52.

VIKING PLACE-NAMES IN THE EASTERN–CENTRAL AREA



KEY

Streams

Land over 250m

PLACE-NAME ELEMENTS

- X rigg
- O beck
- ✱ howe
- ▲ carr
- Δ murk
- ■ moss
- ● foss
- + others

supposed that this was the main type of farming in this area, especially on the higher parts. The settlements with Viking names are on the lower ground, Goathland itself being one, and a number of isolated farms in the eastern-central area have names of Viking origin, e.g. Struntry Carr (811025), Key Green (804047). This strongly suggests Viking settlement in areas later resettled in the Medieval period. (Map 16) These settlements are on the boulder-clay area which would have provided fertile soils when cleared of woodland. However, the eastern-central area was part of Dic wapentake (later, Pickering-lythe), which suggests control from the Limestone Hills area in the south. It has been suggested by some writers, e.g. Smith, 1928, that the Norse settlement in this area may not have been completed until the twelth century and so it is possible that the settlements above were made later than the Viking period sensu stricto.

At the Gale Field and Moss Slack Goathland sites, Zone E has a three-fold pattern. It begins with a phase of clearance which is not very marked because the local woodland was still in existence, followed by a slight regeneration of woodland and diminution of clearance phenomena before the third phase, which corresponds to the clearance of the local woodland. It is assumed that the first phase above corresponds to the Viking period at Fen Bogs and the second to the period of lower clearance phenomena before the Medieval clearance. At Moss Slack the Viking period is characterised by an increase of <u>Gramineae</u> and <u>Pteridium</u> and the reappearance and expansion of Plantago lanceolata. There are no records for cereals until after the local woodland is cleared at this site, but records for other clearance indicators include Rumex spp., Artemisia, Compositae, Umbelliferae, Chenopodiaceae, Cruciferae, Ranunculaceae and Melampyrum. Fraxinus and Salix expand and Fagus is recorded, but the decrease in the other tree species is not very noticeable except in the case of Tilia.

At Gale Field, the increase in the Gramineae curve is the most marked feature of the early part of Zone E. A great expansion of Plantago lanceolata and Pteridium is noticed, along with abundant records for other herbaceous species, e.g. Plantago major/media, Rumex spp., Artemisia, Compositae, Umbelliferae, Chenopod--iaceae, Cruciferae, Ranunculaceae, Melampyrum and Urtica. There are two records for cereal grains during this period, which may be significant, as the local woodland would probably have filtered out most of these grains. As at Moss Slack Goathland, the tree species which suffers most is Tilia, but decreases are also noted in Quercus and Ulmus, while Fraxinus, Fagus and Salix increase. It seems that the clearance is a little more marked at Gale Field than at Moss Slack, possibly because the former site was a little nearer to the settlement area. Arable/pastoral indices have been calculated for the peaks of the clearance (80cm-70cm at Moss Slack; 180-135cm at Gale Field) and the figures are 74% and 81% respectively. As at Fen Bogs, this indicates a basically pastoral system of farming but with some signs of arable cultivation.

We may look now at the two diagrams from upland sites, where the opening of Zone E was thought to have been later than at Fen Bogs (sections 5.4 and 5.5). At Simon Howe Moss a change is noted on the total pollen diagram at c.127cm, when a decline is seen in arboreal pollen and especially shrub pollen. The main shrub involved appears to be Corylus and amongst the trees Betula and Ulmus suffer most. Just at this level a peak is seen in Cerealia, Gramineae, Plantago lanceolata, Rumex spp. and Artemisia (cf. the D/E boundary at Fen Bogs). Throughout the period heath species are increasing and they reach a peak as the clearance phenomena decrease again. Then, at c.80cm, heath species decline again as Gramineae expand and the clearance phenomena, especially Cerealia, reassert themselves. This pattern is reminiscent of that seen at Fen Bogs, particularly the greater emphasis on heath species in the first part of Zone E and on Gramineae in the latter part, and again a clear reciprocal relationship is seen between the two, suggesting agricultural use of the uplands as well as the lowlands. It appears that the period from c.120cm on the diagram represents Zone E and that the phase from 67cm to 37cm, which was tentatively identified as this zone (6.3) represents the climax of the clearance. This regional diagram has picked up the cereal pollen from the Viking clearance, although the decrease in the woodland is less well seen than at Fen Bogs. It appears that the decrease here was mainly of shrub pollen, which is not unlikely, as the regeneration of Zone D in the upper parts of the valleys had been mostly of shrubs rather than high forest trees.

On the May Moss diagram, as at Simon Howe Moss, the increase in non-arboreal pollen leading up to what was originally identified as Zone E is seen to start some way further back. From c.90cm to the climax of the zone at 40cm cereals are recorded in increasing amounts, as are _Plantago lanceolata, Rumex_ and the other clearance indicators. Before this there is a short period of lower clearance phenomena and a break in the cereal pollen curve, preceeded in turn by another period of cereal records and high clearance phenomena which extends back to c.160cm. At this site, however, _Gramineae_ are higher in the first phase of the zone and heath species in the latter part, the opposite pattern to that seen at Simon Howe Moss. Again there is a reciprocal relationship between _Gramineae_ and heath species, which suggests that these changes were affecting the upland vegetation.

Therefore, it seems that a three-fold pattern is seen at all five sites in Zone E, with a short period of inactivity separating the Viking and Medieval clearance phases. The first part of Zone E has been found to be earlier than was originally thought at the two upland sites, and the whole zone as now recognised is seen to be broadly comparable in length with that at the lowland sites. The first part of Zone E, the Viking phase, appears to have been one of predominantly pastoral agriculture, but with some arable cultivation, presumably in the lowlands. A study of the place-name evidence suggests the possibility of settlement and agriculture in the eastern-central area itself, especially towards the north of the study area, around the village of Goathland.

8.7 The middle part of Zone E.

After the Viking period there was evidently a decrease in agricultural activity, seen at all sites and concerning both arable and pastoral indicators. This suggests a decrease in population in the area rather than a change in land use. As this is within the period of documentary records, we may seek for written confirmation of a depopulation after the Viking period. The obvious source to turn to is Domesday Book, which records not only the picture in 1086 but also some of the changes which had taken place since pre-Conquest days.

The effects of William's "harrying of the north" have already been mentioned (3.1) and it was noted that a redistribution of settlement probably followed it. Although many vills in the area were recorded as "vasta", it seems improbable that William's men caused widespread destruction in the area, especially on the higher ground. The general picture from Domesday Book is one of lack of agricultural activity, e.g. only one plough is recorded in Eskdale and no meadow land. Farra (1961) notes that most of the settlements named in Eskdale (except two whose locations are unknown) were on the north side of the dale, i.e. with a southerly aspect.

Goathland is not mentioned, the nearest settlement to the area known to have been in existence at this time being Egton. One of the problems with Domesday Book must always be how accurate it is, especially as, with so many different recorders at work, its accuracy probably varies a great deal from one part of the country to another. There are three possible reasons why Goathland is not mentioned. Firstly, it could be because there was no settlement there; secondly, it might be that the recorders did not venture up the densely wooded Murk Esk valley (N.B.this is the only south-bank tributary of the Esk with nucleated settlement of any antiquity); thirdly, it could be that Goathland was recorded under Pickering, an explanation suggested by Buckley (1971). The woodland which became the Royal Forest of Pickering is mentioned in Domesday Book and its dimensions are fairly accurate. Goathland is at the northern end of this area and, if there was no arable land being worked in the vicinity, could have escaped particular mention. From the palynological and place-name evidence described above (8.6) it seems probable that there was some settlement at Goathland at this time. One of the latter explanations seems likely; indeed, it is possible to accept both, because if the recorders were working from the southern end of Pickering-lythe wapentake, it is quite possible that they did not travel up through the forest to see what was at the northern end.

Domesday Book does not record moorland grazing, a sad omission in this area. It was noted above (3.1) that most of the high watershed area was associated with settlements in the Limestone Hills area, e.g. Pickering Moor, Allerston High Moor, Goathland itself was associated with Pickering as part of the ecclesiastical parish of Pickering until the nineteenth century. This suggests a connection with the area to the south going back before the Norman Conquest and probably traceable to the Anglian settlement of the Limestone Hills or to the Danish administrative division into wapentakes. If the land was already associated with Pickering before the Vikings settled there, this could explain an otherwise enigmatic association. If the harrying of the north caused widespread redistribution of population it is quite possible that the people living in the area around Goathland, unknown to William's men and therefore unmolested, might have moved down to the mother settlement in the south. Hodgson (1965) notes the probability of the concentration of resources on the best vills, and Farra (1961) notes that there was less devastation in the Limestone Hills area than on the coastal plateau or in Eskdale, although most vills had dropped in value and arable farming had contracted. Thus a rationalisation of population and resources would almost certainly have favoured those vills in the south rather than those further north. It may be noted that the recession in the middle of Zone E is more marked at the northern two of the sites than at the more southerly ones.

Several other writers have recognised a phase of woodland regeneration and decline in agriculture which they correlate with "the harrying of the north", e.g. Birks, 1965, at Lindow Moss, Cheshire. The harrying itself lasted only for the duration of one winter, but its effects were probably exacerbated in this area by raids from the Danes and Scots. However, it is not an event which one would expect to be able to recognise as such on a pollen diagram. The period of recession which is seen on the diagrams presented here is not to be labelled "the harrying of the north", but to be interpreted as a phase of depopulation and migration following the Norman Conquest which saw the abandonment of arable agriculture in the eastern-central area and its development further south. This period formed a hiatus between the Viking settlement and the recolonisation of the area in Medieval times, particularly by the monasteries. It is probably a little later in date than the harrying of the north itself, perhaps late eleventh or early twelth century, and it is interesting to note that the approximate calculations for the chronology of Zone E suggested a date about this period for the commencement of this phase. It is to be expected that a certain time lag will be involved before such effects become visible on the pollen diagrams, and taking this into account the phase seems to fit in well with the known pattern of events.

8.8 The later part of Zone E.

The later part of Zone E corresponds to a resurgence of clearance phenomena at all sites and must indicate the return of agriculture into the area. It is likely, of course, that a certain amount of grazing had continued un the uplands during the recession phase, which is less well marked at the two upland sites; but this next period must represent a recolonisation of the study area itself. The documentary evidence suggests that this occurred from the twelth century onwards.

The recolonisation has been described above (3.1). Farra (1961) states:

> "The foundation of numerous monasteries and nunneries in the twelth century, followed by their rapid growth and organised exploitation of farmland, marked the beginning of a new era in the agricultural development of the region."

It will be recalled that there was no large religious house in the eastern-central part of the Moors, although the Whitby Strand boundary came as far west as the ridge on which Lilla Howe, High Woof Howe and the others stand to the east of May Moss,(an interesting re-use of what was a Bronze Age trackway, according to Elgee (1930)). Smaller religious establishments included the hermitage at Goathland and the priory at Grosmont, and in both cases the nucleated settlement seems to have been centred on these religious houses.

The area to the west of the Whitby Strand boundary, however, was part of the Royal Forest of Pickering, and was preserved for hunting with only limited grazing rights and legal arable agriculture. Thus, although there was some arable agriculture in the Murk Esk valley, the main part of the area was not cultivated and was either grazing land or preserved woodland.

Returning to the pollen diagram for Fen Bogs, we may examine the nature of the vegetation changes accompanying this recolonisation of the area. The main change, as was noted earlier, is in the expansion of _Gramineae_ at the expense of heath species. _Pteridium_ expands, as do most of the clearance phenomena. _Plantago lanceolata_ expands and _Cerealia_ remain low in the first part of the period, but _Plantago lanceolata_ drops again when _Cerealia_ expand and it is only at the end of the zone that both are high. Arable/pastoral indices have been calculated for three samples from this latter part of

Zone E, for 87cm, 74cm and 64cm, and the figures are 50%, 30% and 56% respectively. These figures are all much lower than any previously obtained for this diagram and indicate a much greater emphasis on arable agriculture, especially the middle figure above. They are all within the category of "mixed farming" according to Turner, which agrees with what is known of the agricultural practices of the time. The pollen spectra show a wide range of herbaceous species present, both arable and pastoral indicators, some of which have been absent from the pollen record since Zone C, e.g. Centaurea spp., Cirsium, Sanguisorba officinalis and Stachys type.

A similar range of taxa is recorded at Moss Slack Goathland and Gale Field. At Moss Slack this part of the diagram is believed to have been shortened because of a period of erosion (vide supra, 5.2), but at Gale Field it is seen clearly and includes such taxa as Leguminosae, Polygonum, Saxifraga, Linum catharticum, Convolvulus, Valeriana and Lotus as well as the commoner "weed" species.

At Simon Howe Moss, an increase in Pteridium and Equisetum is seen and again a wide range of herbaceous species is present, including Humulus/Cannabis type. As at Fen Bogs, Plantago lanceolata decreases when Cerealia begin to rise, but both are high by the close of the zone. The arable/pastoral index for the period 77cm-57cm at this site is 48%, which again is lower than that for any of the other clearances so far. The fact that during Zone C the index at this site was generally lower than that for Fen Bogs suggests a more even spread of agriculture in Zone E within the region.

At Gale Field the arable/pastoral index falls from 80% after the initial clearance of the woodland (at 95cm) to 64% at 77cm, but this is considerably higher than the figures for Fen Bogs or Simon Howe Moss, indicating that the area around Goathland, which is the chief arable one close to the region today, was not so important in the Medieval period. At May Moss a figure of 26% for 60cm is lower than any other so far obtained, which implies that the arable area was nearer to this site than to Gale Field, i.e. to the south or east of the eastern-central area. We know that this was an important period for agriculture on the Limestone Hills in the south, but the agriculture carried on by the monks of Whitby Abbey to the east was also of considerable importance, and both these areas may have contributed to the high arable pollen at May Moss. Thus we see that the expansion of agriculture around Goathland in the north of the region was slower than in the area to the east or to the south.

Hollings (1971) has traced the Medieval settlement of the area around Goathland. Some of the settlements recorded were ecclesiastical, e.g. the hermitage (the "Abbot's House"), Malton Close (a grange of Malton Priory) and the Chapel (where the church now stands). However, there are also records to show that there was a considerable amount of lay settlement, such as that at Darnholm, Somerholm, Hamerholm and Thwayte,[1] and a mill was recorded in Goathland by 1300 AD.

1 It is interesting to note the Norse names of these settlements. This could imply either continuing colonisation by Norse into the twelth and thirteenth centuries, or a strong Norse dialect spoken in the area at this time.

As much of the eastern-central area was part of the Royal Forest of Pickering, arable agriculture was restricted to two types of area. Firstly there were the grants of parcels of land, such as the grant of one carucate to Osmund the Priest and the brothers at the hermitage of Goathland in 1108 by Henry I; secondly there were the illegal assarts which were made in the Forest, such as those reported by a Forest Inquisition in 1334 on Allantofts to the north of Goathland (Turton, 1894). In both cases, small isolated pieces of land were involved. The settlement appears to have had a dispersed form from its beginning, which again indicates land held in severalty, and there are no records of open fields at Goathland indicative of large-scale village agriculture. Therefore, it is not surprising that the pollen diagrams do not suggest that arable agriculture was very important in the area around Goathland in the Medieval period.

However, there may have been a considerable amount of grazing, especially on the higher areas to the east of the Whitby Strand boundary. It is known that Whitby Abbey had large flocks of sheep and it is probable that lay tenants had also, although there are few records to prove this. There are references to cows at Goathland which show that cattle were also kept on the lower ground. Further west the monastic establishments such as Rievaulx Abbey controlled vast areas of high moorland as sheepwalk and this was a period of pastoral agriculture organised on a scale far larger than anything seen previously. The grange of Malton Priory at Goathland was probably established primarily for sheep farming, and no doubt all the available upland pasture was used. It was only the presence of the

Royal Forest in this area which restricted sheep grazing.

This prolonged grazing pressure must have produced changes in the vegetation of the higher areas. On the diagrams from May Moss and Simon Howe Moss we see a gradual increase in the pollen curves of the heath species throughout this period, particularly marked in the <u>Ericaceae</u> curve. It is probable that this gradual increase in heath vegetation was the result of the continued grazing, especially of sheep. The arboreal pollen curve does not suffer very much, as by this time the woodland was confined to the dales and lower areas. This is shown by the much more sudden and substantial decrease in arboreal pollen in Zone E at Fen Bogs, Moss Slack and Gale Field than at the two upland sites. Therefore, it appears that the extension of heath vegetation was at the expense of grasses and other herbaceous species rather than of trees and shrubs, and the curve for <u>Gramineae</u> is noticeably lower than it was in Zone D on the diagrams from upland sites.

On the diagrams from Gale Field and Moss Slack Goathland, however, a different effect is seen as here the local woodland was cleared at this period. There are abundant documentary references to woodland from the Forest Records, and many examples of the felling of trees to show that a considerable deforestation was taking place throughout the fourteenth century, despite the official preservation of the Forest. For example, from the Coucher Book of the Duchy of Lancaster there are references to the selling of sixty oaks in Allantofts at 1/- each by one of the Keepers of the Forest, and to the felling of oaks for the construction of Scarborough Castle. It was not only tenant farmers who were involved in the illegal felling, but also forest officials and local landowners, including the ecclesiastical ones; for instance, the Abbot of Whitby is accused of felling thirty-six oaks for the repairs to his house in Goathland (i.e. the hermitage). There are references to literally hundreds of trees, mostly oak, felled within the area in the fourteenth century, and also references to woods "de veteri vastatus" (despoiled of old) which show that this had been going on for some time.

Therefore, it is not surprising that the woodland at Gale Field and Moss Slack Goathland should have been removed during the Medieval period, as demand for timber was great. Among other uses was that for charcoal for iron smelting. A thirteenth century iron furnace, now in the Whitby Museum, was found near Moss Slack Goathland. In 1313 the Minister's Accounts show an entry of 13/11d for the sale of dry wood for the use of a smelting-place and charcoal factory in Wheeldale and Newtondale. Others are known to have been in existence at Levisham, Glaisdale and Rosedale. Waites (1964) has stressed the importance of iron mining in the settlement of the area to the south of Eskdale. As noted before, these furnaces must have caused a considerable amount of deforestation. It may well have been the sudden felling of a large area of woodland on the channel sides which caused the erosion and deposition of clay bands at Moss Slack.

The references to woodland in the Medieval period are often associated with poaching offences in the Forest. One of the easiest ways to catch deer was to drive them towards boggy areas where they would get stuck and provide sitting targets. So the sites for pollen analysis themselves are often mentioned, e.g. in 1293 Robert Acklam et al and the Lord of the manor of Borrowby took three harts and hinds at Thrush Fen (= Fen Bogs); in 1328 William Moor, Robert Chiburn and William Moor Junior et al took a hind in Mawmose (= May Moss); in 1330 Simon, son of Robert Wood, et al took a hind in Simondeshou Mosse (= Simon Howe Moss) and sent it to Thomas Duffield at Whitby, (Turton, 1894). Ellerbeck is mentioned frequently, as are other watering places where again deer might be caught fairly easily. However, this also reflects the increasing concentration of woodland in the river valleys and the least accessible places as more and more of it was removed.

Although the higher parts of the area were losing their forest cover, the existence of large areas of heather moorland is not suggested from the pollen diagrams for Zone E. The historical records have many references to heather, bees, turves, etc. for the East Ward of the Forest (e.g. Langdale, Cloughton) but few for the West Ward (i.e. the study area). For example, the Minister's Accounts for 1313-14 state:

> "De turbis in bruera, melle et cera in alta mora nil hoc anno."

The importance of pastoral agriculture is stressed in these accounts by the many references to sheep and lambs and to sales of these and their hides.

8.9 Zones F and G on the pollen diagrams.

The top part of the Fen Bogs diagram has been divided into two zones on the basis of changes in the arboreal/non-arboreal pollen ratio. At c.70cm a slight increase in arboreal and shrub pollen is noticed which rises to a peak at c.40cm. From 30cm to the top of the diagram another resurgence of non-arboreal pollen is seen, so that Zone F appears from the total pollen diagram to represent a slight regeneration of trees and shrubs. The arboreal pollen curves show this increase to be made up mostly of *Betula* and *Fraxinus*, and the increase in the *Coryloid* curve is also very well marked, so this regeneration was evidently of pioneer and shrub species rather than of high forest trees.

On the non-arboreal pollen curves the main change is the re-expansion of heath species and *Cyperaceae* and the contraction of *Gramineae*. This suggests a decrease in the area of grassland and an expansion of moorland, and the change is seen to be quite a sudden one. From the records of other herbaceous species, however, it is clear that the E/F boundary does not represent a decrease in the number of herbaceous species present but a change in their importance relative to one another. This strongly suggests a change in land use rather than a decrease in agricultural activity in the area.

Taxa which are less frequent in Zone F than in Zone E include *Plantago major/media*, *Filipendula*, *Rosaceae*, *Succisa*, *Urtica* and *Stachys*; while those which increase in frequency in Zone F include *Humulus/Cannabis*, *Rubiaceae*, *Chenopodiaceae*, *Compositae*, *Centaurea cyanus*, *Artemisia*, Rumex spp., Plantago lanceolata and Cerealia. This suggests an increase in the importance of arable agriculture, as several of the latter group are among Godwin's arable indicators (Godwin, 1967). It was noted before that a decrease in grazing, which is a more extensive form of agriculture than arable cultivation, might lead to a regeneration of trees and shrubs in some parts of the area. The arable/pastoral index for Zone F at Fen Bogs (60cm - 30cm) is 37%, which suggests a greater emphasis on arable agriculture than in Zone E. The date for this change at Fen Bogs is thought to be the end of the fifteenth century (radiocarbon date = 390 ± 100 BP; for true date, see 6.1).

At c.30cm on the diagram from Fen Bogs another change in the composition of the non-arboreal pollen is seen, corresponding with a decrease of arboreal and shrub pollen to minimal values. Taxa which decrease in importance in Zone G include Cerealia, Artemisia, Centaurea cyanus, Chenopodiaceae and Humulus/Cannabis; whereas an increase is noted for Urtica, Scleranthus, Ranunculaceae, Filipendula, Rumex spp. and Plantago spp. This suggests an increase in the relative importance of pastoralism, which the arable/pastoral index for this zone of 65% confirms. The dating of this change in emphasis can only be tentative. On the Fen Bogs diagram it comes approximately half way through the section between the D/E boundary and the surface. As the peat near the top may be less compressed, it seems probable that the change occurred sometime after the beginning of the eighteenth century.

We may compare Zones F and G on the Fen Bogs diagram with those on the other diagrams from lowland sites. At Gale Field an increase in arboreal and shrub pollen is seen starting shortly after the clearance of the local woodland at c.70cm. This regeneration phase was tentatively correlated with Zone F at Fen Bogs (vide supra, 6.3). However, the increase in the cereal pollen curve, which accompanied the regeneration at Fen Bogs, does not start until c.50cm at Gale Field, which suggests that some woodland regeneration had taken place before this change in land use at this site. If the original position for the E/F boundary is adhered to, the expansion of arable cultivation around Goathland must have been later than elsewhere, and the arable pollen at Fen Bogs cannot have been coming from there. The alternative interpretation is to place the E/F boundary at 50cm instead of 70cm at Gale Field, thereby including the regeneration phase from 70cm to 50cm in the top part of Zone E.

The F/G boundary at Fen Bogs was characterised by both a decrease in arboreal and shrub pollen and also a change towards pastoralism. Once again, these two characteristics do not coincide on the diagram from Gale Field. The decrease in arboreal and shrub pollen is at c.45cm on the Gale Field profile from the site in the plantation, and at c.70cm at the site in the clearing. However, the arable/pastoral indices indicate that the change towards pastoralism was later than this; figures for 100cm, 50cm and 30cm on the diagram from the clearing are 83%, 33% and 54% respectively, suggesting a position at c.40cm for the change in land use. At this level a further decrease in the arboreal and shrub pollen curves is noted. This is thought to be the better position to draw the F/G boundary, as both conditions are satisfied. It is probable that a change towards pastoralism would be manifest in a similar set of changes on diagrams from both upland and lowland sites, as pastoralism affects a large area of land. Arable cultivation, on the other hand, would be concentrated in the lowlands, and might well lead to a decrease in arboreal pollen at lowland sites but an increase at sites higher up, further away from the arable activity. Thus it is suggested that the F/G boundary be drawn at 40cm on the diagram from the site in the clearing and the E/F boundary be drawn at 50cm on the diagram from the site in the plantation, coinciding with the land use change rather than with the regeneration phase.

The Moss Slack Goathland diagram shows a similar pattern to that at Gale Field, with the arable/pastoral index remaining at 66% during the regeneration of woodland at the top of Zone E, but falling in Zone F to 42% at 19cm and 29% at 15cm. Then it rises again to 51% at 11cm, 55% at 7cm and back to 66% again at 3cm. The evidence from these three sites suggests that the arable phase near Goathland was preceeded by a slight regeneration of woodland and that the extension of cultivation in the vicinity caused a decrease rather than an expansion of arboreal and shrub pollen on the lower areas.

We may turn finally to the two upland sites. At both these sites the cereal pollen curve behaves in a similar way to that at Fen Bogs, being high when the arboreal and shrub pollen expand in Zone F and dropping when they decline again in Zone G. The behaviour of the Plantago lanceolata curve and the other weed species is also similar to that at Fen Bogs and the arable/pastoral indices for the arable phase are 41% and 48% and for the pastoral phase 64% and 83% at May Moss and Simon Howe Moss respectively. The slightly higher figures for both zones than those at Fen Bogs, imply the greater distance between the former two sites and the cultivated areas.

Therefore, the picture from the pollen diagrams is as follows. At the end of the Medieval period, a change in land use took place with the emphasis shifting from pastoral to arable agriculture. On the lower land around Goathland itself this involved some further clearance of the remaining patches of woodland; but on the higher moors the decrease in grazing pressure following the change allowed some trees and shrubs to regenerate. This was probably on the dalesides, as an expansion of Calluna and Ericaceae shows that the main change on the higher areas was from grassland to heather moorland. After this, at some time probably in the eighteenth century, a further shift of emphasis in agriculture led to a decrease in arable farming and a renewed interest in pastoralism which has continued until the present day.

8.10 Documentary evidence for the changes in Zones F and G.

Throughout the Tudor and Stuart periods there are documentary references to the woodland in the eastern-central area from the records of Pickering Forest. Buckley (1971) quotes a list of "Standing Woods in Gotelande" in 1562, from the Duchy of Lancaster records. The total (nearly all oaks) comes to over 12,500 trees. The survey states that all these were trees of over 200 years growth, which Buckley suggests is evidence for a lull in the felling of trees over the previous two centuries, as so many were felled in the fourteenth century. This could partly account for the regeneration of arboreal pollen seen on the diagrams from Gale Field and Moss Slack Goathland at the top of Zone E. Buckley also quotes Commissions and Pleadings for 1562 - 1571 which show that over 800 trees were felled during this period, so obviously there was a resurgence of felling in the sixteenth century, which might have contributed to the decrease in arboreal pollen in Zone F at the sites near Goathland.

There are two surveys of the woods which were made in the early seventeenth century; the first, in 1608, describing the woods in Wheeldale, Newton Dale and Baindale, says:

> "...the woode there groweth upon steepe bancke sides, and will yeelde but little monye."

This confirms the impression that the only woodland left by this time was on the steep dalesides in inaccessible positions. John Norden's survey of 1619-21 was made in order to establish the boundaries of the "Honor" of the Forest and to enquire into the extent of the woods, the assarts made illegally, the common rights and whether the various fines and rents were still being paid to the Crown by the tenants. From these terms of reference it is obvious that the area was no longer being used as Forest in the strict sense and that the control of the Duchy of Lancaster was not enforced very rigorously. As we might expect from this, the enquiry found many assarts had been made, e.g. one of 200 acres on Wheeldale Moor by M. Raulfe Salven of Egton Manor. The boundary had been altered illicitly on the eastern side too, by Sir Richard Egerton, who put a new boundary stone on "Whynny neb" (Whinny Nab) and a cross (presumably, Malo Cross) and "directeth to Ellerbeck heade over wormesike, to Lilhow crosse", thereby appropriating to himself the area of May Moss from the Forest.

Also the rent for many of the earlier enclosures was no longer being paid, e.g. some of those on Allantofts, and the common rights to certain types of foliage and small timber were being abused by the people of Pickering township:

> "There is little timber lefte in the sayde forests, And that it hath bene taken and felled long since And that which is lefte in Pickeringe woods, is ill preserved but powled, and cutt, by the haulfe bole, And the bowghes for the moste parte, dismembred and stollen awaye by idle people of the towne, and others, so that in twentie trees, a man shall scarcelie finde one whole tree...."

The people were obviously beginning to regard the Forest as their own property, and when twelve coppices were formed they pulled down the hedges, thinking that they would usurp the herbage from their cattle (Turton, 1894). They had been helping themselves to larger timber too, and references are made to oaks, alders, maple and ashes in Newton Dale. Fifteen presentments are mentioned, nine of which offences were committed in Newton Dale. This is explicable, as Newton Dale seems to have been about the only place where there was any substantial woodland left within the Forest:

> "the forests game shoulde be redd deere, but few lefte within the forests, and they that are raunge into confininge woodes of Sir Thomas Posthumus Hoby, havinge little or noe covert els within the forests, but Newton Dale onlie, where they are often disturbed by stealers of woode, so that it is manifeste that for everye redd deare in the forrest, there are 5,000 sheepe."

This last estimate is probably an exaggeration but it does stress the overall importance of pastoralism within the area at this period, even at a time when arable agriculture was expanding. Despite the woodland left in Newton Dale, there are several references to enclosures within it, and to a settlement at Fen Bogs (Thrush Fen):

> "Thomas Bulmer, a turner, or worker of wooden vessells hath for the space of two yeares laste paste, lyved at the howse of one Edwarde Robinson of Thrusse Fenn near Newton Dale, where the sayde Bulmer hath take Alders, and other woode to the worth of -xl^{s}."

Could this have been the original settlement at the southern end of Fen Bogs near the ruined cottages and drained pastureland?

So there was still some woodland left in Newton Dale in the seventeenth century, but the higher ground had obviously long since ceased to support any trees. Wheeldale Moor is described by the jurors as "meane heathie and boggye grounde", confirming the impression from the pollen diagrams that much of this higher ground had gone over to heath vegetation since Zone E.

The records for the later seventeenth and eighteenth centuries show the gradual appropriation of the rest of the Royal Forest by the people of the area. In 1707, a surveyor of the manors of Rosedale, Goathland, Snainton and Brompton said that,

> "I do find that the same do severally consist of moores and waste lands onely.... all which moores of Rosedale, Goateland and Brompton are very barren grownde and covered with ling and bent throughout."
>
> (Turton, 1894)

Thus there is documentary confirmation for the increase in heath species in Zone F, seen on the pollen diagrams. The records suggest that Newton Dale was one of the few areas with any sizeable amount of woodland left, and so changes in this woodland might account for the fluctuations seen in the arboreal pollen curves at Fen Bogs and the two upland sites in Zones F and G when little change is noticed at the other two sites. The regeneration of woodland at Moss Slack Goathland and Gale Field in the last part of Zone E probably reflects a local recovery after the first felling in the fourteenth century, and when arable agriculture expanded in Zone F the last of this woodland was removed.

There is also some evidence for a gradual increase in arable agriculture afforded by the increasing number of assarts recorded. For example, in 1554-5, Sir Richard Cholmeley ordered each of his tenants in Goathland to enclose a piece of the Commonland, the "Lez Feld Stakes", so that they would have to pay him more rent. However, this would have had a gradual effect and the Forest Records do not give us much information about the apparent decrease in pastoral activity in Zone F at the same time. For this we must look to the area outside the Royal Forest, much of which had been farmed by the monks during Zone E.

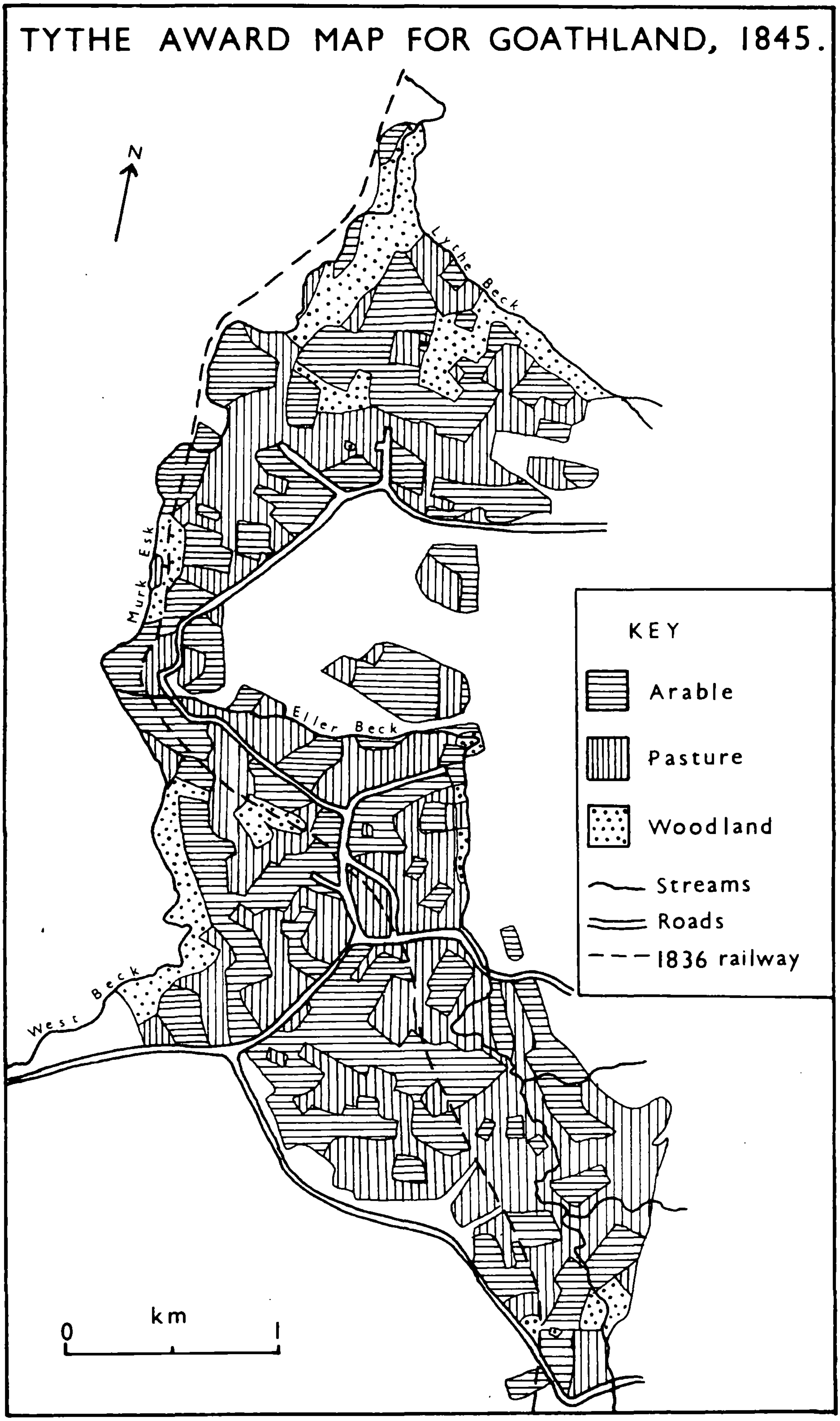
The Dissolution of the Monasteries (1536-39) comes within the statistical error of the radiocarbon date for the E/F boundary at Fen Bogs. The monastic lands were leased or sold off to lay farmers in smaller parcels and often enclosed in the process. Although much of the land was used for pasture as well as arable farming, the lay land owners on the whole did not have the resources to exploit the upland grazings on the same scale as the monks had done. Many of the sheepwalks may have gone out of regular use and areas which had been grazed systematically and efficiently in the Medieval period deteriorated to rough grazings. The quality of the herbage probably decreased too, allowing the heath species to expand at the expense of the better grasses.

It was probably this change in land ownership that was chiefly responsible for the relative increase in importance of arable agriculture after the Dissolution. It must be remembered, however, that the arable/pastoral indices and the documentary evidence both suggest that this area was predominantly one of mixed farming, and even the lowest figures for the arable/pastoral index do not come within Turner's arable category. The general picture for Zone F is one of small-scale subsistence farming, with arable land on the lower ground and moor grazings for sheep and probably cattle higher up.

At the F/G boundary we are faced with an apparent increase in the importance of pastoralism, falling probably somewhere in the latter half of the eighteenth century. This is the period of enclosure on the Limestone Hills and in other areas, but, as was noted earlier, the land in the eastern-central area seems to have been enclosed all along. The next hundred years or so was a period in which the "spirit of improvement" was abroad, and in many dales new intakes were made above the former moorland boundary, to heights of 244-290m (800-950'). However, Farra (1961) notes that at Goathland the moorland edge remained at c.183m (600'). There were some enclosures, nevertheless, and a survey of intakes made in 1776 by Russell, a Duchy of Lancaster official, shows that much of the newly enclosed land near Goathland was used for pasture rather than arable (Buckley, 1971).

There are two agricultural surveys for the turn of the eighteenth/nineteenth centuries, Marshall's "Rural Economy of Yorkshire" (1788) and Tuke's survey for the Board of Agriculture (1800). Both works record the presence of large flocks of sheep on the moors, stocked at a density of one to ten acres and totalling 20,000 to 30,000. Wool was sold to the woollen manufacturers of the West Riding and meat to the expanding ports of Whitby and Scarborough. Another important stock rearing activity on the Moors was bee-keeping, and cattle were kept in the dales.

A change in the crops grown is recorded by Marshall since the more widespread use of liming:


TYTHE AWARD MAP FOR GOATHLAND, 1845.
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> "Before the use of lime was prevalent, much rye was grown on the lighter lands upon the margin of the Vale; and in the Morelands scarcely any other crops than rye and oats were attempted. Now, rye is principally confined to the Moreland-dales; and even there the alteration of the soils by lime has been such, that wheat is become the more prevalent crop."
>
> (Marshall, 1788)

Barley is mentioned, too, as being a traditional crop in the area. Cereal grains were examined in Zones F and G at two contrasting sites, Simon Howe Moss and Gale Field. In both, Secale was seen to be important in Zone F but less so in Zone G. Avena and Hordeum were recorded from both zones, but at Gale Field Triticum was present in Zone G as well. These results seem to support the tentative date for the F/G boundary of late eighteenth/early nineteenth century.

For the mid-nineteenth century we have more detailed information about land use for the area around Goathland. The tithe award map of 1845 (Map 17, Figure 53) for Goathland parish shows the areas under pasture, arable and woodland in the mid-nineteenth century. Of the 1418 acres of enclosed land at this period, 34% was under arable cultivation, 46% under grassland and 20% was woodland (Buckley, 1971). Thus, although there had been an increase in the amount of enclosed land since the beginning of the century and the arable acreage had increased from 378 acres in 1801 to 450 acres in 1845, the relative importance of arable cultivation had not altered significantly and the emphasis was still on pastoralism. When the large acreage of unenclosed pasture is taken into consideration as well, it is easy to appreciate why the pollen diagrams indicate a predominantly pastoral phase for Zone G.

However, the relative decrease of arable cultivation from Zone F to Zone G has not yet been accounted for. There is little documentary evidence for this change, as sources such as the parish agricultural returns do not go back further than the nineteenth century. We may speculate on the reasons for the change in the context of a period when enclosure and improvements were leading to an expansion of arable farming in areas such as the Limestone Hills. The Goathland area had never had an open field system, and this and agricultural areas in the other dales were little affected by the changes. Some intakes were made, as is shown by Russell's surveys of 1776 and 1814 (Buckley, 1971), but these added little to the total acreage of enclosed land. Marshall and Tuke record various attempts to improve areas of moorland for cultivation, but nearly all of these met with failure.

At this time, towns like Whitby and Scarborough and later Middlesbrough were expanding, and, with the help of the developments in transport, a market economy was being established for the first time in north-east Yorkshire. Farmers were looking increasingly outside the area for their markets, and prices for agricultural produce were being controlled more and more by national demand. If the communications network at this time is called to mind (Map 7. Figure 18) it will be apparent that farmers in the Limestone Hills area to the south would have a great advantage over those in the eastern-central area as far as accessibility to markets is concerned. Even the comparative advantage of the latter for supplying smaller areas like Whitby would be diminished by the developments in communications (notably railways), and food for home consumption could be imported to the dales from the Limestone Hills region. It seems probable, therefore, that the dales were unable to compete with other areas in arable agriculture, and this might well have resulted in an increasing emphasis on pastoralism. Thus the changing emphasis in land use in Zones F and G on the pollen diagrams is interpreted as a response to the changing economic conditions of the late eighteenth/early nineteenth centuries.

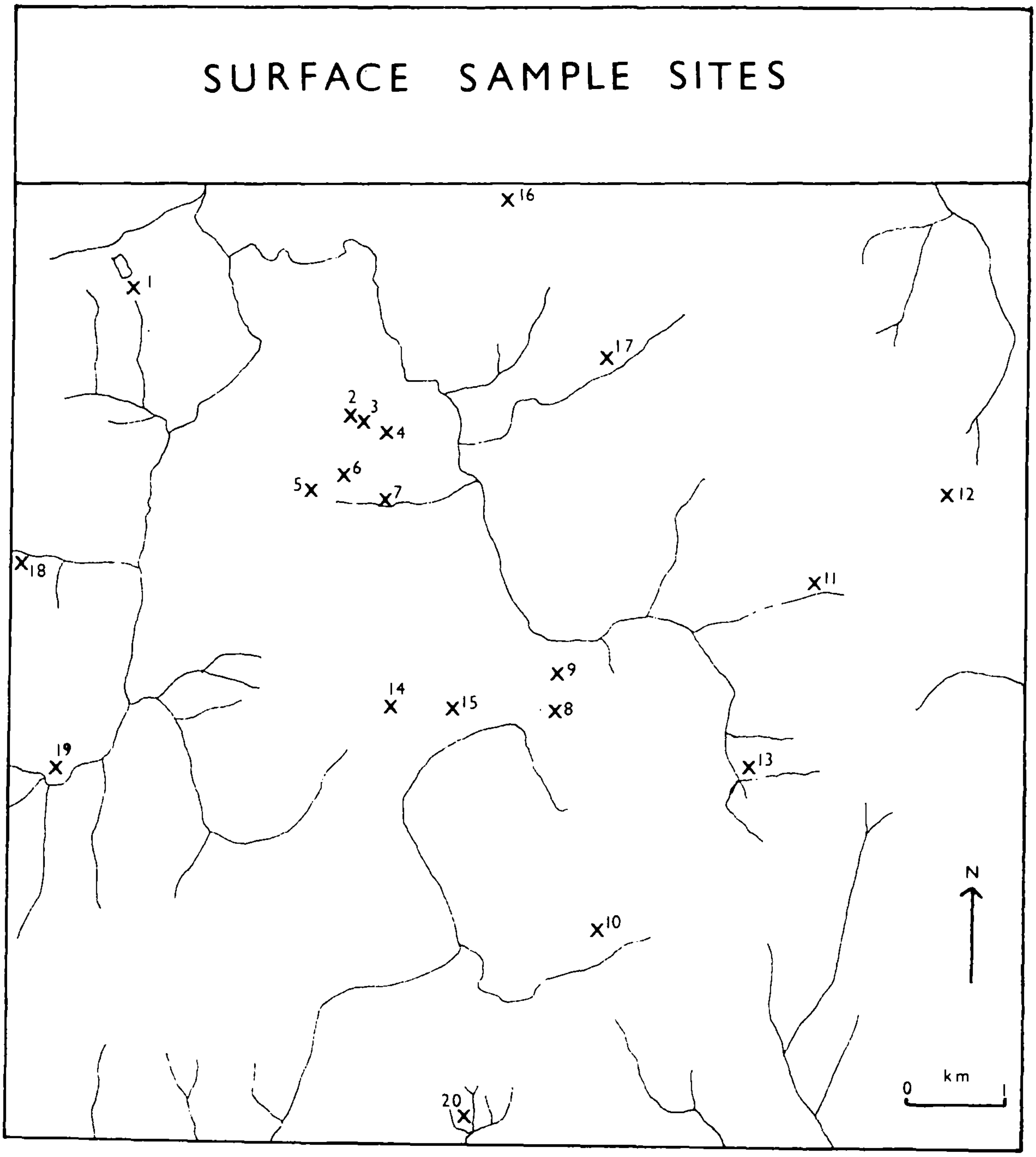
During the last hundred years, economic conditions have led to many minor changes in land use on the North York Moors. For example, more land was ploughed up for arable cultivation during the first and second World Wars. Farra (1961) has traced the details of the shifting position of the moorland edge during this period. Such changes are not registered clearly on the pollen diagrams, mainly because of their small-scale, temporary nature. At Fen Bogs, if the F/G boundary is taken as being c.1870 A.D., 30cm of peat have accumulated in the last hundred years, and this rate of 1cm in 3.3 years is considerably faster than was found throughout most of the diagram.[1] The sampling interval for this part of the diagram was 3cm, which must represent a time span of about 10 years. It is apparent that such short-lived temporary changes in land use as we have seen in the last hundred years are unlikely to show up on the pollen diagram. The period of Zone G as a whole may be considered as one of specialisation in pastoral agriculture.

1 It was noted above (4.1.3) that the top part of this profile was thought to be less compressed than the lower parts, which could account for the apparently faster growth rate near the top.

One final land use change must be mentioned. On most of the pollen diagrams right at the top there is an increase in arboreal pollen related to modern afforestation schemes. The origin of this is seen to be earlier than the twentieth century, and conifers are by no means the only trees to benefit. Ulmus and Betula are seen to expand at a number of sites, while Fagus is important at Simon Howe Moss and Quercus rises at Fen Bogs. There are many examples of shelter belts and small patches of woodland dating from before the Forestry Commission plantations, the Gale Field plantation being one, and this phase of woodland conservation is seen to go back to the nineteenth century or before. It represents a land use change which will be of increasing importance, as the almost complete dominance of Callunetum on the higher areas is making traditional pastoralism less and less profitable.

TABLE 2. KEY TO SURFACE SAMPLE SITES. (See Map 18)

Site number.	Location.	Grid reference.	Illustration.
1	Randay Mere.	812018	Photo 28
2	Gale Field, site in plantation.	833005	Photo 21
3	Gale Field, site in clearing.	834005	Photo 22
4	Gale Field, site in next field.	835004	Photo 23
5	Moss Slack Goathland, sample site.	828000	Photo 27
6	Moor just N. of Moss Slack.	830001	Photo 9
7	Moss Slack, Goathland, eastern end.	837997	
8	Fen Bogs, sample site.	852975	Map 9
9	Fen Bogs, northern end.	853980	Photo 15
10	Near Saltersgate.	856956	Photo 3
11	Head of Little Eller Beck.	880990	Photo 33
12	Green Swang.	892998	Photo 8
13	May Moss, sample site.	874965	Map 13
14	Simon Howe Moss.	834977	Photo 26
15	Between Simon Howe Moss and Fen Bogs.	841977	
16	Between Sil Howe and Goathland.	848028	Photo 31
17	Brocka Beck.	859009	Photo 32
18	Wheeldale Bridge.	801993	Photo 29
19	Near Roman road, Wheeldale Moor.	805975	Photo 14
20	Hole of Horcum.	847937	Photo 30.


SURFACE SAMPLE SITES
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CHAPTER NINE. PROBLEMS OF INTERPRETATION.

9.1 The modern pollen rain.

Surface samples were taken from twenty sites within the eastern-central area, including the five sites used for sub-fossil pollen analysis. The aim was to observe the pattern of pollen dispersal today in order to throw some light upon the patterns revealed in the pollen diagrams. Oldfield (1970) has stressed the importance of using the same sites and employing the same techniques for comparing modern and fossil pollen studies, so *Sphagnum* polsters were chosen as collecting media rather than pollen traps. Cundill (1971) carried out a similar study for the high watershed region to the west of the eastern-central area, which provides a useful comparison with this study.

The sites were chosen so as to get a wide coverage of the area (Map 18), although the distribution was limited somewhat by the availability of *Sphagnum* polsters. *Sphagnum papillosum* or *S. compactum* were used in most cases, but *S. subsecundum* was used at two sites and *S. tenellum*, *S. palustre* and *S. recurvum* once each. The methods of preparation are described in Appendix I. The sites were given numbers in an arbitrary order and the results of the pollen analyses are shown on Figure 56. There is no significance in the vertical arrangement of the data on this diagram. In six cases a lower pollen sum than usual was counted, so the pollen sums have been listed at the end of the diagram.

TABLE 3. ARABLE/PASTORAL INDICES FOR SURFACE SAMPLES.

Site.	Location.	Index.	Land use indicate
1	Randay Mere.	68%	Pastoral.
2	Gale Field, site in plantation.	26%	Mixed farming.
3	Gale Field, site in clearing.	20%	Mixed farming.
4	Gale Field, site in next field.	27%	Mixed farming.
5	Moss Slack Goathland, sample site.	19%	Mixed farming.
6	Moor near Moss Slack Goathland.	18%	Mixed farming.
7	Eastern end of Moss Slack Goathland.	3%	Arable.
8	Fen Bogs, sample site.	7%	Arable.
9	Fen Bogs, northern end of site.	47%	Mixed farming.
10	Near Saltersgate.	33%	Mixed farming.
11	Head of Little Eller Beck.	32%	Mixed farming.
12	Green Swang.	19%	Mixed farming.
13	May Moss, sample site.	16%	Mixed farming.
14	Simon Howe Moss.	67%	Pastoral.
15	Between Simon Howe * Moss and Fen Bogs.	-	
16	Between Sil Howe and Goathland.	33%	Mixed farming.
17	Brocka Beck.	66%	Pastoral.
18	Wheeldale Bridge.*	-	
19	Near Roman road.*	-	
20	Hole of Horcum.	59%	Pastoral.

* Sites where no *Plantago lanceolata* was recorded.

Figure 56.

POLLEN SPECTRA OF SURFACE SAMPLE SITES.

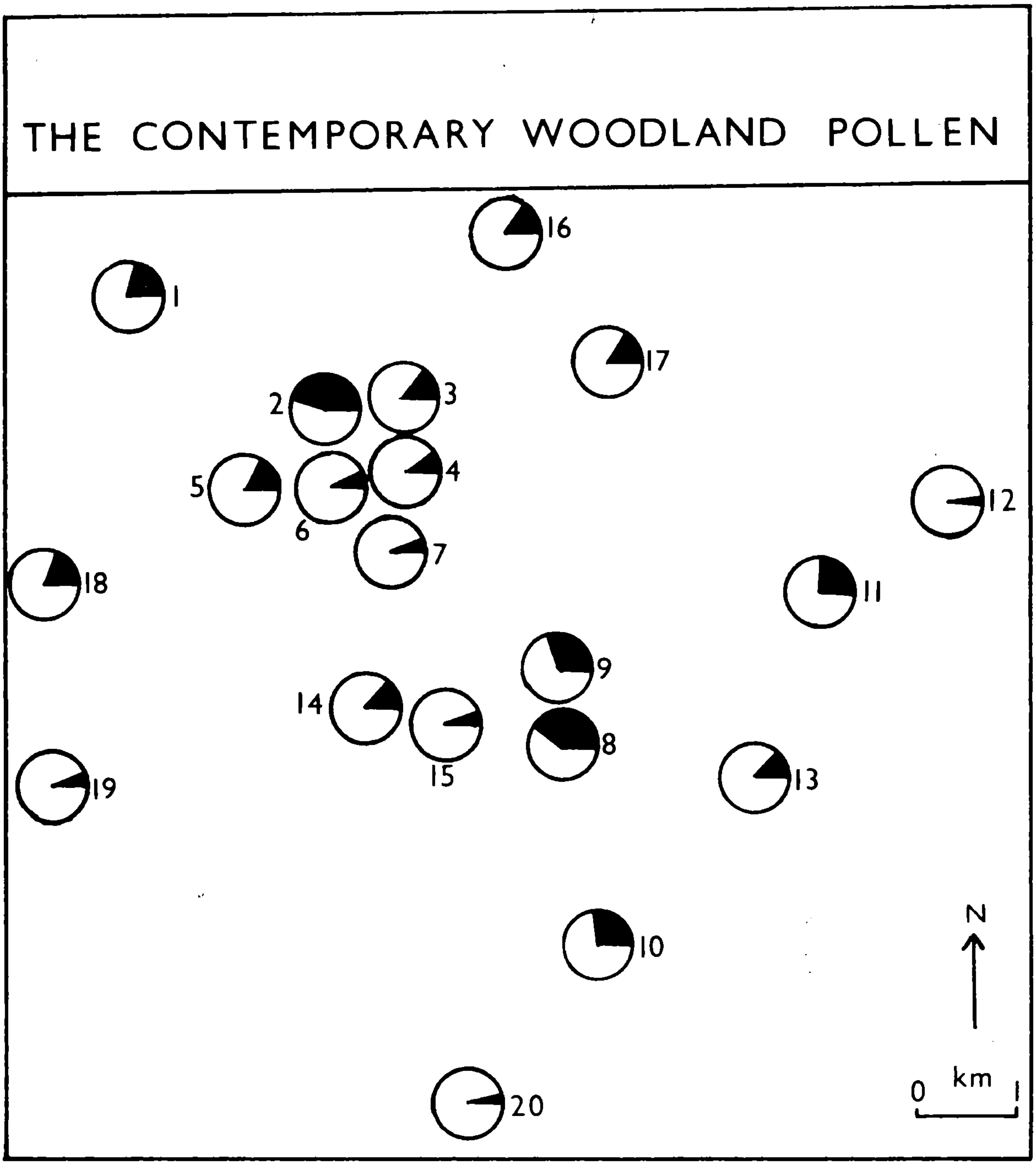
N.B. There is no significance in the vertical arrangement of the data on this diagram.

Sites are numbered as in Table 2.

9.1.1 The extent of the woodland.

It can be seen that there is a considerable variation in the percentage of arboreal pollen recorded at the sites today (Figures 56 and 57). As might be expected, the sample from the Gale Field site in the plantation has the highest percentage of arboreal pollen, 46% of total pollen. The much lower figure of 15% for the Gale Field site in the clearing and the even lower figure of 10% for a site a few hundred metres away in the next field to the east demonstrate how rapidly the arboreal pollen falls off with distance from the plantation. The individual curves for Pinus and Picea illustrate this also, although not to quite such a marked degree (Fig. 56). It can be seen from the arboreal pollen curves that the percentage of Quercus, Ulmus and Fagus is also higher at the site in the plantation, but the site in the next field has more Alnus. The sample from Randay Mere (No.1), close to a coniferous plantation surrounding the reservoir (Photograph 28) has 11% Pinus pollen and values for deciduous trees of about the same magnitude as the Gale Field site in the plantation, although the absence of Picea pollen brings the total arboreal pollen to only 21%.

The sites with the next highest values for arboreal pollen are the two from Fen Bogs (nos. 8 and 9) Here again the influence of modern coniferous plantations is obvious in the figures for Pinus and Picea, although in this case the nearest part of Pickering Forest is over 2km away to the south-west. The figure for arboreal pollen from the Fen Bogs sub-fossil pollen site (No.8) is 40%, which is much higher than those for the two sites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at Gale Field just outside the plantation itself. It seems probable that the reason for this is that the trees of the Gale Field plantation are not flowering very profusely. This is confirmed by a superficial examination of the plantation, which, although some fifty years old, does not have many mature trees with flowers or cones, particularly near the centre where they are planted very close together. The trees in Pickering Forest, in Newton Dale south of Fen Bogs (e.g. Pifelhead Wood, 843950; Talbot Wood, 835948) are, on the whole, tall, healthy, mature trees, not too closely spaced, and producing flowers and cones quite freely. These are probably a larger source of pollen than the trees in the Gale Field plantation.

This idea is confirmed by the relatively high values for Pinus pollen at sites 10, 11 and 13. The latter two are over 2km from the nearest plantations, but these include the mature stands of Allerston and Wykeham Forests to the south and their effect on the pollen figures is marked. The more recently planted parts of Pickering Forest (e.g. Gale Hill Rigg, 813969) are again poor producers of pollen as yet, as is shown by the relatively low values of arboreal pollen, especially Pinus pollen, from the sites in the west of the area (Nos. 18 and 19).

In the case of deciduous woodland, the sites with the highest pollen figures are Fen Bogs (Nos. 8 and 9) and Wheeldale Bridge (No. 18). At Fen Bogs most of this pollen is coming presumably from the Eller Beck valley or the carr woodland at the southern end of the site (Photo 18).

Photograph 28. Randay Mere (surface sample No.1).

From 813016, looking NNW.
The coniferous plantation surrounds the reservoir itself. The floor of the channel (middle distance) shows evidence of peat cutting. The surface sample was taken from a polster of Sphagnum in the centre of the channel.

Photograph 29. Wheeldale Bridge (surface sample No. 18).

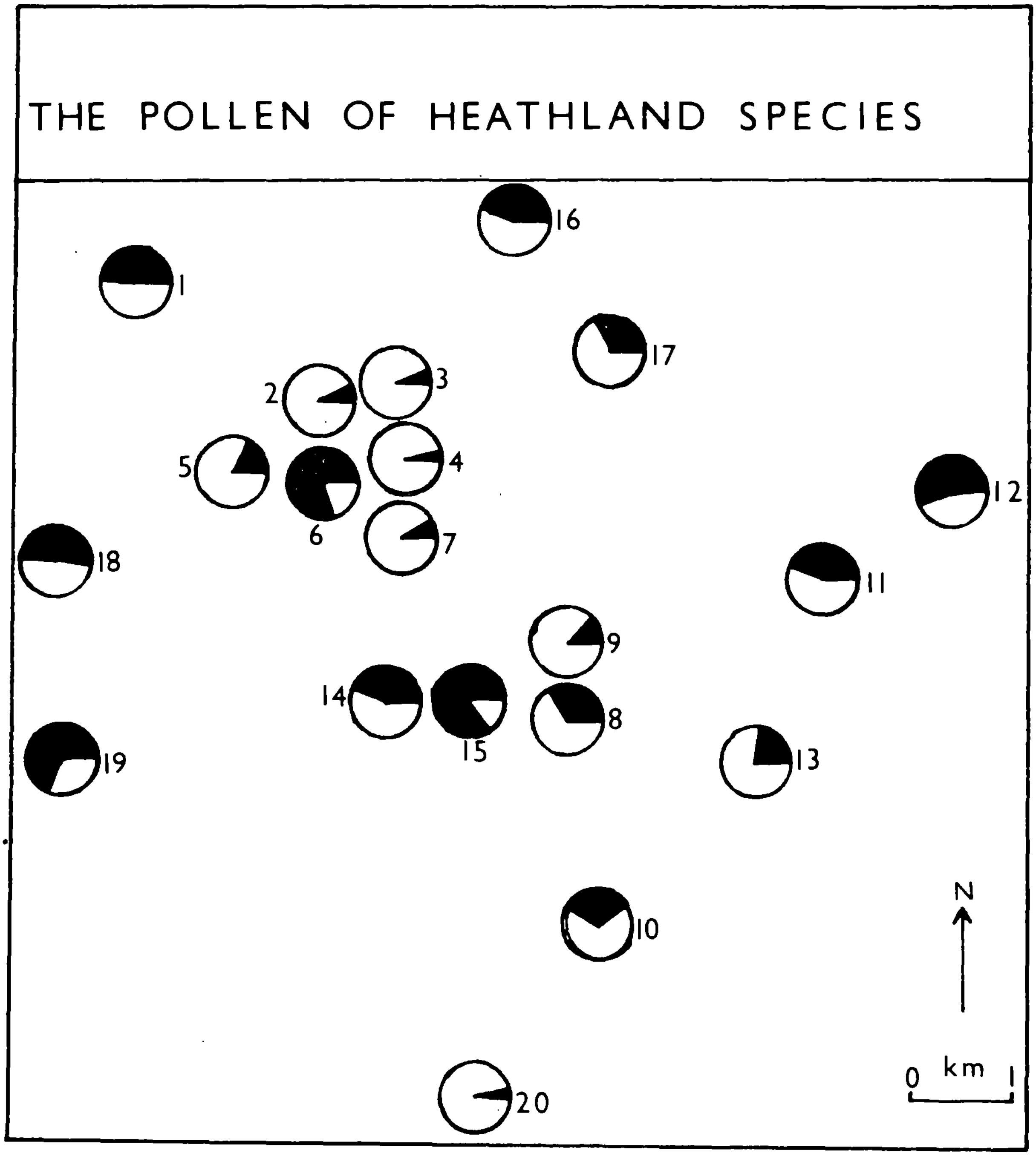
From 802993, looking
Residual patches of deciduous woodland line the valley of the Wheeldale Gill. The beginning of a larger coniferous plantation is seen in the distance. The surrounding moorla[illegible] slopes are covered with Pteridium and Calluna. The surfac[illegible] sample was taken from a Sphagnum polster amongst the Callunetum in the foreground.

This impression is endorsed by the fact that values for Salix, Betula and Alnus are high and these are the species forming the carr woodland. A contrast is noted between the two sites, and at No.8 more Salix and Betula are recorded, whereas site NO.9 has more Alnus, Tilia, Fagus and Fraxinus. This suggests that No.8 is recording the woodland at the southern end but No 9 is recording the Eller Beck valley woodland. By contrast, the woodland closest to site No.18 is a typical mixed oak wood, in the Wheeldale Gill valley (see photograph 29), and at this site the most important arboreal pollen recorded is that of Ulmus, Quercus and Alnus, while Salix is not recorded and Betula is relatively unimportant.

The only other site near to a source of arboreal pollen is No.20, in the Hole of Horcum. Here the sides of the valley have patches of woodland clinging to them, mostly Quercus and Pinus (photograph 30). Very low amounts of arboreal pollen are recorded here, however, which may reflect the rapidly decreasing importance of the local woodland, most of whose trees are old and poor specimens, and which is not regenerating at the present day.

The remaining sites are all a considerable distance from the nearest woodland and the arboreal pollen recorded must be classified as "regional". The effect of distance on the amount of arboreal pollen recorded is evident and the site furthest from woodland (No.12) records only 3.5% arboreal pollen. The contrast between the amount of arboreal pollen at this site and that recorded at sites 16, 17 and 11 is noteworthy. The last three sites are all at heights of 230-240m OD (Photographs 31, 32 and 33), whereas No.12 is at 275m OD (Photograph 8); but, perhaps more significantly, the other three sites are all on south-west-facing slopes, whereas No.12 is over the top of the ridge facing north-eastwards. A similar contrast is apparent between the 13% arboreal pollen recorded at Simon Howe Moss (at an altitude of 240m and with a south-westerly aspect) and the 6% arboreal pollen at site No. 15 (at an altitude of 230m and with a south-easterly aspect).

It may be noted also that the percentages of arboreal pollen recorded at sites 5, 6 and 7 (all near Moss Slack Goathland and with a north-easterly aspect) are lower than many of those recorded at sites on the higher moorlands and further from woodland. For example, at site No. 17 (near Brocka Beck) 16% arboreal pollen is recorded and at site No. 16, 15%. In both cases the nearest source of arboreal pollen is the Eller Beck valley in the Vale of Goathland to the south-west, but they are both c.2km away from this. The Moss Slack Goathland sites are less than 1km from the same source of woodland, but to the south-west of it, and here the percentages of arboreal pollen are 17, 6 and 6. The conclusion seems inescapable that distance alone does not determine the amount of arboreal pollen recorded and that its effects can be overridden by that of aspect in relation to the prevailing winds.


THE POLLEN OF HEATHLAND SPECIES
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9.1.2 Heath vegetation.

The curves for Calluna and Ericaceae show that there is a considerable variation in the amount of pollen from heath species recorded at the sites today (Figure 59). Some sites, e.g. Nos. 2,3 and 4, record relatively low amounts; while others, e.g. 1, 6 and 15, record over 50% Calluna pollen. A feature which is immediately striking is the reciprocal relationship between the curves for Calluna and Gramineae. At every site one of these pollen types was the species with the highest recorded value, and herbaceous vegetation was clearly dominant over the whole area. A comparison between the Gramineae and Calluna curves suggests a division of sites into two main categories; those dominated by heath vegetation and those dominated by grassland. This seems to be a reasonable division, as the present-day land use (Map 8) shows the higher ground to be dominated by Callunetum while the enclosed land is grassland or arable with heath species relatively unimportant.

Considering first the group of sites dominated by heath species, we find this group includes sites 1, 6, 11, 12, 15, 18 and 19. The last five of these are well away from enclosed land. No.6 is on the moor between Moss Slack Goathland and Gale Field and the vegetation surrounding the site itself and on the area of Two Howes Rigg to the south is Callunetum (Photograph 9). The site does not seem to have picked up much of the Gramineae pollen from the Moss Slack channel, which is recorded at sites 5 and 7, or that from the enclosed area around Gale Field to the north. Similarly, site No.15 is situated on the moorland between Simon Howe Moss and Fen Bogs and does not record much sign of the carr woodland or the

Photograph 30. The Hole of Horcum.

From 851939, looking SW.

The land to the east of the Levisham Beck has been reclaime for pasture and contrasts with the moorland to the west, dominated by Pteridium and Calluna. The surface sample (No.20) was taken from a patch of Sphagnum amongst the moorland vegetation on the west side of the floor of the Hole. A few remnants of woodland are just discernible on the left of the picture, clinging to the sides of the Hole.

Photograph 31. Surface sample site, No. 16.

From 846027, looking SW.

The surface sample was taken from a Sphagnum polster amongs the Callunetum in the foreground. In the background is the enclosed land around Goathland village.

grassland pollen from the Fen Bogs site to the east. It seems, therefore, that local pollen from the channels does not travel very far outside the channels themselves. At site No.1 (Randay Mere) the sides of the channel are covered in _Callunetum_ but there is a considerable amount of enclosed land to the south-east and east (near Julian Park, 815009). It seems that the pollen from these areas has not entered the channel.

There are several other sites which are situated on the high moorland and where we might have expected a clear dominance by heath vegetation to show up in the pollen spectra. These sites include Nos.16, 17, 13 and 14. At these sites the percentage of _Gramineae_ is higher than might be expected from the local vegetation alone. This suggests that some of the _Gramineae_ pollen has travelled some distance before reaching the sites. In the case of Nos.16 and 17 the most probable source for this _Gramineae_ pollen is the enclosed land around Goathland to the south-west. At No.14 (Simon Howe Moss) the pollen must have come from the south-west again, as the low _Gramineae_ values at site 15 show that little _Gramineae_ pollen is received from the east. No.13 (May Moss) has _Callunetum_ to the north and east and coniferous forest to the south and east. Again the most likely direction for the _Gramineae_ pollen to have come from is the south-west, from the narrow vale of Oxford Clay at the foot of the Corallian escarpment around Saltersgate and Nab Farm (862951) (See Photograph 3). The pollen spectrum from site No.10 confirms this impression. This site is much nearer the enclosed land of the Saltersgate area but also has _Callunetum_ to its north and here the percentage of Gramineae is 35 as compared with 19% for Calluna.

Before considering the sites with a definite dominance of Gramineae pollen we might mention sites 8 and 9 (Fen Bogs), where values of both Gramineae and Calluna are lower than at some of the other sites because of the higher percentage of woodland recorded. There is a marked contrast between these two sites, which are only a few hundred metres apart. Site No.8 records more woodland, being that much nearer to the carr at the southern end of the site. It also records more Calluna than Gramineae. Site No.9 has less Calluna, no Ericaceae and more Gramineae. It must be noted that the channel is wider at site No.8 than at site No.9 and has a more open appearance. It is possible that the pollen at site No.8 has travelled further than that at site No.9 which may give the latter a more local picture.

The remaining sites are those where Gramineae pollen is much more important than Calluna. Of these, sites 2, 3, and 4 (all near Gale Field) are surrounded by enclosed fields. (Photograph 21). Sites 5 and 7 are in Moss Slack Goathland. As noted above, the channel is surrounded by Calluna moorland, so the picture at these two sites must be a very local one with most of the Gramineae pollen coming from the vegetation of the channel itself. Site No.20 is in the Hole of Horcum (photograph 30), which has enclosed fields (pasture) on its floor. Again, the Hole is surrounded by Callunetum, so the Gramineae pollen is likely to be very local.

9.1.3 Local vegetation.

From the *Gramineae* values it has been apparent that some sites are recording a large percentage of local pollen. We may look at other pollen which is presumably of a very local origin. The aquatic pollen is very sparse in the surface samples and a site like Fen Bogs where there is much *Potamogeton*, *Menyanthes* and *Typha* today has not recorded any of these taxa in the contemporary pollen. The *Sphagnum* values may be more significant. Relatively high values are found in the channel sites where *Sphagnum* is an important constituent of the local vegetation, e.g. Nos. 1, 5, 8 and 9, and at the other boggy sites, e.g. Nos.13, 14 and 12. They are also very high at site 20, in the Hole of Horcum, although *Sphagnum* is not very important here. At the sites on the open moor *Sphagnum* is relatively unimportant and at sites 15, 16 and 17 no spores were recorded. This suggests that these spores do not travel very far and that where they are recorded they are of very local origin.

We may compare the *Sphagnum* records with those for *Cyperaceae*. At some sites where high *Sphagnum* values were recorded there are significant records for *Cyperaceae* too, e.g. at Nos.8 and 9 (Fen Bogs), 12 (Green Swang), 13 (May Moss), 14 (Simon Howe Moss) and 20 (Hole of Horcum), although they are less important at 5 and 7 (Moss Slack). This reinforces the idea that these sites have recorded a more local picture than have the others. If this is correct it must be borne in mind when discussing the land use types indicated at the various sites.

Photograph 32. Brocka Beck.

From 860010, looking WSW.
Surface sample No.17 was taken from a _Sphagnum_ polster near the stream in the foreground. The site is surrounded by _Callunetum_ on all sides.

Photograph 33. The head of Little Eller Beck.

From 830990, looking SW.
The surface sample (No. 11) was taken from a polster of _Sphagnum_ amongst the _Callunetum_ in the foreground. In the distance, Fylingdales early warning station can be seen.

9.1.4 Indications of land use.

Turner's arable/pastoral index was calculated for the surface samples to see if the figures would help at all in the interpretation of those calculated for periods in the past (chapter 8). It was not possible to obtain a figure from all the sites, as at three of them no Plantago lanceolata was recorded. The small size of the samples must be borne in mind when interpreting the results from the other sites. Nevertheless, some useful observations can be made.

The figures for the arable/pastoral indices are listed on Table 3. There are four sites with figures of over 60%, indicating a very definite emphasis on pastoral agriculture. These are Nos. 1, 14, 17 and 20. In the case of No.14 this is to be expected, as Simon Howe Moss is some distance from the nearest arable land today. Similarly with No.20, the enclosed land in the Hole of Horcum is all for grazing, mostly for cattle. There is a significant amount of arable agriculture a few hundred metres to the south-east of site No.1, although the emphasis is on pastoral agriculture, especially in the fields nearest to the sample site. It has been suggested (9.1.3) that No.17 receives some of its pollen from the Eller Beck valley near Goathland. Most of the fields to the north-east of the Eller Beck are for pasture (Map 8), but it is worth noting that few of the arable indicators have reached the site (1.5km away) although one cereal grain is recorded. The pollen sum is only 294 and few weed species are picked up, so the result may not be reliable for this site.

The site with the next highest figure is No.9 with 47%. This is the nortHernmost site at Fen Bogs, which is thought to have recorded a fairly local picture. The indication of pastoral agriculture would be in keeping with the land use of the area close to the site, which is grazed by sheep (as was noted in 4.1.2). The contrast with site No.8 is very marked, so much so that it probably indicates that one or both of the results are unreliable. The pollen sum at No.8 was only 325 (cf. 483 at No.9) and pollen was scarce in the sample. The very low figure of 7% is due mostly to the record of 10 cereal grains, and the percentage of 3.1 for Cerealia is the highest of those from the surface samples. The range of other herbaceous species is quite large, but only one grain of Plantago lanceolata was counted. The figure of 7% itself is almost certainly unreliable, but it is not improbable that this site does receive more arable indicators among its pollen, as the picture recorded is thought to be a more regional one than that at No.9.

Sites 16 and 11 have figures of 33% and 32% respectively, which indicate a predominance of pastoralism but with some signs of arable cultivation too. This is fairly easy to explain at No.16, but No.11 is some distance away from the nearest source of arable pollen. It seems unlikely that this pollen is coming from the Goathland area to the north-west, but there is some arable cultivation further south near Saltersgate, mostly cereals such as wheat and barley. This area is c.5km away from site No.11, but the Goathland area is 4km away, so this arable pollen must be travelling a considerable distance, whatever its origin.

To test the hypothesis that the arable pollen at No.11 is coming from the area to the south-west, we may look at the figures for sites 10 and 13 which are further south-west than 11. The figures at these sites are 33% and 16% respectively, which indicate confirmation for the hypothesis, although it must be noted that site No.10 is nearer the agricultural area of Saltersgate than No.13 but has the higher figure. The figure of 16% for 13 (May Moss) is almost within Turner's "arable" category. This endorses the idea that this site receives a regional pollen rain, as it is over 1.5km from the nearest agricultural land.

Site No.12 has a similarly low figure (19%) considering its position. A wide range of weed species is recorded at this site and the pollen sum is over 500. It is difficult to guess where this arable pollen is coming from, as the analysis of woodland pollen did not suggest that much pollen from over the ridge to the west reached this site, and anyway the nearest arable land to the west is over 5km away. There is a little arable agric-ulture in the May Beck valley, 4km to the north (878041), but most of the land is pasture. To the north-east, however, lies the coastal plateau with its boulder-clay cover and a considerable amount of arable agriculture. The distance between this area and site 12 is over 6km, but the figure of 16% for site 13 must be remembered. Although No.13 is just west of the ridge (marked by High and Low Woof Howe, Lilla Howe, etc.),the latter is not very much higher than May Moss and it is possible that some of the arable pollen at May Moss is coming from the east, possibly the Harwood Dale area, and this pollen would be travelling over 8km. Although some of the arable pollen at this site is probably coming from the area near Saltersgate, the addition of some pollen from the east would help to explain the lower figure at this site than at site No.10.

There is one more group of figures to be considered, that from the sites near Goathland. These all have relatively low figures, reflecting the location of the sites in the midst of cultivated fields (Map 8). The figure for site No.7 (the eastern end of Moss Slack Goathland) is very low, 3%. This is based on a generous pollen sum of 1687, but only one grain of Plantago lanceolata was recorded. It is difficult to see why this site should have recorded more arable agriculture than the others in the vicinity, unless the Gale Field plantation is filtering some of the arable pollen at Nos. 2, 3 and 4.

The results of the arable/pastoral survey may not be reliable in detail but do reflect the general pattern of land use within the area. Some sites have apparently recorded a more regional picture than might have been expected. The sites with no Plantago lanceolata[1] recorded, for which the arable/pastoral index could not be calculated, have few records for any agricultural indicators. These sites (Nos.15, 18 and 19) are all several km from the nearest enclosed land and sites 18 and 19 have a large area of unenclosed moorland to their west. At these sites agricultural pollen is insig--nificant in the pollen rain.

1 It is possible that present-day agriculture, particularly pastoral, gives P. lanceolata little chance to flower. In this case its pollen might be proportional to road network density.

9.1.5 Conclusions.

From this survey of the contemporary pollen several conclusions may be drawn, which will be of significance for the interpretation of the fossil pollen diagrams. Firstly, the surface samples show that some of these sites receive pollen from a very wide catchment area. These are generally the sites in high exposed positions, e.g. 13, 12, 11, 17 and 14. By contrast, sites in enclosed situations such as glacial drainage channels record a predominantly local picture, e.g. Nos. 5, 7, 9 and 20.

Another trend brought out in this survey is of the general north-eastwards drift of pollen over most of the area. This accords with the prevailing winds, which are the south-westerlies. However, another trend is noticed at some sites corresponding with a westerly drift of pollen, presumably in association with dominant easterly or north-easterly winds. These trends underline the overall importance of wind direction in palynological studies.

Thirdly, the arable/pastoral indices exhibit a general correspondence to the distribution of arable and pastoral agriculture today. However, the regional component can have a marked effect on the figures, so that the figure for No.12 is the same as that for No.5, although the former is ten times as far from the nearest cultivated land as is the latter.

39 There seems to be a suggestion from the pollen spectra that the non-arboreal pollen sometimes travels further than the arboreal pollen. As the latter is released from a greater height than the former one would expect the distance travelled to be smaller rather than

greater (Tauber, 1965). However, it has been noted that some of the trees produce relatively little pollen, and their close spacing in some plantations must itself hinder pollen dispersal. The remaining patches of deciduous woodland are all on the steep dalesides, so most of the pollen probably remains within the valleys. Cundill (1971) also found that the woodland pollen did not reach the higher parts of the area in large amounts.

To summarise, the most important factor in the recording of pollen today seems to be the regional/local nature of the site, which is a function of the open/enclosed terrain and the aspect of the site. Wind direction and frequency is seen to be another very important factor, as is the nature of the vegetation cover through which the pollen has to pass. All these factors combine with the distribution of the vegetation types to give a very complex pattern of pollen deposition which can only be understood fully when all the factors are taken into account.

9.2 The Site Factor.

In this section the results of the last section will be applied to the findings from the fossil pollen diagrams with the aim of throwing some light on particular problems of interpretation. The conclusions can only be tentative, but it is felt desirable to attempt an analysis of the factors involved, if only to highlight the major problems.

9.2.1 Pollen dispersion and deposition.

Tauber (1965) has stressed the dominantly horizontal rather than vertical movement of pollen and spores, which means that the greater the height at which they are released, the further they are likely to travel before they encounter an obstacle. Herbaceous pollen, therefore, must often reach the ground within a short distance of its source, unless an upward eddy carries it into a higher layer of air. Topography is obviously a very important factor; for example, pollen released in a narrow steep-sided channel will have difficulty in rising out of the channel, and a ridge of higher ground will also form an effective barrier to pollen dispersal. Much shrub and some arboreal pollen travels through the "trunk space", the term being derived from studies in forested areas. It is therefore very susceptible to filtering by the vegetation through which it has to travel, especially if the latter has many small twigs and leaves with sticky or hairy surfaces, such as Salix spp. Of course, for periods in the past it is very difficult to know the nature of the vegetation between the pollen source and the site of deposition, and as the only evidence for this is usually from the pollen diagrams the argument becomes a circular one.

Tauber points out that the component of the pollen which is likely to travel furthest is the arboreal pollen released from the top of the canopy. This component has the dual advantage of not having to pass through filtering vegetation and the slightly greater wind velocities higher up in the air. According to Tauber, it is largely this arboreal pollen which makes up the regional component of the pollen rain. This component may stay in suspension for long periods, according to the meteorological conditions, and a common reason for its deposition is a shower of rain, when the pollen grains act as hygroscopic nuclei. Presumably this means that upland areas with higher rainfall are likely to receive a greater percentage of regional pollen than are lower areas.

From this it appears that meteorological conditions are of great importance in pollen dispersion, especially the strength and direction of the wind and the amount and seasonal distribution of rainfall. As the prevailing winds in north-east Yorkshire are the south-westerlies, it is to be expected that there will be a general movement of pollen in a north-easterly direction for most of the year. However, the dominant easterly or north-easterly winds will probably have a marked effect when they blow (particularly in Spring) as they tend to be stronger. We might expect that the pollen of some early-flowering species will be carried in a westerly direction. Thus this trend is likely to affect the arboreal pollen and some of the "weed" species rather than species such as Calluna which flower later in the year. It was suggested above (9.1.4) that some of the non-arboreal pollen received at sites like May Moss and Green Swang (No.12) was derived from an area to the east, whereas the Calluna pollen was observed to be carried in a generally north-easterly direction (9.1.3).

9.2.2 The sites as pollen traps.

It is obvious that the five sites studied in this thesis must vary a great deal in the extent of their catchment areas. The one factor which is never known to the palynologist is the exact extent of the pollen catchment area of his sites. Even if this were ascertained for the present day, it would not be certain whether or not it was the same in the past. Several factors are involved: the size of the site, its topographical situation, its aspect and the nature of the surrounding vegetation. These factors are not independent and it is their particular combination which gives the variation between the sites.

Fen Bogs.

The site chosen at Fen Bogs was in the wider part of the channel and 67m from the nearest side. From the field stratigraphy it appears that the vegetation in the immediate vicinity of the site has been that of a reedswamp or valley mire for most of its history, but that up to the time of the deposition of the inwash stripe there was some woodland close to the site. This woodland seems to have been mainly a Betula, Salix and Alnus carr. This would be a fairly effective pollen filter and so up till the inwash stripe a local picture would be recorded in the pollen.

The surrounding area was wooded for longer, most of the woodland on the higher ground disappearing in the Iron Age, but that on the steep slopes of the channel sides and further south in Newton Dale persisting until the end of the Middle Ages. The effect of wooded sides to the channel but an open vegetation on its floor would probably have been to filter out some of the pollen from the area immediately surrounding the channel, which would comprise much of the "trunk-space component". The local component derived from the site vegetation must always have been considerable at this site, but the regional component derived from further afield would be important also. Therefore, since the deposition of the inwash stripe, Fen Bogs will have recorded changes in the local site flora, and also the regional vegetation picture for a relatively large area. This regional component was probably from the south and west rather than the north and east because of the prevailing winds. In addition, there is a certain amount of canalisation of air down Newton Dale and so some of the pollen at Fen Bogs has probably come from further south down Newton Dale.

These ideas will influence the interpretation of the Fen Bogs diagram. For the period below the inwash stripe we must assume that all the changes noted on the pollen diagram concern vegetation fairly close to the site itself. Thus the arboreal pollen curve reflects changes in the local rather than the regional woodland, and we must conclude that the woodland surrounding the site was typical Quercetum Mixtum, as found in so many other areas. The temporary clearings in the canopy, tentatively attributed to Mesolithic Man, must also be relatively local phenomena. It has already been seen that there is archaeological evidence to support the idea of Mesolithic hunting activity close to this site, and the differences between the changes seen on this diagram and on that from May Moss strengthen the conviction that the pollen records show a very local picture for this period. The inwash stripe itself is further evidence for very local activity, causing deforestation of the slopes and erosion on the sides of the channel.

From the inwash stripe onwards the lack of woody vegetation on the site itself would have allowed the inclusion of a substantial regional component in the pollen, although the persistence of woodland on the channel sides would mask the effects of changes in the immediately surrounding area. Thus we cannot be sure that the small temporary clearances noted in Zones A and B were so local in origin as were those of Zone VIIa. The difficulties of interpreting the Neolithic and Bronze Age archaeological evidence have been discussed above (Chapter 8) and it was noted that remains from these periods, particularly the Middle Bronze Age, are widely distributed over the North York Moors. The clearings were probably scattered over the surrounding region, and, indeed, clearance phenomena entering the deposit may have originated at several different clearings simultaneously. It is not thought realistic to try to reach conclusions about individual clearances, only to note the increasing clearance activity throughout Zones A and B.

The extensive clearance of Zone C, dated to Iron Age-Roman times, was probably recorded by the regional component of the pollen, as the archaeological evidence suggests that most activity was concentrated round the periphery of the Moors, the nearest area to Fen Bogs being to the south on Levisham Moor. Certainly the arable indicators for the later part of this clearance are most easily explained in terms of Romanised farming on the Corallian outcrop. This seems feasible, as it has been suggested that the regional component was coming mainly from the south or south-west. Some more local activity is also probable, particularly timber felling in connection with iron smelting, and probably grazing of cattle or sheep as well. The combined effect of all these activities could well have produced the prominent clearance seen on the pollen diagram in Zone C.

The regeneration of Zone D was mainly of secondary woodland, particularly species like Betula and Corylus. It seems likely that this effect was caused by the regeneration of woodland in areas where activity had ceased and this could well be in the areas which had been felled for iron smelting. The decline of arable agriculture in the area to the south has been noted, but the continuance of pastoralism is suggested by both the archaeological evidence and the pollen diagram.

The first part of Zone E (the Viking period) evidently saw considerable activity, mainly of a pastoral nature. Comparisons between the diagrams suggest that this was to the north rather than the south of the area and it has been suggested that some activity was carried on around Goathland. From the Fen Bogs diagram a considerable amount of grazing is suggested in the region as a whole and again the clearance phenomena are probably part of the regional component of the pollen rain. In the latter part of Zone E there is evidence from other sites for the clearance of woodland in the vicinity, but the historical records suggest that Newton Dale remained wooded until the end of the Middle Ages: indeed, it was one of the last areas of Pickering Forest to lose its forest cover. So throughout Zone E we have still the two main components of the pollen, the local and the regional components, and the diagram does not tell us a great deal about the moorland areas immediately surrounding the site.

When the woodland filter finally starts to disappear from the channel sides at the beginning of Zone F, we see an increase in Calluna and Ericaceae pollen from the surrounding areas. From Zone F onwards the dominance of the Callunetum is seen clearly on the pollen diagram. In the last two zones we might expect Fen Bogs to record a fairly complete picture of vegetation change in the eastern-central region. This record includes the regeneration of some scrub woodland in Zone F in areas where monastic pastoralism was not replaced by lay agriculture of the same intensity; the emphasis on arable farming in the lowland areas in Zone F; and the trend towards pastoralism in Zone G.

Thus the Fen Bogs diagram starts off as a fairly local one but gives us a good regional picture from about the Neolithic onwards. Although the local component is strong throughout the diagram, as is seen by the high values for Gramineae and Cyperaceae, the diagram records changes from a wide area and not just from the area immediately surrounding Newton Dale itself. Indeed, the pollen from this latter area is less important than the regional component until very near the top of the diagram.

Moss Slack Goathland.

The situation of Moss Slack Goathland contrasts with that of Fen Bogs in that the channel itself is very much narrower and the sample site is only 25m from the nearest side. The channel is cut round the northward-facing slope of Two Howes Rigg and is effectively sheltered by this upland from the prevailing south-westerly winds. Because of its topographical situation it is likely that only a small regional component will be received at this site. The local component may be expected to be strong, as the only direction in which pollen originating in the channel itself can move over any distance is east-west along the channel.

In addition to these topographical factors, the site was covered with closed canopy woodland throughout most of its history. This would have made it even more difficult for regional pollen to reach the site and would have filtered out much of the pollen from the immediately surrounding area. It is to be expected, therefore, that the diagram from Moss Slack Goathland will tell a very local story until the top half metre, when the local woodland was cleared, and that even then the regional component will not be large.

It is not surprising that the Zone C clearance does not show up clearly on this diagram, for its origin was some distance away to the south. However, there are definite indications of activity from the non-arboreal pollen which show that some regional pollen was reaching the site, despite the difficulty of getting there. The arboreal pollen does not record this activity at all because the local woodland was not affected. This endorses the idea that most of the arboreal pollen is of a local rather than a regional origin. For this reason it has been argued that changes in the arboreal pollen on this diagram cannot be correlated with similar changes on the more regional diagram from Fen Bogs (vide supra, 6.3).

The first part of Zone E records clearance activity not only by increases in the non-arboreal pollen but also by a decrease in arboreal pollen. This suggests that this activity was fairly local and it has been noted that there is place-name evidence for Viking settlement in the Goathland region. The decline of this activity is also marked on this diagram, but it is not certain that this coincides with the period of decreasing activity in the middle of Zone E seen on the diaggrams from Fen Bogs and other sites. The clearance of the first part of Zone E on the Moss Slack Goathland diagram may be a very local phase of more extensive regional activity and so the decline of the middle part of the zone on this diagram may refer to the local area only.

When the local woodland is cleared a fundamental change occurs on the pollen diagram. This is not only the decrease of local arboreal pollen but also the extension of the pollen catchment area. Within the top half metre the diagram records a much more regional picture than before and changes can no longer be referred to the immediate area. However, because of the topographical situation of the site it is likely that its catchment area is not so large as that of Fen Bogs, and probably we should see the top part of the diagram as a record of changes in a fairly small region surrounding the site. The inclusion of much more pollen from the moorland area of Two Howes Rigg, as well as the colonisation of the lower channel slopes by _Callunetum_, would account for the big increase in heath species seen on the diagram. The increase in Cyperaceae pollen probably represents the colonisation of the channel floor by herbaceous vegetation once the woodland was cleared.

In the stratigraphy there were several clay bands, indicating erosion, within the top part of this profile, so there may be unconformities in the pollen record. The floor of the channel further east bears many signs of peat cutting, and although the samples for pollen analysis were taken from an uncut face, it is possible that there has been some interference with the peat at this site. Thus for the top half metre the diagram gives us a somewhat unreliable record of changes in the surrounding area, while before this it paints a very local picture.

Gale Field.

The situation of the Gale Field site is very much more open than that of Moss Slack Goathland and the site is not sheltered so much by Two Howes Rigg. However, like Moss Slack, Gale Field has been wooded throughout most of its history, from the beginning of peat growth to the Middle Ages and again for the past fifty years. It is only for the intervening period, from the fifteenth to the nineteenth centuries, that we may expect to see a regional picture in the pollen diagram.

The Zone C clearance is even less marked here than at Moss Slack Goathland, probably because of the greater distance from the pollen source. The Viking clearance of the first part of Zone E shows up very clearly on this diagram, despite the persistence of the local woodland, which suggests that the areas cleared were not very far away from this site. When the local woodland is cleared a great decrease in arboreal pollen is seen, as at Moss Slack Goathland. The top metre of the diagram gives us a very good record of the agricultural changes in the area around Goathland. The more regional pollen rain in this part of the diagram is shown by the dominance of Calluna pollen, which must be coming from the surrounding moorland areas like Two Howes Rigg. The prevailing south-westerlies would probably carry a great deal of this pollen towards the Gale Field site. Again a big increase in Cyperaceae is noted when the local woodland is cleared, probably representing the replacement of woodland by herbaceous vegetation on the site itself.

May Moss.

The situation of May Moss is the most exposed of all the sites, in a shallow basin on the watershed. It is open to both the prevailing south-westerlies and the dominant north-easterlies. From the field stratigraphy it appears that except for at the very beginning of peat growth the site has not been wooded. It may be expected, therefore, that this site will have received a large regional component in its pollen rain as well as a "trunk-space" component from the surrounding areas and a local component from the site vegetation.

However, the presence of woodland in the region as a whole must have filtered out some of the pollen from clearances in the early part of the diagram. Thus the earlier Mesolithic clearances at Fen Bogs are not seen at May Moss, presumably because the pollen from the clearings did not travel very far through the wooded landscape. Similarly, the Zone A clearances are relatively insignificant on this diagram, suggesting that they were not very close to the site.

The Zone B ones are much more marked and show up clearly on the total pollen diagram. This suggests that they were nearer to May Moss and we must recall the many Middle Bronze Age remains in the area, even on the higher parts of the ridges, e.g. High and Low Woof Howe. If Elgee (1930) is correct in supposing that such ridges formed Bronze Age trackways, the considerable amount of Bronze Age activity shown on this diagram could be due partly to the proximity of this prehistoric line of communication.

The Zone C clearance shows up clearly on the May Moss diagram. It is probable that the clearance phenomena were coming from some distance away to the south and west of the site and therefore form part of the regional component of the pollen rain. This period seems to have coincided with the removal of the forest cover from the higher areas. This must have increased the pollen catchment area of the site in that the trunk-space component could be received from a wider area. It is probably because of the relatively open nature of the intervening area that pollen from the Corallian outcrop was able to reach the site. There is no reason to suppose that there was clearance activity in the area immediately surrounding May Moss. This applies particularly to arable agriculture, but the grazing area from the settlements on the northern margin of the Vale of Pickering probably extended at least to the northern edge of the Corallian outcrop, which is only 1km south of May Moss.

The regeneration of woodland in Zone D is seen clearly on the May Moss diagram. It seems likely that the higher areas remained open, so this woodland pollen is probably part of the regional pollen component, derived from the valleys. The first part of Zone E is not seen clearly on this diagram. This is probably because the clearance activity was to the north-west, in the Goathland area, 6 or 7km away. As north-westerly winds are not common and there are the upland areas of Goathland Moor between this area and May Moss, it is not likely that much of this activity would be recorded at May Moss.

The Medieval clearance is recorded more conspicuously. Again the arable pollen must have come from a considerable distance away as part of the regional component, but pastoral farming extended over much of the high moorland to the east of May Moss which was part of Whitby Strand. The regeneration of trees and shrubs in Zone F, when some of this upland pastoral agriculture was abandoned, is not so marked at May Moss as at Fen Bogs, presumably because the woodland regeneration was confined to the lower areas of the valleys, from which little of its pollen would escape to reach the higher areas. The changes in land use in Zones F and G are seen clearly, although much of the activity was at some distance from the site, underlining again the regional nature of this pollen diagram. This is particularly marked as far as the <u>Cerealia</u> curve is concerned and shows that pollen types such as <u>Cerealia</u> are not necessarily indicators of very local activity but can travel considerable distances. For the contemporary pollen it has been suggested that some of these cereal grains are coming from the area to the east, but for the periods in the past it is difficult to say from which direction they originated. This does indicate, however, that the pollen catchment area of the May Moss site is extensive in several directions and this is probably the most regional diagram in the set.

Simon Howe Moss.

Finally, we must consider the diagram from Simon Howe Moss. The situation of this site is somewhat less open than that of May Moss and the site has a general south-westerly aspect. As the prevailing winds are south-westerly we may expect the catchment area of this site to be elongated in a south-westerly direction. As at May Moss, the field stratigraphy reveals that the site itself has not been wooded for the period of peat growth, but the lower reaches of the Blawath Beck valley probably were wooded and this woodland could have filtered out some of the pollen coming from the south-west.

Perhaps this explains the very marked clearance of Zone C on this diagram, when, it has been suggested, the woodland in the Blawath Beck valley was cleared. This would not only result in a decrease of arboreal pollen and increase of non-arboreal pollen from the valley itself, but would also allow more pollen from further afield to reach the site. However, very little cereal pollen is recorded in Zone C, which suggests that the diagram is not so regional as the May Moss one.

From Zone D onwards, the diagram from Simon Howe Moss is very similar to the May Moss one and records changes of a similar amplitude. A considerable amount of cereal pollen is recorded from Zones E and F, and this is unlikely to have originated very close to the site itself. It seems most probable that this originated in the Limestone Hills area to the south of Simon Howe Moss. The change from arable to pastoral agriculture in Zone G is very marked, especially on the Cerealia curve, and the higher value for Cerealia in the surface sample than in those from Zone G suggests that arable agriculture was less important than at present in Zone G within the catchment area of this site. From the documentary sources it seems unlikely that a decline in arable agriculture occurred at this time on the Limestone Hills, so perhaps the changes recorded at Simon Howe Moss refer to a nearer area, such as the farms on the Kellaways Rock to the south, e.g. Wardle Green (830963), Brown Head (810959), Keys Beck (799956). Thus the Simon Howe Moss diagram emerges as a fairly regional one, but with a smaller catchment area than the other upland site, May Moss.

9.2.3 Comparison of the sites.

From the foregoing pages it is obvious that these pollen diagrams are not directly comparable. Some tell the story of the vegetation history of the whole region while others give us information about very small areas within it. These differences are due to a combination of topographic, meteorological and vegetational factors. The interpretations presented above are bound to be imperfect, both because of the lack of sufficient data from modern sites and because of our imperfect knowledge of the mechanisms of pollen dispersal and deposition. It was thought preferable to explore the possible catchment areas of the sites than to leave the whole topic at an implicit level only.

The site with the most regional diagram and with the largest catchment area is May Moss. This is apparent from both the fossil and the contemporary pollen. The other upland site, Simon Howe Moss, also gives us a fairly regional picture, although this site has a smaller catchment area. The reasons for the more regional pollen rain received at these sites are mainly their open, exposed topographic situations and the lack of surrounding woodland to act as a pollen filter.

Fen Bogs is also a fairly regional pollen diagram, because although it is a valley site the channel is broad and open. Here the pollen becomes more regional as the woodland diminishes, first on the site itself and later on the channel sides, and this factor of local vegetation is obviously a very important one. At the other two sites this factor becomes even more important and overrides those of topography and meteorology. The woodland canopy over these sites filtered out most of the regional and trunk-space components and the diagrams tell a very local story until this woodland is removed. After this Gale Field records a fairly regional pollen rain, but Moss Slack Goathland has the added disadvantage of a narrow channel site sheltered from the prevailing winds and the diagram from this site is thought to be fairly local throughout.

May Moss and Fen Bogs both give adequate pictures of vegetational change in the area as a whole, and either diagram could be used for reconstructing a generalised vegetation history. Moss Slack Goathland and Gale Field both provide detailed records of changes within a particular facet of the landscape (the lower ground), while the Simon Howe Moss diagram is more specifically concerned with changes within the upland areas. For particular purposes each one of these diagrams would be very useful; for example, if the agricultural history of Goathland is the sole object of study, the Gale Field diagrams would be adequate on their own. However, for a comprehensive study of the whole area, with details of changes in the different facets of the landscape, all the diagrams are needed. It is the contrasting and comparing of the diagrams from all five sites which allow a full and meaningful study to be made of the changes in vegetation and land use.

CHAPTER TEN. CONCLUSION.

By way of conclusion, we may look at the impact of Man on the vegetation in the different facets of the landscape. Pearsall (1950) suggested that Man's effect on upland areas was three-fold, consisting of burning, grazing and draining. Of these, the first is seen to have been used throughout Man's occupancy of the study area. Charcoal fragments are found from the bases of the two longer profiles and are scattered throughout the whole profile at May Moss. The probable use of fire by Mesolithic hunters to enlarge natural clearings has been noted, and its effects must have been felt repeatedly on the uplands since Bronze Age times. We know that it was an important first step in moorland reclamation at the time when Marshall and Tuke were writing (18-19th centuries). In all these cases the use of fire was probably localised and infrequent. Although it must occasionally have got out of control, it seems unlikely that it was used deliberately to modify the vegetation cover over large areas. The widespread regular burning of vast areas of the uplands dates only from the last two centuries (Zone G on the pollen diagrams) and is associated with the management of the Moors for grouse.

Grazing is an equally long-established activity in the area. It is probable that the Mesolithic clearances, as seen on the pollen diagrams, were maintained by the grazing of wild animals in the clearings created by Man. It has been suggested that pastoralism was the dominant activity on the higher ground during the Bronze Age period. From the beginning of sedentary agriculture in the Iron Age period, the uplands have retained this role as grazing areas, and although the height of the moorland edge has fluctuated considerably over the centuries, the majority of the land above 180m has remained under pastoralism throughout. Indeed, the uplands have seen fewer changes in land use practice than have the lowlands, so that while cultivation on the enclosed land in the dales has suffered periods of marked decline, such as in Zone D, pastoralism has continued at slightly differing intensities right through to the present day. It is only now, with the increased pressure of motor traffic and the decreased profitability of hill farming, that pastoralism is assuming a less important role in the region.

Draining is less important in this area than burning or grazing, but has had a considerable effect in particular localities. Perhaps its most widespread use is in association with the modern forestry plantations. These now cover considerable areas of the higher land and the effects of their associated drainage schemes have been noted, for example, in the drying of the surface at May Moss. At Fen Bogs, a smaller-scale drainage scheme associated with the construction of the railway has had very marked effects on the vegetation of the site.

The combined effect of these three activities on the flora of the uplands has been marked. The pollen diagrams indicate that most of the uplands were wooded during the Atlantic period, and the loss of this forest cover and the attendant deterioration of soils has been seen as the result of a series of changes set in motion by Man's activities of burning and grazing. More recently, draining has been used in some areas as part of a policy of reversing the change and re-afforesting the uplands.

The changes within the lowland facets of the landscape have been rather different from those on the uplands. The loss of forest cover has again been the major theme, but the cleared land has in this case undergone more marked changes. Often the clearance of the woodland has been for pastureland, which has sometimes been improved by drainage schemes, such as that at the southern end of Fen Bogs. Occasionally the cleared land has been afforested, as at Gale Field; but in most other cases it has been used for arable cultivation, which has involved the introduction of exotic species and the expansion of native "weeds".

Activity in the lowlands has had definite periods of expansion and decline, and these have in turn affected the activity on the upland areas. Ironically, when settlement itself was on the higher areas, the effect on the environment was comparatively limited. For instance, Mesolithic man is assumed to have confined his attention to the upland areas, but his total effect on the vegetation cover was not very marked. Similarly, Bronze Age man is thought to have settled in the upper parts of the dales and to have concentrated his activity on the higher areas, but the changes in vegetation which he produced were small-scale and temporary. It was only when, during the Iron Age period, settlement was established on the lower ground, that Man began to modify the vegetation of large areas of the uplands in a semi-permanent fashion.

It can be seen, therefore, that the crucial condition for large-scale vegetation change is the organisation and permanency of settlement associated with sedentary agriculture. It is suggested that the upland areas could not have supported permanent settlement and sustained cultivation, a theory which is supported even by those who suggest that cultivation was attempted on the higher parts at an early period (Fleming, 1971). It was, therefore, a necessary prerequisite for long-term modification of the vegetation cover that settlement should be concentrated in the lowlands, and from such bases the uplands could be systematically exploited as grazing land and for supplies of timber. It was at the Bronze Age-Iron Age transition that such a change occurred, and it was in the Iron Age that the first large-scale clearance occurred, affecting both upland and lowland facets of the landscape. Perhaps it was this apparent irony that led writers such as Dimbleby (1962) and Simmons (1969) to assume that the large-scale clearance of prehistoric times must have been accomplished by people living actually in the upland area rather than in the dales or round the periphery of the Moors.

Since the Iron Age, the exploitation of the uplands has always been organised from the lower ground. Thus the pastoral activity in the Medieval period on parts of the high Moors was associated with monastic settlement on the lower ground, and Waites (1967) is of the opinion that the key to the success of the monks lay in their integration between arable and pastoral agriculture, between lowland and upland farming. In the Tudor and Stuart periods, the smaller scale of lay organisation was partly responsible for the concentration on arable agriculture in the lowlands. Thus land ownership is seen to be an important subsidiary factor. It was the existence of the area of Pickering Forest, owned by the Crown and later the Duchy of Lancaster, which held back agricultural development in the eastern-central area until the end of the Middle Ages. Today this same area, owned by the Duchy of Lancaster, stands out for the opposite reason, as an area of open moorland surrounded to the south and east by afforested areas.

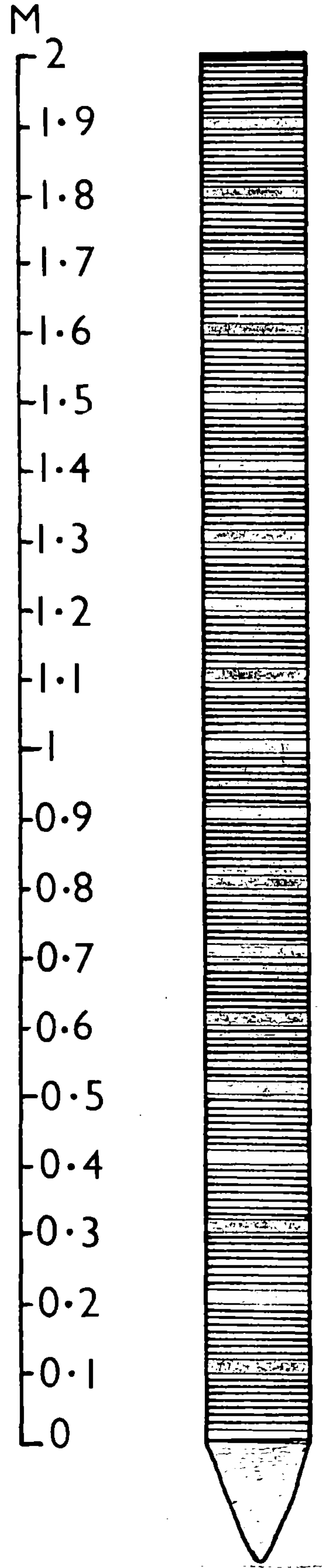
The upland and lowland facets of the landscape appear to have had differing but linked histories of land use and vegetation. Through the study of the five pollen diagrams presented in this work it has been possible to highlight some of these differences and offer possible explanations for the links. The effects of land use practice on vegetation are seen to go back to Man's first occupancy of the area, and the pattern of vegetation today has been brought about by the cumulative effect of land use practices for several millenia.

However, in many ways the most dramatic changes are taking place at the present day. This was seen firstly at the sites themselves. At Simon Howe Moss it was noted that the surface of the peat is eroding and this was attributed to burning in connection with moorland management for grouse. At Fen Bogs, draining in connection with the railway was seen to have brought about the conversion of a reedswamp to an acid Sphagnum mire, and burning and draining have created an area of Molinia adjacent to the railway. At Gale Field and May Moss, the effects of modern afforestation, direct and indirect, were seen to have caused recent changes in the ecology.

In the broader context, the main effect of modern land use has been to reduce the diversity of the flora. Thus on the enclosed arable land a few exotic herbaceous species are dominant, and modern intensive agriculture and the increasing use of chemicals are eliminating many of the weeds which formerly found a niche in the cultivated fields. On the pollen diagrams a decrease in the diversity of herbaceous species was noted in Zone G. Over large parts of the uplands in the south and east of the area, the diversity of the natural deciduous woodland has been replaced by the monotony of the coniferous plantations. The largest area of all is covered with a virtual monoculture of Calluna, and the decrease in species diversity within the last fifty years is apparent from comparing Elgee's descriptions of moorland vegetation with the flora today.

It is a sobering thought that, despite the effects of millenia of Man's influence on the vegetation, modern Man has achieved such dramatic changes in such a short period of time. There is, surely, a good case for conservation and planned management of the Moors in the future to restore some of the diversity of the flora, now that we know how greatly land use practices affect the vegetation.

A COLOUR-CODED, GRADUATED RANGING POLE.



APPENDIX I. FIELD AND LABORATORY TECHNIQUES.

I.1 Field techniques.

I.1.1 Levelling.

As most of the levelling was carried out single-handed, a special technique had to be employed. A "Watts autoset" level was used for the sitings and graduated ranging poles were substituted for a staff. These poles were 2m in length and were colour coded so that they could be read from any direction. The diagram (Figure 63) shows the colour code employed, which consisted of a repeating sequence (the decimetre marks) on a non-repeating sequence (the background half-metre lengths), with the individual centimetres entered in black. The reading was taking by counting these cm marks to the nearest decimetre, which was a known point.

The poles were graduated below the zero mark to the points, so that suitable adjustments could be made to the figures when it was not possible to push the poles in as far as the zero mark. On a hard surface such as a road, the poles were supported by metal tripods; while on very soft ground they often had to be inserted to above the zero mark before they would stand firmly on their own. Thus it was always necessary to note the reading of the ground surface (+ or - so many cm) and to adjust the figures accordingly.

The accuracy of the method was to 1cm, which was thought to be suitable for this type of work. No difficulty was experienced in placing the poles vertically and a vertical spirit level was used to check this. Four such poles were used together, and this eliminated the need for laying out the traverse beforehand with ranging poles, as it was possible to line the poles up with one another to keep to the original bearing by moving two of them at a time. In general there was an interval of 10m between readings, but on steeply sloping ground the interval was smaller.

I.i.ii Vegetation survey.

For the botanical surveys of the contemporary vegetation a metre quadrat was used. This was sub-divided into 16 squares with sides 25cm long. For each species found, the number of squares in which it occurred within the metre quadrat was noted. This allowed a rough estimate to be made of the abundance of the species recorded, (Eg. Potentilla erecta, 7.) This was felt to be a little less subjective than the classification, "dominant, abundant, frequent, occasional, rare", but the latter system was also employed to give additional information. For example, Vaccinium oxicoxxus might occur in all 16 small squares and be "abundant", while Calluna vulgaris might be "dominant" but only occur in 14 of the small squares.

The method of sampling with the quadrat varied. At Fen Bogs, a belt transect was taken from east to west across the site (see Appendix III). At the other sites, a minimum area quadrat was sampled round the boring site itself, while random quadrats in other parts of the sites gave information about other associations in the vicinity.

I.i.iii Sampling.

At two sites (Moss Slack Goathland and Gale Field), some of the samples were collected directly from an exposed peat face by the insertion of tubes into the cleaned section. For non-exposed peat, a Russian-type peat sampler was used, with a chamber 50cm long and 5cm diameter, as described by Jowsey (1966). This had the advantage of allowing the whole sample to be removed and being virtually self-cleaning. Samples for pollen analysis were removed with a fish slice and placed in numbered polythene bags. For the more tenacious deposits, e.g. the bottom metre at Gale Field, a Hiller borer was used from which samples were taken in glass tubes in the field.

For radiocarbon analysis, four duplicate profiles were taken with the Russian-type borer. Slices of peat 3cm deep were taken from three of the profiles while the fourth was used for pollen analysis. The samples, having been cleaned and wrapped in polythene and tin foil, were sent to the Radiological Dating Laboratory at the Norwegian Institute of Technology in Trondheim.

I.ii Laboratory techniques.

I.i.i Preparation of samples.

In the laboratory analyses, standard procedures were carried out which are well documented and need not be described in detail here (e.g. Faegri and Iversen, 1964). Samples were treated with 10% KOH or NaOH and in most cases no further treatment was necessary. Acetolysis was used where there was a great deal of cellulose in the sample, and HF treatment was employed for samples containing inorganic matter. Samples were stained with basic fuschin or saffranin and mounted in glycerol.

I.ii.ii Microscopy.

A Zeiss "Standard WL" research microscope and a Vickers "M 15 C" research microscope were used. Macro-remains were examined at low power (x8); pollen was counted at a magnification of x250.

A minimum pollen sum of 500 total pollen (excluding spores) was counted, from traverses spaced out across the slide. As it was believed that for much of the period under study the area was not covered with closed canopy woodland, an arboreal pollen sum was not felt to be suitable. It was not possible to be certain which species were of local origin; even when definite aquatic or bog species were encountered they might not have originated at the site itself, as is shown by the records of *Potamogeton* at Gale Field and *Typha angustifolia* at Simon Howe Moss in the contemporary pollen. As the aim of the pollen analysis was to elucidate the details of the vegetation cover in the past, it was felt that to make any assumptions about the source of the pollen would be to beg the question. For this reason, the pollen sum included all species recorded, and where a species is thought to be of very local origin, e.g. the peak of *Melampyrum* at 563cm on the Fen Bogs diagram, it is interpreted as such in the text.

APPENDIX II. NOTES ON THE USE OF A LOGARITHMIC SCALE FOR POLLEN DIAGRAMS.

Since the days of Malthus and Darwin, it has been known that biological populations increase in a geometric rather than an arithmetic progression. The exponential curve is widely accepted in demographic studies, and trends in population statistics are generally plotted on a logarithmic scale. Such a scale has not found favour with palynologists, however: Faegri and Iversen (1964), in the context of "composite" diagrams, dismiss it with the words:

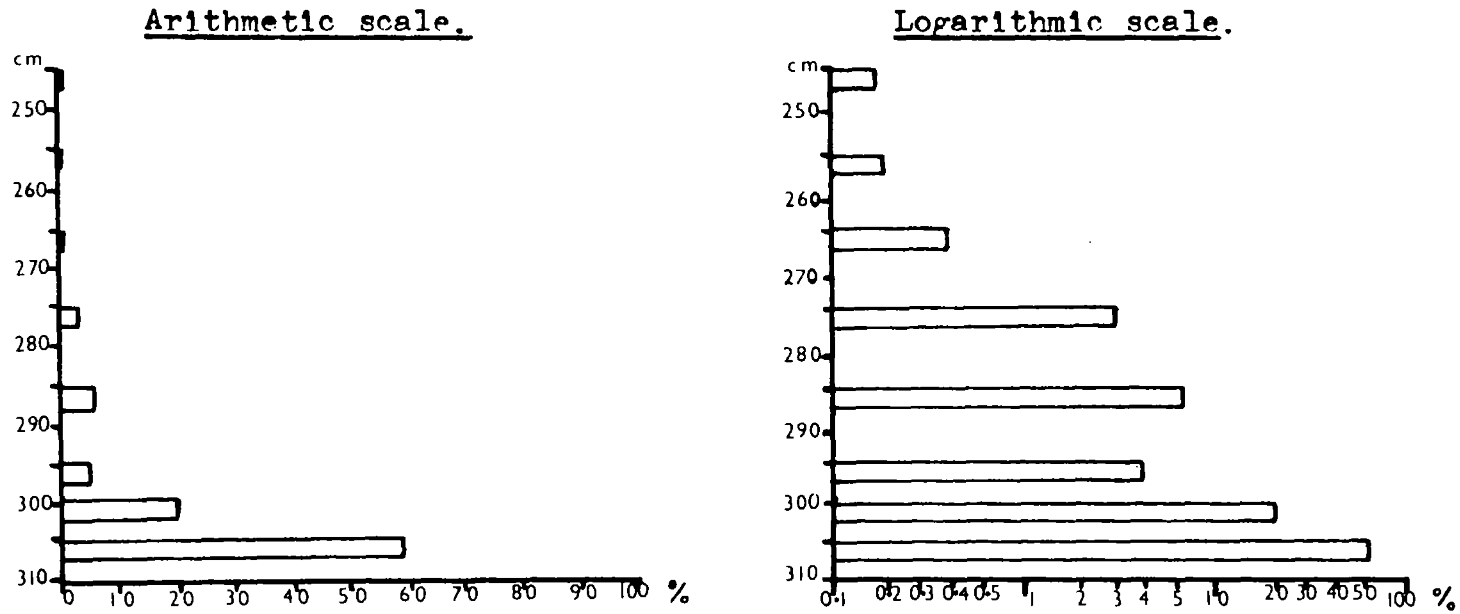
> "Logarithmic scales are not to be recommended, the scale should be linear and consistent throughout."

This consistency, however, means that on a linear scale the herbaceous species which make up only a small percentage of the total pollen are hardly visible, and interpretation tends to be based on the graphs for species which form a conspicuous element in the diagram, e.g. Gramineae. If the linear scale is varied for different species, the individual graphs are not directly comparable. The logarithmic scale has the advantage of a consistent scale for all species, which allows direct comparison between species to be made. On the other hand, the species making up only small percentages of the total pollen are clearly visible on the diagram, and interpretation can more easily be based on all species recorded.

The amplitude of the changes seen on a logarithmic scale reflects the percentage change involved rather than the absolute value of the change. For example, on a logarithmic scale the change from 30% to 60% covers the same linear distance on the diagram as does the change from 1% to 2%, because both these changes represent an increase of 100%. On an arithmetic scale, on the other hand, the linear distance on the diagram would be 30 times as great in the first case as in the second. It is arguable that for biological studies the percentage changes involved are often more important than the absolute changes. For a species comprising only 5% of the total pollen, a decrease of 1% of total pollen represents a 20% decrease in the frequency of the species; but for a species comprising 50% of total pollen, a similar decrease is only a 2% one. Clearly in the first case the decrease is much more significant than in the second case, but on conventional pollen diagrams both changes would be represented by the same linear distance on the diagram. It is only when the figures are plotted on a logarithmic scale that the true significance of the changes is apparent. The diagram below illustrates this point by comparing the same data plotted on linear and logarithmic scales (Figure 64).

The main advantage of the logarithmic scale, and the reason why it was chosen for this study, is the greater prominence afforded to the herbaceous spp. which are relatively rare in the pollen record. It has often been assumed that where only a few pollen grains of a species are recorded, no meaningful pattern will emerge when they are plotted on a pollen diagram. However, the diagrams presented in this thesis show that well-defined and meaningful changes can be seen in the figures for these species when they are plotted on a logarithmic

PART OF THE PINUS CURVE FROM THE SIMON HOWE MOSS DIAGRAM.



On the arithmetic scale the biggest decrease appears to be between the bottom two samples because of the size of the numbers involved; but on the logarithmic scale the drop between the next two samples is seen to be more significant, i.e. 21% to 4%, as compared with 58% to 21%.
The top three samples shown (values 0.3%, 0.2% and 0.17%) are hardly visible on the arithmetic scale, but show up clearly on the logarithmic one, where their relationship to one another can be distinguished.

DIAGRAM TO COMPARE ARITHMETIC AND LOGARITHMIC SCALES.

Figure 64.

scale. This is particularly important when dealing with land use changes, where many of the conclusions are based on the records for these pollen types, (e.g. Rumex, Compositae, Chenopodiaceae.)

Another advantage is the playing down of the fluctuations in species forming a large percentage of the pollen, which are insignificant in terms of percentage changes in these species. When a species is contributing over 80% of the total pollen, fluctuations of the order of 5% are of little significance, and consequently they involve very small linear distances on the logarithmic pollen diagram. For this reason the curves for taxa such as Gramineae, Calluna and Cyperaceae often appear much smoother on the diagrams in this thesis than on conventional pollen diagrams.

The pollen diagrams presented in this thesis are the best evidence for or against the use of the logarithmic scale. The main disadvantage lies in the difficulty of comparison between these diagrams and the conventional ones from other areas. However, it is always difficult to compare land use changes between regions, as they are such local phenomena, and it was the aim of this study to investigate the detailed changes within a small area rather than the general vegetation history of a larger region. Therefore, in this particular case, it is felt that the advantages of the logarithmic scale outweigh the disadvantage of lack of comparability with diagrams from other areas.

APPENDIX III. A COMPUTER PROGRAMME FOR DELIMITING VEGETATION SUB-REGIONS.

Data for 167 metre-square quadrats from Fen Bogs were used (vide supra, 4.1.2). For the 26 species recorded, a value of between 0 and 16 was entered for each quadrat, referring to the number of small squares within the quadrat in which the species occurred, giving an approximate measure of its frequency (Appendix I.i.ii). A computer programme was written which calculated the product moment correlation coefficient for each pair of adjacent quadrats, and the results have been tabulated (Figure 65). From this data, a cluster diagram was constructed (Figure 66). The procedure followed was to join the most similar pairs of quadrats first, (in this case some were identical, r=1.0000), to form the basic groups, i.e. the cores of vegetation sub-regions. Pairs of quadrats were joined in decreasing order of similarity. If one of the quadrats was already in a group, the other member of the pair was added to that group; if both were already in groups, the two groups were joined to form one higher order group; if neither quadrat was in a group, the two were joined to form a new group. In this way, a hierarchy of groups at different levels was built up, until all quadrats were united in one large group. Thus it is possible to regionalise the vegetation at a number of different levels, according to the degree of sub-division required.

Figure 65

TABLE 4. PRODUCT MOMENT CORRELATION COEFFICIENTS FOR ADJACENT QUADRATS.

r 1/2	0.7709	r 30/31	0.9317
r 2/3	0.8715	r 31/32	0.8920
r 3/4	0.8662	r 32/33	0.7631
r 4/5	0.7950	r 33/34	0.8105
r 5/6	0.4364	r 34/35	0.8800
r 6/7	0.7477	r 35/36	0.8179
r 7/8	0.7254	r 36/37	0.8321
r 8/9	0.9179	r 37/38	0.9587
r 9/10	0.9145	r 38/39	0.9095
r 10/11	0.8980	r 39/40	0.9171
r 11/12	0.6921	r 40/41	0.8876
r 12/13	0.9167	r 41/42	0.9903
r 13/14	0.7031	r 42/43	0.9838
r 14/15	0.9891	r 43/44	0.9943
r 15/16	1.0000	r 44/45	0.9737
r 16/17	0.9522	r 45/46	0.9320
r 17/18	0.9633	r 46/47	0.8983
r 18/19	0.8842	r 47/48	0.6002
r 19/20	0.9804	r 48/49	0.9541
r 20/21	0.9923	r 49/50	0.8462
r 21/22	0.9963	r 50/51	0.9709
r 22/23	0.9960	r 51/52	0.9521
r 23/24	0.8475	r 52/53	0.8841
r 24/25	0.9075	r 53/54	0.9849
r 25/26	0.7154	r 54/55	0.9929
r 26/27	0.9612	r 55/56	0.9857
r 27/28	0.9489	r 56/57	0.7129
r 28/29	0.8589	r 57/58	0.9396
r 29/30	0.9436	r 58/59	0.8888

TABLE 4 continued.

r 59/60	0.9811	r 89/90	0.9316
r 60/61	0.9621	r 90/91	0.9889
r 61/62	0.8005	r 91/92	0.9963
r 62/63	0.8764	r 92/93	0.9935
r 63/64	0.7415	r 93/94	0.9996
r 64/65	0.7341	r 94/95	0.9996
r 65/66	0.9415	r 95/96	0.9989
r 66/67	0.7958	r 96/97	0.9262
r 67/68	0.6070	r 97/98	0.6730
r 68/69	0.6276	r 98/99	0.7204
r 69/70	0.9277	r 99/100	0.7802
r 70/71	0.9632	r 100/101	0.9204
r 71/72	0.9854	r 101/102	0.9804
r 72/73	0.9878	r 102/103	0.9318
r 73/74	0.9483	r 103/104	0.9759
r 74/75	0.9629	r 104/105	1.0000
r 75/76	0.9461	r 105/106	0.9826
r 76/77	0.8817	r 106/107	0.9826
r 77/78	0.9205	r 107/108	1.0000
r 78/79	0.9314	r 108/109	1.0000
r 79/80	0.9428	r 109/110	1.0000
r 80/81	0.9876	r 110/111	1.0000
r 81/82	0.9316	r 111/112	1.0000
r 82/83	0.9710	r 112/113	1.0000
r 83/84	0.9952	r 113/114	0.9906
r 84/85	0.9099	r 114/115	0.9959
r 85/86	0.9825	r 115/116	0.9962
r 86/87	0.9782	r 116/117	0.9373
r 87/88	0.8972	r 117/118	0.8092
r 88/89	0.9906	r 118/119	0.8237

TABLE 4 continued.

r 119/120	0.9627
r 120/121	0.8753
r 121/122	0.7632
r 122/123	0.8889
r 123/124	0.8943
r 124/125	0.8770
r 125/126	0.8776
r 126/127	0.8665
r 127/128	0.7297
r 128/129	0.6661
r 129/130	0.7604
r 130/131	0.9887
r 131/132	0.9165
r 132/133	0.9151
r 133/134	0.6632
r 134/135	0.8711
r 135/136	0.8649
r 136/137	0.9982
r 137/138	0.8856
r 138/139	0.2366
r 139/140	0.3755
r 140/141	0.7106
r 141/142	0.4144
r 142/143	0.9897
r 143/144	0.7774
r 144/145	0.9901
r 145/146	0.7822
r 146/147	0.9416
r 147/148	0.9908
r 148/149	0.9529
r 149/150	0.8476
r 150/151	0.8395
r 151/152	0.7238
r 152/153	0.8745
r 153/154	0.7797
r 154/155	0.9717
r 155/156	0.9276
r 156/157	0.8715
r 157/158	0.9323
r 158/159	0.8914
r 159/160	0.8655
r 160/161	0.9719
r 161/162	0.8732
r 162/163	0.8897
r 163/164	0.9541
r 164/165	0.9312
r 165/166	0.9581
r 166/167	0.9427

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Figure 66.

CLUSTER DIAGRAM TO SHOW GROUPING OF QUADRATS.

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