Ecological history and the development of peat on the central watershed of the north Yorkshire Moors

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by

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Abstract

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The peat deposits of a limited area of the North Yorkshire Moors were studied through pollen analysis and associated techniques. The aim of the project was to provide details about the inception of peat growth and man's effect on the vegetation of the area throughout time. Altogether thirteen sites were examined and pollen diagrams constructed from the results. The pollen diagrams gave an outline of the conditions which prevailed on the North Yorkshire Moors from about 6000 years B.P. up to the present day, and showed that the influence of man on the vegetation of the area was very marked. The active removal of woodland by man is seen in three major phases which have been tentatively assigned to the cultural periods of the Neolithic, Bronze Age and Mediaeval. In addition to these three phases, burning of the vegetation appears to have taken place continuously on the upland areas of the moors from the start of peat accumulation. From this it is suggested that man played a part in the formation of the upland peat deposits, although probably only in the role of assisting in the degradation of an already 'poor' environment. The effects of man, which are so clearly reflected in the pollen diagrams of the present study, appear to rule out the possibility of widespread climatically induced vegetation changes for most of the period under examination. It is concluded that while a great deal of new information on the historical ecology of the area has been revealed a great many gaps in knowledge still remain. However, the study provides for a better understanding of an environment created by man through many thousands of years of mis/use, and this information may assist in the formulation of an appropriate conservation policy for the future.

Plate 1 Frontispiece : view of White Gill and Stony Ridge

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The Research Topic

One of the most striking things about the North Yorkshire Moors at the present day is the very treeless nature of the terrain. Only where new coniferous plantations occur and in a few favourable localities do any trees survive. Elsewhere the aspect is one of many miles of undulating heather moorland. Previously the moorland was thought of as being natural and only over the past 20 years has a contrary point of view been put forward. This revised idea was first expressed by Dimbleby after a detailed study, using pollen analysis, of the soils beneath Bronze Age barrows. He attempted to link changes in vegetation with the activities of prehistoric man on the moors (e.g. Dimbleby 1962). A more recent examination of the area has been undertaken by Simmons who has studied the vegetation history of the moors through pollen analysis of peat deposits (Simmons 1969a). The aim of the present study was to extend the work begun by Simmons and attempt to link it with the work of Dimbleby. The present research has concentrated on the pollen analysis of peat deposits over a very limited area measuring 10 x 3 miles (16 x 5 kms.). Particular emphasis has been placed on the analysis of the early periods of peat growth. In this way it was hoped to provide a highly detailed study which contained information about the interrelationship of early man, forest clearance and the formation of blanket peat. In order to accomplish this a large number of peat sites were examined both on the present moorland summits and on the sides of the dales in bogs formed behind landslips. These two major types of sites were used in order to examine the possibility of similarities between the vegetation history of the dales and that of the moorland summits. Two archaeological sites, White

Gill and Glaisdale Moor, were examined in order to assess the effects of early man on vegetation at places where he was known to have been present.

In choosing a small area for the study a number of problems were encountered which ultimately meant that many questions remained unanswered. In retrospect there are a number of lines of research which could have been followed in more detail (Appendix D) although it is hoped to show that the work accomplished does help to answer some questions and provides a distinctive topic and area which fits in with the work begun by Dimbleby and Simmons.

SECTION I

INTRODUCTION

General Comments

The Introduction provides, albeit briefly, the relevant information available on the area up to the start of the present work; Section II lays out the results of the present research and Section III attempts to place the present work within the context of the background of Section I.

The area under study is relatively small measuring 10 x 3 miles (16 x 5 kilometres). It stretches from Stony Ridge (G.R.NZ 634029) in the west to Collier Gill (G.R.NZ 790007) in the east and from St. Helena (G.R.NZ 684037) in the north to Little Blakey Howe (G.R.SE 682994) in the south. The area enclosed in this rectangle includes upland and dale (fig. 1) although all the pollen sites examined are found above 850 feet (290 metres).

The position of the area under examination in relation to the rest of the country in general and to the North Yorkshire Moors in particular may be seen in fig. 2. The area is more or less right in the middle of the North Yorkshire Moors National Park. The use of the term central watershed for the area studied follows the nomenclature used by a number of earlier workers (e.g. Elgee 1930, Anderson 1958, Farra 1961), while other workers use terms such as moors (Rob 1966) or moorland (Fox-Strangways 1894) when referring to this highest area of the North Yorkshire Moors. The central watershed does, of course, spread further east and west than the area outlined above but it was felt that this term was most appropriate, and in the absence of a more precise description, will be used throughout the present work.

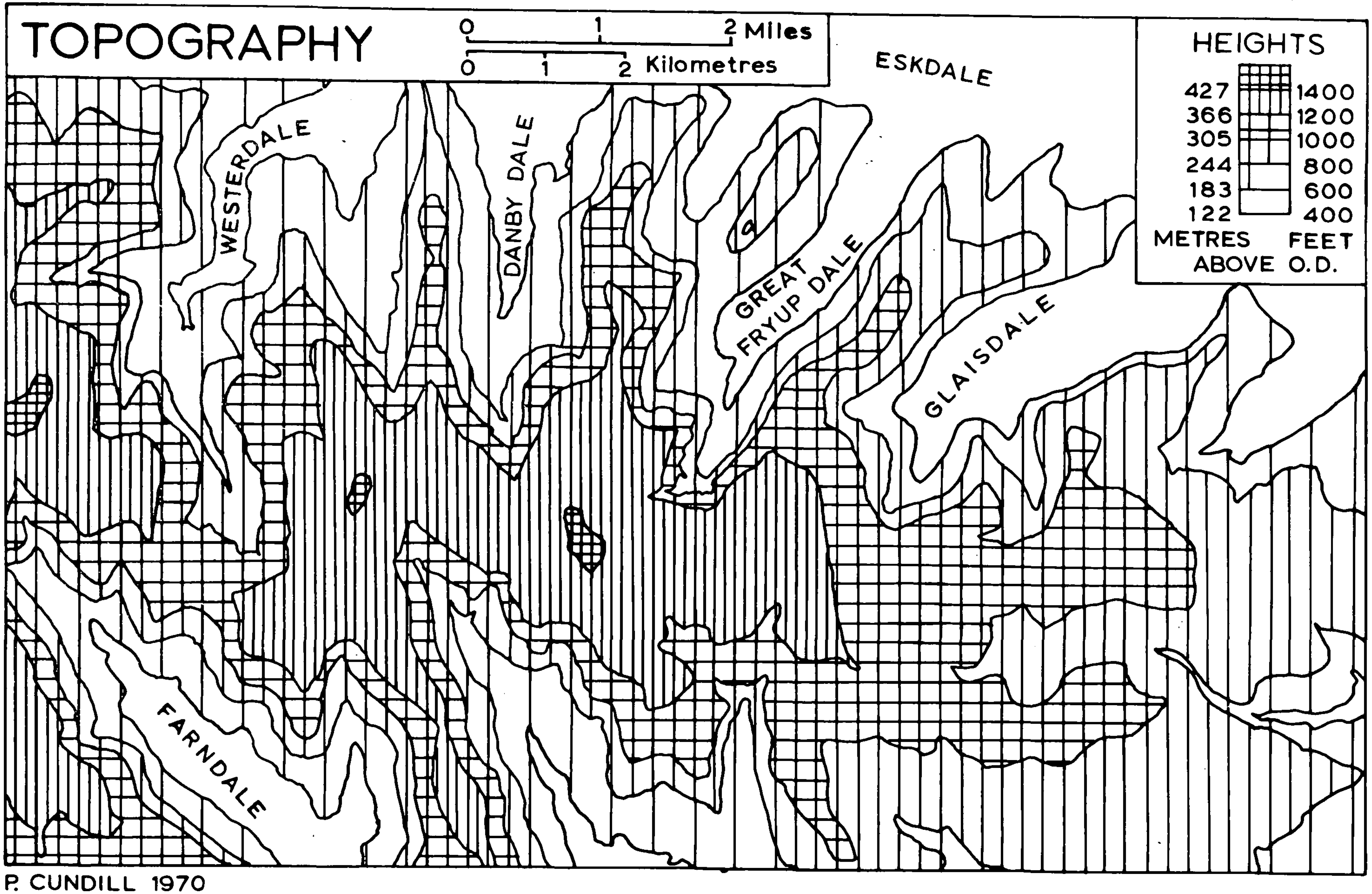


fig. 1 Topography of the central watershed.

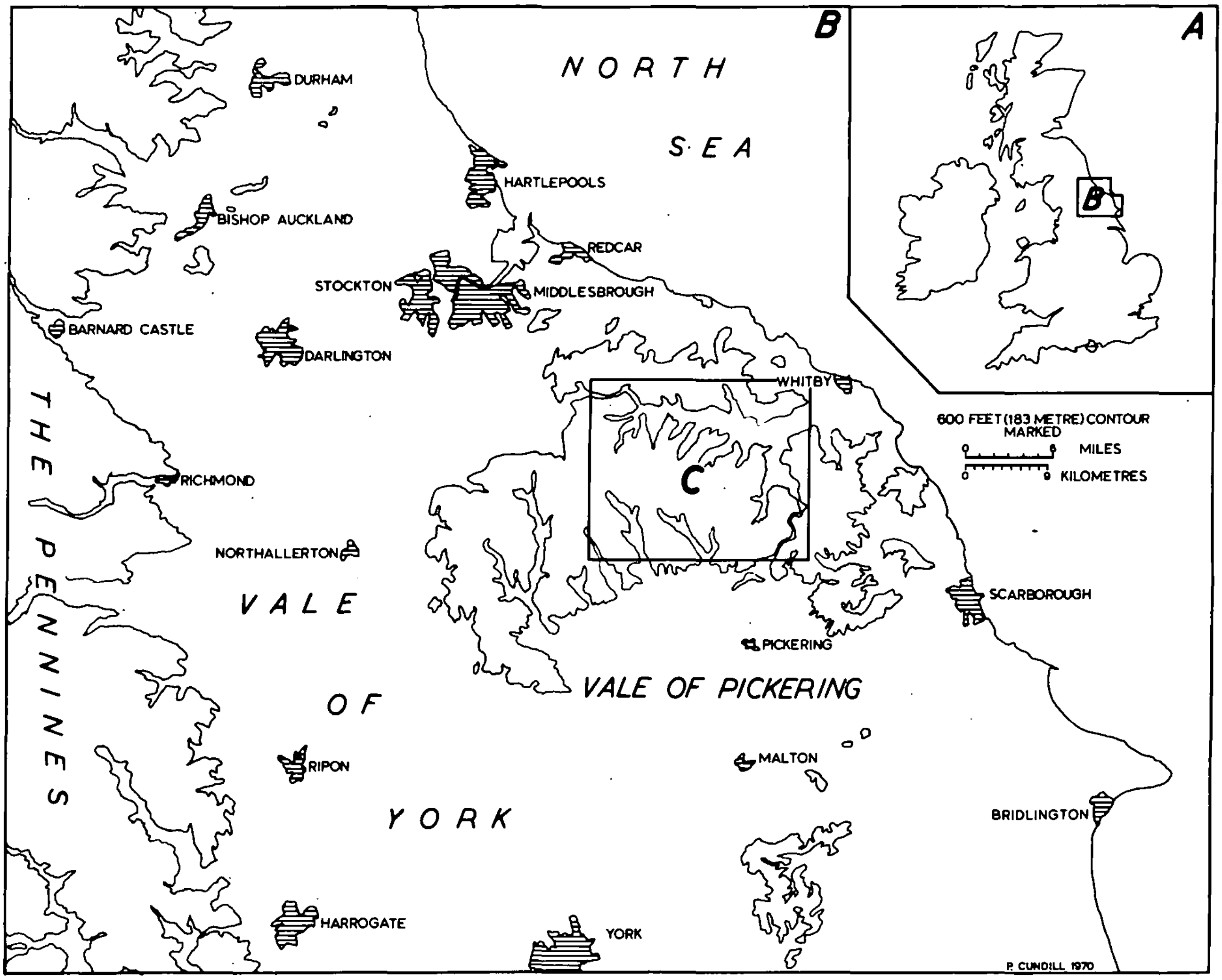


fig. 2 North east England showing the location of the study area. (c)

A. The Physical Background

1. Geological History

In purely geological terms the history of the area can be divided into two major phases: the time when the 'solid' rocks were laid down, and the time when glacial activity took place (Hemingway 1966). Knowledge of the moors during the intervening period of some 180 million years is scanty. The two major geological periods of activity on the moors conveniently form two separate sections of discussion, the glacial epoch also allowing a discussion of the geomorphology of the area.

(i) Pre-Quaternary Geology

The North Yorkshire Moors was one of the earliest areas in the British Isles to be studied thoroughly for its geology. It was found to be an area where there was a very strong connection between topography and geology and where rock types could be traced over a distance. Basically the North Yorkshire Moors are Jurassic uplands.(de Boer 1964), and it is this geological system which was studied initially in Yorkshire (e.g. Fox-Strangways 1892). There are no Triassic or earlier rocks outcropping on the surface of the upland area of the moors (fig.3), and the range of the Triassic in the immediate vicinity of the moors is restricted to the Vale of York where these rocks are mostly masked by later glacial deposits. Similarly there were no further solid rock deposits laid down after the Jurassic apart from the intrusion of the Cleveland Dyke. The geological sequence of the Jurassic (Table A) falls into three parts each separated by a quite distinctive environmental change. The three parts are termed Upper, Middle and Lower (Hemingway 1966, Wilson 1948) and within each of these distinctive parts divisions are recognized distinguished by their fossil plant and animal

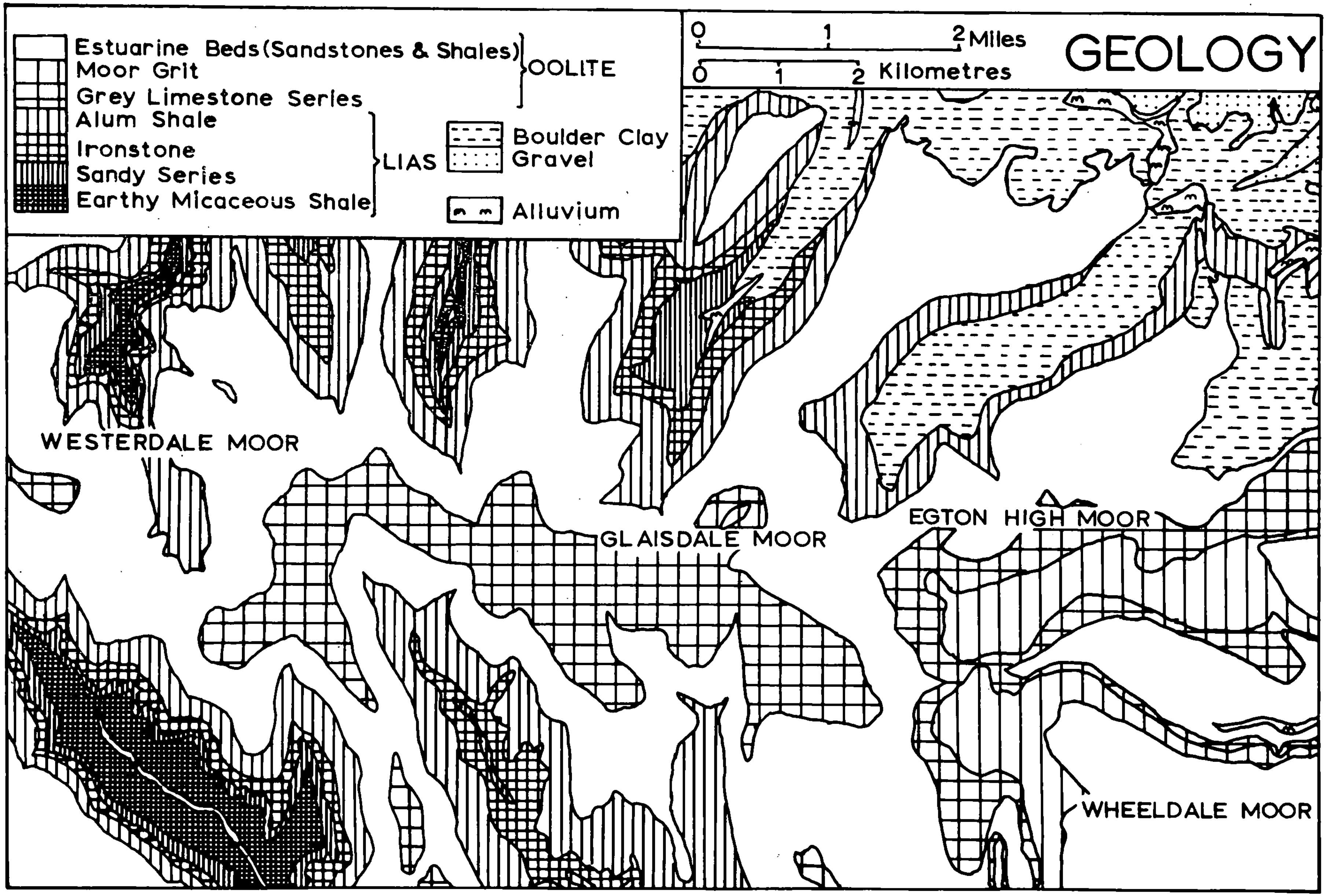


fig. 3 Geology of the central watershed.

assemblages. A brief discussion of the geological sequence now follows.

The conditions of the Triassic period were mainly those of an arid climate, but with the coming of the Jurassic these conditions were ended by a marine inundation of the area.

Lower Jurassic

The initial part of the Jurassic system is termed the Lias and this has a tripartite division into Lower, Middle and Upper. The Lias rocks can be clearly distinguished in the central watershed area since they are relatively soft and they form the bottom and sides of the dales. The Lias series are mainly clays and shales together with many minor bands of ironstones, calcareous mudstones, limestones and sandy bands. The Lower Lias is found only in the very bottoms of the dales and is represented by the Earthy Micaceous Shales (fig.3). The Middle Lias is much more significant in the dales as one part of the series formed an important source of iron in the past (Fox-Strangways et al. 1885), the relics of this mining being found in a number of the dales, for example, Fryup Dale and Eskdale. In fact, the Ironstone Series has been one of the richest sources of bedded iron ore in England (Wilson 1948). The Upper Lias, a deposit of dark shales and clays, also have two minerals which were of great economic importance in the past, alum and jet. Jet rock has been a prized mineral since Bronze Age times while alum, like the ironstone, is no longer economically worked, the industry only surviving until the middle of the last century.

Middle Jurassic

This was a time of great change with the scene switching from one of an open sea to one where the North Yorkshire Moors became engulfed by very thick deltaic deposits from the east.

<u>Table A</u>: Geological sequence for the North Yorkshire Moors (after Wilson 1948)

Quaternary	Recent: Alluvium, River Gravels, Peat	
	Pleistocene: Boulder Clays, Glacial Sands, Gravels and Lake Deposits.	
Tertiary	No Deposits	Cleveland Dyke
		Kimmeridge Clay
	Corallian Series	Upper Calcareous Grit
		Osmington Oolite Series
		Middle Calcareous Grit
		Hambleton Oolite Series
		Lower Calcareous Grit
		Oxford Clay
		Hackness Rock
		Kellaways Rock
		Cornbrash
Jurassic		
	Great Oolite Series	Upper Estuarine Series
	Inferior Oolite Series	Scarborough Grey Limestone
		Middle Estuarine Series
		Millepore Oolite
		Lower Estuarine Series
		Dogger
		- - - - - - - - - Erosion - - -
	Lias	Upper Lias
		Middle Lias
		Lower Lias
		Rhaetic

The scene was a dynamic one with the sea invading the delta three times to lay down distinctive deposits.

The Dogger is a very variable deposit, in some cases consisting of a highly rich'Magnetic Ironstone' which has been worked in the past particularly in Rosedale (Fox-Strangways 1885). The lower beds of the deltaic series are inappropriately termed the Estuarine Series. This series consists of fossiliferous sandstones and shales on the whole, but the conditions of plant growth were such that thin coals were formed. Despite the thin nature of the seams, where they exceeded 11 ins. (28 cms.) thickness they have been worked in the past (e.g. at Rosedale Head, Hamer, Blakey Moor, Winter Gill), and the numerous small pit mounds and even some of the local names (e.g. Collier Gill) show this now past industry. The sandstones of the deltaic series become arenaceous in the west indicating the variable conditions existing on the delta at this time. Of the three invasions of the sea mentioned above only two covered the whole area and these are represented by the Eller Beck and Scarborough beds. The Eller Beck bed varies in its contents, being mainly a sandstone with oolitic limestone in parts. It outcrops round most of the north central watershed area, being recognized in Glaisdale (Winter Gill), Fryup Dale and the very upper parts of Danby Dale and Westerdale. The Scarborough bed plays an important part in the geology of the central watershed as it forms the capping of the watershed from Shunner Howe westwards to Botton Head (Wilson 1948). It also covers a large area of Egton High Moor (Fox-Strangways et al, 1885). The Upper Estuarine Series has at its base the 'Moor Grit', a massive sandstone which forms the final cap to fairly small areas on the central watershed.

Taken as a whole it is this series of deltaic deposits of the Middle Jurassic, mostly of a highly siliceous nature, that has helped to create some of the main characteristics of the North Yorkshire Moors. These rocks in addition to forming a protective and relatively resistant cap for the softer sandstones and shales of the Lias series, have also had a profound effect on the soils and vegetation of the area.

Upper Jurassic

These rocks do not outcrop in the central watershed area, but form the peripheral rocks of the North Yorkshire Moors. They are found mainly in the southern parts of the moors. The beds were laid down in shallow seas and consist of limestones and sandstones, one of the limestones of which caps the Tabular Hills (the Corallian Series) and has helped to form the distinctive scarp of that range of hills. The Corallian Series also helps to change the character of the country with its calcareous nature, forming a richer soil than the siliceous sandstones to the north.

Post Jurassic events

After the conditions of deposition, the Jurassic rocks were uplifted and folded very gently into a series of anticlines and synclines. The largest anticline is the Cleveland Dome which has formed the general upland mass in the western part of the moorland region and comprises a major part of the central watershed. A further large dome occurs in the east and in between and next to these two major domes a series of synclines occur (e.g. Goathland syncline). The folding was not sufficient to produce serious cracking and disturbance of the rocks and subsequently only a small number of faults can be recognized on the North Yorkshire Moors. There are none in the central watershed area. However, the folding did produce one significant feature and that was the intrusion of the Cleveland Dyke. The dyke rock is a tholeiite or augite andesite (Fox-Strangways et al 1885, Hemingway 1966, Wilson 1948), and is thought to be part of a swarm of basic dykes which originate from the Isle of Mull, off the west coast of Scotland. The age of the dyke has been estimated at 26 million years (Wilson 1948), which would place it within the Miocene. It has been extensively quarried in the past for road stone and the line of the dyke can be clearly seen in many areas (e.g. Sleights Moor) where the quarrying follows it.

The history of the central watershed during the Tertiary era is also involved with the theory of the formation of a series of peneplains or erosion surfaces (Hemingway 1966, Gregory 1962). Hemingway also suggests that during this same period the general east-west line of the Esk was formed by a very much longer and more direct seaward route of the Swale (Hemingway 1966).

(ii) <u>The Quaternary Period</u>

Early studies of the glacial history of the North Yorkshire Moors produced the now classic works of Kendall (1902, 1903) on the so-called overflow channels, in addition to earlier works by the same author (Kendall 1891) and Fox-Strangways (1894). Moreover there was much contemporary work on the drift deposits of adjoining areas and in particular those deposits of Holderness (e.g. Lamplugh 1891). The interpretation of the course of events during glacial times have altered with increased knowledge and the most detailed recent account of the central watershed and its immediately adjoining areas is provided by Gregory (1962a, 1962b, 1965). Despite all the evidence available, no clear and straightforward pattern of events has been forthcoming, although something of a synthesis will be attempted here.

Generally most authors would argue for the presence of one major glaciation effecting the area. However, a number of workers have argued for the existence of an earlier glaciation, of which there is now very little evidence. There is certainly no evidence for local glaciations, despite early arguments for them by Fox-Strangways (1892). Both Elgee (1912) and Hemingway (1958) argue for an earlier glaciation of the moors on the evidence of superficial deposits of pebbles occurring on Wheeldale Moor. Similarly, Dimbleby, from a study of ~~stone~~ ice ~~polygons~~ wedges on the Tabular Hills came to the conclusion that an earlier glaciation was probably responsible for their formation (Dimbleby, 1952a), and Best had to adopt a double glaciation theory to explain the alignment of glacial drainage channels (Best 1955). The date of this early glaciation is not clear as the evidence is not specific although it must be pre-Devensian (Weichselian), since Gregory and other workers (e.g. Lamplugh 1891) argue that the newer drift that is present is too fresh to be anything but Devensian. Wilson sees the ice of the early glaciation sweeping down from the north laying down chalky boulder clay in Lincolnshire. The intervening interglacial before the Devensian saw the removal of much of the older drift (Wilson 1948).

The Devensian drift only covers a limited area of the central watershed (fig.3) and only in Glaisdale and Eskdale does it cover a large section of the dales. The southern dales are drift free and this provides evidence that the central watershed ridge was not over-ridden by ice during the last glaciation. The boulder clay and gravel deposits do not reach any great height on the southern side of Eskdale (800 feet, 244 metres) and all the workers in the area consider the central watershed to have remained a nunatak throughout the last glaciation and only suffering erosion from strong solifluction. The latter is shown by the small altiplanation terraces just above Ladybridge Slack (Gregory 1962a). The ice that impinged on the North Yorkshire Moors came from three different sources and these probably did not arrive and affect the area at the same time. The ice sources were: a) Lake District and Irish Sea, b) Cheviot c) Scandinavian. The recognition of these three sources is based on the erratics in the boulder clays, and, in general, discrete areas may be recognized as belonging to each ice sheet. Clearly the picture is not as simple as this because there was a great deal of mixing and overlapping as the power of each ice sheet was not constant throughout time. In general terms, the boulder clay of the Vale of York contains north-western erratics and that of the coast Scottish and Scandinavian erratics. The different types of boulder clay along the Holderness coast illustrate a shift in power of ice from predominantly Scandinavian ice in the basement clay to predominantly Scottish and north of England ice in the upper clays.

The force of the ice impinging on Cleveland must have been considerable as it moved a block of the main seam of the Cleveland iron ore, measuring 137 x 4 metres, by 150 feet (46 metres) from its original position (Charlesworth 1957). The ice rose to 1000 feet (305 metres) on the Cleveland ridge although only sporadic traces of its presence are found at this height. It may have spilled over into the Esk valley and Gregory finds this quite acceptable in his theories of the glaciation of Eskdale as a whole (Gregory 1962a). The ice is thought to have reached its southern-most point in the Vale of York at the Escrick moraines (Wilson 1948). At the same time the maximum extent of ice in Eskdale was considered to have been achieved

(Gregory 1965) with ice spilling from north, east and west right into central Eskdale. On the other hand Kendall thought that the limits of this ice were marked by the Kildale and Lealholm moraines while Gregory considers these latter features to be a part of the deglaciation of the area. The idea of direct and marginal overflows in connection with a series of glacial lakes, including a lake in Eskdale, was put forward by Kendall (1902, 1903), and has since been strongly criticized by Gregory (1962a, 1962b, 1965). The evidence put forward by Kendall was shown by Gregory to be capable of further interpretations, although he does not dismiss completely the ideas of Kendall. The presence of a lake in Eskdale was still a possible idea although it is only likely to have occurred in the early stages of deglaciation (Gregory 1965). The overflow channels of Kendall were also examined by Gregory, and other explanations put forward as to their origin. The upland channels such as Ewe Crag Slack, (i.e. watershed channels) were found to have a humped longitudinal profile, not very usual for a channel described as a direct lake overflow by Kendall. Gregory puts forward the idea that a great number of these channels may have been formed by sub-glacial drainage.

Gregory also identified a great number of features which Kendall had not noted, including a series of ice marginal benches, eskers at a number of places and kame terraces. The deglaciation of the area was the major topic investigated by Gregory and many of the features recognized were formed during this phase (Gregory 1962b, 1965). The various parts of the Esk valley would have remained filled with ice during stagnation but the ice would have been split into separate lobes. It was within these lobes that the gravel mounds and eskers would have formed.

The history of the area from the last glaciation to the present day still saw the formation of a number of large scale geomorphological features, of which possibly the most significant was that of landslipping. Gregory recognized three different types of landslipping in the North Yorkshire Moors: a) rotational slips, b) Earthflows and c) mass movement involving glacial deposits (Gregory 1962a). Of these rotational slipping and earthflows are by far the most important in the landscape with rotational slipping producing the most spectacular features. The rotational slips are found predominantly on north, north-east and east facing slopes of the dales and their occurrence is largely influenced by the outcropping of the Upper Lias, in particular the Alum shales. It is the failing of the 'weaker' deposits of the shales, overlain as they are by massive bedding of the Estuarine Series, that forms the slips. The slipping takes place when the shales are sufficiently lubricated for them to fail, causing the base of the material to move along the line of the shales. All the rotational slips are now considered to be stabilized and are covered by vegetation. They are regarded as fossil features by Gregory, in some cases now containing peat in the hollows behind the slip face (Gregory 1962a). More mention of these landslips will be made later. Earthflows are features which like rotational slipping are mainly confined to the area of Alum shales. They are probably formed in a similar manner to the landslips by increased lubrication of the shales (Gregory 1962a). Earthflows and mass movement features associated with glacial deposits still occur at the present day (Plate 2) but Gregory suggests that they are on a much reduced scale. The recognition of tors should be noted although these are in an early stage of development. They mainly occur as valley side tors (e.g. on the southern side of the Wheeldale

Plate 2 Earthflow in Westerdale, 1968

Gill valley) and may be associated with the action of periglacial conditions in removing less resistant material from around blocks of Moor Grit (Gregory 1962a).

This gives a summary of the geological background to the formation of the physical landscape of the present day on the moors. It also provides the background from which to move on to discuss related topics.

2. Climate

The amount of information about the climate of the North Yorkshire Moors is very limited. There are no official full meteorological stations on the moors proper and much of the detailed information has to be taken from the surrounding lowland area. The records which exist in the lowlands, at York for example, stretch back into the eighteenth century (Phillips 1855), and many comments about the climate of the area made by early writers such as Phillips are just as valid today. The North Yorkshire Moors is the most easterly upland area of Britain and as such would be expected to have a slightly different climate from the adjacent Pennines, for example.

Rainfall data collected by the Hull waterworks on the central watershed in connection with the proposed reservoir in Farndale is the only detailed meteorological information from this area. It has proved invaluable for ascertaining the level of the rainfall on the watershed proper. The figures for rainfall at a number of selected sites for the moors and surrounding lowlands are contained in Table B. These show that there is only a slight diminution in rainfall from some of the highest points on the moors (1337 feet, 438 metres, Rosedale 18 raingauge) to the dale at Farndale Vicarage (495 feet, 151 metres). Surprisingly enough it is Farndale 10 raingauge at 574 feet (175 metres) which gives the highest average rainfall, and that over 34 years, of 43.3 ins. (1100 mm.) per year. It could be the case that rainfall is higher on the central watershed but the raingauges are reading lower than they should because on exposed ridges the wind may be sufficiently strong to sweep a good proportion of the rainfall over the mouth of the gauge, although there is no evidence to support

Table B - Selected Rainfall sites in and around the North Yorkshire Moors. (from British Rainfall, 1958)

Site	Annual Rainfall average 1916-1950				
	INCHES	MILLIMETRES	HEIGHT ABOVE O.D.		OTHER COMMENTS
			FEET	METRES	
Silpho Moor	33.6	853.4	662	192	Turf wall round gauge
Farndale Vicarage	38.2	970.3	495	151	
Farndale 10	43.3	1099.8	574	181.5	
Farndale 13	41.9	1064.3	1055	322	
Danby Lodge	37.6	955.0	399	122	
Redcar	23.9	607.1	25	8	
Thirsk	25.4	645.2	81	25	
Ampleforth	30.0	762.0	313	95	
Scarborough	25.6	650.2	118	36	
Rosedale 18	41.8	1061.7	1337	438	Turf Wall round Gauge } Figures for 1950-9
Rosedale 14a	41.3	1049.0	1339	439	

this suggestion. There does appear to be a general lowering of average rainfall figures immediately outside the effects of even low hills as while Ampleforth has a yearly average rainfall of 30 ins. (762 mm.) places like Redcar, Scarborough and Thirsk have an average of around 25 ins. (635 mm.) per year. Thus the fall off in rainfall from the high to low ground is in the region of 15 ins. (381 mm.) per year unlike that in the Pennines where a similar figure would be more like 20-25 ins. (508-635 mm.) per year. In general terms the rainfall for the central watershed seems to be in the region of 40 ins. (1016 mm.) per year.

Temperature data is virtually non-existent for the central watershed, because of the lack of recording stations. An idea of the temperature regime at the present day may be obtained from an adjacent lowland site, the I.C.I. agricultural division at Billingham (Table C). The figures may be computed for the equivalent height differential between the moors and Billingham by using the adiabatic lapse rate figure (Barry and Chorley 1968) for dry air of 5.4°F (3°C) per 1000 feet (305 metres). This is not a strictly reliable guide as temperature will vary more widely according to position and hour of exposure and humidity of the atmosphere. On calm nights in the dales, for example, drainage of cool air from the surrounding moors may produce locally colder conditions than on the open moorland.

While the height of the central watershed is not sufficient to seriously impede the growth of plants, quite clearly the growing season will be much shorter than the adjacent lowlands. However, the growing season is still reasonable as shown by Anderson (1958) who demonstrated that it was possible to grow good crops of grass, potatoes, winter rye and oats up to an elevation of 1300 feet (397 metres). This was under careful management but goes to illustrate the point that it is not necessarily the physical factors which are limiting the area to its present vegetation cover.

The other climatological factors are equally poorly documented for the central watershed and most of the information must, of necessity, be taken from general sources such as the Climatological Atlas for the British Isles (Met.Office 1952) or taken from places outside the central watershed. It may have been expected that with the proximity of the coast and the associated sea fret or sea mist which effectively blankets the local area that the incidence of fog would be relatively high. This does not seem to be necessarily the case from the data and the only possible indication is that mists appear to occur more readily along the coast in summer (Met.Office 1952). On the other hand the incidence of sunshine for Billingham seems to be quite usual for the eastern side of England as a whole and does not register the excessive amounts of cloud which could possibly indicate the sea fret (Figure C). Some idea of the frequency of winds can be gathered from the wind roses for Durham Observatory Meteorological Station in the chapter on contemporary pollen data (Section II chapter J.). This does not indicate the severity of the wind simply because the distance from the moors does not make the station suitable for a detailed analysis and the wind roses only strictly give an idea of general directions of winds. Obviously the upland mass, devoid for the most part of trees and tall shrubs, must suffer the full effects of exposure, especially from the wind.

In general terms it would appear that the central watershed has a more severe climate than the surrounding lowlands, although

Table C I.C.I. Agricultural Division Meteorological Reports, with temperature equivalents for the central watershed at 1200 feet (366 metres) : A = I.C.I. Billingham, B = central watershed (lapse rate = 3°C per 1000 feet)

Month	TEMPERATURES (°C)						
	DAILY AVERAGE		DAILY MAXIMUM		DAILY MINIMUM		SUNSHINE (HOURS)
	A	B	A	B	A	B	A
January	3.4	-0.2	5.8	2.2	0.5	-3.1	50.6
February	3.6	0	6.3	2.7	1.8	-1.8	57.2
March	5.3	1.7	8.4	4.8	2.9	-0.7	72.2
April	8.0	4.4	11.7	8.1	4.8	1.2	122.5
May	10.5	6.9	14.3	10.7	6.9	3.3	181.6
June	13.4	9.8	17.3	13.7	10.0	6.4	169.8
July	15.0	11.4	18.5	14.9	11.7	8.1	148.5
August	14.6	11.0	18.3	14.7	11.3	7.7	143.5
September	13.4	9.8	17.3	13.7	10.1	6.5	110.4
October	10.3	6.7	13.7	10.1	7.1	3.5	90.0
November	6.9	3.3	9.3	5.7	4.1	0.5	36.6
December	4.4	0.8	6.6	3.0	1.5	-2.1	31.3

Data are average figures for period 1955-64.

the difference is not so marked perhaps as that between the Pennines and its adjacent lowlands.

3. Soils

The soils of the North Yorkshire Moors have been examined by a number of workers (e.g. Dimbleby 1952b, Anderson 1958, Wood 1970, Crompton 1961), and a few generalized comments may be made. Both Anderson and Wood recognize the very close connection between soils and solid geology due to the absence of drift from the central watershed. The area within which the pollen sites are situated contains very poor soils of a mainly acid nature, although if the dales are included within the area then the variety of soil types increases. For the purposes of the following discussion peat will be included, although the boundary between peat and soil is sometimes difficult to define. Bower states "that it is generally agreed that for ordinary purposes a soil may be regarded as a peat only when it contains 60% or more of organic material" (Bower 1959).

The soils on the central watershed are strongly influenced by the parent rock material and only vary markedly with topography. Wood recognizes six main soil types on the moors as a whole: podzol, brown earth, gley, calcareous, organic and recent, but of these only podzol, gley and organic are represented on the upland parts of the central watershed (Wood 1970). He shows the connection between solid geology and certain soil types and an example from the central watershed is contained in Table D. It is differences in aspect, drainage and vegetation which produce differences in the soil types of the area. Dimbleby recognizes four different soil types which occur below Callunetum at the present day: humus iron podzol, thin iron pan soils, gley podzols and peaty gley podzols (Dimbleby 1962). The latter type he recognizes only from "heavy parent material

<u>Table D</u> Examples of soil types on the central watershed (after Wood)

Geological Material	Soil Type	Drainage Characteristics
Estuarine Series	Peaty Podzol	Free
	Peaty Gley	Poor
	Groundwater Gley	Very poor
	Hill Peat	Poor

at high altitude (e.g. Ralph Cross)." All the soil types, except for Wood's organic category, are recognizable as having a thin raw humus with a bleached A_2 horizon, and it is only when the lower soil horizons are examined that differences occur. (Dimbleby 1962). The characteristics of the soils of the central watershed are ones formed under relatively heavy rainfall, which removes the available nutrients in the upper layers of the soil by leaching. The process is assisted by the accumulation of an acid mor humus on the surface, which further ensures the acid nature of rainwater percolating downwards. A further factor which assists the formation of a base-poor soil is the parent rock material which is mainly coarse-textured sandstones and gritstones. This process is one which has been assisted by many hundreds or even thousands of years when the moors were devoid of woodland or shrubs of any kind. Formerly the brown earth soils noted by Dimbleby under Bronze Age barrows (Dimbleby 1952c, 1962), were common on the moors, in contrast to the ideas of Jacks (1932) and Elgee (1912) who believed that the moors always had poor leached soils.

The soils of the moors contrast sharply with those of the dales. This is partly a topographic factor as well as a geological factor, as the sides of the dales are steep and form a relatively sharp line with the moors above. The dales contain soils derived from moderate base status rocks of the Lias, and these tend to fall into the categories of gleys and gleyed brown earths. Even though these soils are 'better' than those of the upland moors they still may show signs of podzolization locally (Anderson 1958). The rainfall of the dales is usually not quite as high as that of the moors and Anderson argues that as the dales were not cleared of forest until the eighth or ninth century A.D. the soils have not had time to be degraded like the upland soils.

The organic category described by Wood is divided into two types: basin peat and hill peat. Wood uses 10 ins. (25 cms.) depth of organic material to be the minimum limit of a soil described as organic. The formation of a basin peat usually succeeds a ground water gley (Wood 1970), passing through a peaty gley stage, where mineral flushing is common, to a pure organic stage (e.g. at May Moss). This description and classification is not altogether applicable on the central watershed as the term 'basin' could be applied to most of the separate hill peat masses (fig. 4). This is unlike the Pennines where basin peats (topogenous) may be separated from climatic climax blanket peats and shallow peats (Phillips 1969). The peats found on the North Yorkshire Moors are of similar types over large areas, although the formation of these peats are perhaps somewhat more difficult to explain than Wood has suggested. A map of the peat over a large area of the central watershed, showing peat depths, has been constructed (fig. 4), and some discussion of the peat in the area now follows.

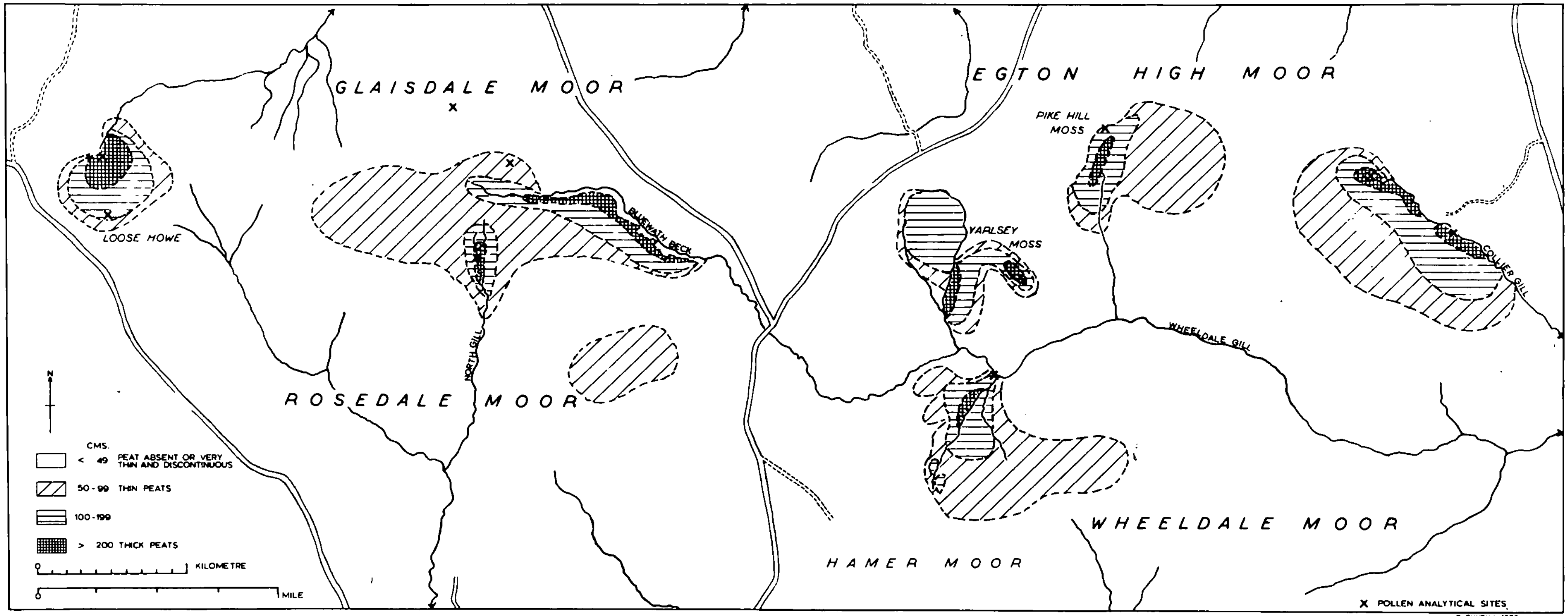
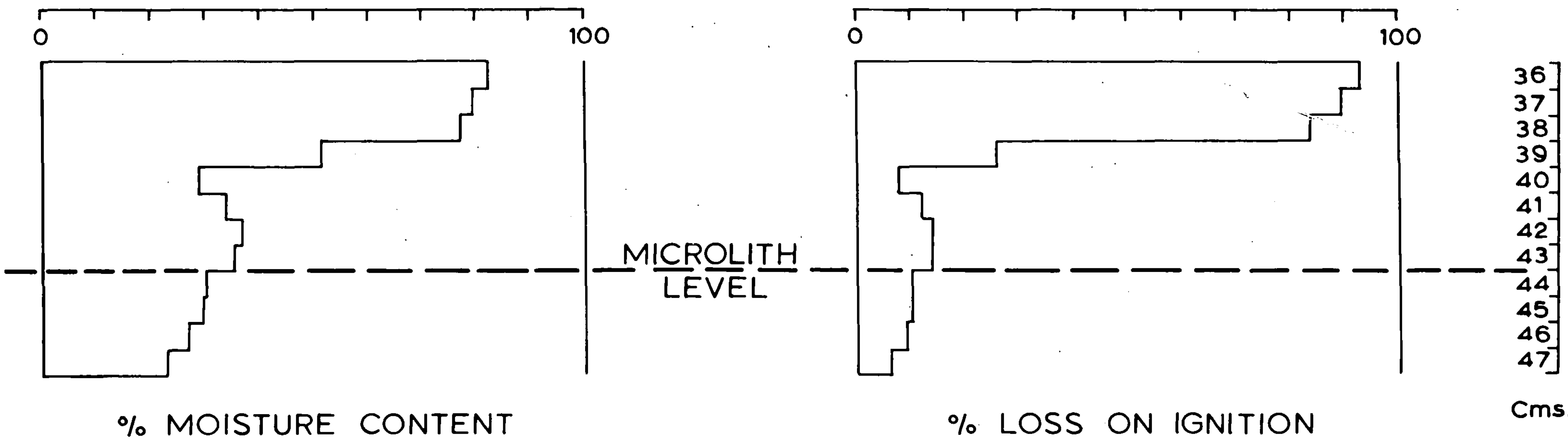


fig. 4 Peat depths on the central watershed.

Most of the peat on the central watershed would fall into the category of hill or blanket peat and it is only in the glacial meltwater channels (Simmons 1969a, 1969b), called swangs or slacks, and in the small bogs held up by landslips that another category of peat may be recognized. The blanket peat separates into discrete areas (fig. 4), although it will be noted that peat of less than 50 centimetres depth has not been shown on the map. This is for two reasons : the problem of recognizing and mapping what is a very variable cover of thin peat from aerial photographs and field observations was regarded as too difficult, and the depth of 50 cms. agrees reasonably well with the minimum depth of two feet used by the Geological Survey (Fraser 1943, Bower 1959). The boundaries of the peat are not marked as solid lines on the map (fig. 4) because they are more variable than the generalized lines used. However, the delineation of the general shape of the peat masses is considered fairly accurate from the many excursions made across the area. The diagram does not cover all the peat masses as small areas of peat also occur to the west round Ralph Cross and Howdale Hill, and probably even further west outside the area studied. Moreover, there are a number of peat masses to the east at May Moss and Harwood Dale in addition to the numerous channel bogs. The area covered by the diagram illustrates the greatest concentration of blanket peat on the North Yorkshire Moors. Fox-Strangways (1885) recognized this : "The principal areas of hill peat occur on the watershed of the country spreading over the grit on Egton High Moor and on the moors above Rosedale and Farndale."

The hill peats could be described as falling into two broad categories based on their gross stratigraphy : peats containing wood at the base and those without wood at the base. It was initially thought that a time stratigraphic unit could be involved in this difference (Simmons and Cundill 1969) but these ideas have been revised in the light of pollen analysis of sites at Trough House and Loose Howe where at the latter a date of zone VI and VIIa is proposed for the material immediately below the pure peat which contains no wood (Section II) A full description of the detailed stratigraphies are given for each pollen site in Section II, but perhaps a comment can be made that the blanket peat is of a very simple character being mainly made up from monocot remains. The only readily recognizable remains in the peat are the layers of Eriophorum, light bands of Sphagnum and wood remains (mainly Betula). This is a remarkably simple pattern when compared with the glacial drainage channel bogs or the landslip bogs where many more stratigraphic types may be recognized.

Another remarkable feature about the blanket peat is that in a number of instances it appears to have commenced growth on almost solid rock (e.g. at Pike Hill Moss, Bluewath Beck) a situation quite difficult to explain, but one which could be bound up in the Flandrian evolution of the moors and the intricate effects of early man on the moors (Section III). At the base of other peat profiles there is a variable layer of what is described as minero-organic material (e.g. at White Gill, Glaisdale Moor, Loose Howe). This is probably a former soil and has proved to be the source of interesting pollen spectra (Sections II and III). At White Gill a mineral content analysis was made of the basal material, including the minero-organic material (fig. 5). A sharp transition from the minero-organic material to pure peat is evident and is similar to results obtained by Pearsall from the Pennines (Pearsall 1950). At the base of other profiles from the central watershed there



P. CUNDILL 1970

fig. 5 Mineral and water content analysis of peat at White Gill.

may be a pure mineral material, often yellow or orange in colour, which, like the minero-organic material, may be the remains of a former soil. Pollen is not well preserved in this material however, and very little can be said about its history.

The fact that the majority of peat masses on the central watershed occur in basins is a useful one in suggesting a reason for their formation. Drainage would have been impeded on the flatter ground of the basin and peat would have accumulated here first. As the bog expanded it would have spread over the shallow sloping land around the basin. However, the peat has not spread far from the basins unlike in the Pennines, and this restriction of peat expansion may be the result of lower rainfall in the North Yorkshire Moors; Bower,(1959) noted in the Pennines that generally the higher the rainfall, the deeper the peat. The hill peat on the central watershed does not reach a great depth; the maximum depth is found at Bluewath Beck where the peat is just over three metres deep. Most of the separate peat areas appear to have a core in excess of two metres, from the numerous depth testing and sample borings.

4. Vegetation

The vegetation of the moors produces a very distinctive pattern with sharp contrasts between the moorland proper and the dales. This is a pattern formed primarily through exploitation by man, although helped to a degree by the inter-related factors of climate and soils. The vegetation of the moors is by no means 'natural' or relic, and is more the product of history.

One of the most striking features about the vegetation of the upland of the central watershed is the absolute dominance of the plant Calluna vulgaris, better known as heather or ling, which covers most of the 'non-cultivated' land. The status of the heather as a dominant species is perpetuated by burning; either the deliberate burning of old heather in the winter months to promote fresh growth, or the accidental burning which accompanies the summer and the influx of holiday-makers into the area. Calluna is a copious producer of seeds; a robust plant will produce about 158,000 seeds in one year (Gimingham 1960) and after a matter of five years, new heather plants may be fully established. Where the acid mor or peaty humus is particularly poor, there is a tendency for Vaccinium, particularly Vaccinium myrtillus, to come in, and in other instances where the soil is slightly better Pteridium may appear. An idea of the vegetation of the great mass of the central watershed may be gained from the following species lists from a number of sites:

A. Pike Hill Moss (G.R. NZ/758013)

Calluna vulgaris	Empetrum nigrum
Vaccinium myrtillus	Eriophorum vaginatum
Polytrichum commune	Hypnum spp.

B. Wheeldale Moor (G.R. SE/783989)

Calluna vulgaris	Vaccinium vitis-idaea
Empetrum nigrum	Hypnum spp.
Vaccinium myrtillus	

C. Cock Heads (G.R. NZ/727016) - From Godwin 1957.

Calluna vulgaris	Eriophorum vaginatum
Erica tetralix	E. angustifolium
Vaccinium myrtillus	Trichophorum caespitosum
Empetrum nigrum	Juncus squarrosus

In all cases Calluna is overwhelmingly dominant and the other species are of relatively minor importance, although Vaccinium myrtillus tends to become locally dominant, to the exclusion of all other plants on Wheeldale Moor, on the rocky ground towards the break of slope leading down to Wheeldale Gill. The Calluna dominated vegetation tends to cover the plateau-like summit of the central watershed, but as soon as a distinctive break of slope occurs (i.e. this would be also a change in drainage conditions and probably a change in soil conditions), the vegetation pattern usually alters. The edges of all the dales show this change, in many cases to one of Pteridium dominance.

On the upland of the central watershed there is the valley of Wheeldale Gill which has not breached the capping of the Estuarine series. Morphologically it is a steep sided 'V' shaped valley compared with the dales which are also steep sided but very much deeper, broader and flat floored. The vegetation of the Wheeldale Gill valley is interesting as it contains a far wider range of plant species than the surrounding moorland. It also contains remnants of a deciduous woodland although whether this is a planted woodland or a relic of an older and more extensive natural wood is difficult to say. At the present time the woodland is heavily grazed by sheep and regeneration of the deciduous tree species appears to be almost at a standstill. The species within the woodland are:

Quercus (petraea)	Ilex aquifolium
Betula (pubescens)	Vaccinium myrtillus
Alnus glutinosa	Pteridium aquilinum
Sorbus aucuparia	Hypnum spp.

The dominance of the trees seems to be shared between Quercus and Betula and the ground flora seems to vary with the intensity of the canopy. In general, the ground flora is dominated by Vaccinium with Pteridium coming in where the tree canopy is lighter (e.g. under Alnus). Ilex is not very frequent and a further species Crataegus monogyna also appears in the valley but tends to grow away from the woodland. The bottom of the valley, away from the woodland, is quite wet and in this habitat the vegetation is composed of:

Myrica gale	Drosera rotundifolia
Erica tetralix	Potentilla erecta
Sphagnum spp.	Vaccinium myrtillus
Potamogeton spp.	Blechnum spicant
Polytrichum commune	

Myrica gale was growing abundantly in this situation, certainly the only extensive cover of this species in the area under examination. The only other areas of fairly variable plant types are the small flushes which occur on the steep slopes of the valley. One such flush contained :

Sphagnum spp.	Vaccinium vitis-idaea
Myrica gale	Blechnum spicant
Cirsium spp.	

In fact, this is very similar to the species list from the valley bottom. Otherwise, the valley sides are covered completely with Pteridium, except where a recent coniferous plantation has been established. The effect of the grazing pressure of sheep is shown quite clearly when the areas inside and outside the fence surrounding the plantation are examined. While the species lists would not be very different the growth of, for example, Myrica gale is far more vigorous behind the protection of the fence.

Other sites of vegetational interest in the central watershed area are those of the landslip bogs. They show a wide range of plant species; e.g. St. Helena (G.R. NZ/683038) ;

Juncus articulatus	Vaccinium myrtillus
Juncus squarrosus	Eriophorum angustifolium
Juncus spp.	Drosera rotundifolia
Polytrichum commune	Nardus stricta
Empetrum nigrum	Carex panicea
Sphagnum spp.	Erica tetralix
Potentilla erecta	

It is possible that many of the species present here were once very much more abundant on the upland moors, but they have since been destroyed by burning and grazing. An area such as Howdale Hill shows a slightly wider range of species together with a decrease in the dominance of Calluna. The Calluna is interspersed with Eriophorum angustifolium, Sphagnum spp. and Erica tetralix and it was the contrast with surrounding Calluna dominated area that made it appear possible that the site contained a different sub surface (Section II, Chapter F).

From the work of Elgee (1912) it seems that perhaps even in the early 20th century there was slightly more variety of vegetation on the central watershed than there is today. For example, he describes the moors at Rosedale Head as containing a very high proportion of Eriophorum vaginatum, which they do not at the present day. Furthermore from the stratigraphy and pollen analysis of the peats on the central watershed it would appear that the complete dominance of Calluna over very wide areas is a relatively modern phenomenon (Section II).

The slopes into the dales present a more varied mosaic of plant types than on the upland moors. Although many dale sides do contain strong elements of moorland vegetation, mainly in the form of the ericaceous plants, they also contain many patches of relic woodland or scattered trees and shrubs. The area called Fryup Hills, a fine series of landslips at the head of Great Fryup Dale, illustrates one set of plant types. The area is mainly dominated by Pteridium with Juncus growing in the wet flushes behind the landslips and Alnus, Quercus, Betula, Sorbus aucuparia and Crataegus monogyna occurring sporadically throughout. The landslips at Blakey (G.R. SE/675996) show a similar dominance of Pteridium but a more complete species list is available and includes:

Sphagnum spp.	Potentilla erecta
Eriophorum angustifolium	Juncus spp.
Calluna vulgaris	Cirsium spp.
Erica tetralix	Pteridium aquilinum
Polytrichum commune	Nardus stricta
Festuca spp.	Empetrum nigrum
Vaccinium myrtillus	Carex panicea
Sorbus aucuparia	
Salix spp.	

Elgee recognized the importance of Pteridium on the slopes of the dales and attributed its presence in this position to better soil conditions (no iron pan or thick peat) and more shelter than on the open moors (Elgee 1912).

At varying heights down the sides of the dales the moorland ceases and farmland takes over. The fields of cultivated crops and meadow grasses take the place of Calluna and Pteridium. Some of the higher 'intakes' next to the moorland boundary have been abandoned and are in the process of reverting to moorland, as are fields close to abandoned moorland farms, at Winter Gill and Hamer House, for example.

B. Background of Previous Research

The previous research carried out on the North Yorkshire Moors splits fairly easily into two sections, archaeology and botany. While these two sections can be dealt with separately it is interesting to note that throughout the history of research in the area there have been a number of workers who have combined a study of the two disciplines. (e.g. Elgee and Dimbleby)

1. Archaeology

Even Elgee who was the first person to produce a thorough going account of the archaeology of the moors (Elgee 1930), recognized the value of the work of his predecessors, most of whom did their research in the 19th century. Elgee drew heavily upon their results and where there were no published results he even examined the artefacts which they had discovered. Probably one of the most famous of these earlier workers was Greenwell who studied in great detail the barrows of the British Isles (Greenwell 1877), although only four of the barrows examined were situated on the central watershed, above Egton Bridge. He provided careful descriptions and measurements of one of the Three Howes group although all he found in the barrow was a pile of burnt bones and one piece of "calcined flint chipping". Another person of the 19th century who spent a great deal of time excavating barrows especially those on the moors was Atkinson, the vicar at Danby for many years. He was interested in all aspects of the moors and sets down a description of the area, its folk lore and customs together with his barrow digging expeditions in his book "Forty Years in a Moorland Parish" (Atkinson, 1891). However, because of shortcomings in the labelling of artefacts and the scattered nature of Atkinson's published work, Elgee found difficulty in placing some of the artefacts and discovering the position of some of the explored barrows (Elgee 1930). Despite these shortcomings,Elgee made full use and acknowledged the value of Atkinson's work, in his own book "Early Man in North-east Yorkshire" (Elgee 1930). This is the classic archaeological work of the area and while it contains many points which are now open to objection, it still remains the basic text on the archaeology of the area. In this work Elgee recognized the full sequence of archaeological events and showed the importance of Bronze Age man and his impact on the moors although his explanation as to why the Bronze Age barrows were constructed on the moors is now open to criticism. At the same time the lack of Neolithic and Iron Age remains in the area was noted.

The significance of the local archaeologist in the study of the moors is apparent today with a strong archaeological group centred on Teesside and the presence of the Ryedale folk museum in the heart of the moors itself. Recent works by people such as Radley and Hayes have tended to concentrate on single cultures and excavations. One of the most recent works is that by Radley which gives a general account of the activities of Mesolithic man on the moors and attempts to date the cultures of the area (Radley 1969). Dimbleby has produced much work relating to archaeology, although his approach has mainly been from the angle of soils and historical ecology (e.g. Dimbleby 1952c, 1961, 1962) and will properly fall into the next section.

2. Botany

Strictly speaking people like Atkinson also paid some attention to observations of the botany of the North Yorkshire Moors, although it was not until Elgee wrote a series of articles (Elgee 1910, 1914) and finally his book "The Moorlands of North-east Yorkshire", that a full ecological analysis of the area was achieved. Like his archaeology book, "The Moorlands of North-east Yorkshire" is the classic book on the area in its own field. However, in this book Elgee believed that the moors were 'natural' and had been continuously dominated by Calluna since the last glaciation. It was not until modern studies of the ecological history of the area were undertaken that the real picture emerged. While much work recently has been concentrated on the historical aspects of vegetation, only a little work has been aimed at studies of the present vegetation. These latter studies have concentrated on specific problems such as the status of soils and how vegetation affects these soils (Dimbleby 1952b, for example), and the effects of nutrients on bog plants (e.g. Boatman and Roberts 1963, Armstrong and Boatman 1967).

The increased interest in the historical aspect of vegetation studies through pollen analysis started in the early part of this century and Erdtman made a tour of Great Britain in the 1920's in order to study the development of the vegetation. He travelled to north-east Yorkshire and produced pollen diagrams from sites such as at Kildale (West House), Collier Gill and Goathland (Erdtman 1927, 1928). From these analyses he could demonstrate that woodland was very common throughout the low lying parts of the moors at one time as all his sites were at relatively low altitudes. He also noted the absence of wood in the peat at a great many sites on the central watershed. In general, the work of Erdtman was a very valuable preliminary study, which has become dated by advances in palynological techniques. It was not until the work of Dimbleby in the 1950's that renewed interest was shown in the ecological history of the moors, and even then the approach was different to that of Erdtman as concentration was made on explaining the changes in soils during prehistoric times. Dimbleby attempted to show through the pollen analysis of relic soil horizons buried beneath prehistoric earthworks (e.g. Dimbleby 1952c) that soils on the moors had not remained the same throughout the Flandrian, but had changed as vegetation was affected by man (Dimbleby 1962). He also showed that woodland covered the whole of the central watershed at one time and refuted the idea that Elgee had put forward about the natural state of _Calluna_ on the moors which he had found so hard to explain in relation to the archaeological remains (Elgee 1930). Godwin used data supplied by Dimbleby in an article on the age of soils at Cock Heads (Godwin 1958), but later on challenged both the theoretical and practical basis of Dimbleby's work (Godwin 1961). More recently work by Simmons and Jones has produced modern pollen diagrams from some of the sites originally studied by Erdtman (Simmons 1969, Jones 1969). It is the continuation of this work that the present thesis is concerned with, and attempting to answer some questions not fully studied by the other authors.

S E C T I O N   II

DATA FROM POLLEN AND STRATIGRAPHIC ANALYSES

Introduction

The data ~~is~~ are expressed in the form of pollen diagrams and stratigraphic sections, with maps for the contemporary pollen data. All the pollen sites studied are shown on fig. 6. Two different types of pollen diagram are used: a) the principal pollen diagram: this is based on the total tree pollen count, excluding Alnus, and shows all the pollen types identified during counting; and b) the secondary pollen diagram which is based on the total pollen count (excluding spores and, in certain cases, other pollen types which are noted on the diagrams) and this includes all the trees plus Coryloid, Gramineae, Calluna and Cyperaceae expressed separately. Other pollen types are brought together under the general categories of Other shrubs, Ruderals, Dry land plants, Damp land plants, Aquatics, and Others.

All the pollen diagrams use standard symbols of • = 1-2% of the pollen sum, + = <1% of the pollen sum and X = identified on scanning the slide after completing the count. The horizontal bars on the pollen diagrams, representing the percentage of each pollen type at each level, are of a width equivalent to the width of sample taken for analysis (i.e. to scale). On the diagrams tree pollen types are represented by capital lettering and other pollen types by lower case lettering.

The pollen diagrams are divided into zones using Godwin's 1956 scheme for Great Britain with the use of zones VI and VIIa and the Boreal-Atlantic Transition and the Ulmus decline as used by most workers in Great Britain, although zones VIIb and VIII are not differentiated separately and local sub-zones are proposed for this period.

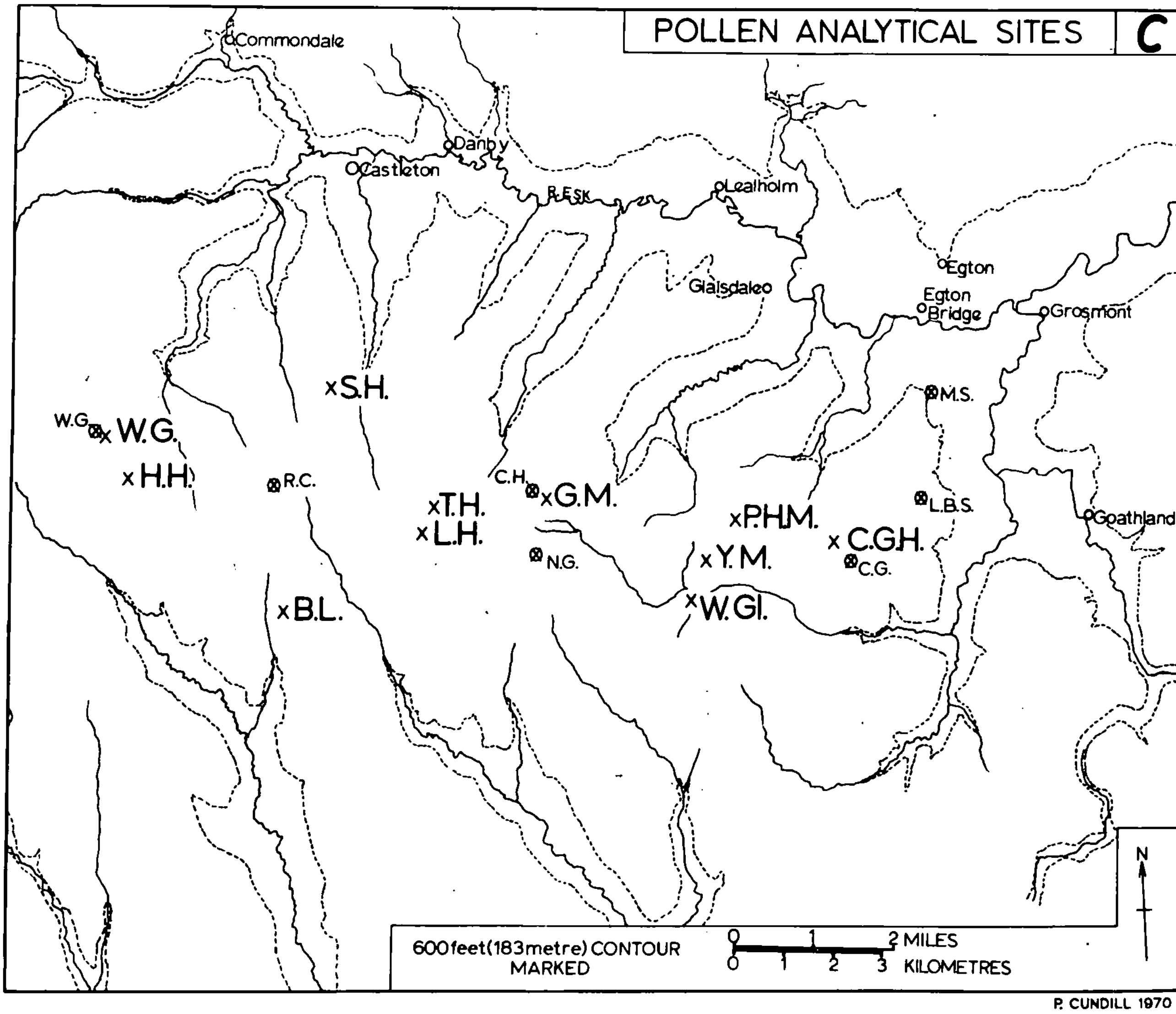


fig. 6 Pollen sites on the central watershed.

x = sites of the present work ⊗ = sites of Simmons and Dimbleby.

Key to site names:

W.G. =	White Gill	G.M. =	Glaisdale Moor
H.H. =	Howdale Hill	W.Gl. =	Wheeldale Gill
R.C. =	Ralph Cross	Y.M. =	Yarlsey Moss
B.L. =	Blakey Landslip	P.H.M. =	Pike Hill Moss
S.H. =	St. Helena	C.G.H. =	Collier Gill Head
L.H. =	Loose Howe	C.G. =	Collier Gill
T.H. =	Trough House	L.B.S. =	Lady Bridge Slack
C.H. =	Cock Heads	M.S. =	Moss Swang
N.G. =	North Gill		

The same stratigraphic symbols are used throughout (fig. 7) including those in the stratigraphic cross-sections of Blakey Landslip and St. Helena sites.

The contemporary pollen rain is expressed in the form of maps of the pollen rain of the central watershed.

Further comments on the presentation of the pollen and stratigraphic data are added below.

a) Total Tree Pollen Diagrams

These are set out in a standard format starting with trees on the left and progressing through shrubs and herbs to spores. A composite pollen diagram (excluding spores and in some cases Sparganiaceae and Melampyrum where these latter two are clearly local in origin and over-represented) is also added with broad categories of Trees (excluding Alder), Alder, Shrubs and Others delineated. The tree pollen sum is calculated from the sum of the total grains counted of Pinus, Betula, Quercus, Ulmus, Tilia, Fagus and Fraxinus. Alnus is excluded from the sum by virtue of its very local nature at a number of sites. There are certain problems associated with the use of a total tree pollen diagram, especially in an area where there is little tree pollen (Faegri and Iversen 1964), and the interpretation of the ecological history has been worked out on the basis of the total tree pollen and the total pollen diagrams together.

The scale on the total tree pollen diagrams varies with different plant spp. and particular care must be taken in checking the relative percentages of the spp. being examined. Such changes in scale were unavoidable without resorting to an unwieldy diagram or a diagram in several parts or without excessive tabulation of percentage figures on the diagram itself.

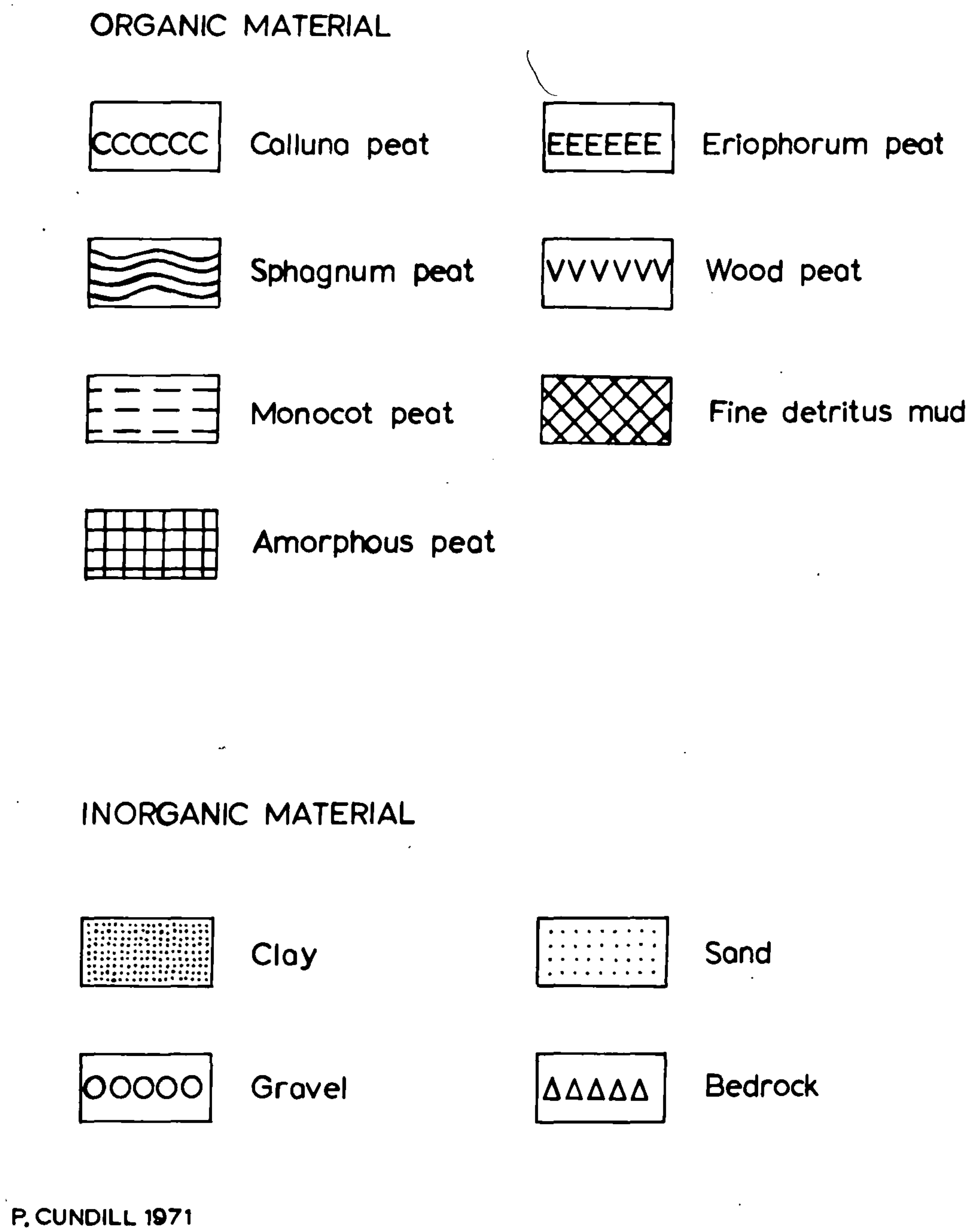


fig. 7 Stratigraphic symbols

It was felt that it was better to reduce the horizontal scale of individual spp., particularly with the N.A.P. spp., and to show the full range of percentages on the diagram as this presents a more complete visual picture.

b) Total Pollen Diagrams

These diagrams are laid out in much the same standard way as the total tree pollen diagrams. The total pollen diagrams play an extremely important part in the interpretation of the ecological history of the area, as they produce a clearer picture of the behaviour of the major pollen types in the upper parts of most of the profiles; i.e. where there is little tree pollen. The biggest drawback is the expression of the many minor pollen types on the diagram even though these minor pollen producers may be quite significant in ecological interpretation. As all the pollen types are marked on the total tree pollen diagram, a limited amount of grouping into categories described earlier has had to be done on the total pollen diagram. This brings the percentages to significant levels in some cases, but in general it reduces the great mass of data at very small percentages.

The grouping of Other shrubs is relatively straightforward and includes spp. such as Salix, Ilex, Hedera, Prunus/Sorbus, Acer. The other categories are less clearly defined, although perhaps Ruderals cover a fairly distinctive list of spp. Most of the spp. regarded as Ruderals are taken from Godwin where they are further divided into pastoral and arable types (Godwin 1968). The pollen types included in the Ruderals category are those such as Plantago lanceolata, Rumex, Artemisia, Ranunculus, Cruciferae, Chenopodiaceae and Compositae. The categories of Dry and Damp land plants are very difficult to determine and those pollen types which cover plants from a wide range of habitats are included under the broad general category of Others. This latter category includes pollen types such as *Rosaceae* and *Umbelliferae*. Aquatics form a fairly distinct category, although in one or two cases they are excluded from the pollen sum because of their highly localized nature. A complete list of the species within each category is given in table E.

The percentage scale on the total pollen diagrams is constant throughout.

c) Local Zonation Scheme for Pollen Diagrams

Five local sub-zones are recognized and they cover the major periods of change on the pollen diagrams post *Ulmus* decline. The sub-zones are referred to as NY 1, NY 2, NY 3, NY 4 and NY 5 on the pollen diagrams and in the text, although in some cases it has proved too difficult to differentiate these sub-zones and in this situation sub-zones have been grouped together. The synchroneity of the sub-zones cannot be shown without radio-carbon dating, but from the similarity of many of the pollen curves it would seem unlikely ~~if~~ that they were not broadly synchronous. A simple outline of the period the sub-zones are suggested to have covered is indicated in table F. The full implications of the use of these sub-zones is discussed in Section III.

d) Contemporary Pollen

In order to illustrate possible trends, a series of maps of the contemporary pollen rain on the central watershed have been drawn utilizing data of various groupings of pollen types

Table E Categories used in total pollen diagrams with lists of spp. included in each category

a) Other Shrubs

- Hedera
- Ilex
- Prunus / Sorbus
- Salix
- Acer

b) Ruderals

- Plantago lanceolata
- Rumex
- Artemisia
- Ranunculus
- Compositae
- Chenopodiaceae
- Cruciferae
- Urtica
- Centaurea cyanus
- Vicia
- Polygonum aviculare
- P. convolvulus
- Rhinanthus
- Spergularia
- Scleranthus

c) Dry land plants

- Stellaria holostea
- Mercurialis
- Dianthus
- Melampyrum
- Hypericum
- Verbascum

d) Damp land plants

- Valeriana
- Filipendula
- Drosera
- Succisa
- Lychnis
- Polygonum bistorta

e) Aquatics

- Potamogeton
- Sparganiaceae
- Typhaceae

f) Others

- Other Rosaceae
- Potentilla
- Umbellifereae
- Rubiaceae

Table F An outline of the vegetation types covered by the local zonation scheme.

NY 1	-	*Quercus*, *Alnus*, Coryloid woodland
NY 2	-	*Alnus*, Coryloid woodland. Expansion of ruderals. *Tilia* curve becomes discontinuous.
NY 3	-	*Betula*, *Quercus*, *Alnus*, Coryloid woodland.
NY 4	-	Low tree values. High values of *Calluna*, Gramineae, Cyperaceae and ruderal types.
NY 5	-	Low tree values, but *Pinus* and *Ulmus* major constituents. Complete dominance of *Calluna*. Reduction in range of N.A.P. types present.

or single significant spp. Thus a map of tree pollen percentages, including Alnus in this case, as a percentage of total pollen (excluding spores) has been compiled. The percentage groups, or classes, varies from map to map and the boundaries between the groups are only tentative, but overall there is a series of maps from which any possible trends in the pollen rain may be observed (Section II, J.). Comparisons may then be made between the prevailing climatic conditions over the period of sampling and the position and approximate type of present vegetation. To this end a base map of woodland and the moorland edge has been produced in the same format as the pollen rain maps. The 31 contemporary pollen sites are marked as dots on the maps.

e) Stratigraphy

The use of stratigraphic symbols has followed in the main Faegri and Gams (in Faegri and Iversen 1964) although certain modifications have had to be made to accommodate particular peat descriptions which are not adequately covered by this scheme. Some of the symbols used in the present work are combined in certain stratigraphic situations to make the stratigraphy more explicit. Thus where the Eriophorum symbol is found with the symbol for monocot peat, then the deposit is an Eriophorum/monocot peat. The use of the term monocot, even though it does cover Eriophorum, has been adopted because of the problem of assigning large thicknesses of blanket peat, and some basin peats, to a particular plant type. Bartley (1964), also uses this term in descriptions of peat profiles from the Pennines. Thus, while there may be Eriophorum remains within a peat deposit, it is not always clear whether or not the peat should be simply described as an *Eriophorum* peat, as in most cases the definite *Eriophorum* remains form a very small part of the total peat. In such cases a general term and symbol seems more appropriate.

The symbols used in the diagrams are of necessity simplifications, and the full stratigraphic descriptions are given in the text for each analysed profile.

A. St. Helena Landslip

Grid Reference : NZ / 683038

Height above Ordnance Datum : 990 feet (302 metres)

Depth of sampled profile : 357 cms. (St. Helena 'A')
and 692 cms. (St. Helena 'B')

Method of sampling : Russian borer.

The site is a small bog which has formed behind a landslip on the eastern side of Castleton Rigg. A description of the formation of the landslip is contained in Section I, A, 1, (ii). The bog overlooks Danby Dale and is behind the highest of a series of slipped masses. The general appearance of the site may be seen in Plate 3 and the dimensions of the bog are shown in fig. 8 along with the position of boreholes. The bog splits into two major sections with a thin neck of peat between them. A series of borings were made into the bog and a stratigraphic cross section east-west was constructed across the deepest part of each of the two major sections of the bog. The deepest profile from both the cross-sections was sampled for pollen analysis, and the pollen sites are referred to as St. Helena 'A' and St. Helena 'B' in the text.

The Stratigraphic Cross Sections

The two cross sections are drawn in detail in fig. 9, St. Helena 'A', and fig. 10, St. Helena 'B'. The cross sections although levelled to obtain the shape of the surface of the bog have not been levelled to Ordnance Datum.

The two cross sections are quite different in character of deposits, and differences are similarly found in their individual pollen records. St. Helena 'B' cross section is very much wetter throughout the profiles than St. Helena 'A'. In fact at some levels it proved extremely difficult to sample

Plate 3 General view looking south of
St. Helena landslip bog

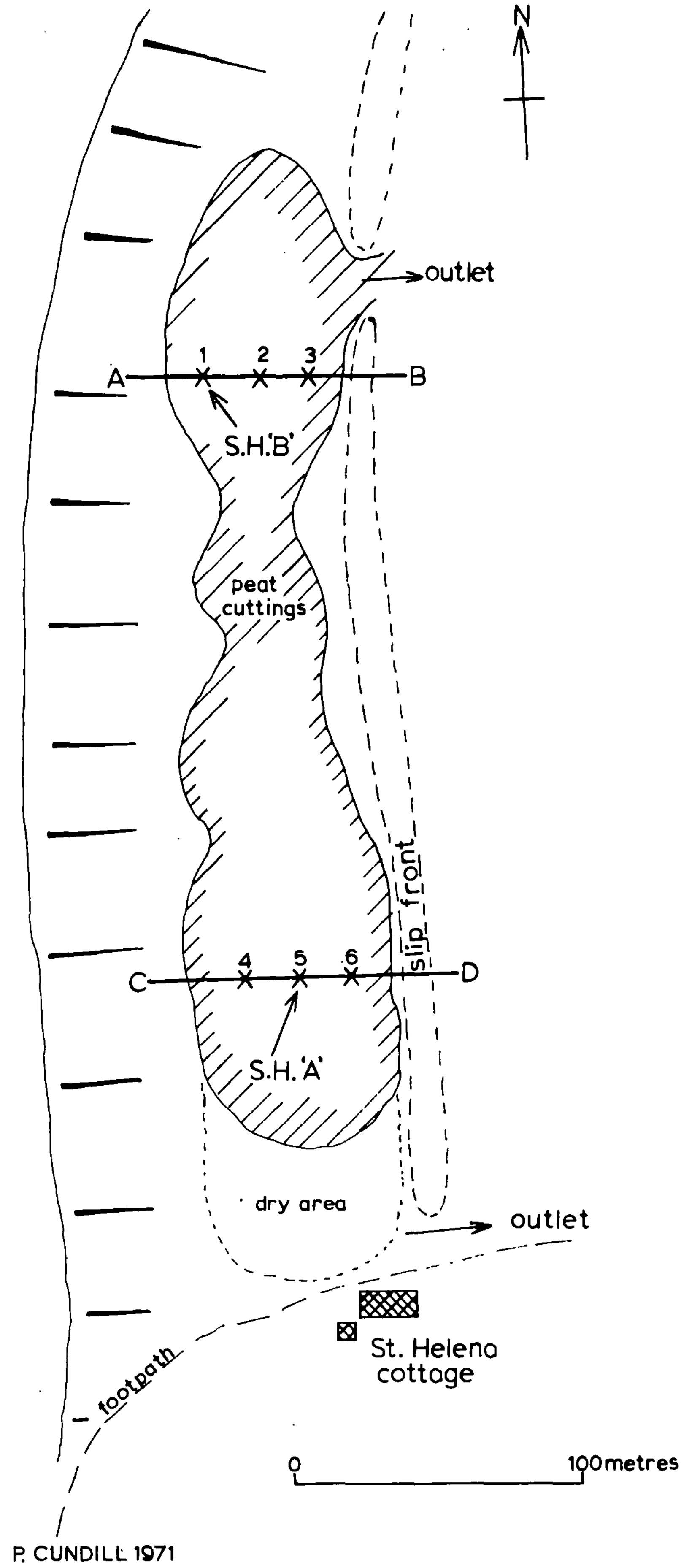


fig. 8 Sketch plan of St. Helena landslip bog showing the position of the cross sections and boreholes (shaded area represents Juncus)

St. Helena 'B' because of the water content of the deposit. Both the sampled profiles had wood peat at the base, but from this point onwards the two profiles differ. A description of the phases of peat accummulation for the two cross sections is outlined below.

(a) St. Helena 'A' cross section

In all probability the site was initially a carr woodland with *Betula*, *Alnus* and *Salix*, with *Betula* and *Salix* wood remains actually identified. The situation of the bog surface at this time was quite likely to have been damp but there are no indications of open water conditions, although the presence of Sparganiaceae in the pollen spectrum would seem to suggest some reed swamp nearby. During the period of wood peat accummulation some inwash of mineral material took place, but this did not completely cover the surface of the bog. Conditions then changed on the bog surface with the cessation of tree growth. This change is not shown in the pollen record probably because a fringing woodland still remained and this contributed the large amounts of tree pollen recorded. The bog surface became ombrogenous in character with a predominance of monocot plants although there is very little recognizable *Eriophorum* initially. A further inwash of mineral material occurs early in the ombrogenous peat stage when silt appears to cover the surface of the bog. Occasional bands of *Sphagnum* are found in the upper part of the cross section.and recognizable remains of *Eriophorum* become far more abundant closer to the present day surface. The levelled cross section shows a very slight doming of the surface.

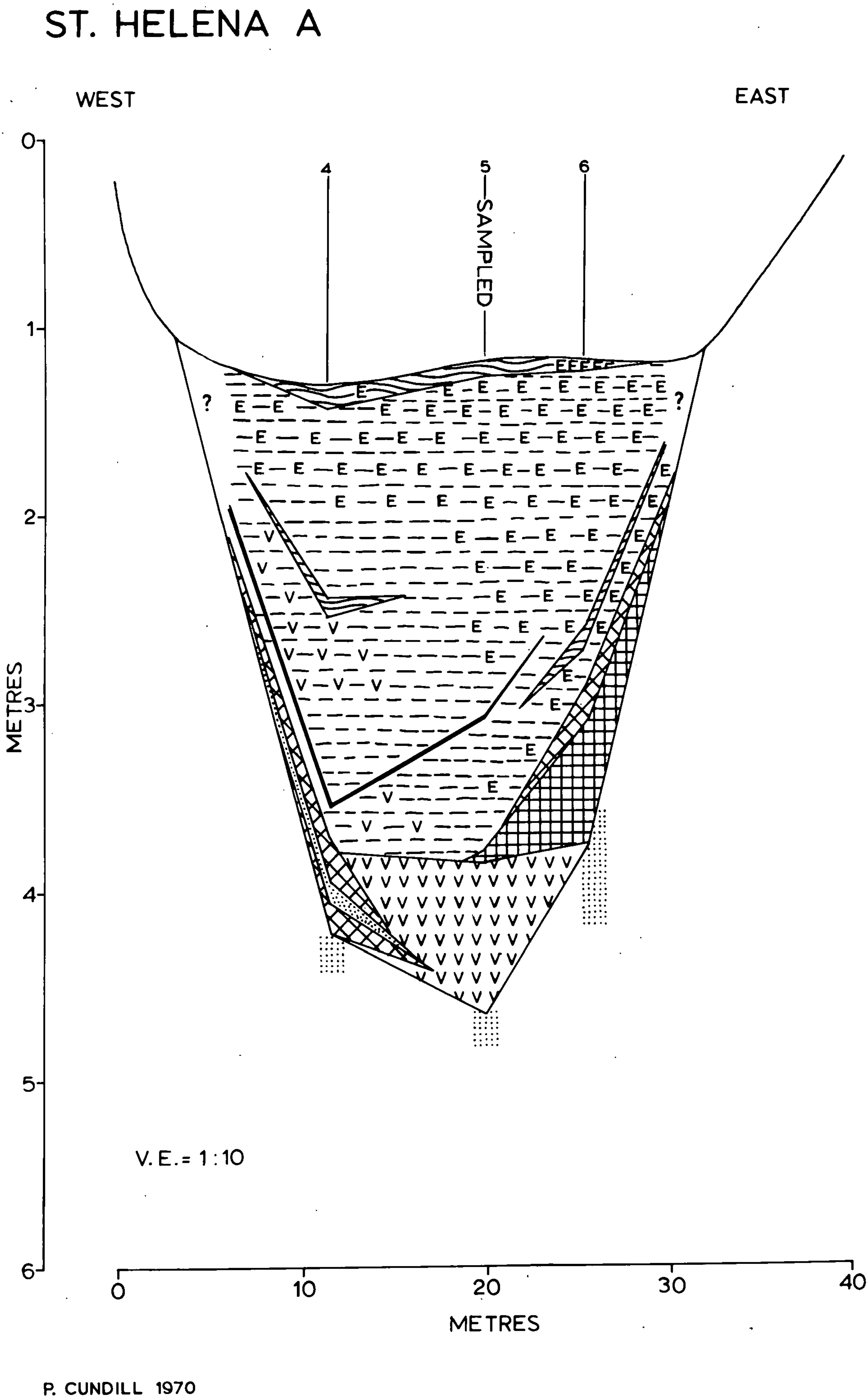


fig. 9 Cross section at St. Helena 'A'.

b) St. Helena 'B' cross section

Peat accummulation started on what must have been initially a fairly dry site. From the pollen evidence, *Betula*, *Quercus* and *Coryloid* appear to occupy the site during this stage, although the situation changes rapidly as *Alnus* becomes the predominant tree, perhaps because of a rise in water table. The site then appears to have become flooded and an amorphous peat deposited. The state of the bog surface soon reverts back to a wood with *Alnus*, *Betula* and *Salix*. The continuing wetness of the conditions is exemplified by the occasional high peaks of Sparganiaceae in the pollen record but like St. Helena 'A' there is no indication where the reed swamp was actually growing although it was possibly situated where the amorphous peat now exists at the eastern edge of the bog. During the woodland (carr) stage a silt layer was apparently deposited right across the surface of the bog. Above this layer the number of trees on the bog appears to be reduced, and the remains of wood that do exist are mainly those of *Betula*. The bog surface probably remained wet, and a reduction in size of the *Betula* tree remains to small twigs , may indicate that the tree was growing around the edges of the bog or on slightly elevated areas of the bog surface. The final stage is one where monocot remains predominate and only a peripheral fringe of woodland persisted. Perhaps conditions had become too damp in the centre of the bog for trees or shrubs to survive. However, wood is found much closer to the present surface than at St. Helena 'A'. This is one of the major contrasts between the two cross sections, and it is amplified by the differences in the two pollen records.

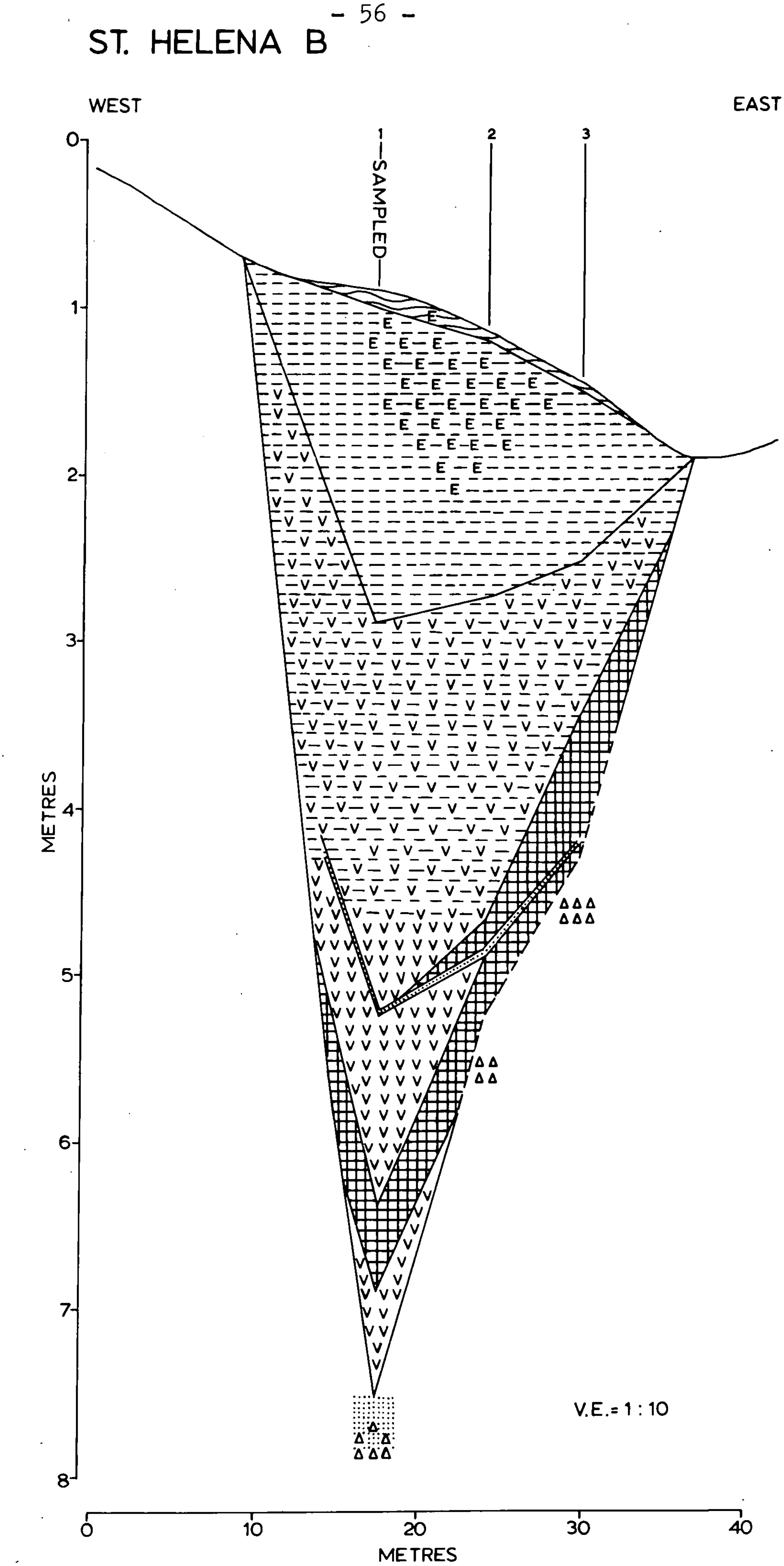


fig. 10 Cross section at St. Helena 'B'.

The Present Vegetation

The present surface of the bog has what might be described as the usual acid bog plant grouping, and a full list of these plants has been given in Section I, A, 4. The damp bog surface is surrounded by *Juncus* spp. while on the drier area of the cliff face and landslip front the dominance of *Pteridium aquilinum* with a considerable amount of *Vaccinium myrtillus*, especially on the slipped face, was noted. The two almost separate sections of the bog have in general two main groups of plant spp. The St. Helena 'B' area is very wet and the surface is covered for the most part in varying amounts of *Sphagnum* spp. and *Eriophorum angustifolium* while the southerly St. Helena 'A' area is considerably drier and is mainly covered with *Eriophorum angustifolium*, *Erica tetralix* and *Calluna vulgaris*. The variation between the two sections of the bog is one which appears to be almost a continuation from the past.

Pollen and Stratigraphic Analyses

(i) St. Helena 'A'

Stratigraphy : (cms.)

0 - 9	Fresh unhumified *Sphagnum* peat.
9 - 186	Monocot peat with *Sphagnum* and *Juncus* seeds (mostly *Juncus effusus*) : unhumified at the top becoming more humified through the deposit. Wood at 128 cms. and *Sphagnum* band at 85-86 cms.
186 - 188	Grey silty inwash stripe.
188 - 237	Mid-brown, medium humified, monocot peat with *Sphagnum*.
237 - 255	Dark brown, highly humified, monocot peat.

255	- 279	Dark brown wood peat (<u>Salix</u> and <u>Betula</u>). <u>Corylus avellana</u> nut at 260 cms.
279	- 281	Sphagnum band.
281	- 346	Dark brown wood peat (<u>Salix</u> and <u>Betula</u>).
346	- 348	Transition to blue-grey clay.
348	- 357	Pure blue-grey clay

Point of borer in impenetrable material at 372 cms.

<u>Introduction</u>

The diagrams from this site are difficult to zone although an attempt has been made to fit them into the sub zone scheme adopted in the present work. From the percentages of <u>Ulmus</u> it is clear that the base of the diagram may be dated as post <u>Ulmus</u> decline. In fact no <u>Ulmus</u> pollen was recorded at 354 cms, the lowest level counted. The whole diagram therefore falls into zones VIIb and VIII. The only sharp boundary on the diagrams is that which falls at 108 cms. when there is a very rapid change from woodland to open conditions. Sub zones NY 1 and NY 2 are grouped together on the diagrams from this site as a separate sub zone NY 2 cannot be recognized, although the base of the diagrams appears to be sub zone NY 1 in character. The difficulty in recognizing sub zone NY 2 means that the boundary between sub zones NY 1/2 and NY 3 is a very tentative one and is based primarily on the increased importance of <u>Betula</u>.

<u>Zones VIIb and VIII</u>

There is no indication of how far into zone VIIb the start of peat growth at the site occurred although an indication is perhaps given by the fact that <u>Fagus</u> does not appear until 280 cms. in the profile. The very low percentages of <u>Ulmus</u> and <u>Tilia</u> at the base could be argued as being immediately post

ST. HELENA A

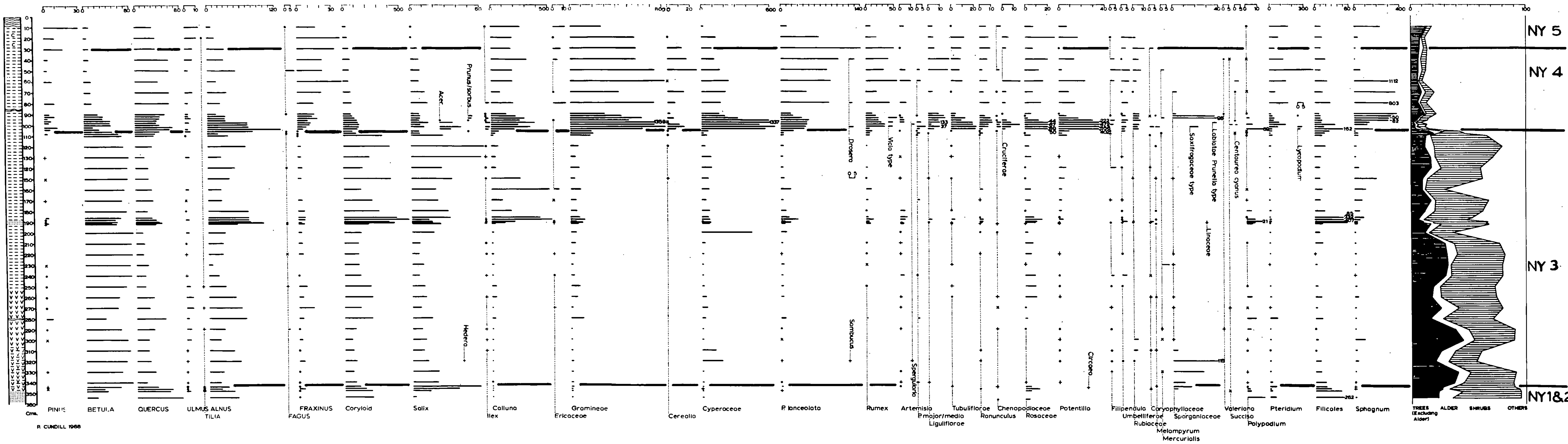

% OF TOTAL POLLEN (EXCLUDING SPORES AND SPARGANIACEAE)
NY 5
NY 4
NY 3
NY1&2
Cms.
PINUS
BETULA
QUERCUS
ULMUS
ALNUS
TILIA
FAGUS
FRAXINUS
Coryloid
Salix
Acer
Prunus/sorbus
Hedera
Calluna
Ilex
Ericaceae
Gramineae
Cerealia
Cyperaceae
P. lanceolata
Drosera
Sambucus
Rumex
Vicia type
Artemisia
Spergularia
P. major/media
Liguliflorae
Tubuliflorae
Chenopodiaceae
Ranunculus
Cruciferae
Rosaceae
Potentilla
Circaea
Filipendula
Umbelliferae
Rubiaceae
Caryophyllaceae
Melampyrum
Mercurialis
Sparganiaceae
Saxifragaceae type
Labiatae Prunella type
Linaceae
Centaurea cyanus
Valeriana
Succisa
Polypodium
Pteridium
Lycopodium
Filicales
Sphagnum
TREES (Excluding Alder)
ALDER
SHRUBS
OTHERS
R. CUNDILL 1968

fig. 11 St. Helena pollen diagram, profile 'A'. Percentages of total tree pollen.

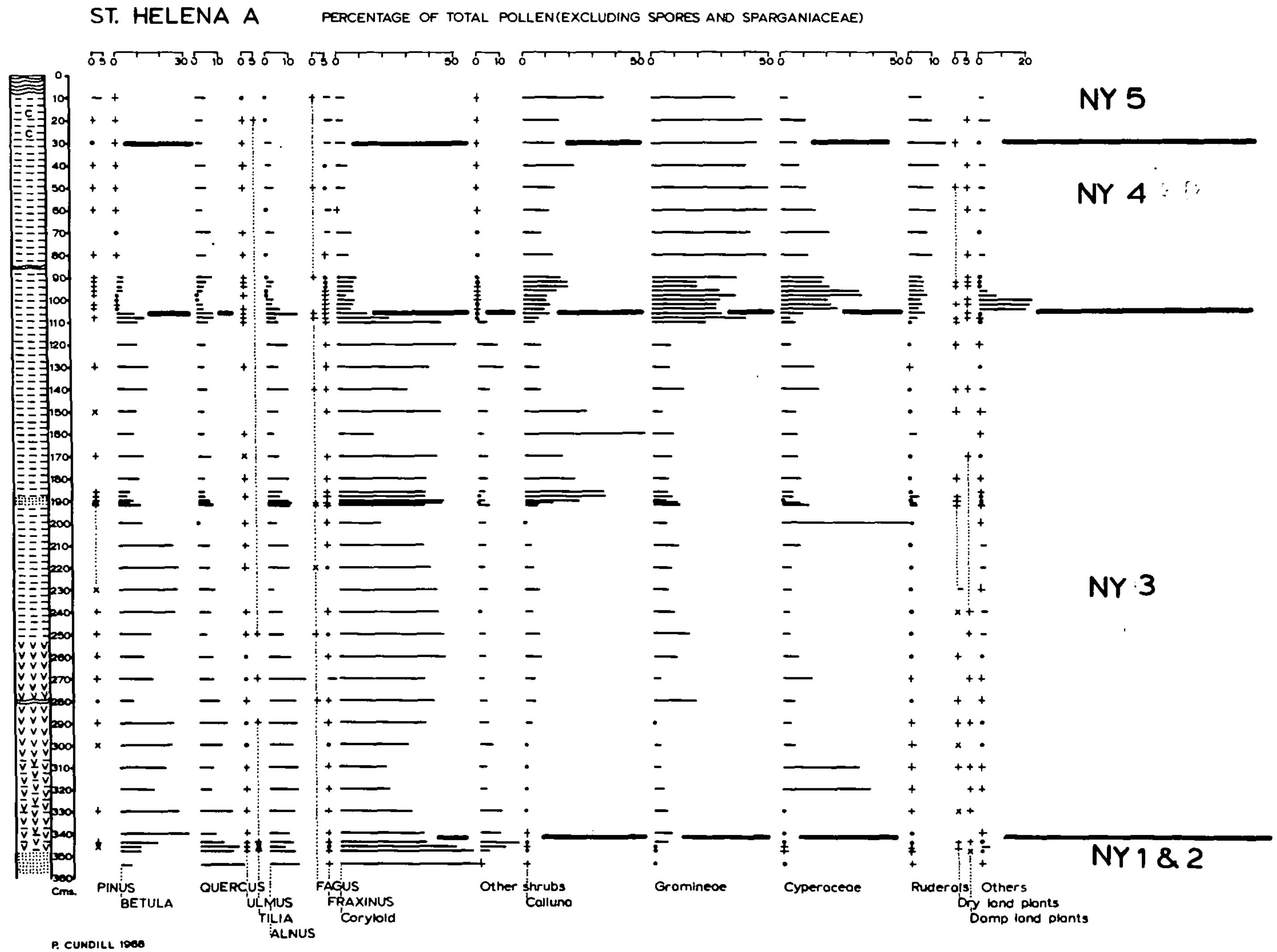


fig. 12 St. Helena 'A' pollen diagram. Percentages of total pollen.

Ulmus decline, although confirmation of this suggestion could only be made with a radiocarbon date.

Sub-zones NY 1 and NY 2

This is the initial phase of peat accumulation which is accompanied by a rapidly varying pollen spectrum. Initially a Quercus/Alnus/Corylus dominated woodland existed with a ground flora of Filicales but this changes very rapidly at the beginning of sub-zone NY 3 with Betula becoming more important than Quercus, and Salix becoming more important amongst the shrubs. Salix is perhaps reacting partly to increasing dampness at the site. Despite an overall dominance of trees and shrubs, disturbed habitats must have existed as witnessed by the almost continuous curve of Plantago lanceolata from the base of the profile upwards. The plantain is accompanied by sporadic appearances of Artemisia and one or two other ruderals. It is quite possible that this ruderal pollen was derived from plants growing on the cliff face at the western edge of the bog, as the slope is steep and may have retained a variable amount of disturbed ground. The other N.A.P. types do not indicate very much although it may be likely that the Calluna finds are also derived from the cliff face.

Sub-zone NY 3

At the beginning of this sub-zone, on the total pollen diagram, there is a distinct phase when forest seems to be in recession and N.A.P. types expand rapidly. However this phase is mainly the result of a rapid expansion of Cyperaceae and Sparganiaceae, the other N.A.P. types not being affected. This could be interpreted not necessarily as a widespread woodland recession but as a sudden and short-lived flush of sedges and reeds in the patches of open water on the bog surface.

These pools may have been created by a slow rise in the water table. There was possibly some reduction in shrubs on the site at this time and the Cyperaceae and Sparganiaceae types may have invaded the bog surface in response to this reduction in competition. However, the phase is only short-lived and Coryloid appears to regain much of its lost ground.

The major woodland components of sub-zone NY 3 are almost certainly local as the stratigraphic remains confirm. Pieces of Betula wood are abundant and a Corylus avellana nut was found in the sampled profile. Quercus must have been quite local, although from its percentages in the pollen diagrams it was probably found on the drier areas a little way from the bog. Alnus does not reach the same levels it does at St. Helena 'B', the most prolific tree pollen producer at St. Helena 'A' being Betula. Corylus (see Appendix B) must have formed a thick shrub layer throughout the phase and was probably growing and flowering in the less dense patches of woodland. There is a slight increase in N.A.P. types compared with sub-zones NY 1 and NY 2, and this may indicate a slightly greater area of open land than during the earlier period. Fagus appears for the first time during sub zone NY 3 and Tilia disappears, only reappearing again almost at the present day. The pollen curves in general remain quite steady during the present sub-zone suggesting that there was little human activity in the immediate area.

Later on in sub-zone NY 3 there is a quite sudden expansion of Calluna and at one stage Calluna reaches more than 50% of total pollen. This phase commences with an inwash of inorganic clay over the surface of the bog. Initially at this level no strong change in the pollen curves occur, even though it has sometimes been regarded that the inwash stripes represent zones of woodland clearance brought about by anthropic activity (Jones 1969). There is, however, a remarkable expansion of Filicales at this level perhaps indicating a flush of ferns across the site and growing in response to the inwash of mineral material. It is interesting to note that the only times when Filicales are noticeably high are when a high level of inorganic material is present.

It is after the inwash stripe that there appears to be an important increase in *Calluna* values although these are not accompanied by a reciprocal decrease in trees. In terms of total pollen, *Betula*, *Alnus* and *Quercus* show minor reductions but it is possible that woodland recession was not very great. However, some open land must have been created as is indicated by a slight expansion in ruderals at the same time(e.g. *Plantago lanceolata*, *Rumex*, *Artemisia*). There is no indication whether this open land was created by anthropic activities or whether increasing instability on the cliff slope of the landslip led to an expansion in habitats for ruderals, and perhaps for *Calluna* as well.

At the height of the *Calluna* expansion, Coryloid also declines sharply although tree pollen percentages ~~don't~~ do not seem to be affected greatly. *Calluna* may indicate a period of relative dryness on the bog surface, as at the present day *Calluna* seems to be confined to the relatively drier parts of the bog. The phase of high *Calluna* also contains the highest single value of *Calluna* in the profile.

Towards the end of sub-zone NY 3 there is a final phase of woodland when *Betula* and *Salix* expand and there is a decline in N.A.P. types. The expansion of woodland is quite marked and possibly trees and shrubs invaded the bog. Gramineae, Cyperaceae and *Calluna* reach levels similar to those recorded before the period of high Calluna and the character of the woodland at the site must have been similar to that of the pre-Calluna expansion phase.

Sub-zone NY 4

The period starts with a sudden and far reaching decline in tree and shrub pollen accompanied by an equally marked rise in N.A.P. types. The site quite clearly changes from one with a thickly wooded appearance to one of open aspect. The sudden nature of the change and the plant types which appear in response to the change show that this is a man-made clearance. The ground must have been greatly disturbed as ruderals, for example, Plantago lanceolata, Rumex, Tubuliflorae, Liguliflorae, expand at a rapid rate. The presence of agricultural activity nearby is indicated by the sudden appearance of Cerealia pollen coupled with, for example, Centaurea cyanus. Light demanding shrubs such as Sorbus aucuparia appear for the first time, and Pteridium also expands, probably in response to the clearance of the area. A series of peaks in Sphagnum commences at this time possibly because the rate of run off of rainwater was increased by the removal of woodland, resulting in a temporary rise in water table in the bog. The appearance of Drosera at the same time would tend to confirm this suggestion. Although Calluna expands at the clearance level, it is Gramineae and Cyperaceae which share the dominance of the pollen spectrum, each occupying up to 40% of total pollen. The situation does not drastically change through the sub zone although Gramineae becomes the dominant N.A.P. type and Cyperaceae suffers a decline after the initial impetus provided by the clearance.

<u>Sub-zone NY 5</u>

This sub-zone occupies the uppermost parts of the diagrams and is distinguished by the changing role of certain tree spp and N.A.P. types. <u>Pinus</u>, <u>Fraxinus</u> and <u>Ulmus</u> all expand to the point where they are in a similar position to that of today. N.A.P. types decline in the number of spp present, and indicators of agricultural activity become scarcer perhaps reflecting a gradual run-down, especially of arable agriculture, in the area.

(ii) St. Helena 'B'

Stratigraphy : (cms)

0 - 10	Surface green-grey Sphagnum / Eriophorum peat.
10 - 84	Mid-brown monocot peat with some Eriophorum and wood remains (mostly Betula). Juncus effusus seeds at 20 cm.
84 - 150	More humified mid-brown monocot peat with Eriophorum but very little wood (Calluna rootlets towards the base).
150 - 431	Dark brown monocot peat with increasing wood down the profile. Wood layers (Betula) at 162-165, 215-217, 228-230, 316-319, 322-323, 327-329, 336-341, 422-424; (Alnus) 263-265; (Salix) 297-298. Juncus effusus at 235 cms. Very wet in parts.
431 - 433	Light grey silty inwash stripe.
433 - 500	Mid-brown monocot peat with a darker section 481-500 and a wood layer (Betula) 464-481.
500 - 519	Lighter mid-brown monocot peat with a wood layer (Betula) 511-513.
519 - 575	Darker mid-brown monocot peat with wood layers 526-528 (Alnus) and 533-534 (Salix), and a layer of Eriophorum 536-540. Becoming far more amorphous in general below 550 cms, and with a wood layer 560-565.
575 - 600	Very dry, orange-brown amorphous peat.
600 - 663	Very wet, mid-brown wood peat.
663 - 684	Light blue grey clay with wood remains 665-673.
684 - 692	Orange-yellow weathered bedrock.

Point of borer hit solid at 707 cm.

Introduction

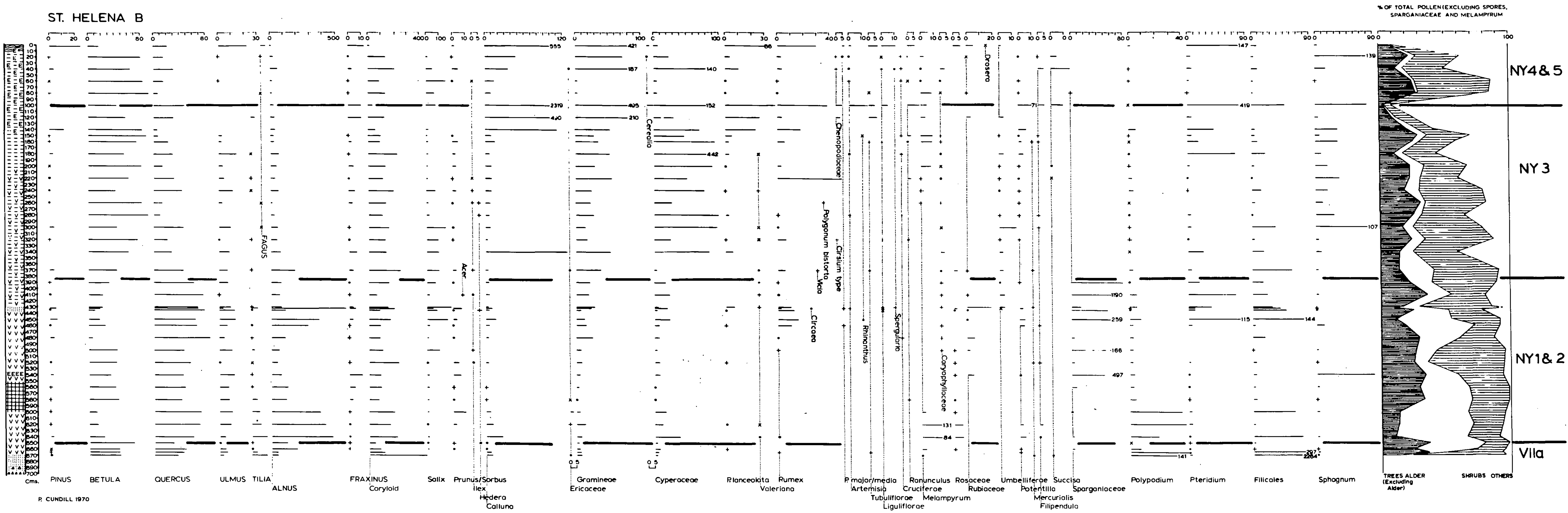
This is the deepest sampled profile from the central watershed with 670 cms. of peat. The profile has only been analysed as a skeletal outline, most of the sampling having been carried out at 20 cm. intervals. This was because once the basal samples had been analysed it was clear that peat growth did not commence at the site until sometime in zone VIIa. The pollen 'date' was later confirmed by a radiocarbon date from 665 cms. which gave (GaK - 2708) 5390 ± 220 years B.P. This would fall within late zone VIIa if a date of around 5000 years B.P. is accepted for the Ulmus decline in this part of England.

The diagrams, like those from St. Helena 'A', are difficult to zone, and a separate sub zone NY 2 is not recognized. Sub zones NY 1 and NY 2 are combined and the boundary between these subzones and NY 3 is placed tentatively at the same level as at St. Helena 'A', that is, where Betula expands and Quercus declines.

Zone VIIa and the Ulmus decline

Peat accumulation started in zone VIIa and the site at this time was covered with thick woodland of Betula, Quercus, Ulmus, Tilia, and Coryloid. Alnus is also very important, but does not expand greatly until slightly later. Accumulation of peat may have been slow at first and not until zone VIIb did accumulation accelerate. A feature of the basal samples is the very high percentages of Filicales spores, a situation which recurs at many sites from the central watershed. Coryloid is also a dominant pollen producer in the initial stages of peat formation but it is ousted by Alnus. Occasional grains of ruderals are found in zone VIIa and it is probable

ST. HELENA B



P. CUNDILL 1970

fig. 13   St. Helena 'B' pollen diagram.

Percentages of total tree pollen.

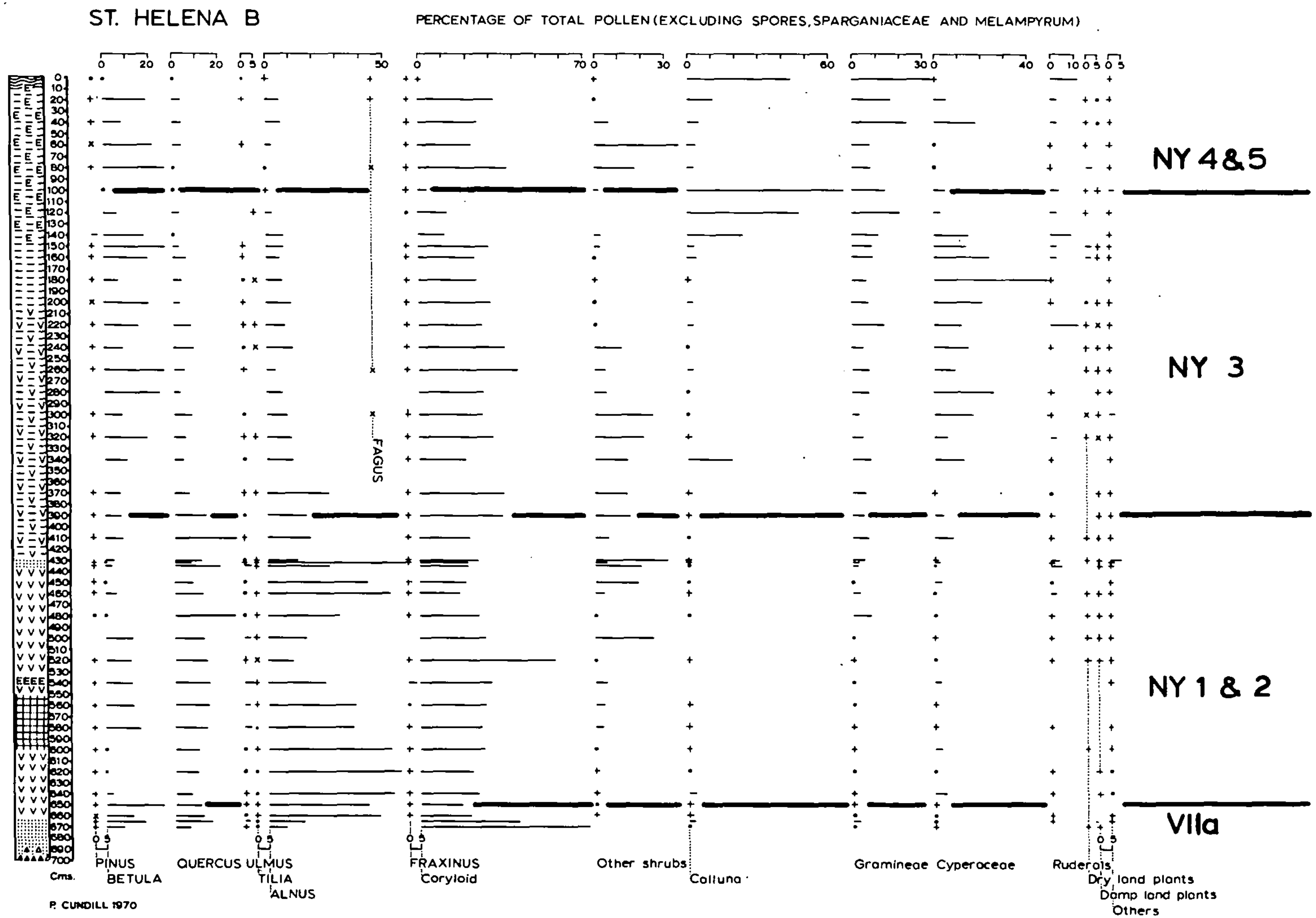


fig. 14 St. Helena 'B' pollen diagram. Percentages of total pollen.

that these were derived from plants growing on the disturbed ground on the steep cliff face section of the landslip.

The *Ulmus* decline has been tentatively placed at 650 cms. where *Ulmus* drops to very low percentages. *Tilia* also suffers a decline, unlike other sites where it generally expands at the *Ulmus* decline. The woodland composition changes slightly at this point with a reduction in *Quercus*, *Alnus* and Coryloid and an expansion in *Betula*. Whether this is a significant part of the *Ulmus* decline is difficult to say. In addition there is no direct evidence for clearance at the site and no expansion in N.A.P. types or appearance of any ruderal pollen types, so if this level is the *Ulmus* decline it is unlike any other *Ulmus* decline from the area.

Zones VIIb and VIII

Sub-zones NY 1 and NY 2

The early part of zone VIIb is characterized by a massive increase in *Alnus*. *Betula* appears to decline to relatively low levels and certain N.A.P. types, notably *Melampyrum*, flourish during this period. Spores of *Polypodium* and *Filicales* also seem to be in relative abundance. The change in woodland character from that of VIIa may be due to a period of increased dampness on the bog surface brought about through a number of possible reasons, for example, blockage of the normal drainage outlets or increased runoff from the moors into the bog. There are, however, no indications of human interference with the woodland. The *Alnus* during this phase is quite clearly local in distribution as is witnessed by the clustered groups of grains found during the counting of these levels.

The woodland changes character at 590 cms. with the decline in importance of Alnus and the reappearance of Betula at a high level. This is perhaps the result of the bog surface becoming drier, although there is little other change in the general character of the woodland to adequately explain the expansion of Betula. The Betula phase also sees the reduction of Melampyrum, Filicales and Polypodium which appear to have been strongly associated with the high Alnus values of the previous woodland phase.

Towards the end of the high Betula values there is a period when Coryloid expands to a peak with an associated drop in Alnus values, perhaps indicating a further drying out of the bog surface.

There are, however, peaks of Sparganiaceae around this time which indicate that reedswamp must have been growing very close to the sampled site, a further factor which complicates the interpretation of the woodland changes. Possibly Coryloid may have been expanding around the fringes of the bog rather than on the bog itself. There are no indications of anthropogenic activity to explain the variations in woodland composition at the time, as some highly local ecological factor may have been at work.

The woodland changes character yet again at 490 cms. when Alnus once more expands and Betula declines. In association with the change in woodland composition there are peaks of Sparganiaceae pollen. Salix also has a peak at 500 cms, perhaps a further indication of the wet conditions at the time. The high levels of Rumex and slightly higher levels of Gramineae are an unusual feature at around 440 cms. and may be connected with anthropogenic activity. This is perhaps supported by the occasional peaks of Pteridium and the whole process may have been sufficient to trigger off the inwash of mineral material on to the bog surface at around 430 cms. Significantly a range of other weeds for example, _Plantago lanceolata_, _Artemisia_, Liguliflorae also appear during the inwash period, further strengthening the case for some anthropogenic activity in the area. This activity may have been confined to the moorland above the landslip but was sufficient to be recorded both in the pollen and the stratigraphy of the bog. It is interesting to note the difference from the inwash stripe at St. Helena 'A' where no indications of human activity were recorded in association with it. At St. Helena 'B' the indications of human activity may represent sub-zone NY 2. However, the evidence does not show such a sharp clearance phase as that in the blanket peat pollen diagrams and for the purposes of the present site no sub-zone NY 2 is recognized.

Sub-zone NY 3

Betula and Coryloid became the dominant woodland spp. during this sub-zone. _Fagus_ appears for the first time at this site in the early stages of the sub zone. A general increase in N.A.P. types is apparent and fluctuations in the pollen curves become quite erratic during this phase. It could be argued that the predominance of _Betula_ and Coryloid is connected with a more disturbed landscape generally with these two spp. helping to filter out the regional pollen record which would show clearance phases. There are numerous levels at which clearance indicators may be seen although these are confined to short periods and _Betula_ and Coryloid quickly regenerate to restore the woodland of the site. However, the general trend is one towards clearance with probably regeneration becoming more difficult owing to soil degradation. Moreover, by this stage a considerable depth of peat had accumulated and the surface of the bog was becoming dominated by spp. such as Cyperaceae, Calluna and Gramineae which would also increase the total N.A.P. values recorded.

The situation reaches a head at the end of sub-zone NY 3 with a large scale clearance of woodland, and the appearance in considerable quantity of Calluna. At the peak of the clearance this spp. comprises 70% of all pollen. However, other spp. also expand at the same time, and Gramineae, Cyperaceae and ruderals, for example, Plantago lanceolata, Rumex, Artemisia, Tubuliflorae, Liguliflorae, all reach significant levels. At the peak of the clearance Cerealia pollen appears for the first time and this probably indicates that cereal growing was taking place. The dating of this clearance phase is tentatively placed at the sub-zones NY 3/NY 4 boundary although without a radiocarbon date this cannot be confirmed.

Sub-zones NY 4 and NY 5

These two sub-zones are combined at St. Helena 'B' as it is difficult to separate them on the basis of five pollen counts. The most significant feature of this period is the active regeneration of woodland. Betula, Coryloid and Salix are the main woodland spp. which expand and this must have formed a dense scrub or carr round the edges of the bog. N.A.P. types are drastically reduced to low levels at the same time, indicating the cessation of agricultural pressure on the site. It is likely that the woodland was only very local both from the evidence of St. Helena 'A' and from the fact that groups of grains of the three main woodland spp. were frequently found during counting.

The situation again reverts to one of widespread clearance at 2 cm., the level nearest the surface, where the shrubs Coryloid and *Salix* are reduced to low levels. The N.A.P. types increase in response to the clearance of the area and the pollen spectra begins to approach that found in the contemporary sample. Amongst the tree spp., *Pinus*, *Ulmus* and *Fraxinus* reach present day percentages and perhaps reflect reafforestation in the area. Amongst the N.A.P. types, *Calluna* becomes the dominant spp. The 2 cm. level is the only count which shows a sub-zone NY 5 pollen assemblage, although a single count cannot be regarded as the basis for the recognition of the sub zone.

Comparisons between St. Helena 'A' and 'B' profiles

The two sites, although they are only 230 metres apart on the same bog surface, show substantially different pollen spectra.

There are serious implications for the interpretation of pollen diagrams when two closely adjacent pollen profiles are not immediately comparable. The two profiles from St. Helena differ in particular in the upper parts where in St. Helena 'B' there is not the clear and continuous lack of woodland after the early sub-zone NY 4 clearances that there is in St. Helena 'A'. An examination of the woodland types which regenerate so readily at St. Helena 'B' after the early sub-zone NY 4 clearances show that these are dominated by *Betula*, Coryloid and *Salix* which, as already has been suggested, formed a carr woodland at this end of the bog. This is not an unusual situation at the present day as a woodland of the type envisaged exists in Tranmire slack (NZ / 767119, Plate 4). The interesting point is that pollen from the woodland at St.

Plate 4 Carr woodland in Tranmire slack, 1969

Helena 'B' did not travel even the short distance of 200 metres to register in significant quantities at St. Helena 'A'. The travel of tree pollen from the edge of a woodland is discussed further in Section II, J , but at the present site the pollen record illustrate how local the pollen production has been in the past.

The differences between profiles 'A' and 'B' at St. Helena may almost be summarized from the general stratigraphic differences. Profile 'A' has no tree remains apart from in the basal 50 cms. while 'B' has tree remains for almost 4.5 metres of its 7 metres depth. This is reflected in general pollen terms by a higher total tree and shrub pollen record throughout profile 'B' than in profile 'A'. Up to and just after the inwash stripes recorded in both profiles the woodland conditions appear to have been much the same. It would be tempting to correlate the two inwash stripes, but the dangers of doing this on the basis of highly localized pollen sources are obvious and the need for an independent dating method is quite clear in this case.

The St. Helena 'A' profile may have been influenced by the position of the cottage known as St. Helena which is located at this end of the bog. Pressure on the woodland through grazing or removal of wood for fuel may have been more pronounced in the area adjacent to the cottage. Cutting of the bog peat for fuel appears to have been more actively undertaken at this end of the bog and may also be connected with the presence of St. Helena cottage.

While there are a number of points which allow some tentative correlation of the 'A' and 'B' profiles from St. Helena and explain the major differences between the two sites, there must still remain some grounds for concern over the interpretation of regional pollen changes from sites where highly localized and restricted pollen production is possible. This is a danger which is not only applicable to the two landslip bogs examined in the present work but must also be recognized as a possible danger in the misinterpretation of sites of a similar nature such as slacks or riverside situations.

B. <u>White Gill</u>

Grid Reference : NZ / 639026

Height above Ordnance Datum : 1270 feet (387 metres)

Depth of sampled profile : 48 cms. (White Gill) and
8 cms. (White Gill 'A')

Method of sampling : monolith tins and tubes.

Two profiles have been examined from this site, White Gill and White Gill 'A', and while they have been taken from a position very close to one another (approximately 20-30 cms. apart), they will initially be discussed separately and then compared. White Gill is a full profile while White Gill 'A' is a short basal profile examined first in order to gain a picture of the environment at the inception of peat growth. Both profiles contain microlithic waste flakes of Mesolithic age preserved in situ at the base of the peat.

The site is the classic one for the finds of Mesolithic artefacts on the North Yorkshire Moors and abundant material may still be collected with comparative ease. The finds of microliths covers quite a considerable area on the fairly steeply sloping eastern side of Stony Ridge (Plate 1). The area is covered by a shallow depth of peat which nowhere appears to reach one metre, and which is severely dissected and eroded by small drainage gullies. In some parts of the site the peat is eroded down to the bedrock while in others the peat is still intact. The two profiles were taken from an area which is being actively eroded. A narrow gully had formed and it was noticed that a few microlith cores and waste flakes were appearing in the side of the gully at the junction between the peat and mineral material. The area was excavated to reveal a vast quantity of partly worked flints, which are all now in the possession of R. H. Hayes. Some of the flints were actually embedded in the orange-yellow mineral material and others were appearing at the junction of this material and the peat. The area was excavated to between 1.5 and 2 metres south of the erosion gully to find the extent of the flint site. It was discovered that the present peat surface and drainage channels bore no relationship to the mineral soil surface which dipped towards the south (fig. 15). At the same time the abundance of flint remains decreased rapidly until only one or two small waste flakes were found, although these were beneath nearly half a metre of peat, compared with the very thin peat layer close to the gully, and found in a different stratigraphic context from the majority of flints. They were situated in a minero-organic material a few centimetres above the basal pure mineral material, and this situation appeared to offer a better opportunity of dating the incorporation of the flints into the peat than at other sites. It may be that all the flints in the excavated area are of the same age and the small flints which formed the basis of investigation at this site were only small pieces which fell into some kind of muddy pool on the periphery of the main flint site.

(i) White Gill

Stratigraphy : (cms.)

0 - 40	Dark brown wet amorphous peat, highly humified, with many seeds of *Juncus effusus* towards the base.
40 - 48	Dark brown wet amorphous peat with some monocot remains together with silica. Microlith at 44-45 cms. and abundant *Juncus effusus* seeds throughout.

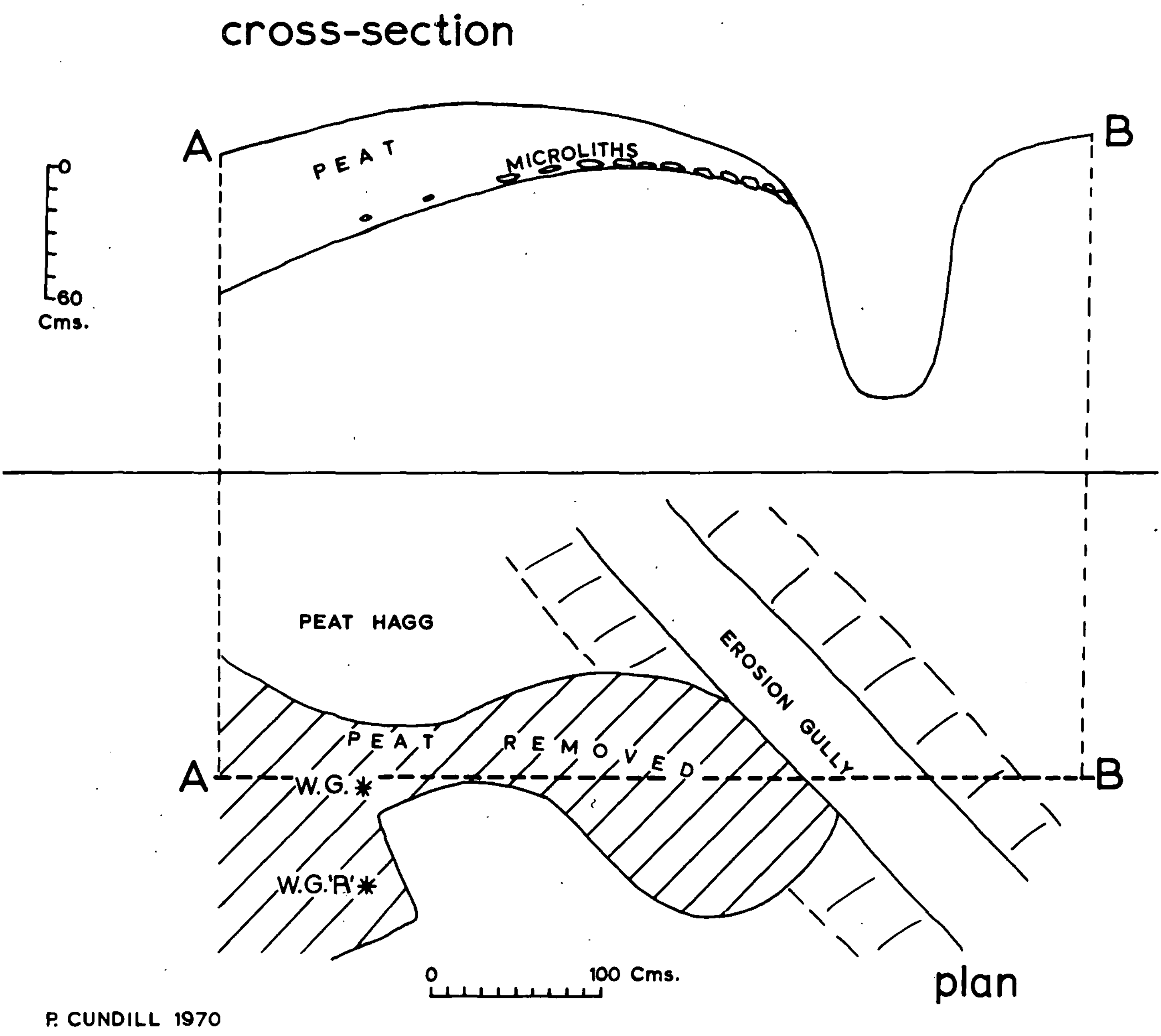


fig. 15 Sketch plan and cross section of the flint artefact site at White Gill.

48 + Yellow-orange mineral soil grading very rapidly into bedrock.

Present day vegetation: Dominantly Calluna with a little Empetrum and much bare ground.

Introduction

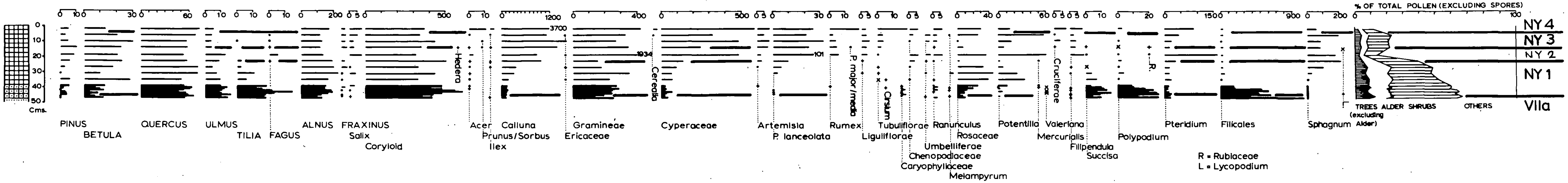
The profile is very difficult to zone especially close to the base and around the microlith where clearly most interest lies. In the absence of radiocarbon dates a tentative zonation scheme has been adopted.

Zone VIIa and the Ulmus decline

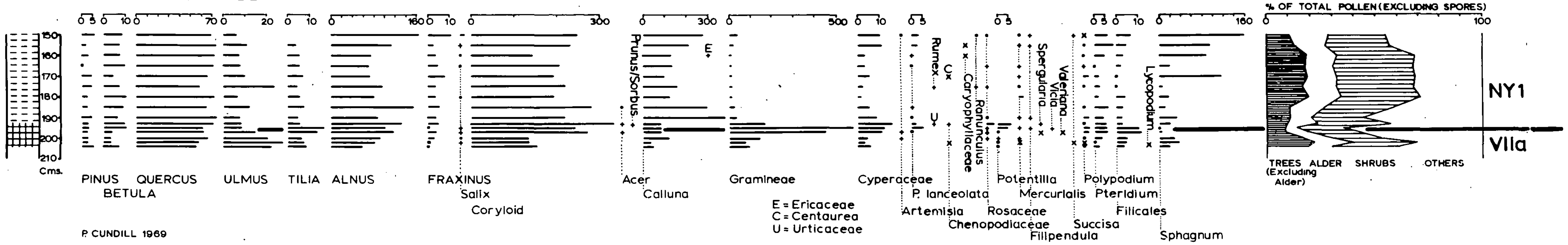
It would seem likely that by its very nature the minero-organic material at the base of the profile was very slow to accumulate. This may explain the very fluctuating nature of the pollen spectra at this time, although in general terms these fluctuations are not substantial. The period before the primary Ulmus decline has a relatively low percentage of trees and shrubs measuring in the region of 70% of total pollen. Dimbleby working on an adjacent site described such levels as being indicative of closed woodland conditions, although in comparison with other sites in the present work where trees and shrubs comprise 90% of total pollen this description could be open to modification. Certainly the trees formed an important part of the scene at White Gill at this time although perhaps the woodland was of a 'patchy' nature with occasional open areas. It has been suggested already that small pools may have existed on the surface at this time and these may have influenced the amount of open land in the area.

The usual VIIa assemblage of forest trees is in evidence from the site with Alnus and Quercus dominating the scene.

WHITE GILL



TROUGH HOUSE



UPPER: fig.16 White Gill pollen diagram.

Percentages of totaltree pollen.

LOWER: fig. 37 Trough House pollen diagram.

Percentages of total tree pollen.

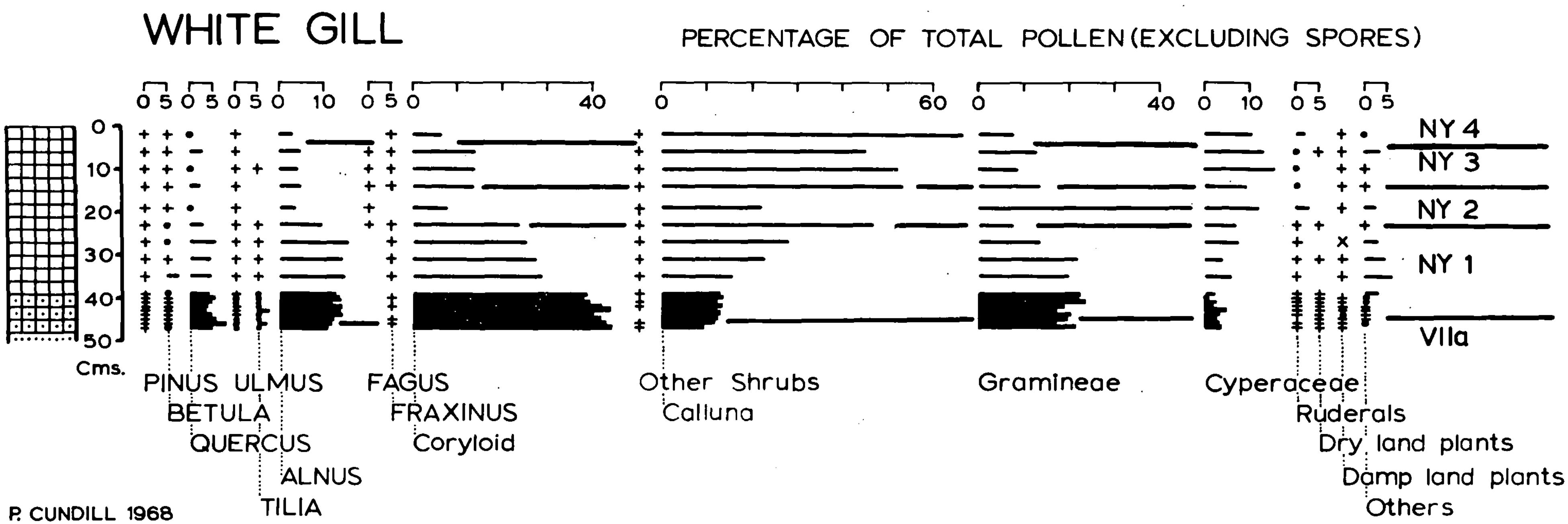


fig. 17 White Gill pollen diagram. Percentages of total pollen.

Ulmus is recorded at relatively high levels while Tilia reaches abnormally high levels. For some reason which is not immediately apparent Tilia seems to be particularly favoured at the site and must have been growing very close to the sampled profile for it to have been recorded in such quantities bearing in mind that it is partly entomophilous in its distribution of pollen. Coryloid is the only shrub found in any quantity and it is quite likely to have occupied the more open areas (or the fringes of these) as well as providing an understorey for the trees. Amongst the N.A.P. types the presence of certain herbaceous spp. is interesting (e.g. Stellaria holostea which appears in woods at the present day). The very high percentages of Filicales are also interesting and it would seem that there is a close connection between Filicales and the presence of mineral material as at other sites. The Filicales disappear at White Gill once pure organic peat begins to accumulate. Undoubtedly the ferns played an important part in the ground flora of the woodland of the site.

Ulmus, at its characteristic decline, drops to below 10% of tree pollen and Quercus and Betula also decline. Furthermore Plantago lanceolata appears in very small quantities for the first time at the Ulmus decline and at the same time pieces of charcoal were found in the stratigraphic analysis of the profile. The incorporation of the flint waste flake into the profile is just prior to the primary Ulmus decline and it would appear likely that man was affecting the woodland through the use of fire at the Ulmus decline. The burning of woodland was unlikely to have been extremely close to the sampled profile as the pollen evidence for clearance is limited. At about the time of the Ulmus decline or immediately following it there is a remarkable peak of Tilia which reaches 34% of tree pollen. This seems to be a common feature of a number of pollen diagrams from the present study and is discussed in more detail in Section III. It is a feature which has been used to further justify the placing of the Ulmus decline tentatively at 43-44 cms. Coryloid reaches a peak immediately after the Ulmus decline possibly in response to the recolonization of burnt areas. This is followed by a minor peak in Betula which may be a further stage in regeneration of woodland.

Zones VIIb and VIII

Sub-zone NY 1

While the general total percentage of trees remains steady or only declines marginally throughout this subzone, the pattern of trees gradually alters. A slow decline in Ulmus and Tilia is observed overall while Betula expands. At the same time a gradual decrease in Coryloid pollen is offset by an increase in N.A.P. types such as ruderal spp. which begin to appear with more regularity. Charcoal appears with more frequency in the macroscopic remains indicating the use of fire in an adjacent area if not on the site. The major N.A.P. types which gradually expand during this sub zone are Calluna and Cyperaceae. Calluna may indicate a gradual acidification of the soil at the site which on its own may have discouraged the active continuous growth of Coryloid and certain tree spp.

Sub-zone NY 2

At the beginning of this sub-zone Alnus and Coryloid begin to decline rapidly and Quercus also suffers badly. At the same time there is a striking expansion of N.A.P. types, and in particular Gramineae. More significantly ruderals, particularly Plantago lanceolata, expand to a peak along with other spp. (e.g. Potentilla, Filipendula) pointing to a clearance phase initiated by man; Pteridium also reaches a single high peak. At the height of the clearance Tilia disappears and in general terms the total percentage of tree and shrub pollen drops to below 20%. The opening up of the woodland must have been quite sudden and striking and there are indications of longer distance travel of tree pollen with the first appearance of Fagus at this time together with an expansion of Ulmus, the latter perhaps gaining a relatively larger share of tree pollen because it was not so affected by the clearance. The clearance at this site may have been the result of active removal of woodland for example by the use of fire in order to increase grazing for domestic stock or it may have been the introduction of domestic stock itself which brought about the destruction of woodland. There are no indications of cereal growing.

Sub-zone NY 3

There is a recovery of trees and shrubs after sub-zone NY 2 clearances, but they do not reach pre-clearance levels. There appears to have been continuous pressure on the woodland as charcoal is found at every level and this is coupled with the fact that the degradation of the soils must have reached a stage where regeneration of trees and shrubs was slowed down. The woodland which did survive and attempt to expand may have been situated close to the stream of White Gill. A few trees and bushes exist here at the present day. Betula, Quercus and Alnus make a slight attempt to expand during this sub zone, as does Coryloid, but none of them reach very high percentages before a further decline sets in.

Sub-zone NY 4

This final decline in trees and shrubs is recognized in other diagrams from the central watershed although this correlation is based on limited evidence. Ruderal pollen types (e.g. *Plantago lanceolata*, *Artemisia*, Tubuliflorae, Liguliflorae) rapidly expand in the upper levels of the diagrams and cereal grains are found for the first time. The cereal pollen grains were probably derived from the dales but the scale of clearance and character of clearance is very similar to that assigned to the NY 4 clearances at other sites. *Calluna* expands to a very high level which is more akin to the situation found in the upper parts of diagrams from, for example, Loose Howe and Howdale Hill. The confirmation that this clearance phase is the last clearance of any size recorded at the site is not forthcoming as the peat profile has been truncated. The lighter brown, drier and more fibrous *Calluna*/monocot peat recognized on the surface nearby, is lacking from the sampled site. Because of this and the resultant lack of a full pollen diagram sub-zone NY 5 cannot be identified although perhaps something of the nature of the pollen spectra from the missing peat may be seen in the full profile from Howdale Hill less than one mile (1.6 kilometres) to the south east of White Gill.

(ii) White Gill 'A'

Stratigraphy : (cms.)

0 - 7 Dark brown wet amorphous peat with silica. Microlith at 5 cms. and abundant *Juncus effusus* seeds. Frequent charcoal throughout.

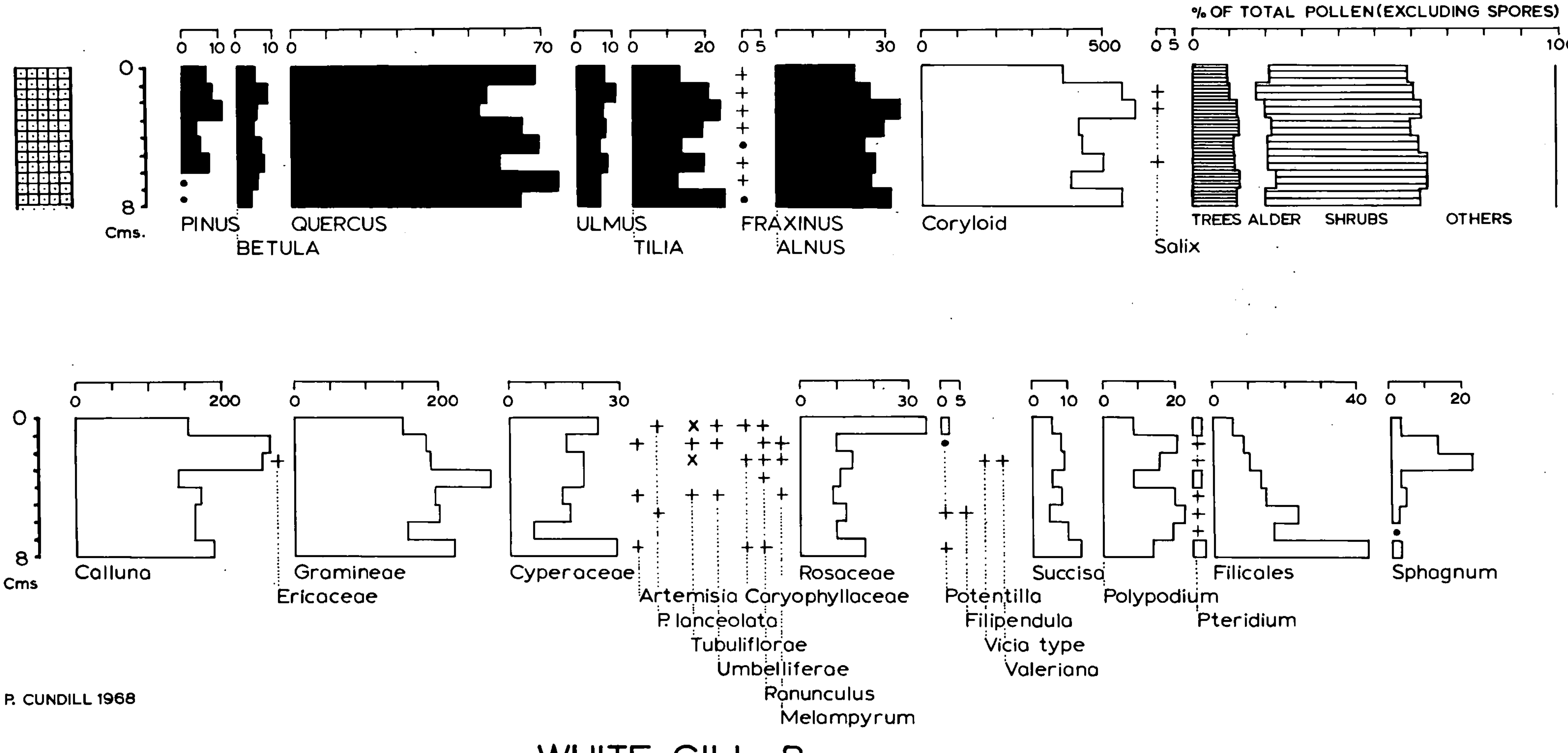


fig. 18 White Gill 'A' pollen diagram. Percentages of total tree pollen.

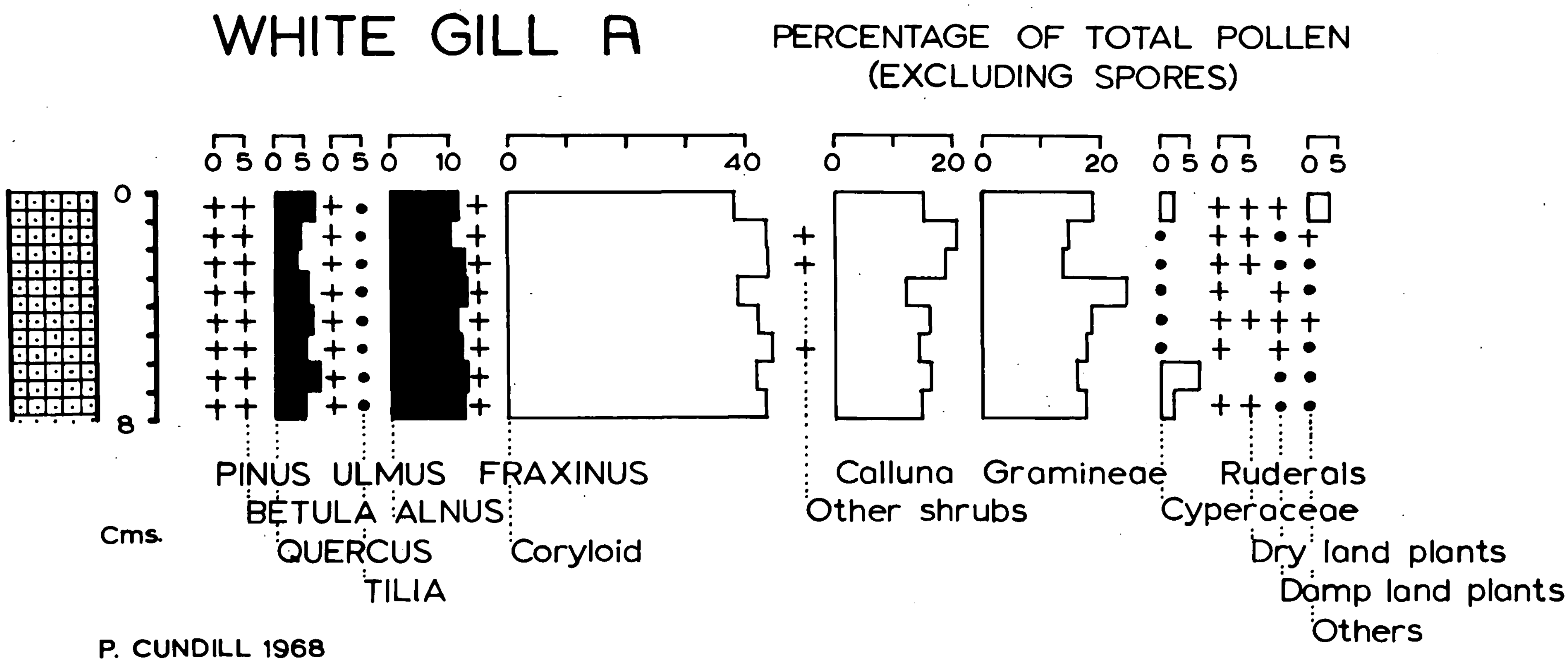


fig. 19 White Gill 'A' pollen diagram. Percentages of total pollen.

7 - 8 Yellow orange mineral soil rapidly grading into bedrock. Juncus effusus and charcoal present.

Present day vegetation : as for White Gill.

The profile is a very short basal one with a microlith embedded in situ in it. The analysis does not reveal a great deal and it was found necessary to examine the main White Gill profile to obtain a full picture of the ecological changes at the site.

The zonation of the profile is particularly difficult and while it appears to fall within VIIa at an initial glance this conclusion would not fit in completely with the zonation ascribed to White Gill. There are no significant changes in the pollen spectra throughout the profile and certainly no indications that man was influencing the vegetation in any way at the level of the microlith. While the general range of trees is compatible with a VIIa date for the profile as a whole there are certain features which would not fit in with the ideal zone VIIa pollen assemblage. The high percentages for Tilia have already been noted in the White Gill diagrams and characterise the White Gill 'A' tree pollen. Coryloid and N.A.P. types make substantial contributions to the pollen rain and as in White Gill they may indicate that the woodland was not of a completely closed nature. There are occasional grains of ruderal pollen types (e.g. Artemisia, Plantago lanceolata, Tubuliflorae) which may indicate some disturbance of ground near the sampled site, and the abundant finds of charcoal throughout would perhaps indicate a level of disturbance which is not altogether indicated by the pollen spectra. Possibly the woodland at the site formed a mosaic with Coryloid scrub and open ground also present.

All these points would still not help in deciding the zonation of the diagram, although tentatively it would appear to be within VIIa or perhaps early VIIb.

Comparisons of Profiles from White Gill

While the two profiles of the present work are comparable it may be useful to examine these in the context of the analyses Dimbleby has carried out in the same area (Dimbleby 1962). The pollen analysis of Dimbleby's work has been redrawn from the original figures as a total pollen diagram in the same format as the present diagrams in order to facilitate ease of comparison. The White Gill site of Dimbleby contains microliths in situ but in a different stratigraphic context to those of the present work. At Dimbleby's site they are found at the boundary of the pure mineral material and the peat. Similarly the pollen analysis carried out by Dimbleby goes back further in time than the present analyses but does not continue up to the present day peat surface. Dimbleby allots the microlith industry to the Atlantic period (zone VIIa) on the basis of high *Alnus* and *Quercus* percentages. This basis would also follow if strictly applied to the level of the microliths in the present work. Dimbleby notes the low percentages of *Ulmus* and *Tilia* values and regards them as being of no diagnostic value. He therefore recognizes no *Ulmus* decline. It is equally difficult to identify an *Ulmus* decline on the present diagrams of total pollen and it is only on the basis of the total tree pollen diagram that one is tentatively suggested.

The only major difference between Dimbleby's diagram and the present ones is the latters' very much higher Coryloid values. This difference presents no problem in explanation

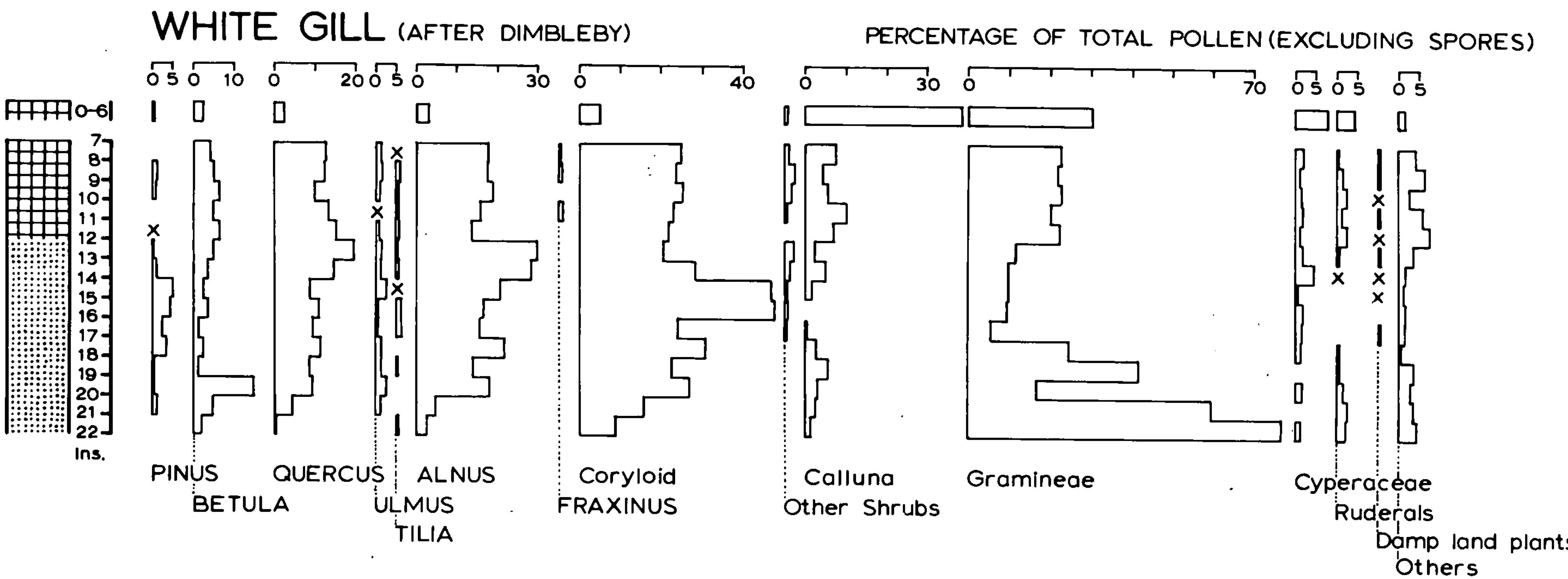


fig. 20 White Gill pollen diagram. Percentages of total pollen calculated from data obtained by Dimbleby.

as the Coryloid may be a purely local factor in the pollen rain at this site.

It would appear that the two sets of diagrams accord reasonably well, with Dimbleby's analysis covering a very early period of vegetation development and overlapping strongly in zones VIIa and VIIb with the present analyses which continue the history of vegetation development into later times.

C. Blakey Landslip

Grid Reference : SE / 674996

Height above Ordnance Datum : 1060 feet (323 metres)

Depth of sampled profile : 500 cms.

Method of sampling : Russian borer.

Stratigraphy : (cms.)

0 - 18	Fresh yellow green *Sphagnum* peat with a few *Eriophorum* remains.
18 - 50	Mid-brown monocot/*Eriophorum* peat with some *Calluna* and *Sphagnum*. Very wet.
50 - 100	Wet, mid-brown monocot/*Eriophorum* peat with some *Sphagnum*. Some *Juncus effusus* seeds.
100 - 150	Mid-brown monocot/*Eriophorum* peat with less *Eriophorum* and slightly drier and more humified than 50-100 cms. Some *Juncus* spp. seeds (*Juncus squarrosus* at 105 cms.)
150 - 195	Mid-brown monocot peat with virtually no *Eriophorum*. *Juncus effusus* seed at 175 cms.
195 - 223	*Eriophorum* band; dark brown and wet.
223 - 234	Mid-brown monocot peat with abundant *Juncus effusus* seeds.
234 - 241	Mid-brown monocot peat with a series of three light grey inwash stripes in it.
241 - 246	Mid-brown monocot peat with abundant *Juncus effusus* seeds.
246 - 350	Mid-brown wood peat with mostly *Betula* remains, although *Alnus* occurs at 255 cms.

	Juncus effusus seeds throughout.
350 - 364	Mid-brown fine detritus mud with *Juncus effusus* seeds.
364 - 400	Mid-brown wood peat with mainly *Betula* remains. *Juncus effusus* at 375 cms.
400 - 472	Very wet wood peat; not possible to sample.
472 - 492	Fine detritus mud with *Juncus effusus* at 485 cms.
492 - 500	Blue grey clay with angular fragments.

Borer in impenetrable material (sand or clay) at 515 cms.

Introduction

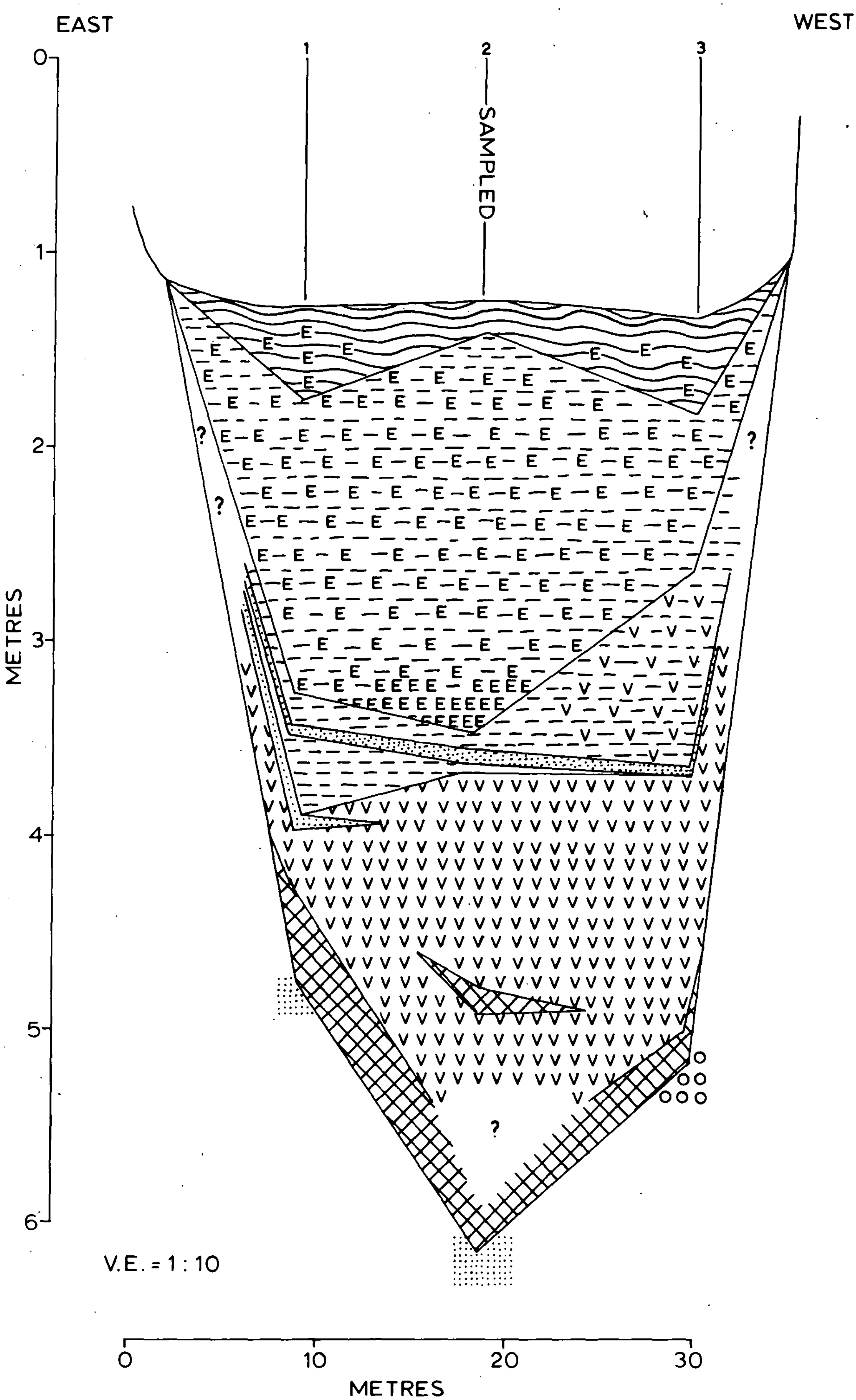
The site is a small bog which has accumulated behind the highest of a series of landslips facing west into Farndale (Plate 5). The other landslips although mostly poorly drained do not have the bog development that occurs at the sampled site. The depth of the bog was tested by pushing down rods at a series of sites. A cross section was also constructed by putting down three borings east-west across the deepest part of the bog, and levelling in the surface of the bog. The deepest profile from the cross section was selected for pollen analysis.

The stratigraphic cross section

The cross section is of a similar shape to that at St. Helena 'A' with the basin having steeply shelving sides and a flat base. The infill of material is deep, reaching five metres at the sampled site. The basal material of the site, a fine detritus mud, is quite different to that found at St.

Plate 5 General view looking north of Blakey landslip bog

BLAKEY LANDSLIP



P. CUNDILL 1970

fig. 21 Cross section of Blakey Landslip.

Helena. It would appear that the landslip site at this time probably contained a pond which stretched the full width of the site and in which the fine detritus mud could accumulate. In time the pond was invaded by trees although this section remained extremely wet. The wood was primarily an Alnus carr probably with some Betula round the edges of the bog area. A couple of silt inwashes occurred towards the end of the carr woodland stage, the upper one, from the pollen evidence, coinciding with much of the removal of woodland in and around the bog. The bog changes to one of a Cotton-grass character after the inwash stripe stage, with a small section of Betula fringing the western edge. The situation must have remained wet and the woodland clearly did not re-invade the site fully. The bog appears to have slowly developed into a true ombrogenous bog at about 50 cms. with Eriophorum and Sphagnum becoming the major plant spp., a situation which largely exists at the present day.

The Present Vegetation

The site may be divided into three general sectors: a) the bog surface proper, b) a slightly higher flush surface at the southern end of the bog and c) the landslip cliff and face and the moorland edge. A full spp. list of the plants at Blakey Landslip is found in the Introduction (Section I, A, 4) although a more detailed discussion of the vegetation will be attempted here.

The bog surface is extremely wet in places and where this is the case a Sphagnum carpet flourishes. At the northern end there is a small pond which dries out in the summer. The drier areas of the bog stand out clearly as those areas occupied by Calluna vulgaris although Calluna is not the

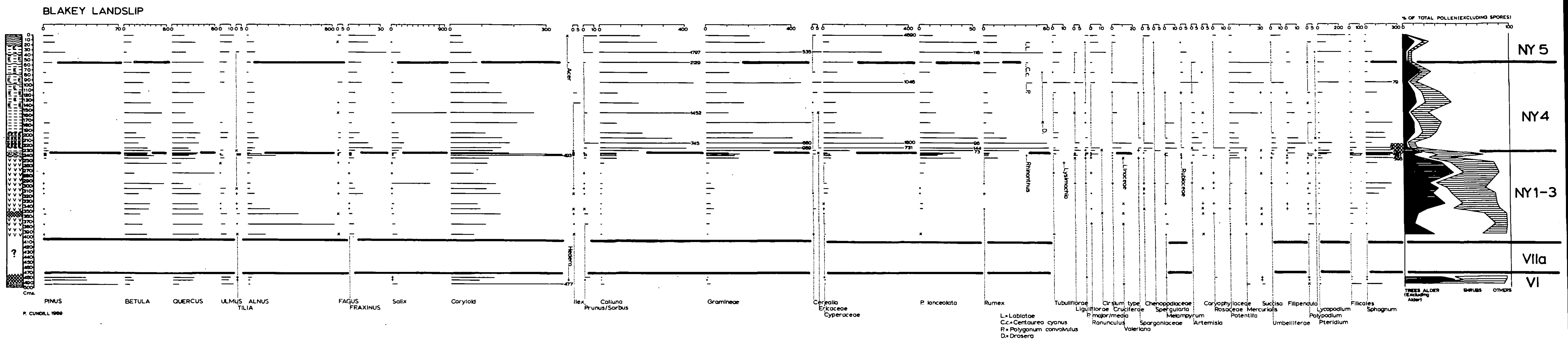

BLAKEY LANDSLIP
PINUS
BETULA
QUERCUS
ULMUS
TILIA
ALNUS
FAGUS
FRAXINUS
Salix
Coryloid
Ilex
Calluna
Prunus/Sorbus
Gramineae
Cerealia
Ericaceae
Cyperaceae
P. lanceolata
Rumex
L.= Labiatae
C.c.= Centaurea cyanus
P.= Polygonum convolvulus
D.= Drosera
Tubuliflorae
Liguliflorae
P. major/media
Ranunculus
Cirsium type
Cruciferae
Valeriana
Chenopodiaceae
Spergularia
Sparganiaceae
Melampyrum
Artemisia
Caryophyllaceae
Rosaceae
Potentilla
Mercurialis
Succisa
Umbelliferae
Filipendula
Lycopodium
Polypodium
Pteridium
Filicales
Sphagnum
Acer
Hedera
Rhinanthus
Lysimachia
Linaceae
Rubiaceae
% OF TOTAL POLLEN (EXCLUDING SPORES)
TREES ALDER (Excluding Alder)
SHRUBS
OTHERS
NY 5
NY 4
NY1–3
VIIa
VI
Cms.
P. CUNDILL 1980

fig. 22 Blakey Landslip pollen diagram.

Percentages of total tree pollen.

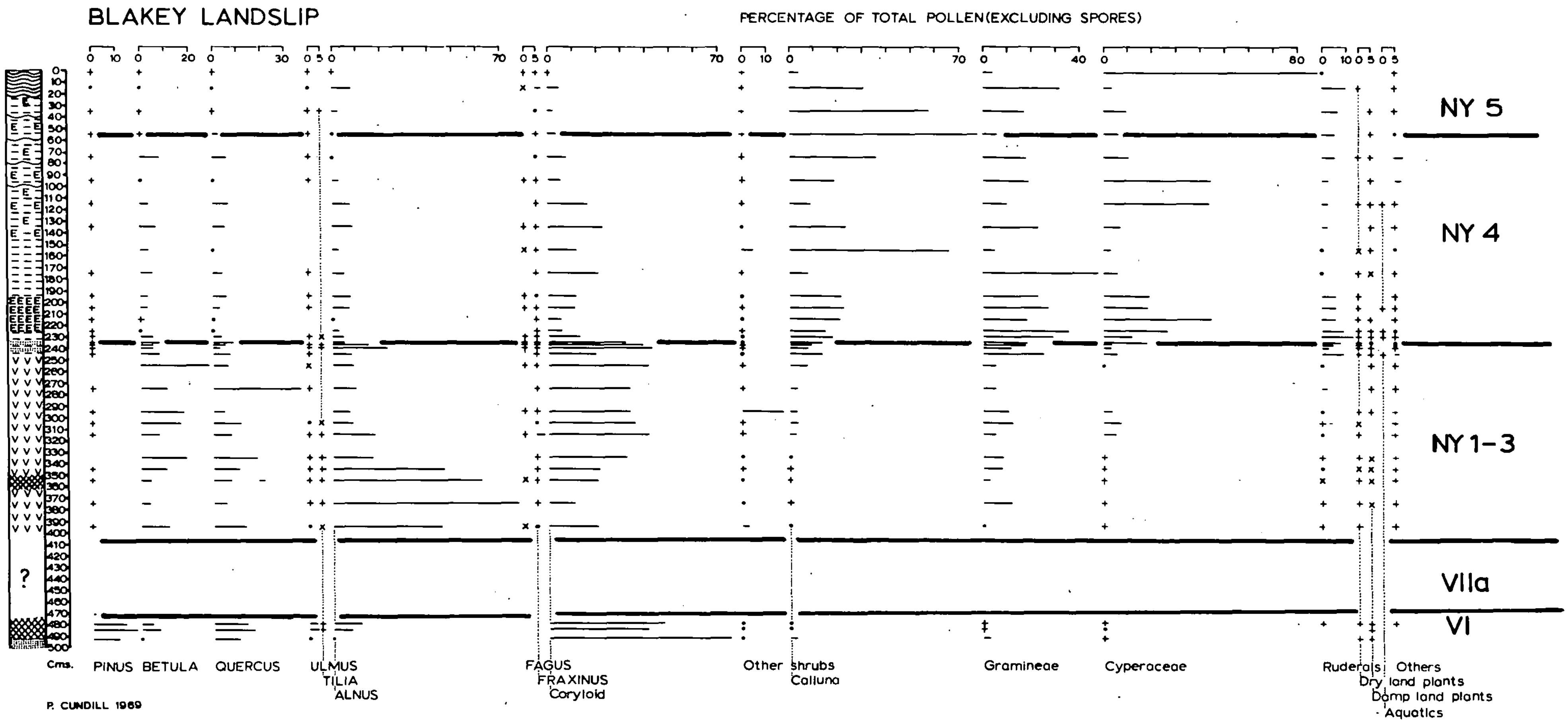


fig. 23 Blakey Landslip pollen diagram. Percentages of total pollen.

dominant sp. as *Eriophorum angustifolium* also grows in abundance particularly in the damper areas. The other spp. are of lesser importance with *Potentilla erecta* and *Erica tetralix* occurring on the drier parts.

The flush area has quite a different plant assemblage compared with the bog surface as *Juncus* grows in profusion together with some Gramineae, Cyperaceae and *Cirsium*. These plants also grow over the southern drainage outlet of the bog.

The cliff slope at the back of the landslip contains the occasional shrub of *Sorbus aucuparia* and one *Salix* bush. Gramineae spp. are abundant all over this area together with a fair amount of *Calluna*. At the top of the cliff and on to the moor proper *Calluna* becomes the dominant sp. with a little *Empetrum nigrum* and *Vaccinium myrtillus*. On the rest of the landslip complex *Pteridium* appears to be the dominant sp. with the occasional bush of *Sorbus aucuparia* and patches of *Juncus* in the wet flushes.

The Vegetation History

It was hoped that the pollen record from the bog would give an idea of the ecological history of Farndale. Unfortunately the gap in samples from 400 - 472 cms. due to the very wet nature of the deposit includes much that would have been of interest including the Boreal-Atlantic transition, all of zone VIIa and part of early zone VIIb. However, the pollen record is still of considerable value as the clear zone VI pollen assemblage at the base is well before the late zone VIIa date recorded from the base of St. Helena 'B'. Moreover, the later clearance episodes are fairly sharp and provide comparisons with the sites from the high moorlands, for example, Howdale Hill and Loose Howe.

Zone VI

This is characterised by high Pinus and low Alnus values. The presence of Quercus and Ulmus as the other main tree spp. is also shown. However, the dominant spp. within the confines of the landslip area itself is clearly Coryloid and it is interesting to note also the presence of a little Prunus/Sorbus pollen. It could be argued that the Coryloid and Prunus/Sorbus pollen indicate the existence at the site of a very thick shrub cover growing away from the shading effects of trees. Perhaps the steep cliff at the back of the site provided a suitable situation for this growth of shrubs. The N.A.P. values remain at a very low level and clearly the tree and shrub cover must have been very dense, shading out the herbaceous plants. It is interesting to note however that a little Calluna was present even at this early stage and the single grain of Plantago major/media indicates disturbance of the environment probably on the steep cliff at the back of the landslip.

Zones VIIb and VIII

Sub-zones NY 1 - NY 3

The three sub-zones are grouped together on the present diagrams as the gap in sampling makes it very difficult to produce a clear interpretation of the available evidence.

The base of the material at 400 cms. where sampling recommenced is clearly within zone VIIb. Fagus is present, admittedly at a low level initially, and Ulmus and Tilia appear at post Ulmus decline percentages with Tilia becoming discontinuous after 305 cms. Fraxinus is also present as a continuous curve, indicating perhaps that regeneration was occuring in certain areas after the Ulmus decline. One of the most distinctive features about this period is the dominance of Alnus in the pollen spectra, especially at 375 cms. where it comprises 80% of total pollen. It can only be surmised that this pollen is coming from a very local source probably an Alder carr woodland on the bog. Betula and Quercus appear to be the main constituents of the woodland away from the Alnus dominated areas. Corÿloid remains at a high level although its pollen may be suffering from the swamping effect of Alnus, resulting in an incorrect interpretation of the importance of Coryloid. This factor may also be influencing other spp. The decline in Alnus occurs at 335 cms. although it is not clear why Alnus should decline at this level. Perhaps conditions on the bog surface were becoming more favourable for other tree spp. allowing these to invade the former Alder carr. In general terms the woodland becomes more mixed after the decline in Alnus, and Coryloid appears to become more important. Some open or disturbed ground must have been present throughout sub-zones NY 1 - NY 3 because of the appearance of Plantago lanceolata and occasional other ruderal types. The only difficulty in explanation is presented by the presence of cereal pollen grains at several levels during these sub zones. It is difficult to ascertain from the available evidence where cereal crops could have been growing. There appears to be a general expansion of N.A.P. types after the decline of Alnus but this may be due to the partial removal of the swamping effect created by so much locally produced Alnus pollen.

Towards the end of sub-zones NY 1 - NY 3 the woodland suffers a serious decline with a rapid fall in tree and shrub pollen and accompanied by a reciprocal rise in Calluna, Gramineae, Cyperaceae and many of the herbaceous spp. as well as spores. The decline is really two phased as after an initial decline there seems to be some regrowth of trees and shrubs and then a second and more forceful decline reducing trees and shrubs to very low levels.

Sub-zone NY 4

The pollen spectra immediately after the sub-zone NY 3/NY 4 boundary shows a situation very similar to that of today with very low tree and shrub percentages and high N.A.P. values. At the same time the effects of such a wholesale clearance appears to have produced a reaction on the surface of the bog itself. The removal of woodland and shrubs from around the bog may have increased run off into the bog and resulted in a smear of silt being deposited across the surface. Perhaps the resultant increased wetness is also shown by the very rapid expansion of Sphagnum together with the appearance of Sparganiaceae.

The phase of maximum clearance appears to be short lived and is followed by limited regeneration of trees and shrubs probably on the steeper and less agriculturally useful parts of the dale. The curves of the major tree and shrub spp. show gradual expansions and declines without indicating major clearances or regeneration although at about 140-150 cms. regrowth of Betula and Coryloid around the site must have reached a fairly high level. However, the importance of N.A.P. types and in particular Gramineae, Cyperaceae and Calluna throughout the sub-zone should not be underestimated and certainly the overall dominance of heath and open land is not challenged by regeneration of trees and shrubs.

The final clearances at the end of the sub zone are associated with the reduction of Betula, Quercus, Alnus and Coryloid, and the expansion once more of Calluna and ruderals. The area must have taken on an appearance at this stage which was very similar to that at the present day.

Sub-zone NY 5

This period is notable for its relatively low values of tree and shrub pollen although there is a certain amount of regeneration after the final decline of sub-zone NY 4. There appears to be yet a further decline in trees and shrubs almost at the present surface of the bog but this may be the result of the swamping effect of sedge pollen which reaches nearly 90% of total pollen. At the present day the sedges form an important constituent of the bog vegetation although perhaps not enough to be so significant in the pollen rain. The greater representation of trees such as Pinus, Ulmus and Fraxinus may be linked with afforestation schemes. The peak of Prunus/Sorbus pollen at 2 cms. shows a situation which could be continued to the present day where several bushes of Sorbus aucuparia grow around the bog. Similarly the expansion of Pteridium near the top of the diagram may show the early stages of bracken infestation which now affects much of the landslip complex.

D. Loose Howe

Grid Reference : NZ / 703009

Height above Ordnance Datum : 1410 feet (430 metres)

Depth of sampled profile : 198 cms.

Method of sampling : Russian borer.

Stratigraphy : (cms.)

0 - 7	Fresh rootlet peat; mainly *Calluna*.
7 - 9	Orange fibrous band of unhumified monocot peat.
9 - 102	Mid-brown monocot peat, light in colour and finer at the top becoming more fibrous and darker with depth. Pieces of charcoal throughout.
102 - 137	Mid-brown monocot peat with some *Eriophorum* fibres and some charcoal.
137 - 153	Dominantly *Eriophorum* peat with some monocot.
153 - 184	Monocot peat with *Eriophorum* remains. Black bands (cf charcoal) at 165, 171, 174, 182-3 cms.
184 - 194	Dark grey brown amorphous peat (with cf charcoal bands at 187 and 194 cms.) grading into :
194 - 198	Dark brown minero-organic material.

Tip of borer in impenetrable orange brown sand at 213 cms. and solid rock at 223 cms. discovered by using borer rods only.

Present day vegetation : *Calluna* dominated moorland with very little *Sphagnum* and *Empetrum* together with some mosses (cf Hypnum).

Introduction

The site is on one of the highest points of the moors, and is situated only a matter of 150 - 200 metres due north of the Bronze Age barrow of the same name (Plate 6). The base of the profile illustrates a very compact zonation and this will be discussed in detail below.

Zones VI and VIIa and the Ulmus Decline

This is one of the two blanket peat sites proper that has something of a zone VI pollen assemblage at the base. In this instance there is only one counted level that displays a suggested zone VI pollen assemblage and for this reason a separate zone is not recognized. The dominant tree appears to be Alnus although it is followed closely by Pinus and it could be argued that this indicates a time very close to the Boreal-Atlantic transition. However, it is Coryloid which dominates both the total tree and total pollen counts and must have been the major plant sp. at the site. N.A.P. values are relatively high and with Coryloid must have combined to form a scrub with occasional patches of open heath. Tree pollen percentages are low, comprising only 2.5% of total pollen, although how much this is a result of the superabundance of Coryloid pollen is difficult to judge. The peak of Filicales is similar to that found in the minero-organic material at other sites, for example, White Gill and Glaisdale Moor.

On the present pollen diagrams there are only two levels where a zone VIIa type pollen assemblage is recorded. Within these two levels there is an indication of a usual VIIa

Plate 6 General view of the moorland leading up to Loose Howe

LOOSE HOWE

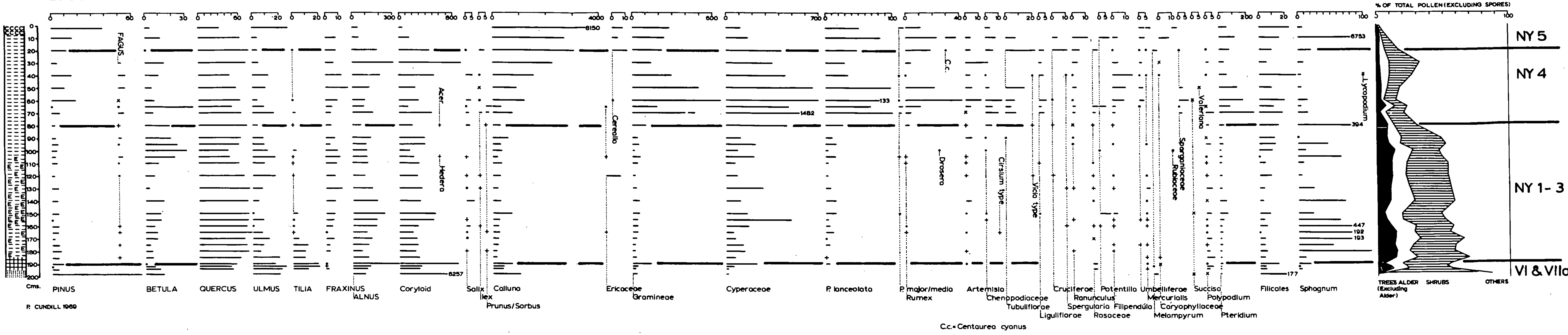

PINUS
FAGUS
BETULA
QUERCUS
ULMUS
TILIA
FRAXINUS
ALNUS
Coryloid
Acer
Hedera
Salix
Ilex
Prunus/Sorbus
Calluna
Ericaceae
Cerealia
Gramineae
Cyperaceae
P. lanceolata
P. major/media
Rumex
C.c.
Drosera
Artemisia
Chenopodiaceae
Tubuliflorae
Cirsium type
Liguliflorae
Vicia type
Cruciferae
Ranunculus
Spergularia
Potentilla
Filipendula
Rosaceae
Umbelliferae
Mercurialis
Sparganiaceae
Rubiaceae
Coryophyllaceae
Melampyrum
Succisa
Valeriana
Polypodium
Pteridium
Filicales
Sphagnum
Lycopodium
% OF TOTAL POLLEN (EXCLUDING SPORES)
TREES ALDER (Excluding Alder)
SHRUBS
OTHERS
NY 5
NY 4
NY 1- 3
VI & VIIa
Cms.
P. CUNDILL 1969
C.c.= Centaurea cyanus

fig. 24 Loose Howe pollen diagram.

Percentages of total tree pollen.

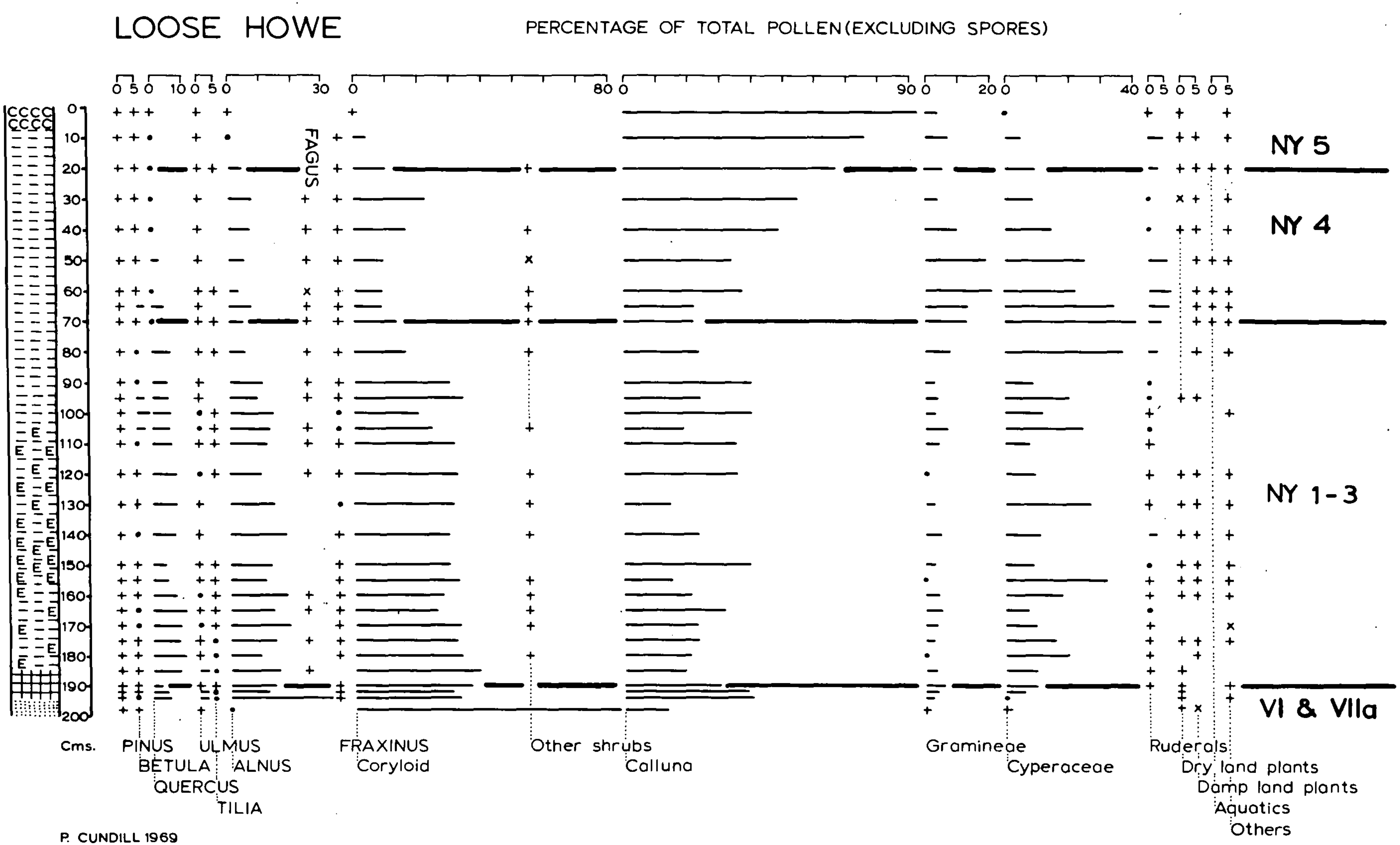


fig. 25 Loose Howe pollen diagram. Percentages of total pollen.

woodland with Quercus, Ulmus, Tilia and Alnus together with a considerable amount of Coryloid. At the same time Calluna percentages are very high comprising some 40% of total pollen which perhaps indicates that the woodland did not have a completely closed canopy. In connection with this latter suggestion finds of charcoal are abundant at the base of the peat showing that fire must have periodically affected the woodland. Whether or not this fire was connected with the activities of man is discussed in more detail in Section III.

The position of the Ulmus decline as shown on the present diagrams has taken into account a number of factors. The decline usually occurs before the first appearance of Fagus and commonly at the highest peak of Tilia on the diagrams from the central watershed. Furthermore at the Ulmus decline on the present diagrams there is a general reduction in woodland and the first appearance of ruderals such as Plantago lanceolata and Rumex. Calluna, Gramineae and Cyperaceae also exhibit peaks at this level, as does Coryloid.

Zones VIIb and VIII

A number of problems exist in the sub division of the pollen diagrams during the early phases of zones VIIb and VIII. While there are a number of indications of episodes which might be equivalent to sub-zones NY 1-3, in the absence of clear evidence these three sub zones are grouped together on the present diagrams.

Sub-Zone NY 1 - 3

Once the Ulmus decline is over the woodland reverts to a relatively stable position with Quercus and Alnus as the dominant trees while Ulmus and Tilia values fluctuate rapidly.

The peat proper started to accumulate at a rapid rate during this period so the previous compaction of zones ends very quickly. Percentages of Calluna and Gramineae are reduced after the Ulmus decline as the woodland recolonized areas that were cleared. Some disturbed ground is still present as indicated by the persistence of a few ruderals such as Plantago lanceolata.

There appears to be a general change in vegetation between 140 cms. and 160 cms. when there is a reduction in trees and shrubs and an expansion of N.A.P. types, possibly indicating a minor phase of clearance. The effects of this clearance may be shown by the expansion of ruderals and the appearance of some ruderal spp. not seen before, such as Liguliflorae, Plantago major/media, Chenopodiaceae. It may also be shown by an increase in Calluna, a decline of Ulmus and Quercus, and an expansion of Pteridium. N.A.P. types at this stage represent 50% of total pollen although in general terms the clearance phase is not a marked one.

A further stage of expansion of trees and shrubs follows the minor clearance phase. The expansion is mainly in terms of Quercus and Alnus although Betula begins to play a more important role in the woodland. The presence of charcoal in the stratigraphy of this period would seem to suggest that although there was no widescale effort to clear the woodland some burning was being carried out perhaps in order to increase the area of grassland or simply as an aid to hunting. This form of manipulation of the environment continued until the end of sub-zones NY 1 - 3 when a really massive clearance of woodland began.

Sub-zone NY 4

The clearances of this phase, although of a widespread nature are very gradual at the present site when compared with the same period at other sites. There appears to be a pattern of expansion and then decline amongst the N.A.P. types as the clearance period progresses. Initially Cyperaceae expands and reaches a peak and is followed very rapidly by Gramineae which does not reach the same level. Later both these pollen types decline and are replaced by Calluna. This process can be seen most clearly in the total pollen diagram. An explanation of this process may be that as the clearance progressed, greater run off of rainwater ensued through the removal of trees and shrubs. There may have been an increase in the number of damp hollows and flush sites as a result of this, encouraging members of the Cyperaceae family to expand in numbers. On the better drained ridges, habitats may have been suitable for the growth of Gramineae. However, in the long term impoverishment of the soils through grazing and the continuation of burning may have led to the rapid increase in Calluna.

The trees and shrubs are reduced to low levels by the clearances although percentages remain sufficiently high for the suggestion that some remnants of woodland survived on the steeper slopes of Rosedale. Most of the reduction in tree and shrub pollen percentages must reflect the widescale removal of woodland in Rosedale itself. Quercus, Alnus, Betula and Coryloid are the major types affected by the clearances. At the same time there are indications of some increases in percentages of Pinus, Fagus and Ulmus pollen perhaps due to the more regional nature of the pollen rain after the clearances.

While tree pollen percentages remain at low levels after the full impact of the clearance phase there was some regrowth of Coryloid scrub possibly on the upper slopes of Rosedale. This regrowth of shrubs does not appear to have affected the expansion of *Calluna* and quite clearly on the whole the area must have taken on an appearance very similar to that of the present day by the end of the sub-zone.

Sub-zone NY 5

This period is one of final removal of woodland and shrubs and total domination of *Calluna* in the pollen spectrum. The final removal of woodland may have been due to the policy of moorland burning undertaken to encourage the growth of *Calluna* as food for grouse and sheep. At the same time agriculture within Rosedale appears to have become more important as shown by the increased percentages of Cerealia pollen and the pollen of spp. associated with agriculture (e.g. *Centaurea cyanus*).

E. Yarlsey Moss

Grid Reference : NZ / 762005

Height above Ordnance Datum : 1060 feet (323 metres)

Depth of sampled profile : 213 cms.

Method of sampling : Russian borer

Stratigraphy : (cms.)

0 - 7	Fresh rootlet *Calluna* peat.
7 - 83	Mid-brown monocot peat with occassional *Eriophorum* remains.
83 - 87	Light brown *Sphagnum* peat.
87 - 94	Mid-brown monocot/*Sphagnum* peat.
94 - 97	Light brown *Sphagnum* peat.
97 - 102	Mid-brown monocot/*Sphagnum* peat.
102 - 213	Mid-brown monocot peat with occassional *Eriophorum* remains.

Borer hit impenetrable rock base at 228 cms.

Present day vegetation : Dominantly *Calluna* with a little *Sphagnum* in wet hollows and some other mosses(e.g. *Hypnum*) growing beneath the *Calluna*.

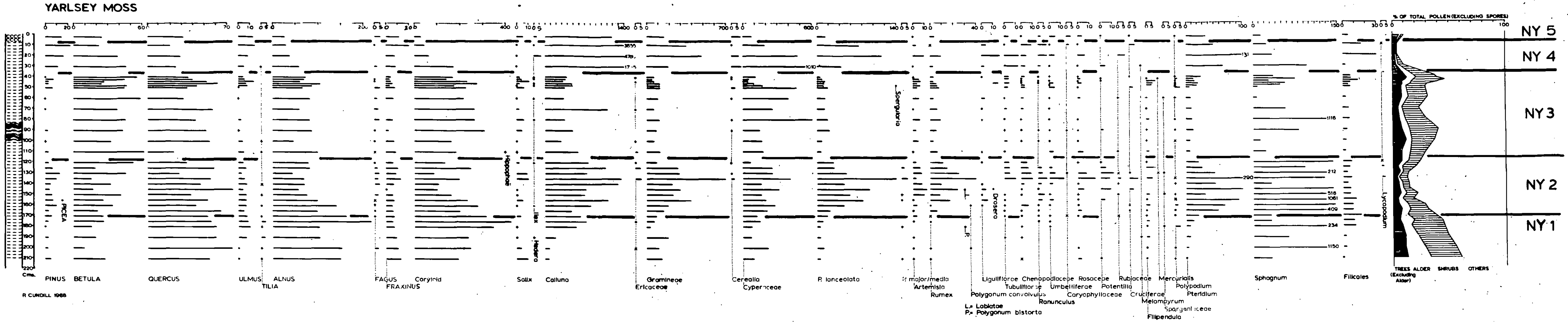
Introduction

The site is on a ridge of the moors and overlooks Wheeldale Gill which is several hundred metres to the south. The site does provide some comparisons with that at Wheeldale Gill although there are problems in that the two sites do not cover the same time span.

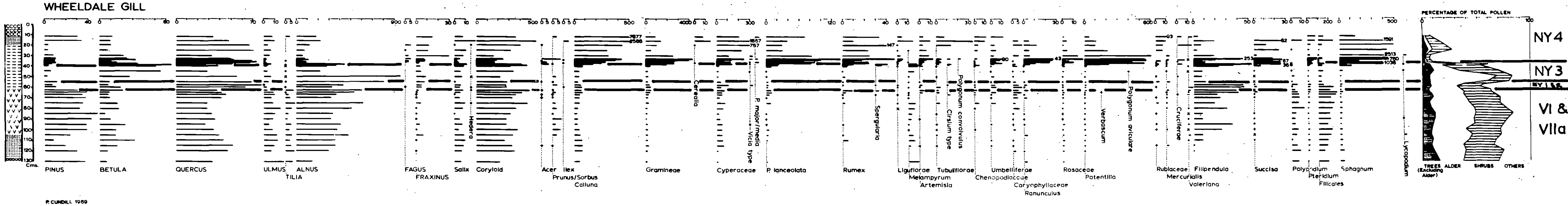
Zones VIIb and VIII

The base of the profile would appear to be some time in early zone VIIb from the appearance of *Fagus* and the very low

YARLSEY MOSS



WHEELDALE GILL



UPPER: fig. 26   Yarlsey Moss pollen diagram.
Percentages of total tree pollen.

LOWER: fig.33   Wheeldale Gill pollen diagram.
Percentages of total tree pollen.

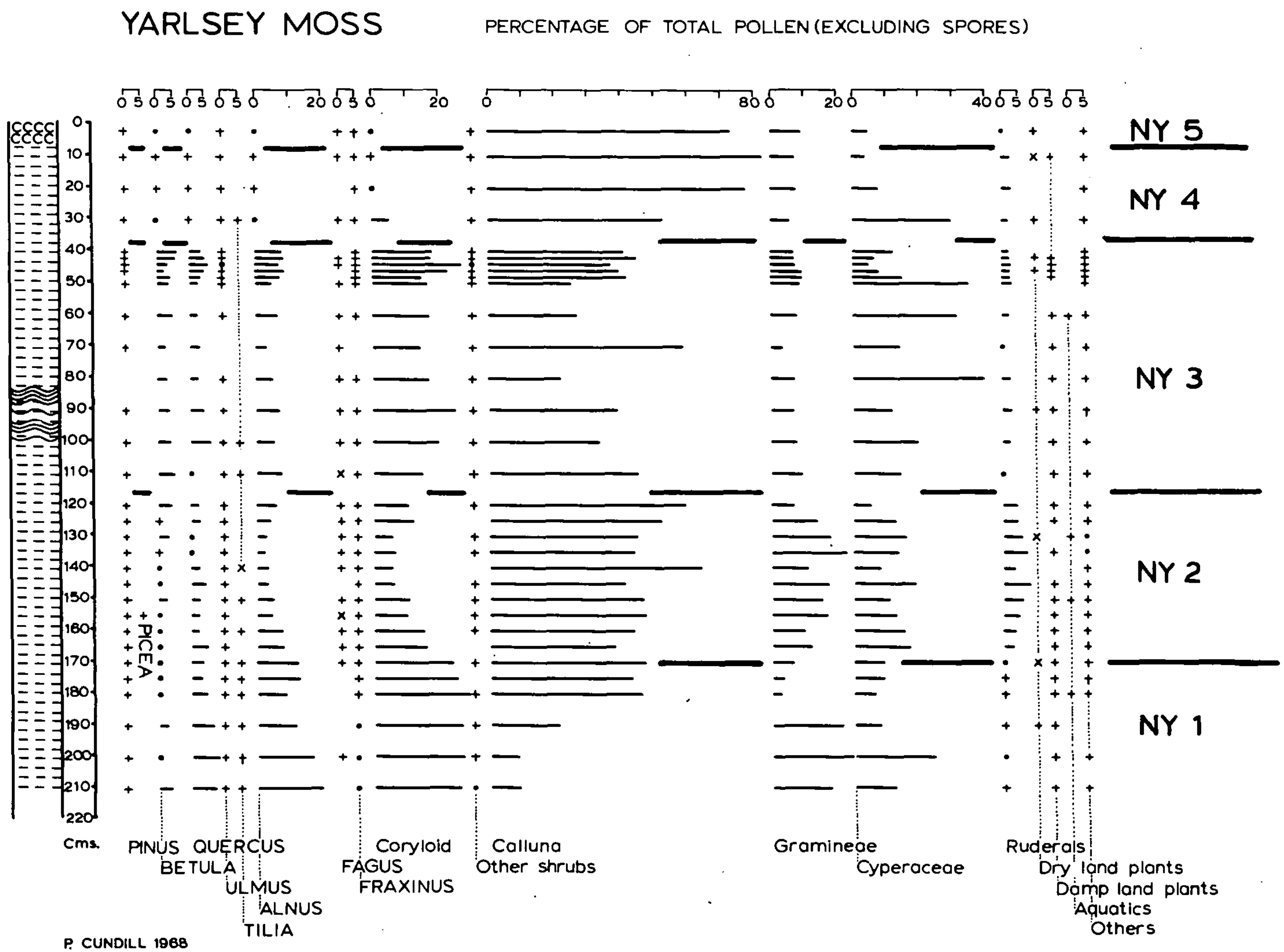


fig. 27 Yarlsey Moss pollen diagram. Percentages of total pollen.

percentages of *Ulmus* and *Tilia*. Exactly how close the base is to the *Ulmus* decline is not clear from the available evidence.

Sub-zone NY 1

The beginning of this period is notable for the high tree and shrub values although even at this early stage N.A.P. values are already 45% of total pollen. The woodland at this time consisted mainly of *Quercus*, *Alnus* and *Betula* with some *Fraxinus* although from the high N.A.P. values it is clear that existing woodland must have been patchy on the moorland ridges. The N.A.P. types are dominated by Gramineae, *Calluna* and Cyperaceae, and the presence of ruderals (e.g. *Plantago lanceolata*, *Artemisia*, Chenopodiaceae.) indicate that some disturbed ground existed as well. The high levels of N.A.P. may indicate the effects of man on the woodland of the area from *Ulmus* decline times onwards or even earlier (Section III).

Coryloid provides the dominant shrub of the period although like the trees it appears to gradually decline with time. Perhaps the non-expahsion of trees and shrubs was due to the effects of increased dampness or increased grazing pressure or even the continued use of fire by man. However, no charcoal is found within the stratigraphic remains attributed to this period so there is no direct support for the latter suggestion.

Amongst the N.A.P. types Gramineae initially expands although it is quite rapidly followed by *Calluna* which reaches 40% of total pollen by the end of the sub-zone.

Sub-zone NY 2

This is a period remarkable for the length of continuous disturbance of the environment by man. The period is marked by a major decline in tree and shrub pollen values accompanied by a rapid expansion of a wide range of N.A.P. types. The decline in trees is seen mainly in a reduction of Alnus and Quercus, and probably on the ground this was the result of the pushing back of trees and shrubs towards the Wheeldale Gill valley.

There are really three minor clearance phases within the major clearances of sub-zone NY 2 and these reach a peak at 136 cms, 146 cms. and 156 cms. They appear to be much the same in nature and are connected with the removal of woodland by fire, charcoal being found predominantly at these levels in the macroscopic remains. At 136 cms, cereal pollen grains appear for the first time and as these are linked with increased percentages of Tubuliflorae and Chenopodiaceae it seems probable that some grain crop production was being carried out nearby. The greatest expansion of ruderals is amongst Plantago lanceolata and Rumex which are more allied to pastoral farming and this was probably the major form of agriculture practiced during sub zone NY 2. Gramineae and Pteridium also reach peaks at 136 cms further indicating the intensity of clearance at this level. The 146 cms and 156 cms clearance phases do not have such significant increases in ruderal pollen and are only distinguished from the general level of clearance by minor peaks of Plantago lanceolata, Rumex, Gramineae and Pteridium. The single grain of Picea at 156 cms is not regarded as significant as it is likely that this is a product of long distance wind transport. Similarly the peaks of Pinus in the tree pollen sum diagram may be more a reflection of reduced filtration due to reduced tree and shrub cover, that is, producing a more regional pollen spectra rather than an actual increase in the sp. As the general clearance phase comes to an end some slow regeneration of trees and shrubs mainly Betula, *Quercus*, *Alnus* and Coryloid, takes place.

Sub-zone NY 3

The woodland during this period is mainly composed of *Quercus*, *Alnus* and *Betula* with Coryloid as the main shrub. The woodland does not recover sufficiently after the clearances of sub-zone NY 2 to reach the levels recorded in early sub-zone NY 1 and probably the bulk of the woodland was situated in the valley of Wheeldale Gill. Two minor declines in the tree and shrub pollen curves occur at 50 cms and 70 cms and these are accompanied by peaks in ruderals. Quite possibly these levels reflect clearance phases but as the changes in the pollen curves are of a fairly minor nature the clearances may not have been great or alternatively they may have been distant from Yarlsey Moss. Occasional Cerealia type pollen grains are found within sub-zone NY 3 although these may be the result of long distance wind transport of pollen. At this point in time the peat had reached a reasonable thickness, in excess of one metre, and probably the site was already an open blanket bog with a mixture of *Calluna*, Gramineae and Cyperaceae covering the greater part of its surface.

Towards the end of the sub-zone there is an odd and quite marked rise in tree and shrub pollen which must have come about by a reduction in the influence of man in the immediate area, allowing trees and shrubs to approach more closely to the site than for a very long time previously.

Sub-zone NY 4

The peaks in tree and shrub pollen at the end of sub-zone NY 3 quickly change to a very sharp decline at the opening of the present phase. It is the woodland spp which recover after the sub-zone NY 2 clearances (i.e. *Alnus*, *Betula*, *Quercus* and Coryloid) which are affected the most, and only remnants of woodland must have survived in the Wheeldale Gill valley after the present clearance. This clearance was certainly on a large scale as is shown by the expansion of almost every N.A.P. type, and in particular Calluna. The latter sp. reaches in the region of 80% of total pollen and this continues more or less up to the present day surface of the bog. Cyperaceae initially expand but this increase is not sustained. The ruderals also increase but do not reach the levels recorded during the sub-zone NY 2 clearances. Perhaps this is because the pollen of these spp. now has to travel further to reach the site. Cerealia type pollen grains are also recorded as clearance progresses although it is probable that these grains are the product of long distance transport as the heather nature of the moorland surrounding the site makes a local source of cereal pollen unlikely.

Sub-zone NY 5

This is a minor phase at the top of the diagrams when there is a slight expansion in trees and in particular Pinus, Quercus, Betula and Ulmus. Changes in N.A.P. are slight although there is a trend towards a reduction in the number of spp. perhaps as a result of moorland management for grouse and sheep.

F. Howdale Hill.

Grid Reference : NZ / 646021

Height above Ordnance Datum : 1330 feet (405 metres)

Depth of sampled profile : 68 cms.

Method of sampling : Russian borer.

Stratigraphy : (cms.)

0 - 6	Fresh surface rootlet peat, Eriophorum and Calluna.
6 - 50	Mid-brown monocot peat with some Eriophurum
50 - 68	Mid-brown monocot peat becoming finer and more amorphous than 6 - 50 cms.

At 83 cms. borer point in impenetrable sandy material.

Present day vegetation : dominantly Calluna with some Eriophorum angustifolium, Sphagnum and Erica tetralix.

Introduction

The site is on a long ridge immediately to the east of White Gill, and helps to provide a link between the White Gill site and the sites at St. Helena, Blakey Landslip, Loose Howe and Trough House in addition to the site examined by Dimbleby at Ralph Cross. The profile covers the more recent phase up to the present day which is missing from the analysis at White Gill. The peat at the site at the present day still appears to be accumulating as Sphagnum and Eriophorum are quite abundant within the mass of the more commoh Calluna. The profile is not very deep when compared with many of the sites from the moors, although it does still provide useful and interesting pollen data. Several borings were made in the

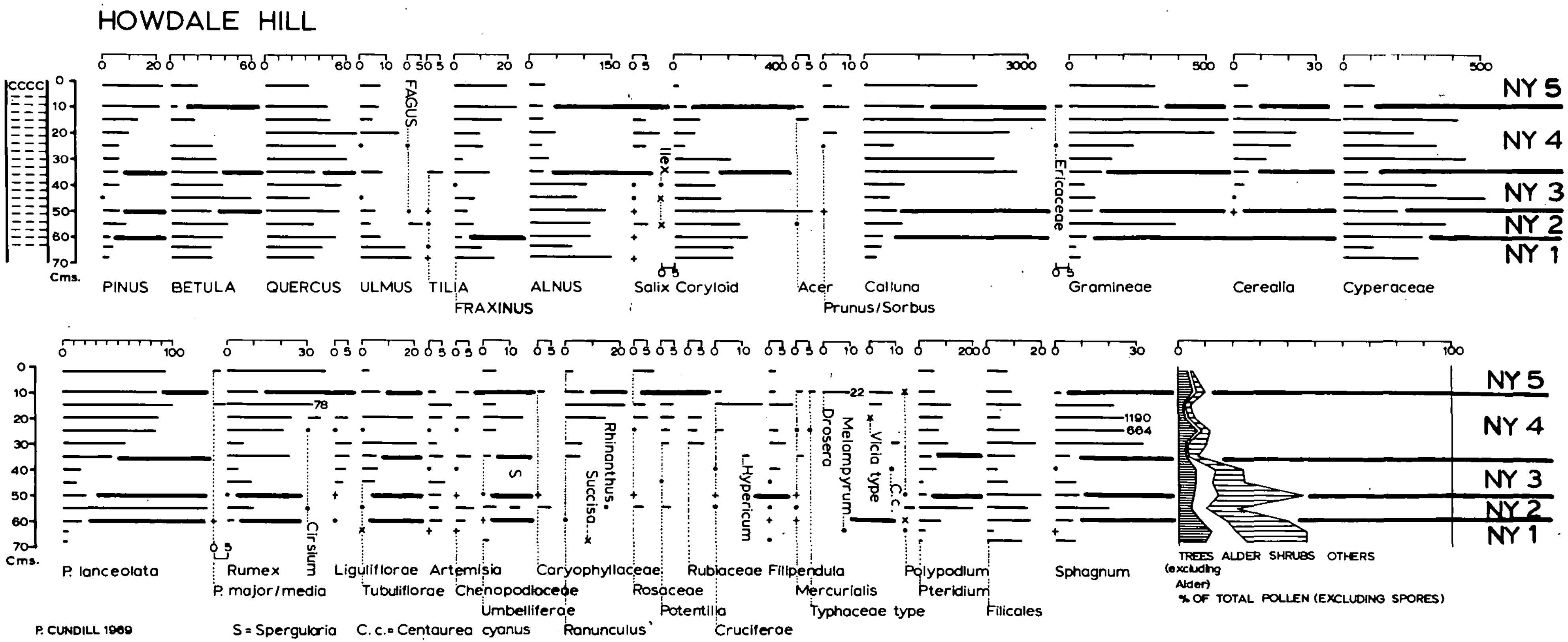


fig. 28 Howdale Hill pollen diagram. Percentages of total tree pollen.

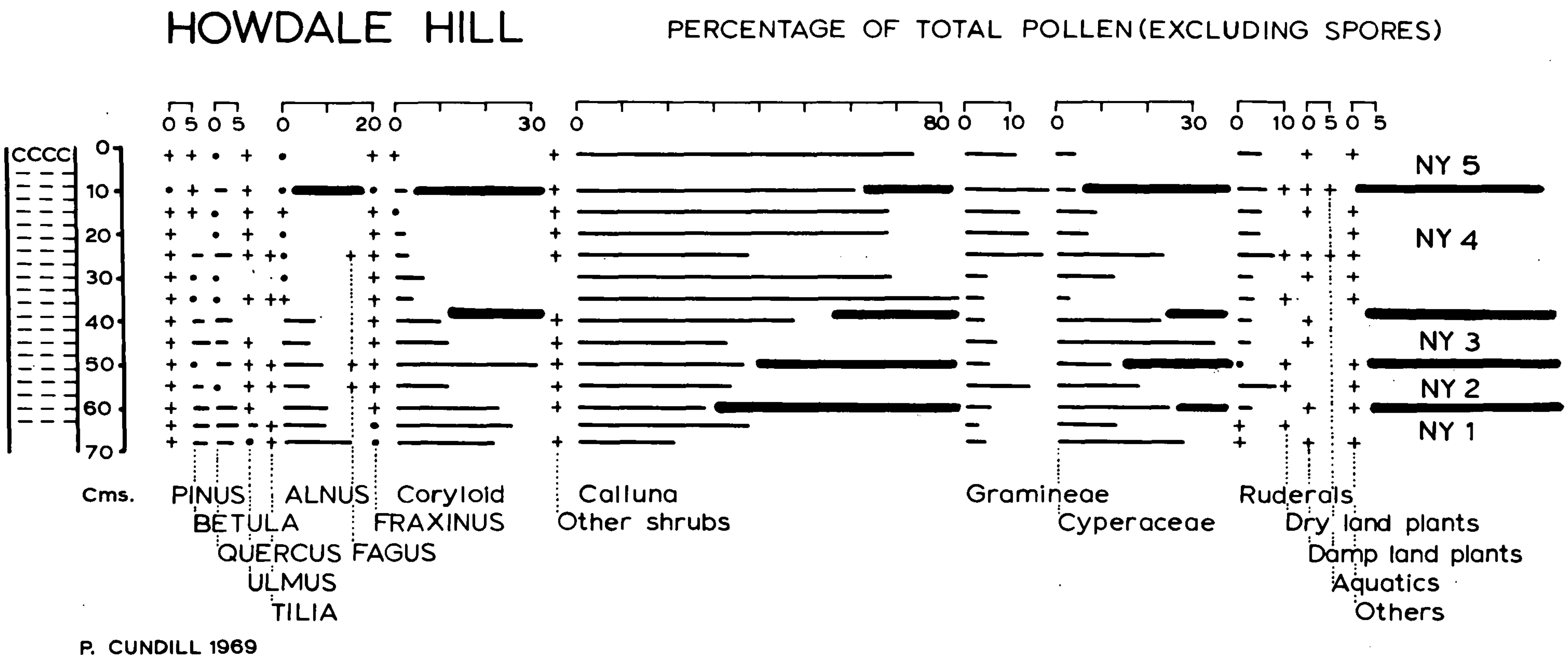


fig. 29 Howdale Hill pollen diagram. Percentages of total pollen.

small peat mass at Howdale Hill but no depth of peat greater than that of the analysed profile was encountered.

The diagrams are difficult to zone as there are few of the traditional features of pollen diagrams such as the Ulmus decline. Something of a comparison with White Gill may be made and some of the features of the two profiles are similar. A tentative scheme of zonation is outlined below.

Zones VIIb and VIII

Sub-zone NY 1

The base of the profile illustrates a pollen spectrum which indicates that trees, mainly *Quercus*, *Betula* and *Alnus*, still command an important role in the vegetation at that time. However, even though *Ulmus* percentages are fairly high, *Tilia* appears only at low levels and this lends support for dating the base as zone VIIb. In addition N.A.P. types are very high from the start and include a few ruderal spp. which would seem to suggest that some opening up of the landscape had already begun. All in all the indications would seem to favour a VIIb date for the inception of peat growth, although this tentative date can only be confirmed by radio-carbon dates. Sub-zone NY 1 occupies only a narrow band in the profile before a major vegetation change occurs.

Sub-zone NY 2

This period is properly indicated by only one counted level at 55 cms. However, the change in vegetation is quite marked and of a similar nature to the sub-zone NY 2 recognized from White Gill. The period is one of clearance of woodland with the greatest effects being felt by *Quercus*, *Ulmus* and

Coryloid. At the same time there is a massive expansion of N.A.P. types, particularly Gramineae and _Plantago lanceolata_. _Calluna_ percentages were already high from sub-zone NY 1 and do not show much in the way of change during the clearance phase. _Tilia_ disappears at 55 cms. a feature recognized for sub-zone NY 2 at a number of sites on the central watershed. Fire probably played a major part in the clearance of woodland as charcoal remains are found throughout the profile. The woodland which was cleared may have been on the more sheltered slopes immediately below the summit of the Howdale Hill ridge, the ridge itself probably appearing as a heathy open area.

Sub-zone NY 3.

The clearance phase of sub-zone NY 2 is only short-lived and some active regeneration takes place afterwards. This regeneration is seen mainly in terms of _Quercus_, _Alnus_ and Coryloid and the woodland reaches almost pre-decline levels. At the same time N.A.P. types are rapidly reduced although _Calluna_ remains in a very strong position. However, this situation does not persist for very long as Coryloid soon begins a fairly sharp decline which allows N.A.P. types to recover their importance. The reduction of Coryloid may be due to shrub clearance by fire around the edge of the remaining woodland, as the major tree types are not immediately affected in the same way as Coryloid. Initially it seems that Cyperaceae and a host of ruderal pollen types expand to fill the gap left by Coryloid. At this point _Cerealia_ type pollen also appears for the first time, although it is not until 30 cms. that it reaches significant proportions. The placing of the sub-zone NY 3 - NY 4 boundary is very difficult although the level chosen coincides with the final decline in Alnus and the large scale expansion of ruderals, e.g. Plantago lanceolata, Rumex, Tubuliflorae.

Sub-zone NY 4

Tree pollen during the early part of this phase is reduced to the very low level of 5% of total pollen. Clearly the phase is one of almost total removal of the remnants of woodland. The period was one of increased agricultural activity which may be illustrated, by the high percentages of Cerealia and associated pollen types (e.g. Centaurea cyanus) which probably travelled from Farndale to the present site. At the site Calluna expands very markedly at the NY 3 - NY 4 boundary and seems to take over some of the importance of Cyperaceae after the initial expansion of the latter in the early stages of clearance. The landscape at the time must have been similar to that at the present day with Calluna dominating the vegetation; Calluna percentages reach 85% of total pollen at 35 cms. The continuation of grazing and burning would have allowed Calluna to remain the dominant sp., and prevented the regeneration of trees and shrubs except in a few favourable areas such as the sides of the dales.

Sub-zone NY 5

This is recognized as a fairly short and fairly recent period when there appears to be a marginal decline in agriculture, a slight re-expansion of woodland mainly in terms of Quercus, and the first signs of the modern monoculture practiced on the moors. This has resulted in the decline in number of spp. present, especially N.A.P. types, and the final overall dominance of Calluna. The recent nature of the period is perhaps also shown by the expansion of Pinus and Fraxinus, possibly indicating the policy of re-afforestation practised in the last two centuries. The count at 2 cms must closely approximate to a contemporary pollen spectrum from the area and allows the continuation of the vegetation history right up to the present day.

G. Glaisdale Moor

Grid Reference : NZ/728015

Height above Ordnance Datum : 1220 feet (372 metres)

Depth of sampled profile : 131 cms.

Method of sampling : Peat blocks (see below)

Stratigraphy : (cms.)

0 - 75	Mid-brown monocot peat
75 - 129	Mid-brown monocot peat with abundant wood remains (mainly *Betula*)
129 - 130	Minero-organic material which rapidly grades into pure mineral material (orange in colour) at base.

Present day vegetation : Dominantly *Calluna* on an eroding peat area. Frequent and large areas completely devoid of vegetation.

Introduction

The material for analysis was collected by Mr. J. Bartlett, curator of Hull Museums and was kindly made available in November 1967. The site is one where a number of flint implements of Mesolithic character were discovered on the surface of the peat. The distribution of the flints was noted and a pit dug in order to obtain a peat profile for pollen analysis. Peat blocks, three in number, were excavated, labelled and transported to Hull where they were stored in a sealed condition in the basement of one of the Hull museums (Bartlett 1968) until removal to Durham in 1967. No flint microliths were contained within the monoliths, but one of the flints recovered from the surface of the peat had some peat adhering to it and

GLAISDALE MOOR

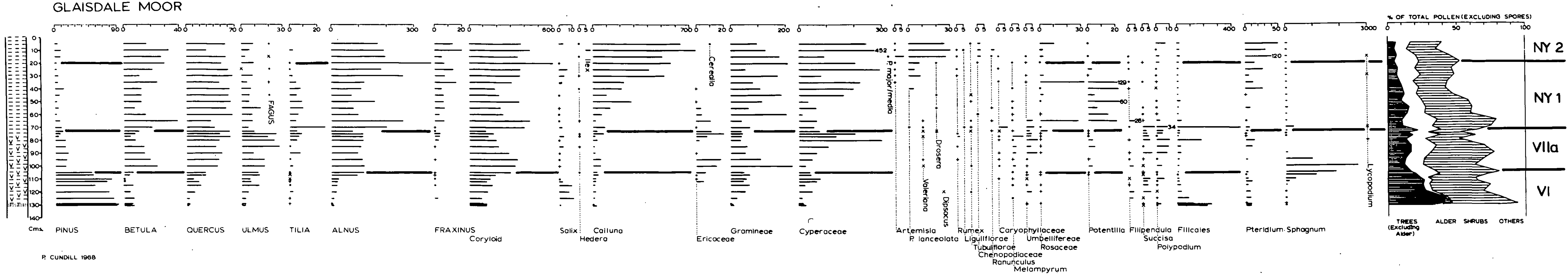


fig. 30 Glaisdale Moor pollen diagram. Percentages of total tree pollen.

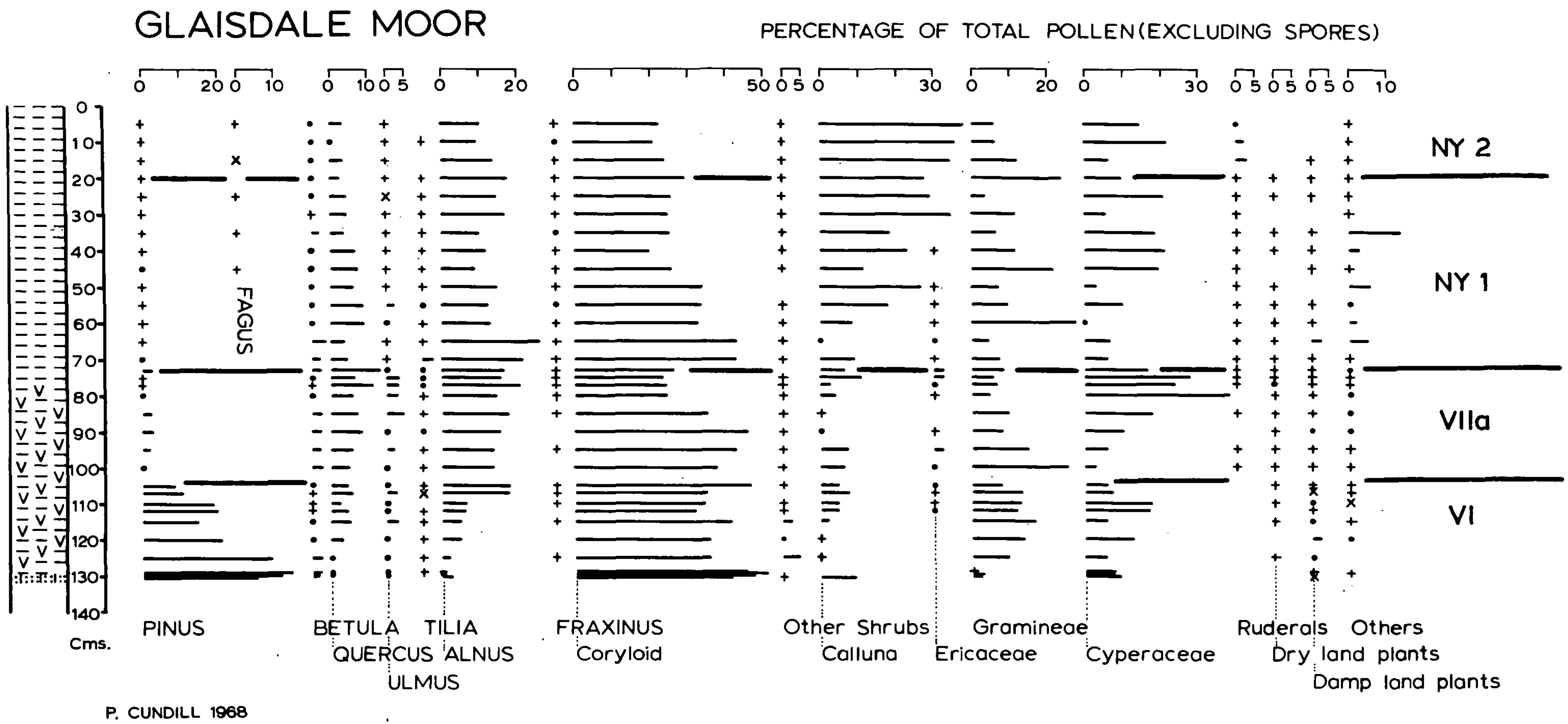


fig. 31 Glaisdale Moor pollen diagram. Percentages of total pollen.

this was analysed by Churchill at Cambridge. From the resulting pollen spectrum it was suggested that the peat was of VIIa age (Bartlett 1969).

It appears that the peat profile is not a complete one and is truncated at the top owing to the fact that the sampling area is undergoing erosion at the present day and already the upper peat over much of the area has been removed. Nevertheless the analysis of the profile shows that it is a very useful one in that it starts in zone VI and extends well into zones VIIb and VIII.

Zone VI and the Boreal Atlantic transition

This period is distinguished by its high *Pinus* values which are associated with a little *Betula*, *Quercus*, *Ulmus* and *Alnus*. The values of *Pinus* reach their highest level close to the base of the profile, in the minero-organic material, where they attain values of 90% of tree pollen and nearly 40% of total pollen. Notwithstanding the over representation of *Pinus* in the pollen rain, these are high figures, although from this point onwards they tend to decrease with *Quercus* and *Alnus* taking over from *Pinus*. As this changeover occurs there is also a change in stratigraphy from the minero organic material to a pure organic peat. The Coryloid pollen values remain at relatively constant levels throughout the part of zone VI represented on the diagrams. *Salix* percentages are at the highest level during zone VI and the decline at the Boreal Atlantic transition may be attributed either to the invasion of its habitats by the rapidly expanding *Alnus* or the filtering out of its pollen due to a more dense woodland. Amongst the

N.A.P. types Gramineae and Cyperaceae are dominant, although initially there is a peak of Calluna. The Filicales values are high during the minero organic phase but are rapidly reduced when pure organic peat starts to form. In general terms tree pollen values (mainly Pinus) gradually decline during zone VI while N.A.P. values expand. The Boreal Atlantic transition is very clear at this site and a radiocarbon date of 6250 ± 220 years B.P., GaK 2709, has been obtained for this level.

Zone VIIa and the Ulmus decline

This period is characterised by the high values of Alnus, even though it amounts to only 20% of total pollen at this site. There are also fairly high values of Quercus and Ulmus, and to a lesser extent Betula. However values of N.A.P. are surprisingly high (e.g. Calluna, Cyperaceae and Gramineae) for a VIIa woodland and when this is coupled with the sporadic appearances of grains of ruderals (e.g. Rumex and Tubuliflorae) it seems possible that there were openings within the woodland, although whether these were man made is a controversial point. Amongst the shrubs Coryloid appears to be the most important with its pollen nearing 50% of total pollen at the beginning of VIIa, although later on this is reduced.

The fluctuations of the tree pollen at and just before the Ulmus decline are exceedingly complex. There appears to be a couple of minor declines in Ulmus before the main recognized decline, but these have been disregarded on the grounds that the decline at 73-75 cms. is well marked.even on the total pollen diagram. The Ulmus decline is not strongly marked in terms of a sharp expansion in N.A.P. types and the only hints of the activity of man at this level are the occasional finds of <u>Plantago lanceolata</u>, Tubuliflorae and Liguliflorae pollen. It is possible that the Glaisdale Moor site was not adjacent to a cleared area or perhaps was sufficiently open already not to register a significant clearance in pollen terms.

<u>Zones VIIb and VIII</u>

These two zones are tentatively sub divided into sub-zones NY 1 and NY 2 on the present diagrams. This means that there must have been a substantial depth of peat, covering sub-zones NY 3 - NY 5, all of which has been removed by erosion, although this suggestion could only be confirmed by radiocarbon dates.

<u>Sub-zone NY 1</u>

The period covered by this sub zone is one of gradual overall decline in woodland, although there are a number of interesting fluctuations in the tree curves. <u>Tilia</u> reaches a high level immediately after the decline in <u>Ulmus</u>, a situation regarded as quite common in the pollen diagrams from the central watershed (Section III). <u>Betula</u> and <u>Alnus</u> both expand after the <u>Ulmus</u> decline, the former possibly in response to the recolonization of cleared areas and this may also be the explanation for the expansion of Coryloid at the same time. <u>Fraxinus</u> also appears for the first time after the <u>Ulmus</u> decline as a strong and continuous curve. Values for <u>Quercus</u> and <u>Ulmus</u> fluctuate during sub-zone NY 1 but in general they both decline as the sub-zone progresses. <u>Fagus</u> appears about mid-way through the sub-zone, serving as a clear indicator of the VIIb age of the deposits. Towards the end of the period <u>Tilia</u> values decline and this appears to be one of the indicators that a clearance phase is about to start. The values of N.A.P. types fluctuate strongly during sub-zone NY 1 and while there are sporadic (or even notable in the case of Plantago lanceolata) appearances of ruderals there are no ~~shown~~ sharp indications of clearance phases. Hence the boundary between sub-zones NY 1 and NY 2 is placed where there is a significant change in pollen types.

Sub-zone NY 2

During this phase there is a notable increase in ruderal pollen types (e.g. Plantago lanceolata, Rumex) as well as an increase in the range of ruderal types. Pteridium also expands and the appearance of Cerealia type pollen must indicate man's interference with the environment. The clearance is not sharply marked in terms of a decline in trees and shrubs, but is more part of the general trend of a reduction in woodland which really commenced in sub-zone NY 1.

The truncated nature of the profile unfortunately prevents the discovery of the full ecological history of the site up to the present day.

H. Wheeldale Gill

Grid Reference : NZ / 760997

Height above Ordnance Datum : 920 feet (280 metres)

Depth of sampled profile : 127 cms.

Method of sampling : Monolith tins.

Stratigraphy : (cms.)

0 - 10	Dark brown, very dry and crumbly surface peat; dominantly *Calluna*.
10 - 20	Light brown, very dry silty peat.
20 - 60	Very dark brown and compact monocot peat with occasional fresh *Calluna* roots towards the top and *Betula* remains towards the base.
60 - 105	Wood peat with large pieces of *Betula*.
105 - 127	Light grey sand with occasional organic remains.
127 +	probably river derived gravel (rounded cobbles)

Present day vegetation : dominated by *Calluna* with some ground mosses. In an area close to the stream *Sphagnum* and *Juncus* are found in great abundance together with *Nardus stricta*.

Introduction

The site is in the valley of Wheeldale Gill at a point where the gill enters the western edge of a relatively new coniferous plantation. The sampled profile was exposed through stream erosion of the peat mass, revealing a steep cliff-like peat face. A sketch of the whole peat face is illustrated in fig. 32. The site was utilized primarily because of its proximity to Yarlsey Moss and its markedly different stratigraphy from that at Yarlsey Moss.

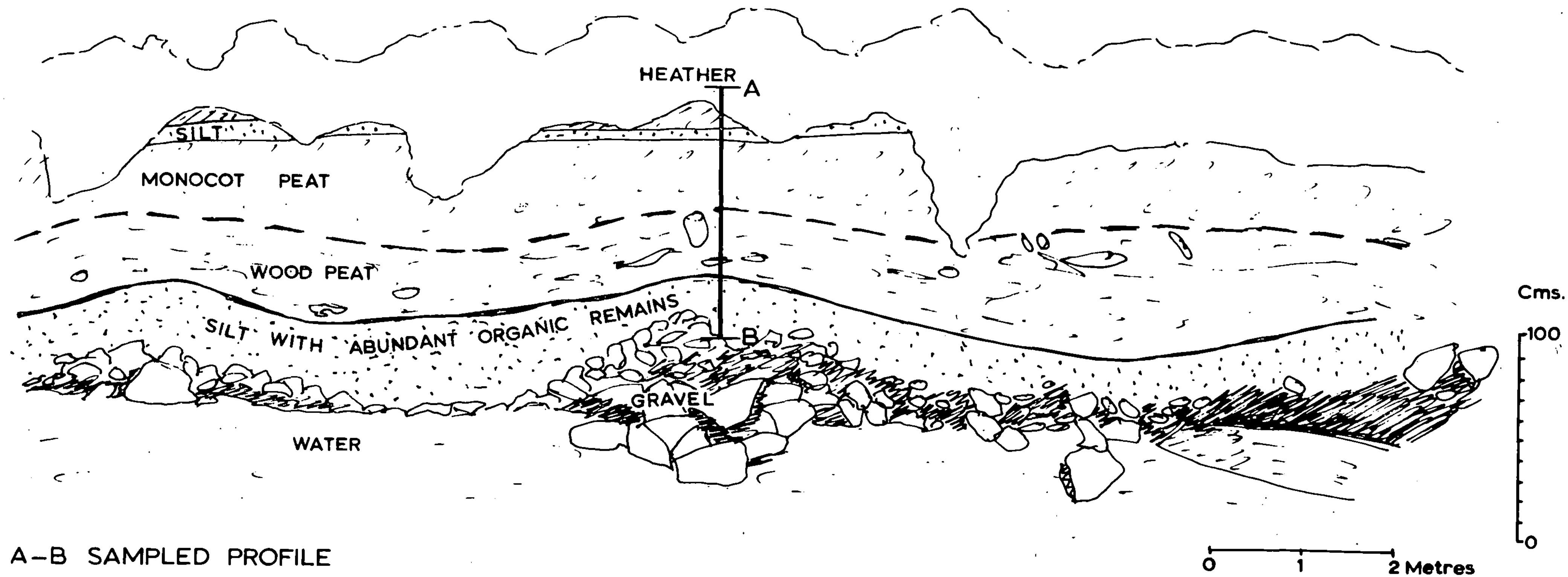


fig. 32 Sketch of peat face at Wheeldale Gill.

Zones VI and VIIa and the Ulmus decline

Most of this period sees little substantial change in the pattern of vegetation at Wheeldale Gill. The dominant tree is Alnus, the other trees, Quercus, Pinus, Betula, Ulmus and Tilia, only contributing 10% of total pollen. Pinus pollen is rather strongly represented both as a percentage of total pollen and total tree pollen, and it is mainly upon this basis that the presence of zone VI is suggested. If the Pinus percentages are aberrant and reflect a local source of pollen then the picture would be somewhat different and the pollen spectrum would fit into a zone VIIa assemblage. The difficulty with placing the lower section of the diagrams into zone VI is the high percentage of Alnus, a sp. which normally expands after the zone VI/VIIa boundary. The period could, however, be late zone VI when Alnus percentages were beginning to rise and because the site is by a stream it may have been an early centre for Alnus growth. Alnus is certainly a local producer of pollen at this site as many groups of grains were noticed during counting. A drawback to this argument may be found in the lowland eastern England sites of Bartley where Alnus does not rise until the beginning of zone VIIa (Bartley 1962, 1966). Probably the only satisfactory way of resolving the difficulty of dating this section of the diagrams would be to have a radiocarbon date for the base of the wood peat at about 100 cms.

The shrubs are dominated by high percentages of Coryloid pollen although some Salix is present and Prunus/Sorbus type forms a continuous curve throughout most of this period. It is possible that the shrubs indicate some areas of less dense woodland where they were able to flower satisfactorily. The

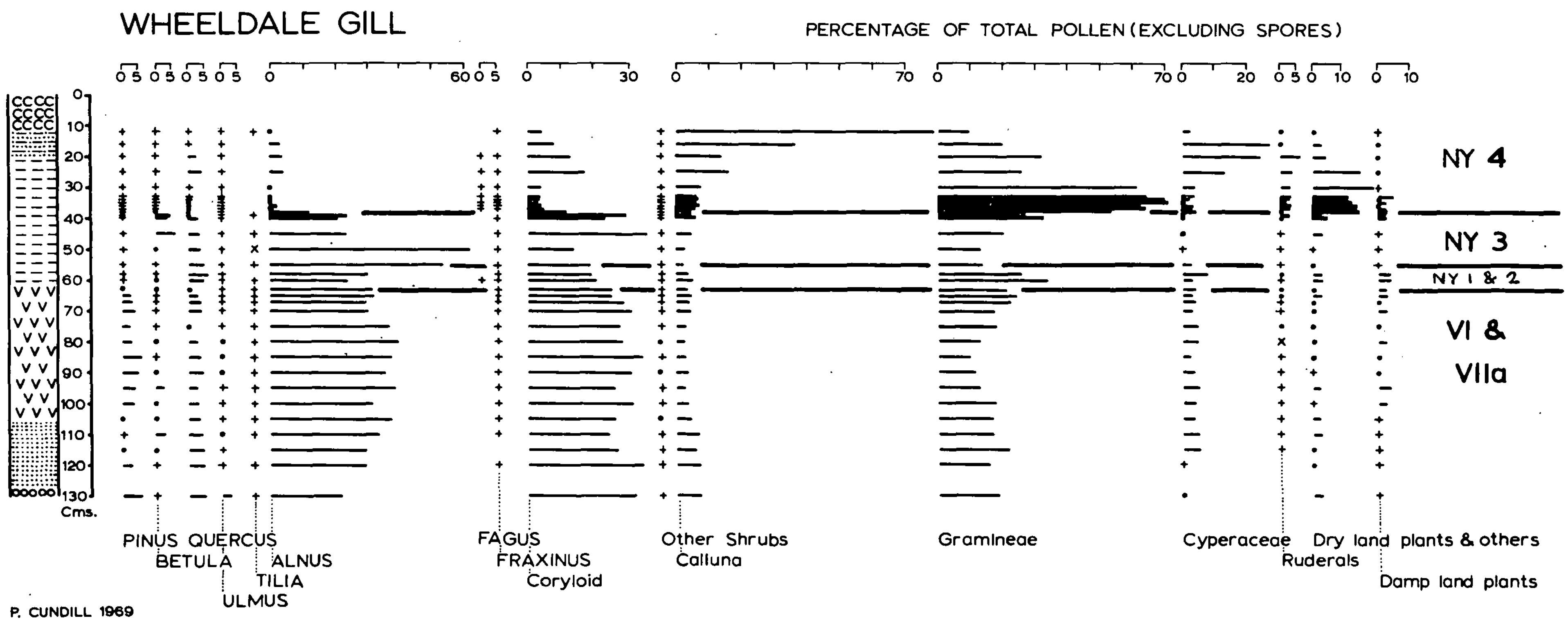


fig. 34   Wheeldale Gill pollen diagram. Percentages of total pollen.

stream may have been changing course frequently and leaving fairly open areas, a possible explanation also for the presence of ruderal pollen (for example, Plantago lanceolata, Rumex, Tubuliflorae, Ranunculus) and aquatic type pollen grains. The damp nature of the conditions is further indicated by the persistent curve for Filipendula and the finds of Juncus effusus seeds in the macroscopic remains.

The initial decline in Ulmus appears to be at about 63 cms. although at this level Pinus has not yet declined. A radiocarbon date (GaK 2712) for 60 cms. gives 3210 ± 90 years B.P. and this level is certainly post-Ulmus decline by quite a large margin if a date of around 5000 years B.P. is normally accepted for the level of the Ulmus decline in England. It could be that there was a slowing down in the rate of peat accumulation at the 60-65 cms. level and there is a change in stratigraphy from a wood peat to an amorphous peat at this level, although the change is not dramatic enough to indicate an hiatus. Placing the Ulmus decline at 63 cms. would also coincide with a temporary peak in Tilia, a feature of the Ulmus decline at some other sites in the present study, and minor peaks in Artemisia, Rumex and Plantago lanceolata, the latter three spp. perhaps indicating a limited opening of the woodland.

Zones VIIb and VIII

Sub-zones NY 1 and NY 2

These two sub-zones have been combined, as even together they form a very narrow band in the diagrams and it would be difficult to separate them on the basis of the available pollen counts.

The level of the radiocarbon date (60 cms.) of 3210 ± 90 years

B.P. (GaK 2712) is also a level of woodland and shrub decline, mainly in Alnus and Coryloid, and an expansion of N.A.P. types. It is also associated with traces of charcoal in the macroscopic remains. The date itself falls within the range of the Bronze Age, a time of great human activity in the area (Section III). It seems quite likely that the woodland of Wheeldale Gill remained more or less intact during this period.

Sub-zone NY 3

Alnus reaches a very high level at 50 cms. where it comprises 60% of all pollen. At 50 cms. and 55 cms. numbers of Alnus grains were seen in groups suggesting the very close proximity of a tree to the sampled site. The percentage of N.A.P. is reduced during this phase, possibly because of the swamping effect of Alnus pollen in the pollen rain. The very high percentages of Alnus are quickly followed by a reduction to pre-expansion levels. A general reduction in trees and shrubs is indicated although Betula and Coryloid percentages show something of an increase.

Fluctuations in the pollen spectrum for 39 and 40 cms. may reflect a compressed sequence of decline - expansion - decline of woodland seen in late sub-zone NY 3 at other sites (e.g. Blakey Landslip). It should be noted that the expansion section is mainly in terms of Alnus and Coryloid, perhaps representing a regeneration phase after the initial reduction of woodland.

Sub-zone NY 4

Trees and shrubs are reduced to very low percentages of about 10% of total pollen at the start of this period. Gramineae achieve the most spectacular rise reaching 70% of total pollen at the same time, although it is by no means the only N.A.P. type to expand at this point. The ruderals (particularly Plantago lanceolata) and Potentilla, Succisa and Sphagnum all show increases as the trees and shrubs are removed. The disforestation is clearly on a massive scale. With the opening up of the woodland Fagus and Acer appear as continuous curves for the first time.

The period of clearance is fairly short on the diagrams and is followed by a limited regeneration phase involving Quercus and Coryloid the latter reaching nearly 20% of total pollen at its peak. The N.A.P. values show a decrease mainly in terms of Ruderals, Filipendula and Potentilla. While Gramineae values show something of a fall, Calluna and Cyperaceae values are rising perhaps as a result of a gradual decrease in the quality of the soils of the area. In the end Calluna values dominate all other pollen types reaching nearly 80% of all pollen at 12 cms., clearly a situation akin to that at the present day when Calluna dominates the landscape. The tree pollen shows a regional and fairly modern (i.e. similar to contemporary samples) picture with high Pinus values, fairly high Ulmus values and the reappearance of Tilia. In general terms the landscape probably presented an open and treeless appearance at this stage with only occasional trees in the moorland valleys.

The top of the diagrams does not represent the top of the profile as the material at the top of the profile was highly oxidised and difficult to sample. No samples were taken for pollen analysis for this reason and so strictly speaking the pattern of events cannot be extended up to the present day. For this reason no sub-zone NY 5 can be recognized.

I. Basal Sites

1. Collier Gill Head

Grid Reference : NZ / 786009

Height above Ordnance Datum : 900 feet (274 metres)

Depth of sampled profile : 225 - 271 cms.

Method of sampling : Hiller borer.

Stratigraphy : (cms.)

0 - 4	Dark brown surface rootlet peat (mainly *Calluna*)
4 - 25	Light brown monocot peat with abundant *Calluna* remains.
25 - 100	Mid-brown monocot peat.
100 - 150	Mid-brown monocot peat with *Betula* wood remains at 116 and 140 cms.
150 - 190	Mid-brown monocot peat with frequent *Betula* remains.
190 - 273	Wood peat (*Betula*).
273 +	Impenetrable sand.

Present-day Vegetation : Dominantly *Calluna* recently burnt.

Introduction

The diagrams from this site are relatively easy to analyse. They cover only the lower 50 cms. of the full stratigraphy, but nevertheless they span the *Ulmus* decline and date the inception of peat growth at the site. The diagrams also provide a useful comparison with those of Simmons (1969a) from a site at Collier Gill several hundred metres downstream but within the same peat mass (fig.4).

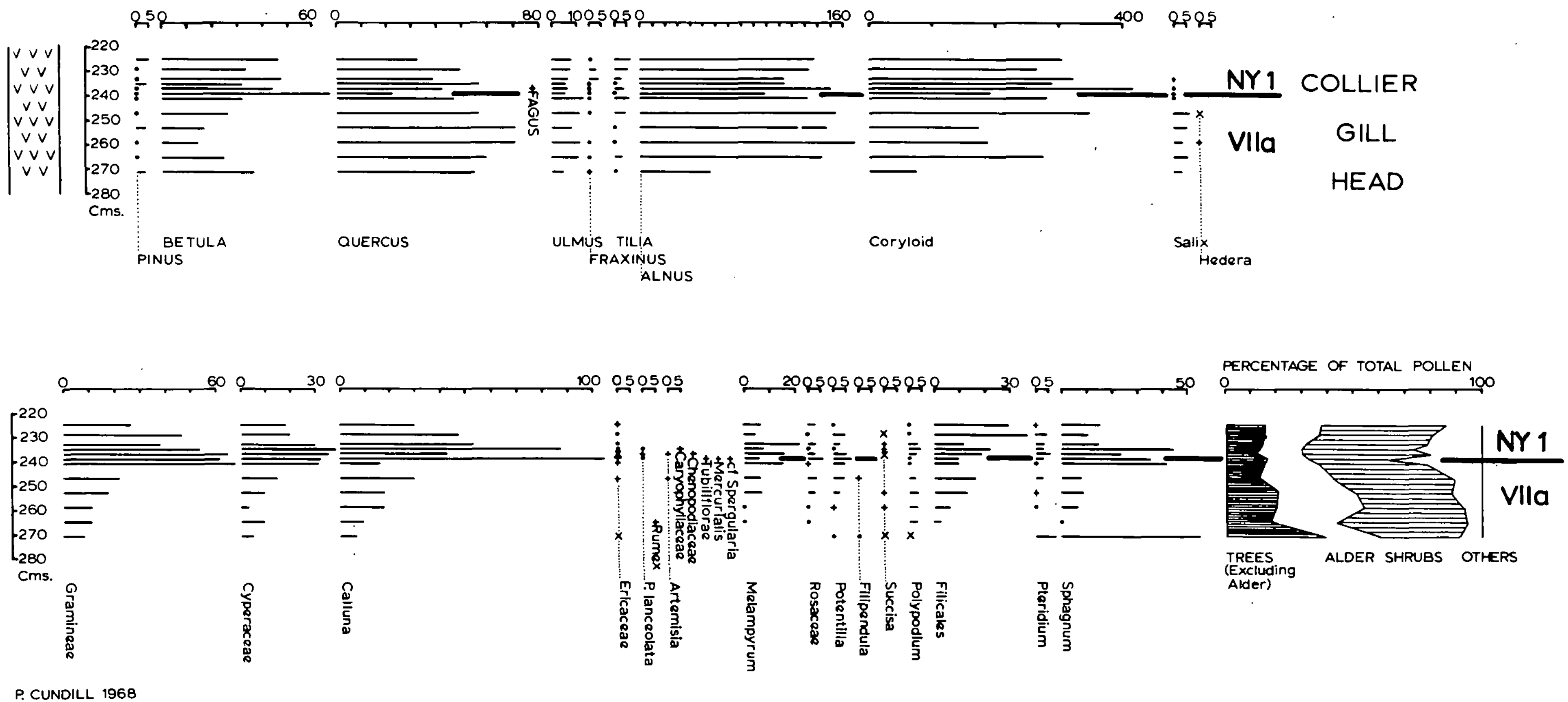


fig. 35 Collier Gill Head pollen diagram. Percentages of total tree pollen.

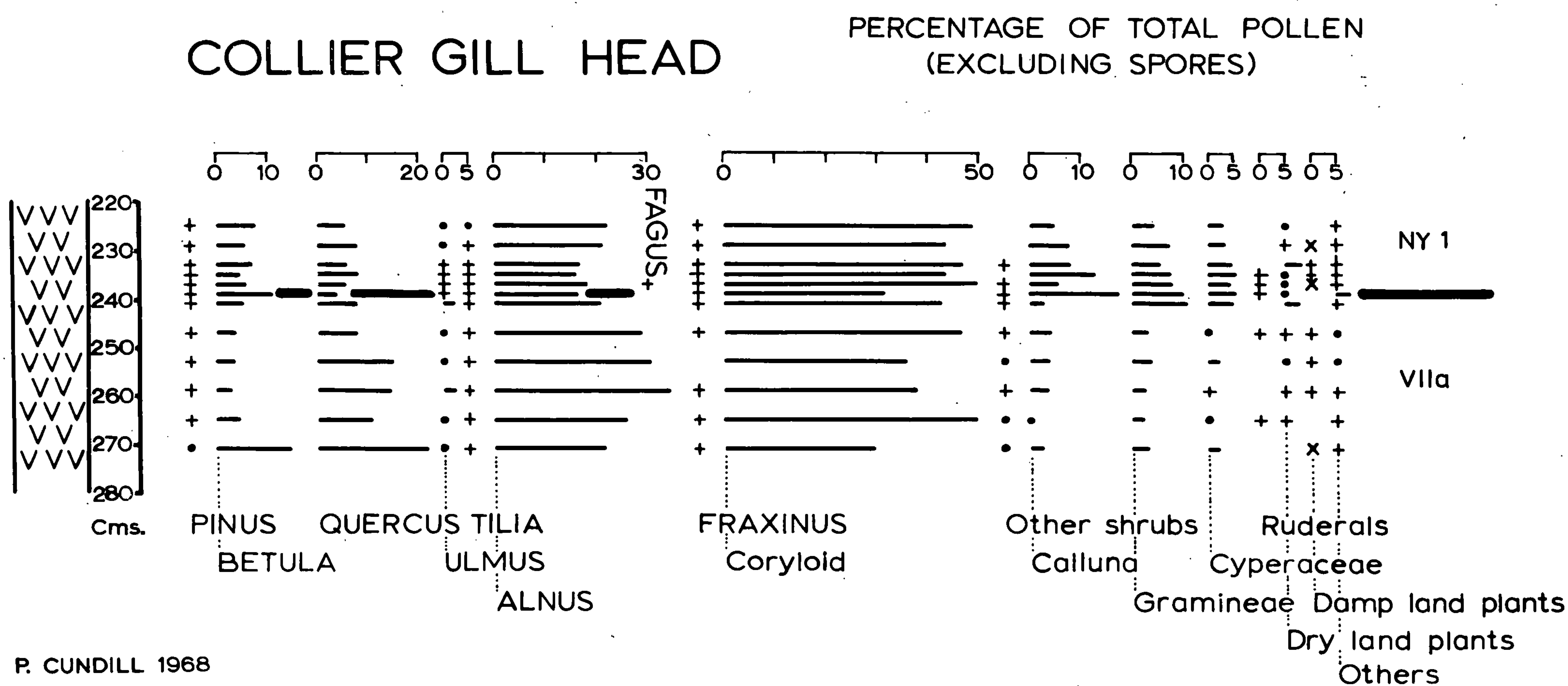


fig. 36 Collier Gill Head pollen diagram. Percentages of total pollen.

Zone VIIa and the *Ulmus* Decline

The base of the diagrams is clearly within zone VIIa. The forest composition is dominated by *Alnus* and *Quercus* with *Betula*, *Ulmus* and a little *Tilia* and *Fraxinus*. There is perhaps a hint of zone VI right at the base of the profile as there is a lower percentage of *Alnus*, although this is not so apparent on the total pollen diagram. The dominance of Coryloid in the pollen rain is quite marked and nowhere does it decline to less than 30% of total pollen. N.A.P. types, mainly Gramineae, Cyperaceae and *Calluna*, remain at low levels during zone VIIa although towards the *Ulmus* decline a gradual expansion of Gramineae and Cyperaceae may be observed. Only one grain each of *Rumex* and *Artemisia* are found in zone VIIa so there are no real indications of clearance. However, one interesting point is that remains of charcoal are found in the peat at all levels from 247 cms. to 226 cms. Some destruction of woodland must have been carried out during late zone VIIa although exactly where this was taking place is not very clear.

The *Ulmus* decline itself is clear and has many of the features commonly recognized as belonging to this horizon. A number of ruderals, even though they are only single grains (e.g. *Plantago lanceolata*, Tubuliflorae, *Chenopodiaceae*), appear for the first time and *Calluna* and Gramineae expand very rapidly. At the same time *Ulmus* and *Quercus* decline along with *Alnus* and Coryloid. An actual overall decline in trees is not very apparent as *Betula* expands at the same time perhaps owing to the tree colonizing the area around the edge of the clearing or owing to *Betula* pollen becoming over-represented after the reductions of *Quercus*, *Alnus* and *Ulmus*. *Tilia* also exhibits a decline at the same level as the *Ulmus* decline but does not show the peaking actually at this level which is apparent at some other sites (e.g. Glaisdale Moor). The significance of the expansion of Sphagnum at the level of the Ulmus decline is difficult to interpret, although it may be connected with increased run off of rainwater after the clearance of woodland.

Zones VIIb and VIII

Subzone NY 1

The whole of the Ulmus decline at Collier Gill Head seems to be a short phase, with the woodland and shrubs recovering fairly rapidly afterwards. Ulmus itself starts a slow recovery and Quercus rapidly regains its pre Ulmus decline levels. The appearance of Fagus at 237 cms. is quite significant as it would tend to support the dating of the diagrams and also perhaps shows that the canopy was now sufficiently open to allow what was probably long-distance transported pollen to be deposited on the bog surface. The peak of Coryloid at 237 cms. may be the first phase of the re-colonization of the cleared area and the decline in Gramineae and Calluna would appear to support the idea of a reduction in open land.

Comparisons between Collier Gill (Simmons 1969a) and Collier Gill Head

There are a number of comparisons and contrasts which may be made between the diagrams from the two sites. The first point of interest is that although Collier Gill dates back further than Collier Gill Head it is the latter which provides the deepest profile. Obviously the two sites have had a different history of peat accumulation although the gross stratigraphies are much the same. Only part of the diagrams on either side of the Ulmus decline can be compared as this is the section of the Collier Gill Head profile which has been analysed. However, despite the narrow period which is comparable there are several comments which can be made. The Ulmus decline at Collier Gill seems complete with no Ulmus recorded at c. 135 cms. whereas the decline at Collier Gill Head is one from 13% to 5% of total tree pollen. Similarly, Tilia does expand immediately after the Ulmus decline at Collier Gill but not at Collier Gill Head. Fagus also does not make an appearance until well after the second Ulmus decline at Collier Gill whereas it appears at the first Ulmus decline at Collier Gill Head. These are relatively minor differences when an examination of the general trends is made. Calluna, for example, expands most significantly at both sites, and Coryloid reacts in the same way at the same time. It could be argued that at Collier Gill there was a slightly different kind of woodland to that at Collier Gill Head, as the total percentage of trees is higher at Collier Gill and this is coupled with the very much higher Coryloid values at Collier Gill Head. Collier Gill has the occasional grain of ruderal pollen within zone VIIa as does Collier Gill Head, and then a wide spread of ruderal types appear at the first Ulmus decline.

The whole analysis seems to favour a similar picture at both sites which is what would be expected from two closely adjacent sites. The differences may be attributed to differential pollen dispersion, and the slightly different woodlands at the two sites may be due to site factors. Localized pollen production would probably explain the differences in Gramineae and Cyperaceae pollen between the two sites.

2. Trough House

Grid Reference : NZ / 704815

Height above Ordnance Datum : 1370 feet (418 metres)

Depth of sampled profile : 150 - 204 cms.

Method of sampling : Russian borer.

Stratigraphy :	(cms.)
0 - 18	Dark brown fresh rootlet peat (mainly monocot).
18 - 51	Orange brown monocot peat.
51 - 102	Mid-brown monocot peat with a little *Eriophorum* and one piece of *Calluna*.
102 - 153	Mid-brown monocot peat with *Eriophorum* and some cf charcoal bands.
153 - 193	Mid-brown monocot peat with *Eriophorum* and frequent charcoal remains.
193 - 204	Mid-brown amorphous graminoid peat with charcoal remains.
204 +	Impenetrable sand.

Present day vegetation : dominantly *Calluna* with a little *Eriophorum* and some ground mosses.

Introduction

The diagrams from the site are the results of the analysis of the lower 50 cms. of the profile. A clear picture of the *Ulmus* decline is shown together with the development of an early zone VIIb woodland. The site should provide some comparison with Loose Howe which is several hundred metres to the south.

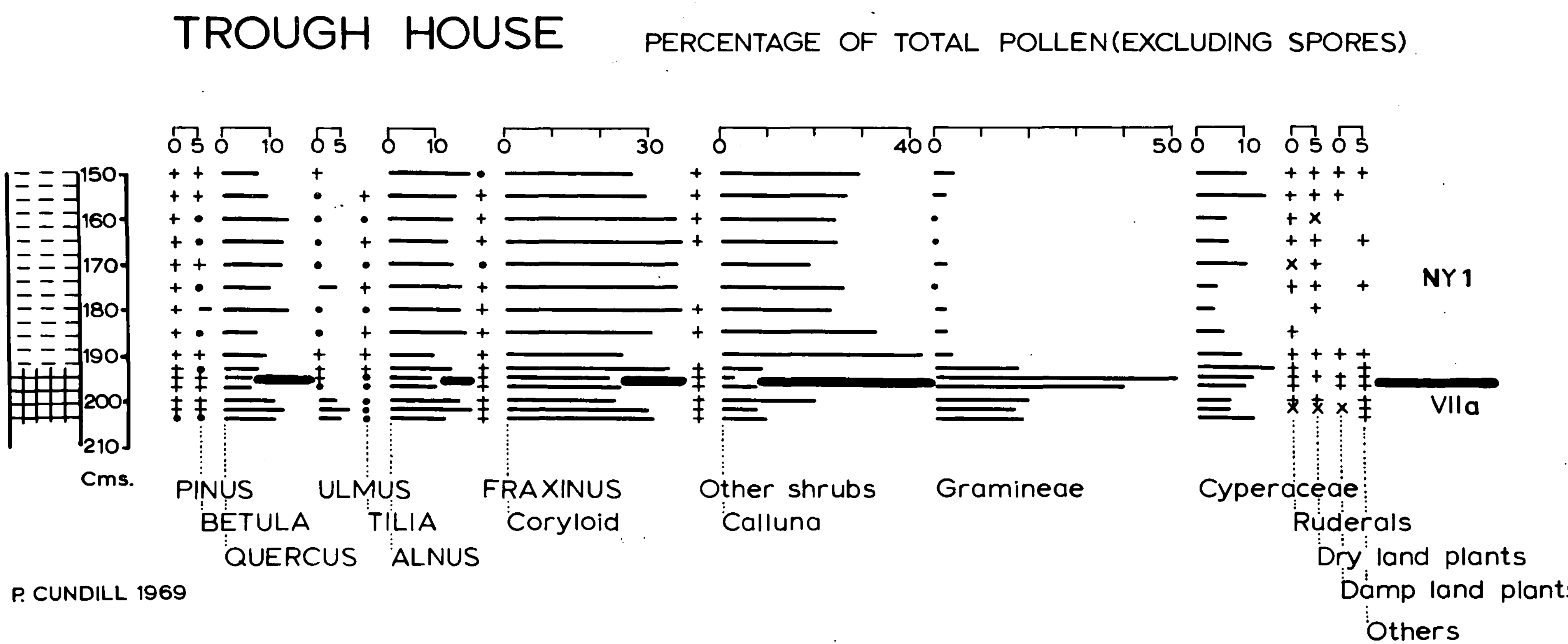


fig. 38 Trough House pollen diagram. Percentages of total pollen.

Zone VIIa and the *Ulmus* decline

A normal zone VIIa woodland is represented by the pollen spectrum at the bottom of the profile with the trees dominated by *Alnus* and *Quercus*. *Betula* percentages are low compared with most sites from the moors. An important point to note from this site is that it is one of only two sites with zone VIIa pollen assemblages and yet containing no wood remains in the stratigraphy. Even so tree pollen percentages are in general relatively high. *Ulmus* values are amongst the highest for any site on the moors and reach 28% of total tree pollen (6% of total pollen). Coryloid percentages are also high throughout the profile ranging from 20-40% of total pollen. However, in addition to the fairly high tree and shrub percentages it should be noted that Gramineae values reach 20% and Calluna 10% of total pollen, making the suggestion of a closed forest at the site open to some doubts. It could be that damp areas were in evidence in shallow hollows on the surface of the ground during zone VIIa at this site, and these in themselves restricted the growth of woodland, resulting in what could be termed 'patchy woodland'. A further factor is that of the effects of early man. While this cannot be directly shown and can only be inferred from the evidence of charcoal remains and occasional grains of ruderal pollen at the site, it cannot be ruled out as a possibility.

The amount of woodland diminished rapidly at the *Ulmus* decline and the area of open and disturbed ground expanded. There is certainly a sharp drop in *Ulmus* although it is by no means as pronounced as at other sites from the moors. Furthermore *Ulmus* remains a constituent of the woodland as it does not decline below 5% of total tree pollen. The most striking feature of the

Ulmus decline level at the site is the peak of Gramineae. Other N.A.P. types expand at the same level, and there is a single find of *Urticaceae*. All the indications suggest a quite usual small-scale opening in the woodland, or an expansion of an already partially open area, which could be attributed to the activities of early man. A further feature of the pollen diagrams which helps to indicate the level of the *Ulmus* decline is the peak of *Tilia* which is recognized at the same level for a number of sites on the North Yorkshire Moors.

One rather odd feature about the VIIa section of the profile was the finds of beetle elytra at all the levels examined.

Zone VIIb

Sub-zone NY 1

The woodland recovers quite rapidly from the *Ulmus* decline and reaches approximately the same position as in zone VIIa. *Quercus*, *Alnus* and *Ulmus* all show signs of expansion after the *Ulmus* decline as does Coryloid. The N.A.P. values demonstrate some curious changes not the least of which is the marked decline in Gramineae and its replacement by *Calluna*. Otherwise N.A.P. values tend to decline as the woodland expands once more and this is clearly illustrated by the virtual disappearance of ruderal types until the top of the sampled profile. The decline in Gramineae and expansion of *Calluna* coincides with a change in stratigraphic type from a graminoid peat to a monocot/*Eriophorum* peat. This change is probably connected with a change in soil status from a grassland soil to a full blanket peat. The process may have been encouraged by the continuation of burning which from the finds of charcoal in the peat appears to have been carried out also after the *Ulmus* decline.

Towards the top of the sampled profile there are a few indications of a sub-zone NY 2. There is a general reduction of woodland and shrubs and an expansion once more of ruderals and other N.A.P. types. *Tilia* disappears, a feature associated with other sub-zone NY 2 levels, but on the whole as the woodland decline is only shown on one or two counted levels and in the absence of a continuous profile a sub-zone boundary has not been recognized from the diagrams.

3. Pike Hill Moss

Grid Reference : NZ / 758013

Height above Ordnance Datum : 1050 feet (320 metres)

Depth of sampled profile : 86 - 115 cms.

Method of sampling : monolith tins.

Stratigraphy : (cms.)

0 - 10	Surface rootlet peat mainly Calluna.
10 - 33	Light brown monocot peat with some Eriophorum remains.
33 - 92	Mid-brown monocot/Eriophorum peat more humified than 10-33 cms.
92 - 108	Dark brown sticky monocot peat with no Eriophorum remains.
108 +	Orange brown sandy mineral material with organic matter at the top; rapidly grading into bedrock.

The present vegetation : An outline of the vegetation at Pike Hill Moss is given in the Introduction (Section I A, 4) together with a plant list. Calluna is the dominant sp. at the site with other spp. playing only a minor role in the vegetation cover.

Introduction

Only a short 30 cms. basal profile was sampled from the main peat mass in order to see when peat growth commenced and to examine a profile which extended into the mineral material at the base of the peat. It was hoped that this would provide a detailed study of a situation which could not be obtained from

Plate 7 General view of Pike Hill Moss site showing peat cutting area

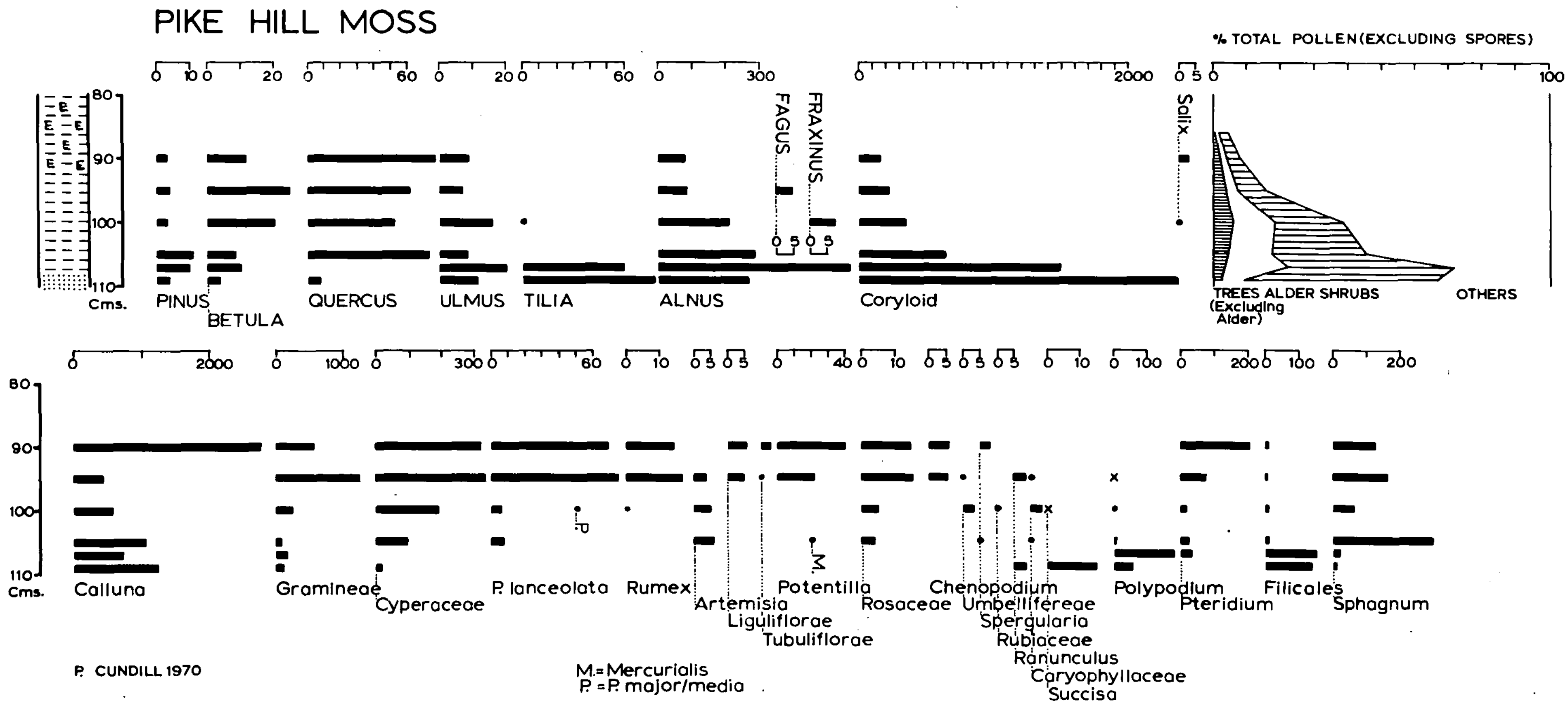


fig. 39 Pike Hill Moss pollen diagram. Percentages of total tree pollen.

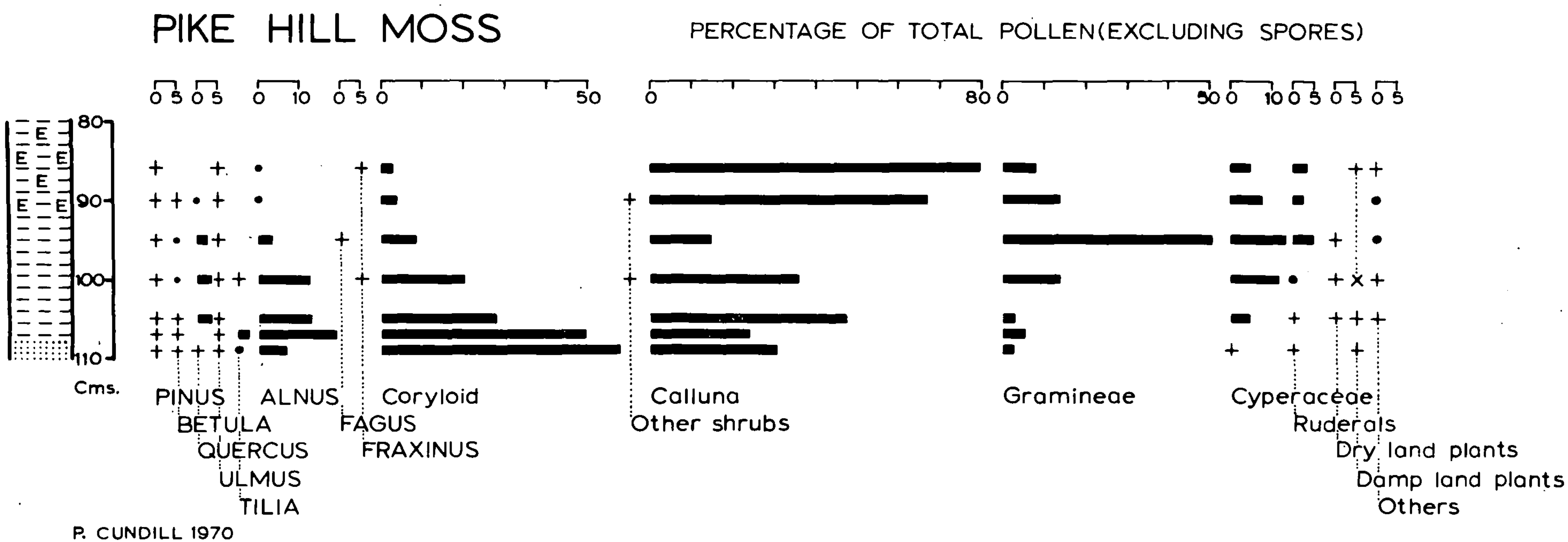


fig. 40 Pike Hill Moss pollen diagram. Percentages of total pollen.

Yarlsey Moss. A monolith sample was collected from an exposed peat face which is being actively cut for peat fuel at the present day.

The percentages of tree pollen in the sampled horizonswere very low and most of the levels were counted up to 1000 total grains. Because of this the total tree pollen diagram produced must be examined with care and perhaps more reliance should be placed on the total pollen diagram.

The diagrams from the site are difficult to zone using the local sub zonation scheme. For this reason no zonation is suggested beyond that of the general classification into zones VIIb and VIII.

Zones VIIb and VIII

The base of the diagrams is difficult to interpret or date, although in the absence of radiocarbon dating it could be regarded as early VIIb. Tree pollen percentages are generally very low at this time with only Alnus as an important constituent of the total pollen diagram. However, Tilia is also recorded at relatively high percentages and must have been growing in the immediate vicinity of the site. Differential preservation of Tilia pollen is not regarded as likely in this instance as there were no signs of extensive erosion of other pollen grains. The very fact that it is recorded would seem to support the suggested early VIIb date for the base of the profile. This can be coupled with the fairly low and erratic percentages of Ulmus which are quite typical of zone VIIb. Tilia disappears once peat starts accumulating. Coryloid is important at the base of the profile but steadily declines with time possibly due to the combined effects of the growth and expansion of blanket bog and the clearance of shrub and woodland by man. The area was clearly quite open from the inception of peat growth as shown by the relatively high percentages of Calluna and the presence of ruderals.

There is a marked change in the character of the vegetation at about 95 cms. and this may indicate a sub-zone boundary. However, the available evidence is not sufficient to distinguish a sub-zone boundary at this level.

At 95 cms. there is a rapid increase in Gramineae coupled with an expansion in ruderal pollen types, including Plantago lanceolata, Rumex, Liguliflorae, Tubuliflorae, indicating a change to more open and disturbed conditions. Conversely, Alnus, the only tree of singular importance at the site, declines together with Coryloid. The appearance of charcoal in the stratigraphic remains above 95 cms. may indicate the use of fire by man. The effect of a run down in the conditions of the soils is perhaps indicated by the fact that Calluna gains dominance of the pollen spectra after the initial importance of Gramineae. Burning may have assisted in rendering the soils sufficiently acid in nature to have allowed Calluna to colonize them instead of Gramineae. The scene represented by the uppermost sample of the analysed section shows Calluna dominated moorland much as the area appears at the present day.

J. Contemporary Pollen

The contemporary pollen sites are spread over a wide area of the central watershed and these are marked on the contemporary pollen spectra maps (fig. 41). The method of constructing these maps is described in the Introduction of Section II. The cover of sites is fairly intensive, there being 31 sites which were fully examined. The samples were prepared (Appendix A) and counted in the same way as the fossil samples in order to ensure complete comparability. As most of the sites are on open moorland the percentage of tree pollen, including Alnus, was particularly low as might be expected, and in most cases total pollen counts of 1000 grains were made. More intensive sampling was carried out where the pollen spectrum was likely to change rapidly and the major example of this can be seen in and around the woodland at Wheeldale Gill.

There are many problems in the sampling and analysis of plants which are still actively growing. There are no indications of how long, for example, a Sphagnum plant, the most frequently sampled sp. in this study, has been growing when it is sampled, or exactly how much of a time span is represented by part of the plant. Similarly no one has effectively measured the variations of pollen production from year to year of all the pollen producers in an area. This is after all a problem which affects fossil as well as contemporary pollen analysis (i.e. exactly how many years are sampled in any given amount of material). It will be assumed that a growing Sphagnum plant will give an accurate guide to the production of pollen within an area over several years, as it provides an ideal surface for the impaction of pollen. Moreover, it provides a damp, slightly acid condition with

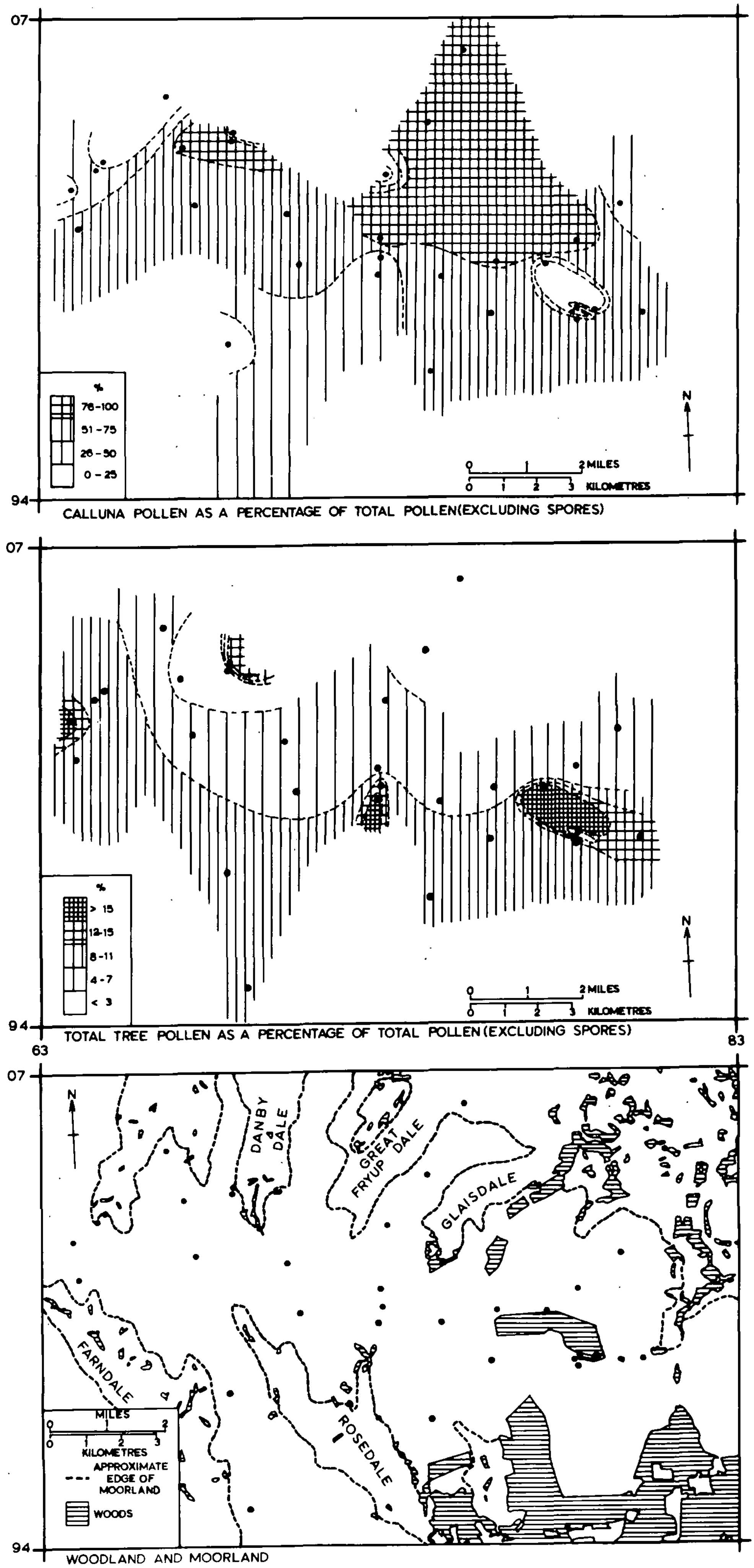


fig. 41 Maps of the distribution on the central watershed of the contemporary pollen of Calluna and trees, and the extent of moorland and woodland at the present day

little micro-organism activity all of which allows the pollen to be preserved extremely well. The general identification of grains from Sphagnum samples never proved to be difficult. Moar, from his work on the Mainland of the Orkney Islands, recognized the usefulness of Sphagnum in obtaining a contemporary pollen spectrum (Moar, 1969). The efficiency of Sphagnum as a pollen collector may be high as Gregory has shown that vertical sticky cylinders, a rough approximation to Sphagnum branches and leaves, are the most efficient surfaces for collecting pollen by impaction (Gregory 1961). Much experimental work with regard to the behaviour of particulate clouds in connection with air pollution, insecticidal aerosols and dispersion of spores, for example, has been carried out in recent years and an account of these studies may be found in Gregory (1961) and Hyde (1969). Something of a summary of the major points will be attempted here and then an assessment of the present contemporary pollen data may be made in the light of this.

In connection particularly with pollen analysis and the interpretation of fossil pollen assemblages, the work of Tauber has been of considerable importance (Tauber 1965) and both Tauber and Gregory recognize a number of fundamental problems in the interpretation of pollen and spore data. The liberation of pollen and spores depends on a large number of factors, the most important one being climate. The flowering plants have mechanisms for dispersing pollen which depend on whether the plants are entomophilous (insect pollinated) or anemophilous (wind pollinated) and Gregory (1961) produced a summary table of these features (Table G). However, Erica and Calluna pollen, for example, is transferred

Table G A guide to typical characteristics of Anemophilous and Entomophilous plants (after Gregory 1961, Table IV)

	Wind Pollinated	Insect Pollinated
Flowers	Lack conspicuous and attractive petals.	Often with bright colours, scent; nectar attractive to insects.
Flower Position	Projecting into air: hanging from bare branches before leaves open (catkins); on erect stalks (grasses); or at end of branches (conifers).	Tend to be exposed to view but not exposing anthers to wind. Flowers usually maturing when plant in full growth and insects abundant.
Prevention of self-fertilization	Male and female organs often in separate flowers or in inflorescences, or on separate plants. If flowers hermaphrodite, one sex commonly matures before the other, or, if sexes are in separate inflorescences the female is above the male.	Flowers usually hermaphrodite with structural or genetic barriers to selfing.
Pollen	Often shed into the air in vast quantities. Shape rounded or often nearly spheroidal or ellipsoidal. Size range narrower than entomophilous pollen and seldom less than 15 μ. Surface typically smooth as seen under the microscope, non-sticky, easily separating into single grains in the air.	Usually restricted pollen production with little shedding. Shape very variable. Size very variable, 3 - 250 μ but often less than 15 μ. Surface typically rough, spiny or warty, often oily or sticky, tending to cohere in clumps.

by wind and insects so the table can only be used as a preliminary guide. Spore liberation is often much more novel than that of pollen dispersion with systems such as exploding capsules to free the spores at the appropriate time.

Pollen is produced mainly in the summer months and Tauber points out that pollen is emmitted preferentially on warm days with a low degree of humidity. Such days are accompanied by large vertical motions in the air (eddies) caused by convection currents. However, it is clear that pollen will be liberated under other sets of meteorological conditions and consequently the dispersion of pollen will be different. When dealing with air movements which involve pollen it is the region close to the ground that is most important and a number of terms have been used to describe the various layers of the atmosphere. These are shown in Table H and basically pollen transport is confined to the troposphere. The troposphere can be divided into the Surface Boundary Layer, the thickness of which is closely linked to the shape of the topography and the meteorological conditions at the time, and the Convective Layer, where temperature decreases with height. Between these two is the Transitional Layer which contains the changeover from diurnal temperature changes and turbulence (i.e. the surface effects) to large scale atmospheric motions. The thickness of the various layers depends on the meteorological conditions at the time, and these in turn will influence how pollen is dispersed and how it impacts on objects.

When considering pollen dispersal over a wide area from a great number of single (or point) sources in the form of plants, it is clear that there is an enormous problem in determining the distance travelled by specific pollen grains. The

Table H The layers of the earths atmosphere (after Gregory 1961)

STRATOSPHERE			Free Atmosphere
TROPOPAUSE			
TROPOSPHERE	Convective (Convection) layer		
	Transitional or outer frictional turbulence layer		Planetary Boundary Layer
	Turbulent boundary layer	Surface boundary layer	
	Local eddy layer		
	Laminar boundary layer		

distance these grains travel is not influenced only by meteorological conditions but by other factors such as the height of the release point above ground (Tauber 1965), an important consideration when assessing herbaceous and tree pollen together. It has been argued that the great percentage of pollen grains from one point source will be deposited close to this point (Gregory 1961, Hyde 1969) but a certain number tend to escape to a greater distance. This can be illustrated in the present work where a site close to the edge of the woodland at Wheeldale Gill shows that tree pollen contributes 75% of all pollen and yet a hundred metres away from the woodland this figure has decreased to 7%. The deposition of pollen is clearly not evenly distributed in a 'pollen rain' as earlier workers believed. Gregory suggested that the principal methods of pollen and spore deposition are: impaction, sedimentation, boundary layer exchange, turbulent deposition, rain washing and electro static deposition (Gregory 1961). All these methods are important under different climatic conditions although a number of them are interdependent; for example in boundary layer exchange, turbulence has a great effect in bringing pollen down to the layer where it can slowly sediment out under the forces of gravity (Gregory 1961). However, there is also a distance factor in the relative importance of these depositional agents and whereas close to the pollen source the mechanisms of impaction and boundary layer exchange are most important, further away rain out becomes the most important mechanism (Gregory 1961). Rain out is an important single mechanism, as a prolonged heavy shower is a very effective way of removing pollen and spores from the atmosphere and depositing them in lakes and bogs (Tauber 1965). However, there is no indication of which method has affected the deposition of any particular pollen grain and therefore it cannot be demonstrated how far or by what means a pollen grain has travelled to reach its destination.

The overall problems in studying contemporary pollen data are clearly enormous and while these are recognized in the present study there are a number of general points which have proved to be very useful in the interpretation of fossil pollen assemblages.

Perhaps the most striking feature of the contemporary pollen assemblages in the present work is the generally very high level of N.A.P. This is hardly surprising with the present nature and distribution of vegetation. Trees are mainly confined to the dales or to certain valleys as in Wheeldale Gill (Section I, A, 4) except where occasional coniferous plantations occur. In the area under study Calluna is the major plant sp. and therefore it is not surprising that this sp. dominates the contemporary pollen spectra. A map has been constructed from the total pollen percentages of Calluna at each site (fig. 41). While the diagram should not be used in detail there does appear to be an overall trend towards higher percentages of Calluna in the north and east. The low percentages of Calluna which appear to occur in the woodland around Wheeldale Gill stand out as an island and a number of sites close to the dales show similarly low percentages. There does appear to be a connection between prevailing winds and the deposition of Calluna pollen although in the absence of full meteorological observations on the central watershed this argument must remain a tentative one. The wind measurements for 1967, 1968 and 1969, that is, a year before and the two years of sampling material for contemporary pollen analysis have been taken from Durham meteorological station and these have been drawn up as three wind roses (fig. 42). Even though the Durham station is some distance from the North Yorkshire Moors it does show what might be regarded as the trend in prevailing wind over the moors. The wind roses do not show wind speeds as these are clearly not likely to be similar for the open moorland conditions. In fact, the wind roses are illustrated to show the general preponderance of winds from the south west which is the normally accepted direction of prevailing winds over the British Isles as a whole. This would seem to suggest a reason for the greater concentration of <u>Calluna</u> pollen in the north and east of the central watershed. Even the site immediately south of Lealholm, despite its position just outside the moorland edge and in an area dominated by sedges and grasses, still has <u>Calluna</u> as 75% of total pollen.

The diagram illustrating total tree pollen as a percentage of total pollen (fig. 41) shows an almost opposite appearance to the <u>Calluna</u> diagram, although by no means completely so. There is still the same general trend with less tree pollen in this case towards the north and east. The maximum total tree pollen percentages are not generally at such a high level as <u>Calluna</u>, even in the Wheeldale Gill woodland and at only one site, at Upper Heads, does tree pollen reach 75% of all pollen. At this site the pollen spectrum is dominated by <u>Pinus</u> as the site is close to the edge of a coniferous woodland. In the other samples in and around Wheeldale Gill woodland total tree pollen percentages reach about 20-30%. These samples are extremely interesting for the wide variations in percentages of individual tree spp. from site to site.

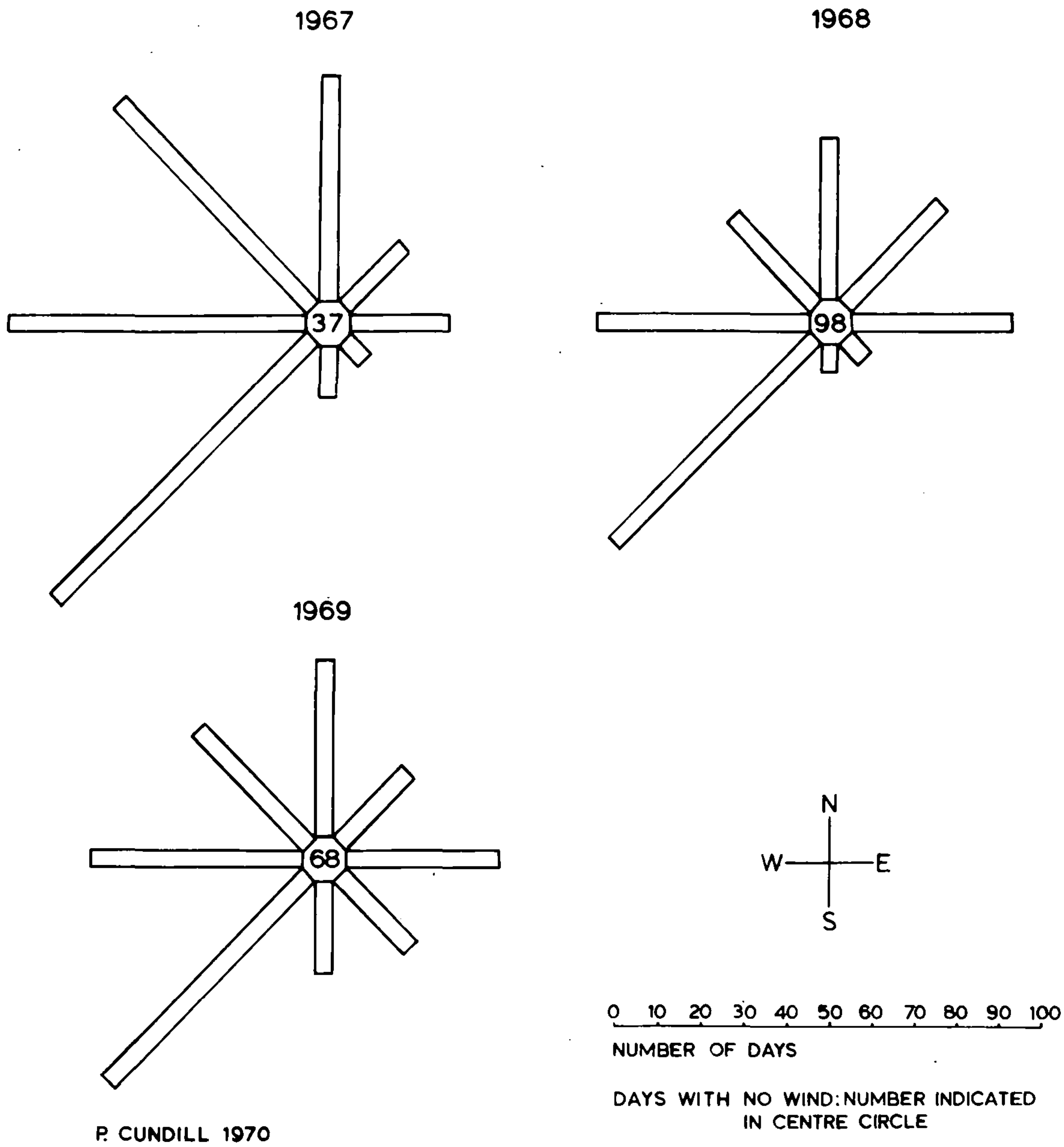


fig. 42 Wind roses for 1967, 1968 and 1969 based on observations recorded at the Durham Meteorological Observatory

While the general pattern of primarily Quercus, Betula and Alnus is clearly reflected in the pollen percentages, at one site Betula is extremely frequent and Alnus low, while at another site all three spp.are at about the same level. In general terms, however, Betula appears to be the most frequent sp. and the presence of Ilex and Sorbus pollen in the samples are quite in keeping with the composition of the woodland (Section I, A, 4). However, pollen grains of Ulmus, Tilia, Fagus and Fraxinus were also found in the same samples and clearly as these trees are not present in the Wheeldale Gill woodland the pollen must be the product of long distance transport. A further interesting point about the pollen from the Wheeldale Gill sites is the generally high percentages of shrub pollen (10-20% of total pollen), mostly consisting of Coryloid. In the absence of Corylus avellana from the woodland, the pollen is probably from the Myrica gale which grows abundantly along the valley, just outside the woodland. At other points on the total tree pollen diagram, principally in North Gill and at Stony Ridge, there are peaks of tree pollen which may have resulted from a funnelling effect of the wind along the valleys. Just below both sites, that is, in the lower valley, there are small woodlands which may have been the source of the pollen although this suggestion can only be confirmed by a detailed examination of these woodlands.

From the contemporary pollen study one or two other points can be made. Perhaps the most interesting observation is the sharp decrease in tree pollen just outside a woodland. One of the most striking illustrations of this is the fact that comparatively very little of the pollen production of the large Forestry Commission plantations to the south has travelled as far north as the central watershed. However, on the other hand at every site some tree pollen was identified and there are many indications that a few tree pollen grains have travelled considerable distances to reach their destination. They will even penetrate the canopy of an existing woodland as at Wheeldale Gill. In addition there is the problem of the swamping effect of Calluna pollen which is difficult to assess.

Although certain implications may be drawn from the present study there are many gaps and many questions which have remained unanswered. Amongst the unanswered questions are those which deal with the real effect of rainfall, in terms of rain out of pollen, at certain periods during the year and what effects topography has on pollen transportation and deposition. The only way of solving these questions lies in a full scale study involving meteorological observations over a wide range of sites, together with an exhaustive study of the vegetation of an area much greater than the sample area. In addition collection of pollen grains should be carried out in standardized pollen traps which are examined at regular intervals. Only then may the results provide an opportunity to make meaningful correlations.

The results of the present study have illustrated some of the many problems associated with the interpretation of pollen assemblages, including fossil pollen assemblages, while providing an outline indication of general trends of two important pollen groups within a limited area. Further work is in the process of being completed in connection with pollen transport, especially by water, in and around the reservoir near Osmotherley on the western edge of the North Yorkshire Moors (Peck, 1969).

K. Miscellaneous Pollen and Stratigraphic Data

1. Pollen data

A few single basal pollen counts have been made on profiles which have not been examined in detail. An outline of the results obtained is tabulated below (Table I).

A suggested zone date may be coupled with each pollen count although these cannot be certain dates without further counts on the profiles. The St. Helena counts 'C' and 'D' both have affinities with zone VIIb although 'D' may possibly be zone VIIa. The counts from Loose Howe 'B' and Bluewath Beck are both much more easily recognizable as zone VIIa in age, with an interesting peak of *Betula* at Bluewath Beck. Loose Howe 'B' provides one unique pollen type to the present work. This is *Rubus chamaemorus*, a plant of open mountains and moorlands at the present day, and together with relatively high percentages of N.A.P. may indicate fairly open conditions at the site at this time. This suggestion may be further supported by the presence of ruderal pollen. There is a contrast between the two higher blanket peat sites and St. Helena which is quite apparent from the tree pollen. At St. Helena tree pollen, including *Alnus*, is in the order of 80% of total pollen while at Loose Howe 'B' and Bluewath Beck tree pollen only amounts to 27% and 35% of total pollen respectively.

2. Stratigraphic data

Stratigraphic records were kept for a number of sites which were visited but which did not yield profiles used for laboratory analysis. These sites are discussed below.

Table I

Miscellaneous pollen sites - outline basal counts :

		Total AP (excluding *Alnus*)	Total Pollen
Loose Howe 'B' (Grid Reference NZ/700012)	200 cms.	204	1581
Bluewath Beck (Grid Reference NZ/739006)	265 cms.	199	686
St. Helena 'C' (Grid Reference NZ/683038)	400 cms.	171	400
St. Helena 'D' (Grid Reference NZ/683038)	590 cms.	159	580

(i) North Gill (Grid Reference: NZ/726007)

This was perhaps the most significant site visited but not analysed. It was previously examined by Simmons and pollen diagrams and stratigraphic recordings have been published (Simmons 1969a). The stratigraphic recordings made for the present work and taken from examination of cleaned profiles along the sides of North Gill showed a great variation in the depth and type of peat. Wood peat was found mainly at the southern end of the North Gill peat mass but the depth of peat over the wood peat varied by as much as a metre. The profiles are discussed in turn starting with site 1 at the southern end of the peat mass and progressing northwards.

Site 1 (depths in cms.)

0 - 20	Surface rootlet peat mostly Calluna and Eriophorum.
20 - 150	Monocot/Eriophorum peat with some Calluna remains.
150 - 170	Wood peat (Betula and Alnus).
170 +	Mineral material plus a little organic material (wood mainly).

Site 2

0 - 20	Fresh rootlet peat, mainly Calluna.
20 - 242	Monocot/Eriophorum peat, mid-brown in colour and fairly well humified.
242 - 273	Wood peat with pieces of wood burnt on the outside. Bands of charcoal present.
273 +	Solid rock base.

The burnt wood remains and charcoal bands in the peat at

Site 2 provide the most interesting features of the two sites, and may be contemporaneous with the site of Simmons at North Gill (Simmons 1969a).

A large proportion of the peat has no wood remains as the other two sites show.

Site 3 (depths in cms.)

0 - 20	Surface rootlet *Calluna*/*Eriophorum* peat.
20 - 155	Mid-brown monocot/*Eriophorum* peat with bands of lighter coloured *Eriophorum* within the profile.
155 +	Sandy and stony weathered bedrock.

Site 4

0 - 20	Surface rootlet peat, dominantly *Calluna*.
20 - 212	*Eriophorum*/monocot peat with less *Eriophorum* towards the base and some *Calluna* remains. Bands of light yellow moss peat (131-156 cms. and 169-184 cms.) and an inwash stripe at 164 cms.
212 - 277	Yellow sandy mineral material.
277 +	Weathered bedrock.

Site 4 is found at the head of the eroding stream section and shows a very interesting and varied profile with ample evidence of inwash of mineral material from the moorland just above the site, and different phases in the accumulation of the peat such as the bands of moss peat. Perhaps Site 4 shows a much greater local and later variations of bog conditions because of its greater proximity to the edge of the main peat mass.

(ii) Fryup Dale Landslips (Grid Reference: NZ/715029)

While no really well developed bogs on the scale of St. Helena and Blakey Landslip were found in this region of landslips, one small landslip did have some accumulation of material. This had a stratigraphy: (depth in cms: Russian peat sampler used).

0 - 18	Surface black rootlet peat (Sphagnum/Eriophorum/Calluna) with one or two narrow bands of inwash silt.
18 - 62	Silty monocot peat with a distinct muddy grey inwash stripe at 34-37 cms.
62 - 91	Mid-brown wood peat with Betula remains.
91 - 104	Pure light grey clay.
119 cms.	borer point struck impenetrable object (stone).

The stratigraphy indicates a great deal of inwash of mineral material which is clearly from the steep sides of the landslip and in this respect the site is analagous with the Pennine landslip sites (Appendix C). However, the depth of deposits is not very great. Other landslip sites from the North Yorkshire Moors contain up to two metres of mineral material with very little organic matter. The fact that no suitable sites for the accumulation of peat are found in most of the areas of landslips may be attributed to the adequate drainage around and through the slipped faces. It is only in one or two special instances that the hollow produced by landslipping has had such impeded drainage that peat has been encouraged to form.

S E C T I O N   III

T H E   D I S C U S S I O N

The discussion will attempt to collate the general features of the 13 pollen diagrams and utilize the contemporary data in the analysis. From this it is hoped to produce a meaningful overall pattern for the central watershed. To make the discussion more orderly it will be dealt with in two parts; Part A according to the pollen zone sequence with additional categories to enable discussion of some of the zone boundaries, and Part B according to the sequence of human cultures.

A. Vegetation changes

1. Pre-Zone VI.

Within the pollen diagrams outlined in Section II there is no indication that the pollen record goes back further than zone VI. Although in many ways this is no drawback when considering the aims and scope of the present project, some discussion of the pre-zone VI period is perhaps in order. This allows the full story of the vegetation on the central watershed to be traced from glacial times up to the present day. In addition there is sufficient material from in and around the moors to give a reasonably clear picture of the development of vegetation during zones III to VI which may be applied to the central watershed.

At several sites there are Late-Glacial (zone III) deposits, and pollen analyses of these show a typical picture of an open landscape dominated by herbaceous plants (Bartley 1962, 1966, Jones 1969). The nearest site to the area under study with a clear Late-Glacial pollen assemblage is found at West House, Kildale (Erdtman 1927, Jones 1969) although there is a further site at Seamer in the Vale of York (Jones 1969). However, in a short paper on the pollen analysis of a mineral soil at Cock Heads (Glaisdale Moor) Godwin describes some pollen types which he suggests have affinities with a Late-Glacial pollen assemblage (Godwin 1958). There are difficulties in interpreting the results accurately because, as Godwin suggests there is the possibility of downwash of pollen of later periods.

Knowledge of the Pre-Boreal period in north east Yorkshire has increased with the investigation of sites at Fen Bogs, Newtondale (Crabtree 1968, Atherden 1969); Moss Swang (Simmons 1969a) and the sites of Jones. Dimbleby suggests a Pre-Boreal date for the base of a diagram from White Gill (Section II, B) on the basis of high N.A.P. values and low tree and shrub values (Dimbleby 1962) although like the Cock Heads site of Godwin the evidence is not completely clear. All of these sites show the usual Flandrian succession of tree species for the British Isles as the climate ameliorated from the cold of the Late-Glacial. Initially _Betula_ expanded although this is closely followed by _Pinus_ (zones IV and V). At Star Carr, at the eastern end of the Vale of Pickering, a Pre-Boreal pollen assemblage was found in association with a Mesolithic (Maglemosian) lake side dwelling. The dating was correlated with late zone IV and a radiocarbon date of 9488 ± 350 years B.P. (Clark 1954) was obtained for the site. A similarly interesting site was found at Kildale Hall where a skeleton of _Bos primigenius_ was found at the base of the peat. Pollen analysis and a radiocarbon date of 10,350 ± 200 years B.P. (GaK 2707) confirmed that the animal belonged to the early Pre-Boreal period (Jones 1969). Both the sites show ample indications of the heavily wooded conditions that flourished in the area soon after the cold of zone III. Undoubtedly the spread of woodland on to the central watershed must have been slower, but there is no indication that woodland did not cover this area. Indeed the Moss Swang site (Simmons 1969a) occupies a position at the eastern edge of the central watershed and indicates a thick Betula-Pinus forest during the Pre-Boreal.

From his pollen analytical studies of mineral soils found immediately beneath the peats in the Pennines, Tallis (1964a) made some interesting observations which may be pertinent to the present study. He refutes Godwin's suggestion of the downwash of pollen in mineral soil (Godwin 1958) simply because the pollen zonation between different layers in the soil was so clear. Tallis describes a great increase in herbaceous pollen as analysis progresses down through the soil and below about three centimetres of mineral soil the pollen spectrum is one which he describes as a 'Late-Glacial type' as it contains many spp. with Late-Glacial affinities, for example, Betula nana, Salix herbacea, Armeria maritima, Botrychium lunaria, Lycopodium spp. However, Tallis does not suggest that these deposits are of Late-Glacial age as they do contain some plant spp. more typical of zone VI times. He describes this rather mixed flora as having 'montane' characteristics and argues that it could be a relic of Late-Glacial times having survived on the bare hill tops of the Pennines until the warmth and dampness of late zone VI and early VIIa eventually destroyed the habitats. It could be that similar conditions existed on the central watershed during zones IV - VI, and although none of the sites in the present study illustrate a 'montane' flora of the type that Tallis describes, there are indications that some of them contain a later stage in this vegetation development.

2. Zone VI

The period is not extensively recorded from the sites in the present study. It forms short basal sections in the hill peats and in one of the landslip bogs, Blakey Landslip, although the anomalous position of Wheeldale Gill has already been commented on in Section II, H. Glaisdale Moor shows the best development of zone VI in the blanket peat proper and has the usual high *Pinus* values coupled with high Coryloid values. The interesting point about the Glaisdale Moor site is that the high *Pinus* values continue into the wood peat and are not confined to the mineral soil below the peat as at many of the sites of Tallis (1964a, b) and Conway (1954) in the Pennines. In fact Tallis finds that the Boreal-Atlantic transition is located at the change over from mineral soil to peat at his sites and it led to the suggestion that there may have been a hiatus at this boundary due to some erosion of mineral soil prior to the deposition of peat later on in VIIa. Tallis suggests that this erosion was brought about by the increased rainfall in the area at the Boreal-Atlantic transition (Tallis 1964a). In the present study, while Glaisdale Moor does not show this hiatus, there could be just such a situation at Loose Howe where a very short depth of material represents zones VI and VIIa. The one available count of suggested zone VI age at Loose Howe further supports the idea of a *Pinus*- Coryloid woodland across the central watershed at this stage. The tree and shrub cover at this time appears to be quite variable from the pollen evidence although the picture may be similar to that described by Phillips for north Derbyshire where at low levels there was a dense forest which thinned out on the higher plateau (Phillips 1969). One interesting point is that at the Hipper Sick site of Phillips, _Pinus_ values remain high long after _Alnus_ values have risen (Phillips 1969), a situation perhaps analagous with Wheeldale Gill on the North Yorkshire Moors. The work of Dimbleby on mineral soil and peat on the North Yorkshire Moors, especially at White Gill and Ralph Cross sites (Dimbleby 1962), further supports the high records of Coryloid from zone VI in the present work although the lower values of _Pinus_ may be more equivalent to those found at Loose Howe.

The high values of fern spores at the base of the present diagrams which extend down into the mineral soil have already been commented on (Section II) although it is pertinent to point out that both Dimbleby and Tallis have also found similar high values in their own work. Dimbleby suggests that peaks of fern spores are due to their differential preservation in material that was aerated (Dimbleby 1957), whereas Tallis refutes this argument on the basis that very little of the pollen in the pre peat soils of the Pennines showed signs of erosion (Tallis 1964b). Tallis also argues the case for the fern spores being of the size of the British Dryopteridoideae and suggests that a kind of dwarf shrub-fern vegetation existed in the Pennines in zone VI times, perhaps a vegetation type analogous to the _Juniperus_ - _Thelypteris_ vegetation described in Scotland (McVean and Ratcliffe 1962). In the present work the _Dryopteris_ type ferns are grouped under the general term Filicales, and while the suggestion of a dwarf shrub-fern vegetation seems possible at some sites such as Loose Howe, quite clearly other sites must have had a more usual thick woodland, for example at Blakey Landslip and Wheeldale Gill. However these latter sites still exhibit very high peaks of Filicales. Perhaps the answer lies partly in the mineral rich nature of the soils as Filicales spore values do tend to drop very rapidly as soon as peat growth commences, partly in the climate which was perhaps relatively dry, and partly in the resulting woody vegetation (Coryloid-Pinus) which may suggest a fairly open canopy.

The nature and extent of the woodland on the central watershed cannot be deduced accurately from the information provided by a limited number of sites. However, it would seem that over the higher parts of the area the hazel-pine woodland was fairly open in nature while in the dales it was much thicker.

3. The Boreal-Atlantic Transition (Zone VI/VIIa boundary)

A rapid and widespread change in the general vegetation pattern of the area occurred at this time. Pinus declines in value and while Coryloid remains at high levels, Alnus expands rapidly. The transition is shown clearly on the diagrams from the central watershed which span this period, although the difficulties in interpreting the Wheeldale Gill and Loose Howe results have already been mentioned. Many workers regard the Boreal-Atlantic transition as a product of changing climatic conditions throughout Britain (e.g. Godwin 1956, West 1968, Pennington 1969, Conway 1954), and there are several points which have been used to support this theory. The invasion of Alnus in such a marked way is thought to indicate an increased wetness in conditions and Tallis notes the first appearance of Sphagnum spores in large numbers at this level (Tallis 1964a).

The present diagrams from the central watershed show these features. Perhaps the diagram with the most classic Boreal-Atlantic transition in the present study is that from Glaisdale Moor.

One of the most significant factors about the Boreal-Atlantic transition is the widespread start of peat growth at this level, perhaps a further indication of increased wetness. Many areas of blanket peat throughout northern England commenced growth at this time (e.g. Conway 1954, Phillips 1969), although not only do species of damp habitats appear in large numbers but there is a general and large scale shift in emphasis of tree spp. from the _Pinus_-Coryloid of zone VI to the deciduous mixed oak forest of zone VIIa which includes _Quercus_, _Ulmus_, _Tilia_ and _Betula_ in addition to _Alnus_. It is interesting to note that at the same time it has been proposed that there was a rise in sea level during which the final inundation of the remaining dry land of the North Sea in addition to the creation of the English Channel occurred (Godwin 1956). Whether this expansion of water area had any appreciable effect on climate is very hard to assess although Clark (1936) recognized differences between the expanse of dry land in the warm, continental Boreal period and the marine transgression phase at the beginning of the warm oceanic Atlantic period. It may have some effect on the North Yorkshire Moors by providing a larger water body in close proximity to the area than hitherto. However, the general effects seen on the pollen diagrams from the central watershed only appear to be of the kind recognized from other parts of the country.

The majority of authors appear to support solely the idea of a climatically induced change in vegetation at the Boreal-Atlantic transition, and while Smith agrees with the general idea of climatic change, he suggests that man may have had an effect on the rate of immigration of trees; for example, Alnus in particular may have been allowed to immigrate at a faster rate. Smith puts forward the idea that the greatest effect of man on the vegetation was through his use of fire and although the evidence is scanty and inconclusive an explanation of the anomalies recognized at the Boreal-Atlantic transition at some sites may be found in such burning (Smith 1970). There appears to be no reason for arguing the influence of early man at the Boreal-Atlantic transition in the North Yorkshire Moors, although the whole question of mans' effect on the woodland environment is discussed below (Part B).

The Boreal-Atlantic transition has been dated by various authors at around 5000 to 6000 years B.C. (e.g. Godwin 1956). Smith describes two dates from Shippea Hill, East Anglia (from Clark and Godwin 1962) which fall on either side of the Boreal-Atlantic transition: 5650 ± 150 B.C. and 4735 ± 150 B.C. (Smith 1970). These may be compared with two recent dates obtained from two sites on the North Yorkshire Moors at West House and Glaisdale Moor: West House gives a date of 6650 ± 290 years B.P. (GaK 2706) and Glaisdale Moor a date of 6250 ± 220 years B.P. (GaK 2709). The date for West House falls within the range covered by the later date from Shippea Hill. Similarly the difference in dates between West House and Glaisdale Moor can be accounted for as the two dates overlap when the mathematical error is taken into account. Quite clearly there is no substantial difference in the date of the Boreal-Atlantic transition between sites although it does appear that the transition occurs slightly later in north east Yorkshire than the rest of the country.

4. Zone VIIa

This is the period described as the climatic optimum when deciduous woodland was at its peak in north-west Europe and certain species with critical temperature thresholds flourished further north than before or since. Not only did temperature rise to a maximum in VIIa but precipitation also rose and these climatic changes coincided with the start of much of the blanket peat growth in Britain (e.g. Tallis 1964a, 1964b, Phillips 1969, Conway 1954, Simmons 1964, 1969a). Similarly at a great many sites on the North Yorkshire Moors blanket peat accumulation proper commenced during this period (e.g. Loose Howe, Collier Gill Head). In addition the peat in the landslip bog at St. Helena also commenced growth at this time. Generally the scene on the North Yorkshire Moors appears to have been one of a woodland composed of Betula, Quercus, Ulmus, Tilia, Alnus and Coryloid. The high percentages of Tilia are quite noticeable at some sites and Bartley has commented on a similar situation for some of his eastern England sites (Bartley 1962). Further comments about Tilia are made below under the section on the Ulmus decline.

The amount of herbaceous pollen in zone VIIa varies quite considerably from site to site and whereas the slack sites of Simmons, the lowland sites of Jones (Simmons 1969a, Jones 1969) and the present site in the St. Helena landslip bog all show closed forest conditions, these may possibly illustrate local conditions of dense forest growth. The blanket peat sites of the present work have highly fluctuating total N.A.P. percentages.

Glaisdale Moor for example has values of N.A.P. which vary from 25-50% of total pollen in VIIa and this may be contrasted with St. Helena 'B' where the equivalent N.A.P. percentage is only about 5% of total pollen, without significant fluctuations. There are also differences between the upland peat sites. For example, Collier Gill Head appears to have a much denser woodland than Trough House on the basis that Collier Gill Head has an N.A.P. value of about 5-10% of total pollen whereas at Trough House the equivalent value is 30-40% of total pollen. However, even though at Loose Howe the greater part of the N.A.P. values consist of Calluna and Gramineae pollen, there is no indication of widespread occurrence of open habitat types (e.g. ruderals) so to what extent the Loose Howe site was 'open' in VIIa is difficult to assess. The extent to which tree percentage values decrease very rapidly away from the edge of a wood (Section II, J) may suggest that at Loose Howe at this time the woodland was only 'thin'. Perhaps the site was slightly damper than the surrounding woodland and discouraged extensive tree growth. At Collier Gill Head there is still a range of N.A.P. types including Calluna and Gramineae but they are not at such significant levels as at Trough House. A further contrast between Collier Gill Head and Trough House is that there are wood remains in the peat at the former site but none at the latter site. In order to explain the presence of wood in the peat and high total tree and shrub pollen percentages at Collier Gill Head it might be expected that a continuous woodland of Betula, Quercus, Alnus and Coryloid existed at the site; However, in suggesting a woodland of this nature a question arises from the fact that the macroscopic wood remains from the peat are almost solely Betula, a situation which exists for most of the other sites from the central watershed, while the pollen percentages for this spp. are relatively low. A similar situation is found at Glaisdale Moor where Betula is the sole wood remain found in the peat and yet Betula pollen percentages amount to only around 2% of total pollen while Quercus, for example, reaches rather more than 5% of total pollen. In the present work the only site where Betula reaches a significant level during zone VIIa is at Bluewath Beck where a single count recorded 17% of total pollen belonging to Betula (Section II, K). The explanation of this apparently anomalous position of Betula at many sites on the central watershed is hard to find unless at the time the spp. was not flowering normally.

It seems quite likely from the available evidence that even the higher parts of the central watershed had some tree cover during zone VIIa although this cover may have been of shrubby nature in parts, judging by the diminutive size of tree trunks and branches contained in the peat and the high incidence of Coryloid pollen from the period, or quite thin in other parts (see also part B). The latter suggestion may possibly be supported by the presence of a continuous, although low, curve for Fraxinus throughout most of the present pollen diagrams. This spp. has been regarded as an indicator of open conditions (Pennington, 1969) and may support the idea of a not completely dense and continuous woodland across the central watershed even during the climatic optimum.

5. The Ulmus decline (Zone VIIa/VIIb boundary)

This is the classic boundary described from pollen diagrams throughout north west Europe. The major change in the pollen spectra consists of a sharp decline in the percentage of

Ulmus pollen, and the interpretation of the significance of this seemingly relatively minor change has been surrounded by controvers ever since Iversen suggested that it indicated the effects of Neolithic man on vegetation (Iversen 1941). Other authors have suggested alternative reasons for the decline in _Ulmus_ and possibly the most popular of these alternatives has been climatic change (e.g. Frenzel 1966). However the greatest number of authors have agreed with Iversen and have assigned the _Ulmus_ decline to the work of prehistoric man even though there are a number of difficult points to answer, some of which are discussed in Tauber (1965).

The _Ulmus_ decline recognized on the present diagrams from the central watershed is not equally clearly seen from all the sites. The most marked decline in _Ulmus_ is apparent from the upland blanket peat sites, for example at Collier Gill Head, Glaisdale Moor and Trough House whereas at some of the lower sites, for example at Wheeldale Gill and St. Helena 'B' it is more difficult to define. The recognition of a separate _Ulmus_ decline and 'landnam' phase is not strictly possible at the present sites although, for example, Iversen and Oldfield, have described this feature for other areas (Iversen 1941, Oldfield 1963). Oldfield does have a primary _Ulmus_ decline and landnam which feed into each other at his western sites, but the two separate stages of _Ulmus_ decline and landnam which he describes for his other sites, with a recovery of _Ulmus_ after the primary _Ulmus_ decline and before the landnam, is certainly not in evidence from the sites on the central watershed. The _Ulmus_ decline from the present sites is closely connected with an expansion of N.A.P. types, of which possibly the most significant group is that of the ruderals. The peaks of ruderal pollen types, particularly Plantago lanceolata were recognized by Iversen as resulting from the disturbance of the forest environment by man through the medium of small scale clearances (Iversen 1941). The pre-requisite of a reduction in total tree pollen at the Ulmus decline (Iversen 1941) is not completely apparent in all the diagrams from the central watershed. However, with regard to Ulmus itself, the sp. does decline from about 25% to about 5% of total tree pollen at Trough House and Glaisdale Moor so the fall is quite marked and is also clear on the total pollen diagrams. At Collier Gill Head the Ulmus decline is sharply amplified by a rapid increase in Calluna and Gramineae in particular although coupled with a noticeable increase in the overall number of N.A.P. types; Plantago lanceolata, Tubuliflorae and Spergularia appear for the first time at the level of the Ulmus decline. The clearance at Collier Gill Head seems to be more clearly seen in terms of the reduction in Coryloid percentages rather than a general reduction in tree pollen. Overall the clearances of the Ulmus decline on the central watershed seem to be of a relatively small scale and short lived, a situation completely in keeping with that described from other areas of Britain. The recovery of the woodland after the Ulmus decline is very clear from the present sites and even Ulmus itself expands once more although its recovery is not sufficient to restore its pre decline position in the pollen spectra. The nature of the Ulmus recovery is similar to that described from many other published pollen diagrams (e.g. Godwin 1956).

The sites of Simmons, especially the two blanket peat sites (Collier Gill and North Gill) show clear Ulmus declines (Simmons 1969a) as would perhaps be expected from their proximity to the sites of the present study. The Ulmus decline at St. Helena 'B' in the present study is not very clearly defined and in this respect it is perhaps similar to the Ladybridge slack site of Simmons (1969a).

Within the present work an unusual feature which is more marked at the blanket peat sites than in the landslip sites is the very high percentages of Tilia recorded at and just before the Ulmus decline. Simmons noted this in his sites from the North Yorkshire Moors (Simmons 1969a) but the percentages, which are on a comparable basis, are very much higher from some of the sites examined in the present study. The most remarkable site is that at White Gill where at one point Tilia reaches about 35% of total tree pollen and steady counts of 10-12% of total tree pollen are found at several levels above and below this single level. Pike Hill Moss has very much higher Tilia percentages as a percentage of total tree pollen than White Gill but the total tree pollen count is low and cannot be strongly relied on. The fact that the high Tilia counts from both sites are from minero-organic material (Section II, B) may suggest differential preservation of the Tilia grains, as was suggested for example by the 40% of total tree pollen count for Tilia at Burtree Lane in the Tees basin (Bellamy et al, 1966). However, in general, the pollen material from the present sites was well preserved and showed no excessive destruction of grains. Trough House is another site in the present study with high Tilia percentages of up to 15% of total tree pollen, although these are actually recorded after Ulmus has started to decline. Glaisdale Moor shows a similar phenomenon, and in general high Tilia percentages seem to be a marked feature of the Ulmus decline. It is difficult to assess the position of Tilia in the woodland at this time and whether the peaks of *Tilia* at the *Ulmus* decline reflect a relative change owing to the removal of *Ulmus* or an actual change through the expansion of *Tilia* cannot be determined from the available evidence. Bartley has also noted relatively high percentages of *Tilia* from some of his north-east England sites (Bartley 1962, 1969) and Simmons suggests that *Tilia* was climatically and edaphically suited to the North Yorkshire Moors as well as to the adjacent lowland areas (Simmons 1969a). It may have been that soil conditions were optimum for the growth of *Tilia* on the North Yorkshire Moors at this time and fulfilled the conditions that Anderson suggested: "They (*Tilia*) are among those spp. which can thrive on dry, shallow, base rich soils" (Anderson 1961). As the soils on the North Yorkshire Moors became leached and peat began to accumulate, there was an inevitable decline in *Tilia*.

There are no radiocarbon dates available at the moment for the *Ulmus* decline on the North Yorkshire Moors and for the time being it must be assumed that the date is somewhere close to 3000 B.C., that is, the generally accepted date for the *Ulmus* decline throughout north-west Europe. Phillips has dated the *Ulmus* decline in the southern Pennines to 3040 $\pm$ 140 years B.C. (Phillips 1969) and it would seem unlikely that a date for the North Yorkshire Moors would be radically different. The radiocarbon date at St. Helena 'B' tends to support this as the date of 5390 $\pm$ 220 years B.P. (GaK 2708) comes just before the *Ulmus* decline in the pollen diagram.

In general terms while there are no real problems in the recognition of the *Ulmus* decline at most of the present sites on the central watershed there are problems associated with interpreting changes recorded in the pollen diagrams at this time and some of these problems will be discussed in Part B.

6. Zones VIIb and VIII

The zonation scheme adopted for this period is entirely a local one and is based on the recognition of a number of general pollen assemblages which can be identified in the pollen diagrams from the central watershed. The synchroneity of the pollen sub-zone boundaries throughout the area cannot be demonstrated without a substantial number of radiocarbon dates and therefore the scheme proposed must be regarded as tentative at the present time. Similarly the linking of the sub-zones with archaeological periods must be considered as a suggested scheme until more evidence is available. As the local sub-zonation scheme is unique to the present work no valid comparisons can be made with other areas in the absence of a series of radiocarbon dates.

(i) Sub-zone NY 1

In general this period is one in which woodland on the central watershed recovers after the *Ulmus* decline although *Ulmus* and *Tilia* remain low. *Alnus* shows quite a marked expansion at some sites (e.g. St. Helena 'B') although it seems likely that this feature is a localized one and may not be contemporaneous at all the sites at which it is recognized. Only a series of radiocarbon dates could clarify the latter point. Even if the *Alnus* expansion is dated at the same time for all the sites, there is no clear indication why such an expansion took place. It is not accompanied by an increase in damp habitat plants so it is likely to have been an increase in the area occupied by Alnus at the expense of other tree spp. The sites which clearly show the Alnus increase all tend to be away from the present open moorland, and the sites which are on the open moorland only hint at an increase in Alnus; for example, both Glaisdale Moor and Collier Gill Head show a slight expansion.

The sub-zone also sees the first appearance of Fagus in most of the present diagrams. This tends to be earlier than in Simmons diagrams (Simmons 1969a) and for the country as a whole. The explanation may be that the general tree cover was becoming less dense on the higher parts of the central watershed even at this early stage and this was sufficient to allow the occasional grain of Fagus to be incorporated in the accumulating peat. It must be remembered that by this time woodland had ceased to grow actually on the blanket bogs of the higher parts of the moors as there are no wood remains in the stratigraphy. Therefore the bog surfaces must have been open, allowing a more regional pollen rain to be deposited. The amount of Fagus is nowhere very great, the lowest grains in the profile from Blakey Landslip for example were found during scanning of the slides and elsewhere percentages are generally less than 1%. At this time Fagus may have established itself on the limestone soils further south of the moors.

Another general feature of the present pollen diagrams from sub-zone NY 1 is the decrease in Coryloid which was possibly due to a number of interrelated factors, such as the slow spread of blanket bog, the destruction of the shrub by fire, and increased grazing pressure. Whichever of these or other factors may have been most important, the trend was clearly one which moved towards less shrub and more herbaceous types as the sub-zone progressed. The higher altitude sites seem to show this more than the lower sites, perhaps a reflection of the vulnerability of the former to external influences. The difference between sites certainly becomes very marked; for example, Howdale Hill and Glaisdale Moor, have approximately 50% of total pollen taken up by N.A.P. types whereas at St. Helena 'B' the comparable figure is about 5-10%. Despite the gradual opening of the moorland summits, the process was not directly akin to a clearance phase and consequently ruderal pollen types are not present in the same numbers as at the Ulmus decline for example.

The area must have had the general appearance of dense woodland in the valleys and dales with a thin scrub cover along the higher parts of the central watershed ridge. Damp and boggy areas would have been increasing in size and number as peat accumulated although the open areas present were certainly not dominated completely by Calluna as yet.

(ii) Sub-zone NY 2

The gradual changes in vegetation during sub-zone NY 1 were disturbed in sub-zone NY 2 by more rapid changes brought about by the clearance of woodland by man. As with the vegetation changes in sub-zone NY 1, those in sub-zone NY 2 seem to have been more marked at the sites from the higher moorland. There are only slight indications of vegetation disturbance at this time at a site like St. Helena 'B' while Wheeldale Gill shows a sharp clearance phase which through the additional information of a radiocarbon date may be tentatively ascribed to the Bronze Age (part B). This particular site probably reflects the well developed clearance phase suggested as being of the same age from Yarlsey Moss a site only a few hundred metres to the north of Wheeldale Gill. All the clearance phases assigned to sub-zone NY 2 from the central watershed are tentatively dated to the Bronze Age as this appears to have been a time of intensive human activity (part B). A more thorough series of radiocarbon dates would probably clarify the situation and allow more certain correlations between sites.

The clearance phase of sub-zone NY 2 shows a typical reduction in woodland and a rapid increase in N.A.P. types including ruderals. Probably the best site illustrating sub-zone NY 2 is that at Yarlsey Moss where the phase is spread over several centimetres of the profile, and where there are a number of interesting features. The gradual build up and decline of a wide range of ruderals can be clearly seen (for example, _Plantago lanceolata_ and _Rumex_) and this is echoed by the behaviour of _Pteridium_ and the sporadic appearance of Cerealia grains at the peak of the clearance. On the other hand the woodland spp. which are most drastically affected by the clearances are _Alnus_ and Coryloid. This is a feature which can be recognized in several diagrams from the central watershed. It seems almost as though the major areas of dense mixed woodland are confined to the valleys of the moors and it is only the thinner and poorer scrub woodland on the upper slopes which was actively cleared. This scrub was likely to have extended some way on to the higher parts of the moors and because of its nature was easily cleared by fire or grazed out by domestic stock. The dominant ruderal pollen types are those indicative of pastoral farming (Godwin 1968) with _Plantago lanceolata_, _Rumex_ and _Artemisia_ all generally at higher values than the arable indicators such as Compositae, Chenopodiaceae and Cruciferae. This is much to be expected from the knowledge of Bronze Age farming activities (Part B). It is interesting to note that Phillips regarded the grazing of animals as a far more important factor in keeping an area open and free from regenerating woodland than the growing of arable crops (Phillips 1969).

The general picture of this period on the central watershed is one of widespread clearance of scrub woodland by man on a scale which had not been seen before. However, this clearance was confined to the higher parts of the moorland ridge and the effects on the lower valleys and dales (cf St. Helena and Blakey Landslip) seems to have been negligible. In most of the diagrams the clearance phase is relatively short lived, for example at Howdale Hill and White Gill, and only at Yarlsey Moss is it a well developed feature. A number of basal diagrams show only the first part of the clearance phase right at the top of the diagram and do not show its full development (e.g. Trough House). The diagrams of Simmons show a clearance phase similar to that of sub-zone NY 2 and he also assigns it to the activities of Bronze Age man (Simmons 1969a).

(iii) <u>Sub-zone NY 3</u>

The period of intensive clearance recognized by sub-zone NY 2 is followed by a time when trees and shrubs make a limited recovery. While ruderals diminish rapidly as trees and shrubs expand once more, they still provide a continuous pollen curve and this indicates the presence of some disturbed ground. The pollen curves are by no means steady during this period and may indicate further clearance phases. However, these must be of a minor nature when compared with the clearances of sub-zone NY 2 and it is also difficult to assign any of these later phases to an archaeological period without radiocarbon dates. The lack of marked clearance is consistent with the archaeological evidence from the area which suggests that post Bronze Age peoples tended to affect the periphery of the moors rather than the centre (Part B).

There appears to be a rapid expansion of Alnus at Wheeldale Gill during sub-zone NY 3, although this must be a highly local reflection of conditions as there is no indication of similar conditions at Yarlsey Moss which is only a few hundred metres to the north. A characteristic feature of several diagrams at, for example, Blakey Landslip and Wheeldale Gill is the decline - expansion phase in woodland and shrubs towards the end of the sub zone. The phase may be almost recognized at Yarlsey Moss and Loose Howe as a more well developed feature. The interesting point is that this feature does not contain a marked increase in ruderals at the decline stage and it may perhaps represent an increase in grazing pressure possibly some time after the Iron Age. The dating must only be tentative in the absence of radiocarbon dates.

Simmons recognizes a phase similar to the present sub-zone NY 3 in his sub zone D where he remarks that at his North Gill and Collier Gill sites there is some decline in ruderals and clearance indicators of the previous sub-zone although the clearance effects were continued (Simmons 1969a).

While the higher areas of the central watershed were regaining a little tree and shrub cover the lowlands remained heavily wooded (e.g. St. Helena, Blakey Landslip), a situation which continued until the massive clearances at the sub-zones

NY 3/4 boundary.

(iv) Sub-zone NY 3/4 Boundary

This is one of the most remarkable and clearly seen vegetation changes in the North Yorkshire Moors pollen diagrams. At many sites the decline in trees and shrubs and expansion of N.A.P. types seems to be very rapid although not all sites show the boundary in such a way. St. Helena 'A', Blakey Landslip and Wheeldale Gill for example show rapid declines in trees and shrubs while it is mainly those sites on the upland blanket peat areas which show a more gradual decline, for example at Yarlsey Moss and Loose Howe, although overall the final result is much the same. The change in pollen types can be equated satisfactorily only with an intensive clearance phase. The pollen evidence bears this out with rapid increases in ruderal pollen types together with the appearance of Cerealia pollen grains in quantity for the first time. Cyperaceae, Gramineae and at some sites *Pteridium* reach peaks at the same time.

From the pattern of the pollen curves from the lower altitude sites at Wheeldale Gill, Blakey Landslip and St. Helena, with the possible exception of St. Helena 'B' where the evidence is more confusing, it would seem that this was the period in which clearance of woodland in the dales was at its peak. Historical evidence (Part B) would suggest, in the absence of radiocarbon dates, that this phase could be tentatively correlated with the period of Mediaeval settlement of the moors. This was the first period when man extensively used the moorland dales (Farra 1961).

The more gradual change at the higher blanket peat sites may be due to their more inaccessible position, although in the end they reach comparable percentages in terms of trees and shrubs as the lower sites.

The sites of Moss Swang and Ladybridge Slack (Simmons 1969a) do not show the clearance at the NY 3/4 boundary to the same extent as most of the present sites and in this respect may be similar to the position found at St. Helena 'B' where an extremely local pollen source masks the more regional pollen pattern. Certainly the upper parts of the Ladybridge Slack diagram are similar to St. Helena 'B' in that there are high peaks of Betula and Salix.

It will be noted that peaks of Sphagnum occur at the height of the clearances at St. Helena, Blakey Landslip and Wheeldale Gill and it is possible that an increase in wetness on the bog surface was brought about by more rapid run off of rain water into the bog. This could have resulted from the removal of trees and shrubs from the area immediately around the bog. A similar effect is not seen in the higher blanket peat sites as trees had ceased to grow in the immediate vicinity of the bog long before the sub-zone NY 3/4 boundary.

(v) Sub-zone NY 4

This phase is generally one of continued farming after the sharp clearances attributed to Mediaeval times. There are fluctuations in the pollen curves during sub-zone NY 4, particularly at Blakey Landslip, although most of these can be attributed to local regeneration of Betula and Salix, and the high levels of N.A.P. are maintained. These minor fluctuations could be correlated possibly with various phases of reduction and expansion in farming which are documented, but without the aid of radiocarbon dating a sub-division of sub-zone NY 4 will not be attempted.

One of the most significant features of the period is the decline in dominance of Cyperaceae and Gramineae and their replacement by Calluna. Perhaps as the former woodland soils were exposed to erosion and leaching they became increasingly acid in nature and favoured the expansion of Calluna. The scenery of the moors at this time must have been similar to that of today with open moorland eventually dominated by Calluna. The remnants of trees and shrubs must have been scattered on the steeper slopes and on the poorer agricultural land in the dales, out of reach of grazing pressure. The small patch of woodland at the northern end of St. Helena bog (i.e. St. Helena 'B') lasted almost up to the present day and must have been typical of the remnants of woodland remaining after the Mediaeval clearances. At the same time there were changes in the tree pollen in terms of an expansion of certain tree types, mainly Pinus, Ulmus and Fraxinus, towards the end of the sub zone. This may have been the effect of active reafforestation on large estates in the southern parts of the moors in the seventeenth century and later.

(vi) Sub-zone NY 5

This could be described as the 'modern' period when the pollen spectra becomes very similar to that found at the present day on the central watershed. N.A.P. types remain dominant in the pollen spectra despite the fact that much marginal farming land must have gone out of production and was probably reverting to Pteridium and Calluna moorland. During this phase Calluna becomes the most important sp. in the pollen spectra except at certain sites where another local pollen producer exceeds it; for example, at Blakey Landslip where Cyperaceae dominates the 2 cm. sample. The dominance of _Calluna_ has really been confirmed over the last two centuries through regular burning, a necessary procedure for managing grouse moorland, and constant sheep grazing. However the pattern of the pollen rain over the moors has been changing slowly through other influences. The active planting of trees by large estates, and by the Forestry Commission in the last 50 years, has resulted in the increases in _Pinus_ and perhaps also _Ulmus_ pollen which can be seen at the top of the diagrams from sites such as St. Helena and Howdale Hill. Coryloid by this stage has been reduced to very low levels, a feature in keeping with the limited distribution of both _Myrica gale_ and _Corylus avellana_ at the present day. Within the sub zone there is the interesting feature of a slow reduction in ruderal pollen perhaps partly an effect of reduced agricultural land and partly the reduction of suitable habitats on the moorland proper through the encouragement of the growth of _Calluna_.

B. The Impact of Man

The pollen zone boundaries and boundaries attributed to a change from the dominance of one prehistoric culture to another are not synchronous. It has become an accepted fact that different cultures tend to overlap one another so the cultural boundaries are by no means clear. The purpose of this part of the discussion is to review the effects of the various cultures on the vegetation pattern described in part A.

1. Mesolithic

This was the first cultural group to appear on the central watershed after the initial warming of the climate early in the Flandrian. A number of authors (e.g. Radley 1969) have recognized three separate cultures within the Mesolithic : Maglemosian, Sauveterrian and Tardenoisian. These cultures cover various time periods and an outline of the periods together with radiocarbon dates is shown below : (after Radley 1969)

Maglemosian	Thatcham	8080 ± 120
		7550 ± 170
	Star Carr	7638 ± 209
Sauveterrian	Ickornshaw Moor	6150
	(Britain becomes an island)	
Tardenoisian	Peacock's Farm	5650 ± 150
	Oakhanger	4400 ± 120
Neolithic		c. 3000

(dates all B.C.)

The first peoples to inhabit northern England after the Late-Glacial were those of the Maglemosian culture who settled at a number of sites throughout the region, but had the general characteristic of choosing lowland lake side and riverine sites for their settlements (e.g. Skipsea, Hornsea, Star Carr). The nearest site to the central watershed is that at Star Carr which has been extensively described by Clark (1954). Radley notes that it is unusual that no sites have been found in the dales or along the coast such as that at Crimdon Dene in County Durham. The Maglemosian peoples had adapted to the forest environment which developed very rapidly after the retreat of the ice and they worked a range of adzes and axes which were suitable for felling trees (Clark 1936, 1954). Hunting was the main occupation for these peoples and the animals pursued included elk, red deer, roe deer and wild pig, while fishing could be carried out in the adjacent rivers and lakes. Collecting berries and nuts must have been a further occupation. Clark pointed out the absence of both agricultural implements and the remains of grain at the settlement sites (Clark 1936). This point is amplified further by Clark in the study of Star Carr where pollen analysis revealed that the site was only a small clearance in a thick woodland and the ruderal pollen types were restricted to the immediate site : "It is clear that the Mesolithic people, by their hunting techniques, were taking advantage of the rich fauna of the forests, whilst still leaving the forest itself virtually untouched." (Clark 1954) There are no indications from the evidence at present available that Maglemosian peoples were attracted to the central watershed.

The Sauveterrian culture which appeared after the Maglemosian was not confined to low altitudes as remains are found at many upland sites in the Pennines (Phillips 1969). These were the peoples who introduced the first truly miniature microliths (Radley 1969). It appears that there is some confusion in terminology between Sauveterrian and Tardenoisian, the latter being the last distinctive Mesolithic culture in northern England, and some authors have tended to group them together. Radley (1969) points out that as the country was cut off from the continent at about 6000 years B.C., the pure Tardenoisian forms of the continent were not so well developed here, and a rather more hybrid form with some Sauveterrian affinities developed. The central watershed probably contains sites with flints which are purely Sauveterrian in character but as these types have not yet been isolated there is no definite evidence for the presence of man on the central watershed before 6000 B.C. The great bulk of flints found on the moors have been recognized as deriving from regional variations along Sauveterrian lines (Radley 1969). The most surprising factor about the Mesolithic flints from the central watershed is the great abundance of sites on ground above 1000 feet (305 metres). Hayes recorded 22 sites all above 1000 feet (305 metres) although these ranged from the finds of a few waste flakes to an elaborate series of flint working areas (Hayes 1958). The major Mesolithic finds on the central watershed are marked on fig. 43. Clark recognized that the site characteristics preferred by Maglemosian peoples and Tardenoisian peoples were distinctly different (Clark 1936), an observation which is clearly applicable to the central watershed despite the problems of describing pure Sauveterrian and Tardenoisian flint types for the area. There is in addition a distinct difference between the flints of Maglemosian type and those of Sauveterrian / Tardenoisian type as the latter contains

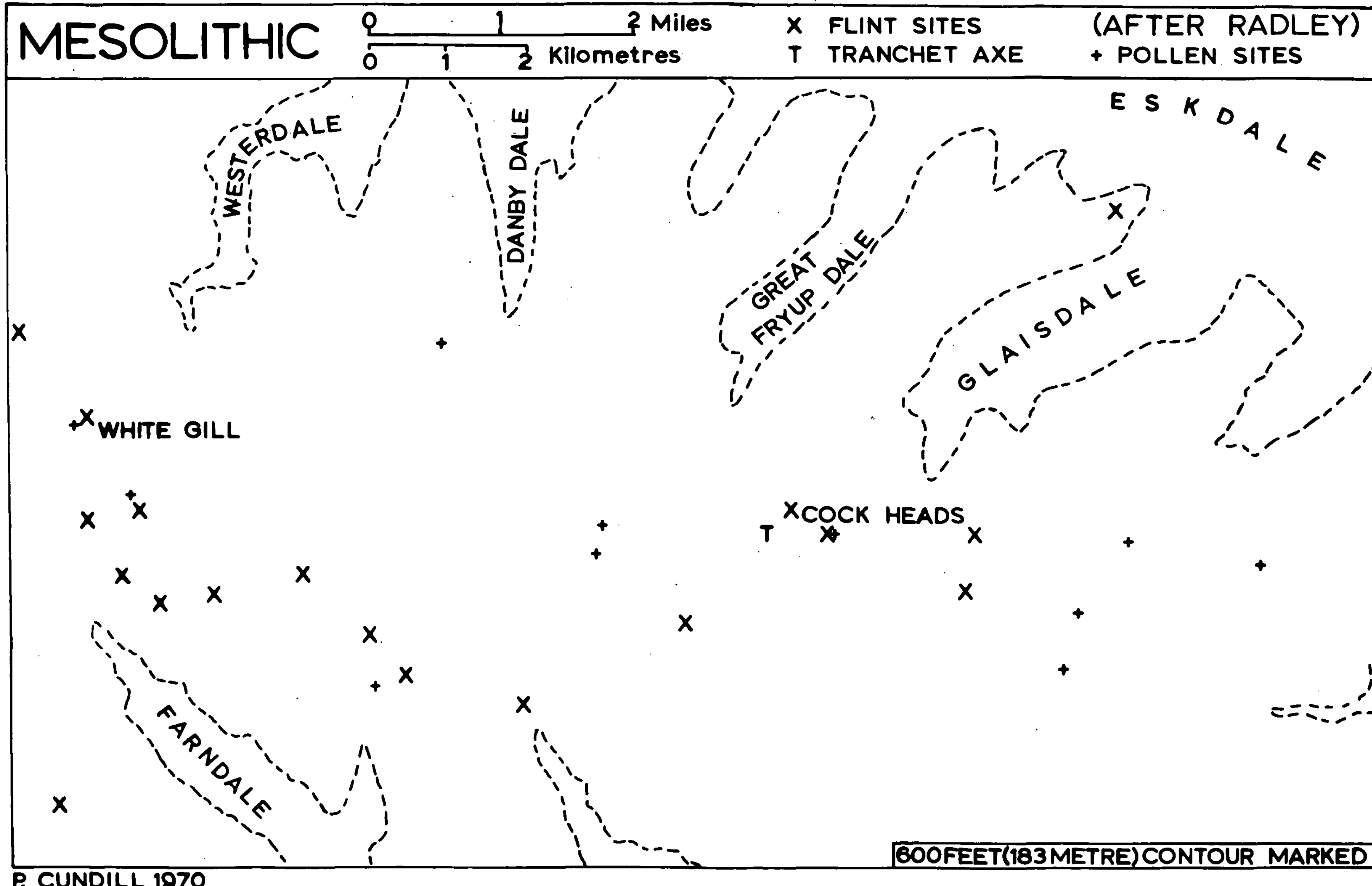


fig. 43 Distribution of Mesolithic sites on the central watershed.

no axe form which would have been useful for tree clearance. It is difficult to argue whether or not this fact gives any indication of the nature of the environment on the central watershed in the late Mesolithic. Radley dates almost all of the flint assemblages from the central watershed as equivalent to zone VIIa while he hints that many of them may belong to late zone VIIa within the range 3000-4000 years B.C. (Radley 1969).

The late dating of the majority of flint sites means that the effects, if any, of Mesolithic man on the environment of the central watershed should be shown in the number of pollen diagrams covering this period. In the past, authorities on Mesolithic cultures have maintained that these early peoples were hunters and fishers, and had a very limited effect on the woodland environment (e.g. Clark, 1936, 1954). To some extent this view has been perpetuated by some pollen analysts (e.g. Godwin 1956) who suggest that there is very little evidence of Mesolithic man affecting the vegetation. In the present work there is no direct evidence of a link between Mesolithic man and removal of woodland. Such a link would have been provided by finds of stratified flints in peat coupled with radiocarbon dates and pollen analytical work. As it is, the present work, being based solely on the results of pollen analysis, can only provide insubstantial evidence for the effects of Mesolithic man on the vegetation.

The pollen diagram for Glaisdale Moor was constructed from material supplied by Bartlett who had found flints of Tardenoisian form with Sauveterrian affinities stratified in a 'lower peat', which is equivalent to the wood peat at this site. Churchill analysed some peat adhering to one of the flints found at the site and ascribed a zone VIIa age to it. Clark commented that there was "an absence of any indicators of cultivation, and low herbaceous pollen frequency." (in Bartlett 1969). The present pollen diagram from Glaisdale Moor does not wholly agree with these comments and perhaps indicates that too much reliance should not be placed upon single pollen counts. While there are only a few finds of ruderal pollen types from the zone VIIa period on the Glaisdale Moor diagram, they do occur and may indicate some disturbed ground. Similarly the percentage of N.A.P. is relatively high and amounts to 20-30% of total pollen although this total fluctuates quite markedly. The percentages of N.A.P. are similar to those found at other sites on the central watershed including White Gill and Loose Howe. These results contrast sharply with those from sites at lower altitudes (e.g. St. Helena) where N.A.P. values are about 5-10% of total pollen.

The evidence from the higher blanket peat sites does not in itself indicate the effects of man on the environment but does allow for the argument that the woodland did not have a completely closed canopy similar to that in the dales. There has been a suggestion (Part A) that there was more shrub vegetation on the higher summits and this in itself may have attracted Mesolithic man to the area, by allowing easier movement and perhaps even easier hunting than in the more dense lowland woods. Mesolithic man quite clearly had the use of fire and flint remains are often found in association with charcoal, as at White Gill where charcoal of Quercus, Betula, Alnus and Corylus has been found at the level of microliths (Dimbleby 1962). Small pieces of charcoal are frequently found throughout zone VIIa deposits from the central watershed and are indicative of frequent fires during this period of time. Simmons has found a substantial layer of charcoal at the base of his profiles from North Gill and this is associated with marked fluctuations in the pollen curves, including the appearance of many ruderal pollen types. The charcoal layer is dated as early zone VIIa and Simmons finds it hard to resist suggesting a link between Mesolithic man and the fire which is represented by the charcoal (Simmons 1969a).

Other causes for the fires during zone VIIa are difficult to visualize especially when the only reasonable explanation is probably that of natural (i.e. lightning) fires. This explanation would appear to be difficult to accept if zone VIIa is to be described as having a mild oceanic type of climate. Lightning fires at the present day are not documented in large numbers in the deciduous woodland areas of the northern hemisphere but where they do occur the fires are generally limited because of the nature of the climate and vegetation. Komarek pointed out that in the eastern deciduous forest of the United States, in spite of the frequency of lightning, fires from this cause are very rarely widespread (Komarek 1968).

The weight of what is mainly circumstantial evidence in the form of widespread finds of charcoal together with numerous flint remains, would suggest that it was quite likely that Mesolithic man utilized fire. This would be in keeping with suggestions that Mesolithic man may have used fire in order to hunt game more easily, either by using fire to flush out game from the woodland or to open up areas of the woodland (e.g. Dimbleby 1962, Simmons 1969c). If, as already suggested, the woodland on the upper areas of the moors was more shrubby than that in the lowlands, then the effectiveness of the use of fire may have been very great in opening up this woodland. The use of fire may not have been completely deliberate, and accidental fires, from for example limited fires becoming out of control, may have been very important in the overall picture. There is, however, in the present work no indication of any kind that fire was used to promote agricultural activities during the Mesolithic and therefore the early suggestions that Mesolithic man was a hunter and fisher can be supported. On the other hand the evidence of the present work, limited as it may be, does add to the growing body of opinion (e.g. Dimbleby 1962, 1967, Simmons 1964, Smith 1970) that Mesolithic man did actively affect his environment.

2. The Mesolithic-Neolithic transition and the Neolithic period

The time at which Mesolithic man finally disappeared from the English landscape has been a topic of discussion for a long time. Several authors have come to the general conclusion that Mesolithic man must have persisted in certain areas well into Neolithic times if not Bronze Age times (Dimbleby 1961, Phillips 1969, Radley 1969). It is difficult to judge how much contact Mesolithic man had with the Neolithic peoples, who arrived in this county from the continent. Some incorporation of Neolithic ideas by the indigenous Mesolithic population may have taken place and in this connection it is interesting to note that several Neolithic knives have been found close to the site at White Gill where numerous Mesolithic flints have been discovered. However, the major distribution of Neolithic remains in north east England appear to avoid, in general, the lowlands of the central part of the North Yorkshire Moors. There is a ring of Neolithic finds around the periphery of the moors but only the occasional flint axe or knife has been found on the moors themselves. A similar pattern is described for the southern Pennines where the Neolithic peoples preferred the fertile forest soils and produced stone axes suitable for felling trees (Phillips 1969). The distribution of Neolithic remains would suggest that perhaps Mesolithic man could continue his hunting on the moorland summits while Neolithic man occupied the lowland areas around or on the fringes of the moors. This suggestion poses some problems when the pollen evidence is considered.

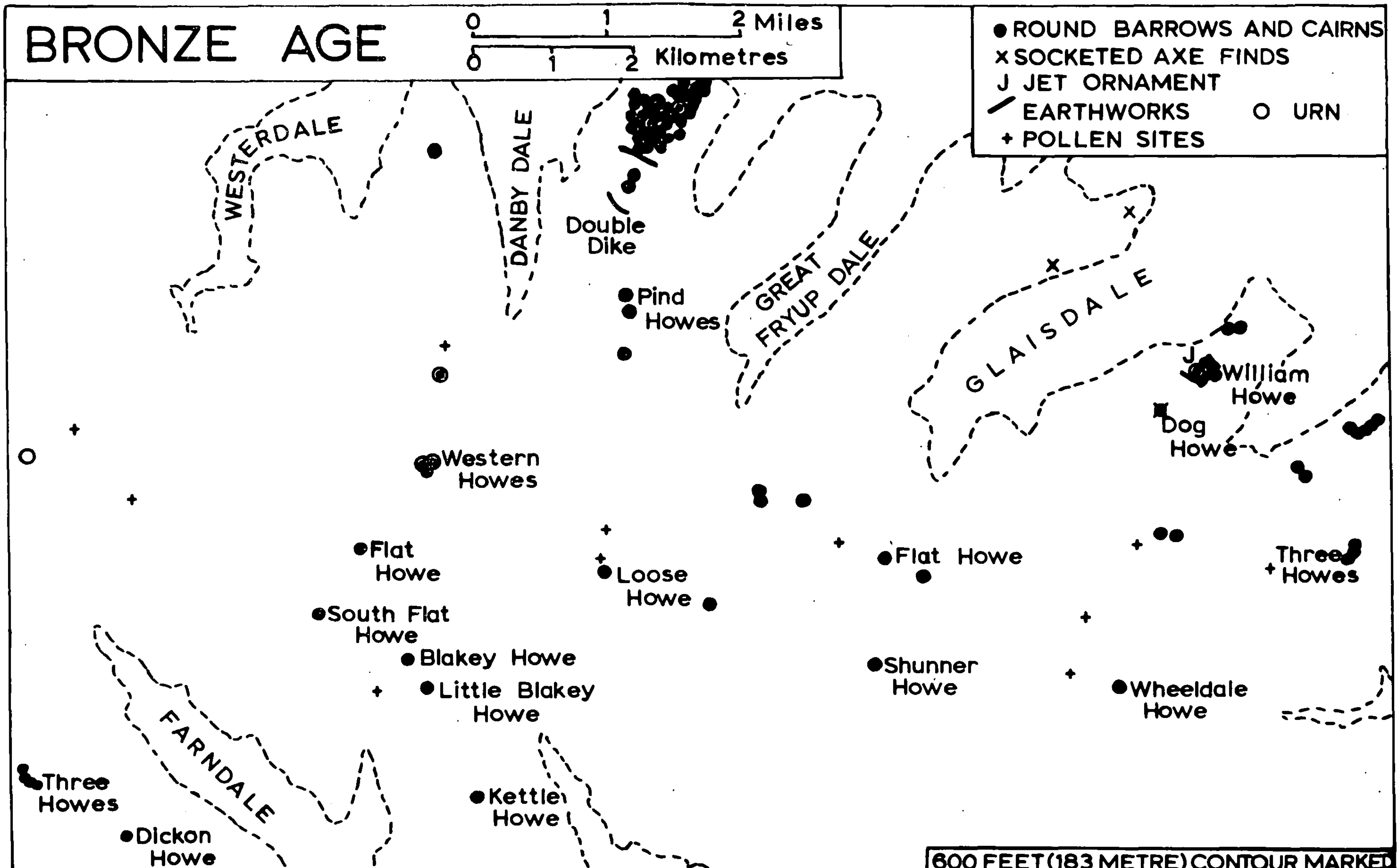
Neolithic man was the first of the prehistoric cultures to introduce a farming economy into Britain and there is now abundant evidence that he first appeared on the scene in this country sometime around 3000 B.C. It has been suggested that the most notable effect on the pollen record of the arrival of this farming culture was that of a decline in Ulmus pollen and a general clearance of woodland in many areas (Part A). This period is the first widely recognized impact of prehistoric man on the vegetation. The present pollen diagrams from the central watershed show clear Ulmus declines apart from the diagram from St. Helena 'B' (Part A), although it would appear from the available pollen evidence that the clearances at this time were fairly limited in nature and relatively close to the pollen sites. Coryloid appears to be the major woodland sp. affected at the Ulmus decline and generally decreases quite sharply. This sp. together with the N.A.P. types could be argued to be local pollen producers and this gives rise to the suggestion that the clearances are fairly local in nature. This interpretation would appear to conflict with the limited archaeological evidence which suggests an absence of Neolithic man on the central watershed and therefore it would be tempting to correlate the late rise of Mesolithic man in the area with the Ulmus decline.

The site at White Gill with a Mesolithic microlith in situ in peaty material may have hopefully clarified the position but here the evidence for an Ulmus decline is by no means clear. Besides it is likely that Neolithic peoples did venture up onto the central watershed, but because of the poor soils, and their own shifting agricultural practices, they made only a limited impact upon the vegetation. The Ulmus decline is remarkably short lived on the central watershed and this may support the idea of very limited clearances by Neolithic peoples. There is no indication in the present work of crop growing at the Ulmus decline and this may lead to the suggestion that the Neolithic farmers were mainly pastoralists. The clearances of the Ulmus decline are the only indications of the effects of Neolithic man on the vegetation of the central watershed as the woodland tends to recover after these clearances and is not greatly affected again until the next major phase of clearance which has been tentatively ascribed to the Bronze Age (Part A).

3. The Bronze Age

It would appear from the number and distribution of archaeological remains of the Bronze Age on the central watershed (fig. 44) that this area proved to be very attractive to these peoples. The distribution of Bronze Age barrows and cairns is, in general, fairly even although there are a few clear areas and a few areas which are intensively covered. Perhaps by this stage certain areas had become agriculturally undesirable because of excessive wetness or poorness of pasture, although this cannot be illustrated from the available evidence.

Two main cultures are distinguished for the early and middle Bronze Age period in highland Britain ; viz. Food Vessel culture



P. CUNDILL 1970

fig. 44 Distribution of Bronze Age sites on the central watershed.

and Collared Urn culture. The latter comes slightly later in the time sequence than the former. The Bronze Age folk in general are a development of earlier cultures and can be traced through from a mixing of Mesolithic and Neolithic and the so called Beaker peoples. Elgee assigned the Beaker and Food Vessel cultures to the early Bronze Age and the Collared Urn cultures to the middle Bronze Age (Elgee 1930), although Phillips mentions the trend towards regarding the Collared Urn culture as part of the early Bronze Age (Phillips 1969). All the cultures appear to have been predominantly interested in pastoral farming in the North of England although they did practise some arable farming.

The pollen analytical evidence for the presence of Bronze Age man on the North Yorkshire Moors has to remain tentative in the absence of a series of radiocarbon dates. On the pollen diagrams of the present work the first major clearance of any significant extent after the Ulmus decline is suggested as being the work of Bronze Age man and may be correlated with sub zone NY 2. This clearance phase can be seen most clearly in the diagrams from, for example, Yarlsey Moss, Howdale Hill and White Gill, and at Yarlsey Moss a few grains of cereal pollen were recorded at the level of the clearance. It would seem that from the distribution of archaeological remains that the Collared Urn culture was the most important culture on the central watershed during Bronze Age times. It seems likely that it was this cultural group which produced the marked clearance effects shown on the pollen diagrams. The knowledge of metal working meant that the Bronze Age peoples could produce metal axes which would have been powerful weapons in the removal of trees prior to farming. However, from the finds of charcoal especially at the clearance levels, it could be argued that fire was still a most significant force in the removal of woodland. The clearances made by Bronze Age man do not appear to be permanent as in every case some regrowth of trees and shrubs took place after the clearance. Dimbleby undertook soil pollen analyses of soils underneath and within Bronze Age barrows, and at Burton Howes barrow near the western extremities of the central watershed, he showed that initially the barrows were constructed within a woodland. Later interments indicated more open conditions while above the level of the interments treeless conditions prevailed (Dimbleby 1952c). The conclusions which Dimbleby reached about the vegetation changes on the North Yorkshire Moors during and just after the Bronze Age do contain some differences from the picture which emerges from the present work. The degree to which sites were wooded appears to be greater in Dimbleby's work than in the present study. However, it should not be forgotten that Burton Howes is a good deal further west than White Gill (the westernmost site of the present work) and as the former is a soil pollen analysis there may not be quite such a full picture of vegetation development which appears to be present in the peat analyses further east. The general conclusions remain much the same from both works; Bronze Age man made substantial and widespread inroads into the woodland which existed on the central watershed at this time.

4. Late Bronze Age, Iron Age, Romans and pre Mediaeval

These various cultures are grouped as there is very little significant evidence both archaeologically and pollen analytically for their presence on the central watershed. Archaeological remains are very limited in numbers and only minor vegetational changes may be detected from in the pollen curves. Each of the cultures will be discussed in turn to indicate what limited evidence there is for their presence on the North Yorkshire Moors.

(i) Late Bronze Age

A few finds attributed to this culture have been located on the central watershed. These have mainly been in the form of socketed axes discovered in the vicinity of Glaisdale (e.g. Elgee 1930). Otherwise the great mass of discoveries of this culture have been made to the south of the central watershed and in particular in Holderness. At Castle Hill, Scarborough, a large settlement was discovered (Elgee 1930) which overlaps into the early Iron Age. There are no clear indications from the central watershed pollen diagrams that this culture seriously affected vegetation in the area.

(ii) Iron Age

Remains of this culture are scarce on the central watershed although important sites have been discovered in Cleveland and on the southern peripheral areas of the North Yorkshire Moors. In the Cleveland area, the hill fort at Eston Nab was occupied during the Iron Age (early Iron Age pottery has been found at the site : Aberg, 1969) and there are collections of Iron Age huts on Kildale Moor (NZ 612115) and just south of Percy Rigg (NZ 631098). The lack of archaeological remains from the central watershed may be reflected in the lack of marked fluctuations in the pollen curves. This may be contrasted with the peripheral moorland areas where fairly intensive farming must have been carried out. Possibly these latter areas show similar features to those described from the southern Pennines where the Iron Age was the period of greatest removal of woodland and most intensive farming activity (Raistrick 1966, Phillips 1969). Iron Age man in the north of England was almost certainly primarily a pastoralist although he probably grew some arable crops.

(iii) Romano-British

The first site of this age to be discovered in the Cleveland area has been described by Hayes and it is interesting to note that this continues an unbroken settlement in the area from Iron Age times (Hayes 1963). Hayes visualizes flocks of grazing animals on the slopes of Cleveland with small patches of cultivation (mainly of wheat, barley and spelt) on lower areas. There is an absence of finds of archaeological remains on the central watershed although the Romans certainly used parts of the moors as a routeway. The intact sections of Wade's Causeway on Wheeldale Moor provide evidence of this and there are also forts for example at Scarborough and Cawthorne (near Pickering) along the southern edges of the moors (Raistrick 1966, Elgee 1930).

(iv) Post Roman

While there are indications during this period of occupation of areas around the moors by Angles and Saxons, for example at Robin Hoods' Bay, there is very little evidence of penetration into the heart of the moors. Raistrick suggests that the British groups fled into the highland areas on the arrival of the Angles and Saxons. The two different cultures then lived contemporaneously in different parts of the moors. He bases this suggestion on the place name evidence (Raistrick 1966) and uses a similar criterion to examine the spread of the Danes in the ninth century A.D. While there are many places which bear names originating from the influence of the Danes, very few are found in the dales leading to the central watershed. It certainly appears that the Angles and later the Danes spread over more land than did the Romano-British peoples, but the former seem to have preferred lower ground than the latter. The last cultural group to appear on the North Yorkshire Moors before Mediaeval times was the Norse peoples. Raistrick suggests that the evidence of "dialect, place names, and cross motifs all show that the Norse penetrated into the north-east moorlands and occupied much of the upland which they would find quite homely as a race of upland sheep farmers." (Raistrick 1966). The pollen evidence may not show this effect very clearly nor the effects of the Angles and Danes on the central watershed as by this time the uplands were probably very open in character over large areas. Moreover, while there may be place names and other evidence for the presence of the Angles, Danes and Norse peoples on the North Yorkshire Moors, there is very little in the way of archaeological evidence for their presence in large numbers. Therefore, it would be difficult to ascribe pollen changes of great significance to these cultures without the additional support of radiocarbon dating.

5. Mediaeval and Later Times

This was the first period when clear documentary and archaeological evidence points to intensive utilization of the dales which lead into the heart of the moors. As Beresford points out it was probably the remote and uncultivated scene which attracted the Cistercian monks (Beresford 1966), the first settlers to have a marked impact upon the vegetation of the dales.

At the opening of the Mediaeval period the records of the Domesday survey show the whole of the central watershed including most of the south facing dales as having no settlement and as not being farmed (Waites 1967). Moreover, there are records of many large woods in Eskdale, for example at Danby, Lealholm and Egton (Farra 1961).

It was during the twelfth century that monasteries were established at various places in and around the moors, for example at Rievaulx, Guisborough, Byland and Keldholme. The utilization of the dales for agricultural purposes was mainly connected with the activities of the religious orders although they concentrated mainly on pastoral farming while lay members concentrated on arable crop production (Farra 1961, Waites 1967). The large numbers of domesticated animals introduced in the pastoral farming of the monasteries must have put great pressure on the remaining woodland especially by limiting regeneration and it may have been this factor in connection with clearance which accounts for the rapid diminution of trees and shrubs in the pollen record at this time. By the thirteenth century woodland had become discontinuous in the dales and heather and bracken were firmly established on the moorland summits (Wightman 1968). Fire must have remained an important tool in the clearance of woodland and scrub, and evidence for its use is found in the charcoal remains in the peat at the level of the Mediaeval clearances. These clearances were the last major period of destruction of woodland on the moors as regeneration afterwards was very limited. The historical evidence shows a continuing expansion of farming throughout Mediaeval times, and this expansion was not simply confined to the farming of the dales. The moorland summits themselves were utilized (Farra 1961, Waites 1967) and Rievaulx may have practised a seasonal movement of sheep and cattle between the sheltered dales and the high exposed moorland. Not only did the monastic period bring farming on a large scale to the area, it was also the first period of extensive extraction of minerals in the dales. Forges for iron smelting were known from Glaisdale as early as 1207 and these rapidly spread into other dales; for example, Rosedale, Danby Dale, Fryup Dale, Westerdale. This may have been a further and highly significant factor in the sudden removal of woodland from the dales, as the demand for charcoal for the iron forges must have been very great.

The dissolution of the monasteries did not have a great effect generally on the pattern of land use as the farming was taken over directly by lay members. The big monasterial estates were split up into farms of various sizes for this purpose. The pattern of agriculture varied quite considerably from dale to dale throughout Mediaeval and later times and may account for the minor variations in tree and shrub patterns which occur between pollen diagrams. The biggest contrast in farming patterns was to be found between the north and south facing dales, and this factor played an important part in the varying rates of enclosure of field systems in the seventeenth and eighteenth centuries (Farra 1961). The process of enclosure reached a peak after 1750 and the rapid increase in the population of the country as a whole coupled with new farming techniques stimulated the expansion of agriculture in the area. A new stimulus was provided by the Napoleonic wars when demand for home produced foodstuffs reached a peak, and large areas of Cleveland were ploughed for the first time to try and meet the demand. Even changes as late in history as these may have an expression in the changes of the pollen curves but it is difficult to correlate the two without definitive dating of the pollen evidence. In the pollen diagrams perhaps the only clear change visible is the gradual decrease in Gramineae and concomitant increase in <u>Calluna</u> which occurs after the Mediaeval clearances and which may be connected with farming practice. This process may have been due to over grazing on the moors and the gradual degradation of the pastures. The continued burning of the moors especially after the rise of grouse shooting as a sport must have accelerated the process of degradation.

The nineteenth century on the moors showed many variations in the fortunes of farming. It was also a period of very great change with a remarkable shift from the emphasis on pastoral farming over to arable farming during the boom era in agriculture between 1850 and 1867. The intake of land continued during the first half of the century and some areas of moorland, for example on the western scarp of the Cleveland Hills, were reclaimed for planting trees.

The twentieth century has been a period of change in agriculture on the North Yorkshire Moors on a similar scale to that of the nineteenth century. The area suffered under the agricultural depression of the 1890's when some arable land reverted to pasture. A gradual decline in agriculture continued through the twentieth century apart from short-lived periods of revival during the two world wars. Perhaps a more significant change in land use was initiated in the 1920's when large areas of moorland were reclaimed for forestry, a process which is still continuing at the present day. A further change has occurred recently in response to large scale mechanization of agriculture. Substantial areas of moorland on the Corallian limestone have been put under the plough and reclaimed for large scale arable and pastoral farming. Some of these changes may be equated with the uppermost sections of the pollen diagrams. The very marked increase in tree pollen, especially _Pinus_, and the complete dominance of Calluna in the pollen spectra of the uplands are reflections of the land use in the area at the present day.

S E C T I O N   IV

C O N C L U S I O N S

A few general conclusions can be made in the light of the material which has been presented and discussed.

No mention of climatic change after the Boreal-Atlantic transition has been made as the pollen and stratigraphic evidence show no indications of climatic change. Other authors (e.g. Godwin 1956) have recognized a change in climate at about 500 B.C. to one of damper nature which has persisted to the present day. Raistrick even uses this reason to explain why there was no Iron Age settlement of the moors after the extensive occupation of this area during the Bronze Age (Raistrick 1966). He does not recognize that the activities of Bronze Age peoples may have rendered many areas of the moors unattractive agriculturally to the new settlers or alternatively, as Elgee suggested, that Bronze Age man survived on the moors while the lower lying peripheral areas were utilized by Iron Age man (Elgee 1930). There is no clear indication of vegetation changes brought about by a change in climate after the Boreal-Atlantic transition from the pollen analyses of the present work. All the vegetation changes that do occur may be more satisfactorily assigned to the work of man. This can be seen on the pollen diagrams by the nature of the vegetation changes; for example, reduction in woodland, expansion of open habitat spp. and the appearance of cereals. There are no recurrence horizons in any of the bogs including the landslip bogs although there are stratigraphic changes. However, even these stratigraphic changes, which are mainly connected with the disappearance of wood remains from the deposits, may be correlated with the removal of woodland by man. The very nature of the woodland removal may have resulted in increased run off of water from the surrounding area. This would have had a significant effect on the small landslip bogs by making the surface very much wetter, and ultimately resulting in a change in stratigraphy. The reasons for the lack of climatic indications in the pollen and stratigraphic evidence may be due to the position of the North Yorkshire Moors in relation to the rest of Britain. The fact that the moors are the most easterly upland area of Britain may have meant that the full impact of climatic change, perhaps to more oceanic conditions, was not experienced by the area. Phillips, in her work on the southern Pennines, also found it difficult to ~~discern~~ distinguish climatic changes from anthropogenic changes in the post Ulmus decline period from the evidence in her pollen diagrams. However, she did suggest that evidence was available in the stratigraphic profiles for increased precipitation at perhaps about 500 B.C. (Phillips 1969).

The evidence for earlier climatic changes on the North Yorkshire Moors is very much clearer and the climatically induced vegetation changes from the open habitat conditions of zone III to the mixed oak forest of zone VIIa follow the pattern described for elsewhere in England. The only problematical transition is that at the end of zone VI when it is usually accepted that the climate over Britain became warmer and damper which encouraged the growth of mixed oak forest and which initiated the accumulation of blanket peat throughout most highland regions. Certainly peat growth commenced at a number of sites on the central watershed at this time although at the great majority of sites it did not start until very much later. What effect the creation of an expanded North Sea at the Boreal-Atlantic transition had on the climate of the central watershed is difficult to assess from the available information, although this factor may have assisted in allowing the formation of a more oceanic climate. Another factor which may have played a part in the start of peat growth is the effect of man on the vegetation although the evidence is not very clear. Smith is inclined to believe that while climatic changes were indeed apparent at the Boreal-Atlantic transition the effect of man may have been to accelerate the subsequent changes in vegetation. It is important to note that charcoal is often found in the peat at the Boreal-Atlantic transition at a number of sites on the North Yorkshire Moors and the influence of man on the vegetation at this early time has been regarded as highly probable (Section III). However, these effects may also be suggested as resulting in only local vegetation changes. It could be that man at this time by his policy of burning helped to accelerate the process of leaching at particular sites and encouraged the growth of bog plants as the climate became wetter. The simple exercise of creating an opening in the woodland may have also been sufficient to increase run-off of water in such an area and create erosion. A response of this nature may have resulted in the accumulation of blanket peat on solid rock, a feature recognized at several sites on the North Yorkshire Moors and elsewhere (e.g. Tallis 1964a). Tallis argues that peat in the Pennines first started growth in topographically favourable areas and at a much later stage spread over the remainder of the area (Tallis 1964a). This argument would fit in with the dating of much of the peat on the central watershed as zone VIIb (e.g. Yarlsey Moss, Howdale Hill, Pike Hill Moss), although erosion must have been widespread over large areas before peat started accumulating, as peat is frequently found resting directly on solid rock or with only a very thin layer of mineral material separating peat from bedrock. The activities of late Mesolithic/early Neolithic man in firing woodland may have been sufficient to provide a starting mechanism for erosion. The extent of these activities cannot be ascertained as a very great area of the central watershed contains no peat suitable for pollen analysis. That the formation of blanket peat is due in part to man may be indicated by the fact that no tree remains are found in peat after the Ulmus decline, except in the more favourable positions of the landslip bogs and Wheeldale Gill. Perhaps the mechanism for blanket peat growth after the Ulmus decline follows the line of: firstly the destruction of trees, then the removal of the remains by erosion and finally the accumulation of blanket peat. The remains of trees within peat of pre Ulmus decline age may be partly due at this time to the thin nature of the peat allowing the tree roots to penetrate into the mineral substrate. The fact that there is a preponderance of Betula tree remains of this age could be connected with the role of Betula as an improver of what must have been rapidly deteriorating soils, in much the same way as it will do today (Dimbleby 1952b).

The picture of the central watershed during the Atlantic period is not at all clear and while the suggestion is put forward that the area was at least partly wooded, albeit by a scrub type vegetation, the situation may have been already complex within a man/environment struggle. The area may have exhibited a mosaic of woodland, shrub and open grass/heath/sedge types as is suggested for White Gill, or the open sections may have been more continuous. No doubt as the blanket bog developed, the damp patches representing the bog became larger and larger open areas within a scrub woodland. By about the time of Bronze Age man, the open areas on the moors were probably quite considerable. It is difficult to suggest exact sizes for the cleared areas.and in addition the area of woodland must have been constantly fluctuating. Perhaps some kind of guide as to the minimum area clear of woodland can be gained by examination of the area of peat greater than 50 cms. depth (fig. 4) as most of this area will have started peat accumulation at or before Bronze Age times. The only drawback with this is that much of the central watershed contains no peat and consequently no pollen record, even though this area may also have been free of woodland in Bronze Age times.

It appears that throughout time man has been linked in some way with the formation of peat on the North Yorkshire Moors. He can only be regarded as an agent which along with other environmental factors has produced the great depths of peat which are present on the moors today. Peat would have probably formed on the moors without the help of man although the process would have been a good deal slower.

There is clearly a dividing line in the present pollen diagrams between those from the watershed proper and those from the landslip sites. The diagrams from the watershed could be regarded as being generally more indicative of the regional pollen spectra. This is especially so with sites such as Loose Howe and Yarlsey Moss where quite clearly after the Ulmus decline total tree and shrub pollen percentages were so relatively low that woodland was not growing on the site. This must have allowed some of the pollen to have been derived from long distance transport. The trunk space component may have still contributed an important level of pollen although the pollen spectrum will have been distorted by the highly local pollen source of the bog plants. The more regional nature of the watershed pollen spectra can be demonstrated by the fact that Fagus appears very much earlier at the watershed sites such as Loose Howe than at the landslip sites such as St. Helena 'B'. Similarly the percentages of Ulmus and Tilia remain higher at the watershed sites than at the landslip sites possibly because at the latter sites much of the A.P. component is derived from local tree pollen. The two different groups of pollen diagrams become much the same after the suggested Mediaeval clearances (sub-zones NY 3/4 boundary), although St. Helena 'B' retains a highly localized A.P. and shrub pattern. It is difficult to judge the importance of the high values of grass/heather/sedge pollen on the watershed diagrams. Even though these pollen types probably grossly distort the picture presented by the pollen results, they must still indicate considerable areas of open land otherwise tree and shrub pollen would dominate the pollen spectra on a scale found in the landslip sites. Contemporary pollen studies show that this is true even where the woodland is fairly 'light', as at Wheeldale Gill (Section II Chapter J).

The effects of man on the woodland of the North Yorkshire Moors is particularly marked after the Ulmus decline and a series of sub-zones have been defined partly on the basis of the intensity of clearance phases. There is a danger that these phases could be viewed as synchronous across the moors. This is a point that has also been commented on by Phillips (1969) and Simmons (1969a) and until a definitive series of dates has been obtained, synchroneity of sub-zones cannot be shown. Simmons (1969a) has adopted a sub-zone scheme for the North Yorkshire Moors which is very similar in many respects to the present scheme and some correlation between the two schemes could be made. However, the recognition of a second Ulmus decline and Tilia decline, as Simmons has suggested, has not been attempted in the present work because of the clear lack of synchroneity of each of the features between diagrams. In some diagrams Tilia disappears relatively early at about the time of the Bronze Age clearances while at other sites it manages to survive until the Mediaeval clearances. In general terms the observation by Simmons that Tilia disappears at a time of greatest human activity is apparent in the present work and broadly agrees with the findings of Turner (1962). As the disappearance of Tilia is so erratic, it cannot be used as an indicator of climatic change as it has been in the past (e.g. Godwin 1956). The increase in acid heath and the disappearance of suitable high base status habitats for the tree together with the activities of man probably all combined to remove *Tilia* from the North Yorkshire Moors until modern times. The disappearance of *Tilia* also coincides at a number of sites with the first recording of *Fagus*, probably the result of a more open tree canopy and thus a more regional nature of the pollen rain, as is suggested by Simmons (1969a). Other sites which contain *Fagus* long before the disappearance of *Tilia* show that the former tree was certainly present in the area from *Ulmus* decline times onwards but required the more open nature of cleared areas before it appeared in the pollen record at some sites.

Discussion of most of the present work has been treated on a chronological basis using pollen zonation and archaeological periods. However a further classification using three broad categories could be made which would help to summarize general conclusions made from the present research. The three categories are :

a) The period prior to peat growth - the present work contains very little data on this period. However, there are a few indications of the existence of both woodland and open areas.

b) Commencement of peat growth - the timing of the inception of peat growth seems to be very variable although in general two main periods appear to exist :

(i) Late zone VI and early zone VIIa - a limited number of sites show peat accumulation starting at this time but they include both lowland and upland sites. While the formation of peat during this period is recognized as being closely associated with a change in climate, the frequent finds of charcoal may suggest that man played a part in the inception of peat growth.

(ii) Zone VIIb - a period of mainly blanket peat formation appears to occur in early zone VIIb. There seems to be no climatic explanation for the growth of peat at this time, and while at some sites it may be linked with the expansion of a pre-existing peat area, at other sites this could not be the case. The evidence points to man as the primary influence in initiating peat growth.

c) Continuation of peat growth - this appears to be very erratic on the central watershed with some sites accumulating several metres of peat while others accumulated very much less than a metre. The pollen evidence is notable for the steady decline in trees and shrubs throughout the period of peat growth. There seems to be no climatic reasons for the major changes in vegetation that take place and the nature of these changes are such that man alone could have affected them.

The development of vegetation on the central watershed together with the suggested correlations between pollen and archaeological evidence is summarised in fig. 45.

In the final analysis the effects of man seem to be extremely significant throughout the ecological history of the central watershed. From his possible effects in influencing the course of peat formation to the virtually complete removal of tree cover from the North Yorkshire Moors during historic times the mark of man has been great. The initial effects were almost insignificant and were helped by the precarious ecological balance of the soils on the moors; but the use of fire coupled with the practice of grazing domestic stock quickly initiated a process of degradation from which the soils never recovered. The present state of the soils is one which is approaching widespread erosion (Dimbleby 1962) and without active conservation the area may reach the final stage in the long road of

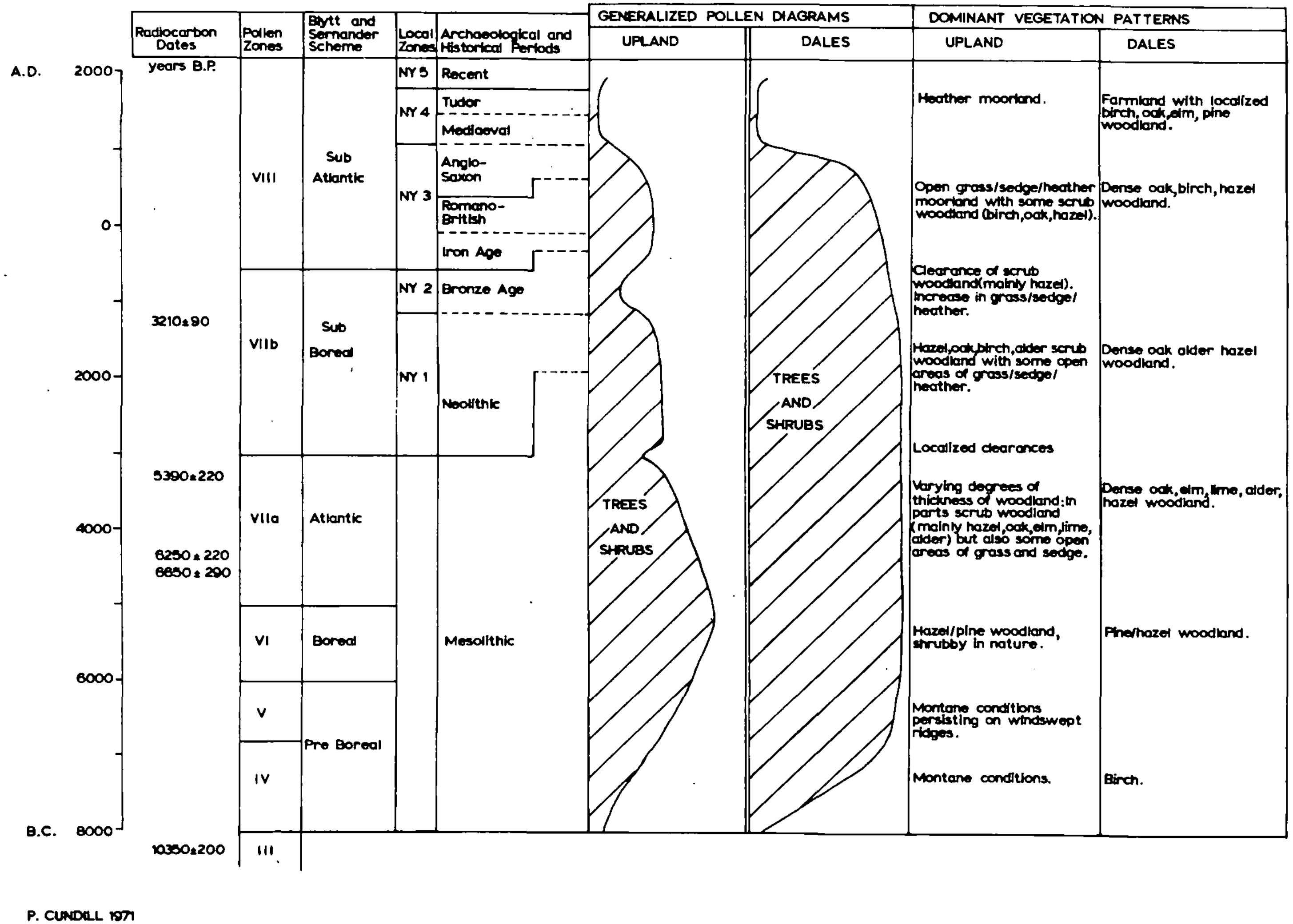


fig. 45 Summary diagram of the stages in the development of vegetation on the central watershed.

degradation which started in Mesolithic times.

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Appendix A Field and Laboratory Techniques

(i) Field Techniques

a) Fossil Material. Samples were obtained for pollen analysis by two methods : collection of profiles using a peat sampler, and monoliths taken from exposed peat faces. The latter method is the ideal way of collecting samples, although it is limited to a few suitable sites where peat sections are exposed. Most of the profiles collected in this way were obtained with the use of stainless steel monolith tins hammered into the prepared peat face. At Glaisdale Moor the peat was dug out as blocks and not collected in monolith tins. The 'Russian' type peat sampler (Jowsey 1966) was used to obtain profiles by boring except for Collier Gill Head where a Hiller-type borer was employed. All samples were sealed in polythene until required for use.

b) Contemporary material. Samples were obtained by carefully collecting material from growing *Sphagnum* hummocks and sealing it in polythene bags. A large amount of material was collected in order to ensure a full contemporary pollen spectrum from each station.

c) Levelling. The levelling was carried out using a quick-set level and a metric measuring staff.

(ii) Laboratory Techniques

a) Pollen extraction. Two techniques were employed ; the alkaline treatment for pure organic material and hydrofluoric acid treatment for siliceous samples.

The alkaline treatment proceeds as follows:-

1. C.1g. of material is placed in a 50 ml. glass boiling tube and c.25 ml. of 10% KOH or NaOH are added. After stirring, the boiling tube is placed in a boiling water bath for 30-60 minutes.

2. The material is passed through a 105 mesh (.0041 ins.) sieve into a 50 ml. polypropylene centrifuge tube. The residue in the sieve is collected for later examination.

3. The sample is then centrifuged for 5-10 minutes at 3000 r.p.m. and afterwards the supernatant liquid is decanted.

4. Distilled water is added to the sample and process 3. is repeated.

5. Centrifuge tube is inverted over a filter paper to remove excess water. Fuchsin stain and glycerol is added to the sample and the material is then ready for microscopic examination.

This was found to be a relatively simple and rapid technique for obtaining good material for counting. The same process was followed for the preparation of contemporary samples in order to ensure full comparability between fossil and contemporary material. The technique is similar to that described by Faegri and Iversen (1964), West (1968) and Brown (1960).

The hydrofluoric acid treatment proceeds as follows:-

1. The process follows that in sections 1-3 of the alkaline treatment.
2. A little distilled water and then 20 ml. of HF is added to the sample. The polypropylene centrifuge tube is placed in a boiling water bath for 60 minutes or more depending on how much siliceous material is in the sample.

3. The sample is centrifuged at 3000 r.p.m. for 5-10 minutes and the supernatant liquid is decanted into a fume cupboard sink.
4. 20 ml. of 10% HCl is added and the preparation is placed in a boiling water bath for 3-5 minutes.
5. Centrifugation is repeated as in 3 and the supernatant liquid is decanted.
6. 20 ml. of 10% KOH or NaOH is added and the sample placed in a boiling water bath for 15 minutes.
7. Centrifugation as in 3 is again repeated and the supernatant liquid is decanted.
8. Distilled water is added and section 7 repeated.
9. As section 5 of alkaline treatment.

The process has the advantage that no violent heating of the HF is required as in the techniques described by Faegri and Iversen (1964) and Brown (1960). It also requires fewer transfers of material from one container to another than in these other techniques. In some cases it was possible to prepare satisfactory samples for counting from siliceous material by subjecting them to only the alkaline treatment. Dimbleby found that this was sufficient for most of his soil samples (Dimbleby 1957). The use of Erdtman's acetolysis process was not found to be necessary on any of the samples examined.

b) <u>Loss on Ignition and Moisture Content Analyses</u>

A series of 1 cm. samples were taken from the basal part of the White Gill monolith. The samples were left in a drying cabinet until a constant dry weight was recorded. The difference in weight between the wet and dry sample was calculated as a percentage value of the original 'wet' weight.

This value represents the moisture content of the sample and is plotted in fig. 5. The dry samples were then placed in an oven at 800°C for two hours and the weight of the sample which was lost on ignition was calculated as a percentage of the original dry weight. This percentage value is plotted on the second graph of fig. 5. The boundary between the pure organic and minero-organic materials is quite clearly shown from these analyses.

c) Radio-Carbon Material

This was taken from the material sampled for pollen analysis. With the monoliths a 1 cm. slice was taken from the whole core at the required level; the edges were carefully cleaned, the blocks wrapped in aluminium foil and placed in polythene bags which were then sealed and labelled. The sample from St. Helena 'B' consisted of a 5 cms. section of the Russian borer sample, carefully cleaned and wrapped as the monolith samples. A full list of the radiocarbon dates obtained for the present work are shown in Appendix E.

(iii) Pollen Analysis : Microscope Technique

Counting was carried out with a Carl Zeiss Photomicroscope. The resolution of the lenses was sufficient for normal traversing and counting to be carried out under x 250 magnification with the use of x 630 (dry) and x 1000 (oil immersion) lenses for difficult grains. Scanning was generally carried out under x 100 magnification. Counting of major pollen types was recorded on a bank of mechanical counters, and other pollen types were recorded on standardized count sheets. All figures were ultimately recorded on the count sheets together with calculated percentages.

Counting proceeded either to 150 tree pollen grains (excluding Alnus) or to 1000 total grains (excluding spores). The 150 tree pollen grains provided the tree pollen sum and the 1000 total pollen grains the total pollen sum. These figures were found to be difficult to keep to in a number of cases as the blanket peat contained levels at which the concentration of pollen was very poor. However, in the majority of cases the counts have been within the quoted limits and in some cases in excess of them. Dimbleby argues that total counts of 250 grains give all the species that are likely to be in excess of 1% of total pollen, and counts above this level only tend to add to the number of species identified rather than alter the percentages of the major species. However, he did add one note of caution : "Nevertheless if any one species is highly predominant it is wise to increase the count to give adequate representation of the subsidiary species" (Dimbleby 1957). The latter case is quite usual with blanket peats hence total counts which are in excess of 1000 grains. The use of a mechanical counter eased the difficulty of counting large numbers of grains of one particular spp.

The identification of fossil pollen posed no particular problems as blanket peat appears to be a very adequate medium for the preservation of pollen grains. Pollen from mineral soils below peats was not always so well preserved, but was still recognizable, and meaningful counts could be made. The only problem encountered during counting was the sparseness of pollen at certain levels, a feature which was also noted by Phillips in the Pennine blanket peats (Phillips 1969).

In the present work, the nomenclature used for plant names follows that in Clapham, Tutin and Warburg (1962), although certain names are used for pollen types, such as Tubuliflorae and Coryloid, which have no direct parallel in Clapham, Tutin and Warburg.

Appendix B

Identification of Pollen Grains

The majority of pollen grains provided no difficulty in identification, but there were a few types where recognition was limited and which deserve further comment because of their importance in interpretation of the ecological history of the central watershed.

a) Corylus avellana - Myrica gale type

The pollen of these two species has been grouped under the general term Coryloid. Many workers, for example, Simmons (1969a), Pennington (1964) and Oldfield (1963), use this term because of the difficulty of separating the two pollen types. Recognition of the two types is possible according to Turner (1969) but this was not attempted in the present work for a number of reasons.

The role of *Myrica gale* in the past vegetation of north-east Yorkshire has been regarded in the present work as similar to its role at the present day, that is, growing on the wet floors of river valleys and in wet flushes, and therefore highly localized in distribution (Section I, A 4.). If *Myrica gale* occupied such a restricted habitat in the past *Corylus avellana* may have covered the drier slopes, forming the understorey of the deciduous woodland and consequently producing the high percentages of Coryloid pollen found in the pollen diagrams. It was only with the burning and grazing of the vegetation and subsequent leaching of the moorland soils that *Corylus* began to disappear. It is tentatively suggested that after the NY 3/NY 4 subzone boundary *Corylus* assumed a similar distribution to that at the present day, and because of this the relative presence of _Myrica gale_ was enhanced. It is probable that a good proportion of the Coryloid pollen at the present day may belong to the _Myrica_ category rather than _Corylus_.

b) _Cerealia_

This pollen category has not been identified to genus level because of the difficulties of separating the various pollen types. The category of _Cerealia_ includes those grains of Gramineae which exceed 40μ in size taking into account the possibility of grains swelling in Glycerine mountant (Faegri and Iversen 1964).

Appendix C

Landslip bogs : some wider considerations

Studies of landslip bogs, those bogs which have accumulated behind the mass of material which moved in the landslipping process, have been carried out in other areas, notably the Pennines, although there are distinct differences between these bogs and those of the present study.

The main workers in the Pennines were Franks and Johnson (1964, 1965) although an additional study was provided by Muller (1967). The Pennine landslips are regarded as being primarily bank failures whereas those on the North Yorkshire Moors are rotational slips (Gregory 1962). The differences between the two types may be seen on purely morphological grounds with the general slumped and tumbled masses of the Pennine slips contrasting markedly with the sharply defined parallel ridges encountered in the North Yorkshire Moors slips. The deposits which have accumulated in the areas of impeded drainage behind the slumped masses vary in general characteristics between the two areas. The material in the Pennine bogs has a high mineral content almost throughout the profile whereas the North Yorkshire Moors bogs are organic with only the occasional inwash stripe and the basal layer containing mineral material. This may be a reflection in the Pennines of an incomplete vegetation cover because of more unstable slopes allowing the inwash of inorganic material at most times. This is shown perhaps in Franks and Johnson (1964) by the very high N.A.P. values. Both Franks and Johnson and Muller date the base of the peat in the landslips to late zone VI or the Boreal-Atlantic transition, a date which accords well with the Blakey Landslip site of the present work. However, an interesting point arises from this. It could be argued that finding the deepest part of a landslip bog, and presumably therefore the oldest deposits, is quite a difficult task as is shown by the St. Helena bog on the North Yorkshire Moors. A series of profiles and cross sections were taken across the bog, but it was more by accident that the deepest profile of seven metres was discovered. This could have been missed quite easily and peat accumulation could have been recorded as starting in VIIb as at St. Helena 'A'. Therefore, it might be argued that it cannot be safely assumed that a profile necessarily shows the earliest development of peat in the bog unless a great deal of preliminary depth testing and stratigraphic boring is carried out. The significance of the pollen dates obtained for the base of the peat in a landslip bog is difficult to assess in terms of the history of the formation of the landslip. Franks and Johnson, and Muller, recognize the date of the base of the peat as recording the uppermost date possible for the landslip to have been formed. The difference in date between the base of St. Helena 'B' and Blakey Landslip cannot be taken as proof that the two landslips formed at different times, and it seems probable that all the landslips on the North Yorkshire Moors were formed more or less at the same time, perhaps in the early Flandrian.

It is interesting to note also that Franks and Johnson (1964) recognize further periods of landslipping in Derbyshire after the initial one in which peat had already started to form. At the two sites examined on the North Yorkshire Moors there are no signs of instability after peat growth had started apart from the inwash stripes.

The incidence of sites on the North Yorkshire Moors where a reasonable depth of peat has accumulated behind landslips is very limited, there being no reasonable sites in the Fryup Hills which is probably the most extensive and most spectacular area of landslipping on the moors.

Appendix D   Further Lines of Research

The present work shows that there are still many gaps in the knowledge of the vegetation history of the North Yorkshire Moors, although it does provide a framework within which new lines of research can be fitted.

While the history of vegetation on the central watershed is not completely clear, many of the problems raised by the present study could be resolved by a series of radiocarbon dates. The dating of the inception of peat growth at a number of sites would help to assess its synchroneity. Similarly a series of radiocarbon dates in two or three profiles would help to provide the sub zone boundaries with definitive dates and indicate whether or not they were synchronous between sites. The anomalies in one or two of the present pollen diagrams, such as the high *Pinus* and *Alnus* values at the base of Wheeldale Gill and the period of incorporation of Mesolithic artefacts in the peat at White Gill could be resolved by radiocarbon dating.

Some mention has been made (Section II, Chapter J) of the unsolved problem of assessing the distance to which pollen is transported and the subsequent difficulties of interpreting fossil pollen diagrams as a result of this. Two pollen diagrams of only 200 metres apart at St; Helena showed very marked differences. Perhaps more pollen diagrams at points between these two sites might clarify the position. However, the importance of contemporary pollen studies is very great as it is only at the present day that a direct comparison can be made between pollen and vegetation. Certainly the limited study carried out in the present work proved useful in the interpretation of fossil pollen assemblages, although a more detailed experiment may have yielded results of even greater value.

The use of historical data was hampered by the lack of definitive dates on the sub zones from the upper parts of the pollen diagrams, but if this situation could be resolved more detailed pollen work might prove very interesting in tracing the development of vegetation during the historical period. Most of the critical levels ascribed to climatic or anthropogenic changes in the present pollen diagrams could be looked at in greater detail in order to provide a better understanding of these changes. Similarly the careful examination of the base of the blanket peat at a large number of sites could lead to a clearer interpretation of the processes which brought about peat accumulation in the past.

These suggestions do not exhaust the number of possibilities for pollen analytical research on the central watershed. They illustrate that much still remains to be done before a clear picture of the development of vegetation in the area becomes available.

Appendix E : Radiocarbon Dates

Dating was carried out at Gakushuin University. The calculation of age was based on Libby half life of C_{14} of 5570 years.

Code Number	Sample	Age in years B.P.
GaK - 2708	S.H. 650-660 Peat	5390 ± 220
GaK - 2709	G.M. 100 Peat	6250 ± 220
GaK - 2712	W.Gl. 60 Peat	3210 ± 90

Appendix F   Total pollen counts

The total pollen counts or pollen sums from which the percentages expressed in the pollen diagrams were calculated (Section II) are tabulated below. Three columns of figures are shown :

a) Sample - the depth of each sampled level (cms.

b) AP - the total tree pollen count (excluding *Alnus*) at each level.

c) Σ P - the total pollen count (excluding spores) at each level.

A.1. St. Helena 'A'

Sample	AP	≤P
10	56	413
20	77	928
30	58	744
40	60	864
50	41	612
60	31	521
70	60	611
80	36	545
90	75	627
92	95	1110
94	41	634
96	57	1020
98	27	1043
100	39	991
102	27	827
104	42	973
106	66	416
108	82	412
110	86	656
120	85	689
130	117	680
140	84	471
150	133	1277
160	42	419

Sample	AP	≤P
170	140	824
180	98	804
186	66	833
188	68	1060
190	67	596
191	145	1464
192	118	680
200	78	633
210	128	432
220	155	490
230	131	405
240	176	586
250	192	986
260	185	1025
270	172	662
280	51	306
290	158	413
300	183	406
310	155	586
320	185	892
330	175	430
340	206	552
344	189	694
346	215	797
348	198	831
354	82	347

A.2. St. Helena 'B'

Sample	AP	ΣP	Sample	AP	ΣP
2	53	671	390	121	540
20	155	675	410	116	325
40	115	933	430	113	657
60	169	678	432	141	1371
80	191	675	435	154	610
100	21	737	450	73	621
120	30	311	460	158	841
140	17	82	480	156	522
150	156	527	500	148	542
160	153	600	520	152	601
180	147	1329	540	153	1208
200	170	724	560	149	500
220	159	677	580	184	557
240	152	806	600	142	1012
260	174	553	620	144	1049
280	169	649	640	97	924
300	149	869	650	179	492
320	164	676	660	167	664
340	38	254	665	163	457
370	146	991	670	80	491

B.1. White Gill

Sample	AP	≤P	Sample	AP	≤P
2	38	2122	41	152	1855
6	96	2361	42	143	1903
10	80	2551	43	134	1863
14	139	3646	44	129	1544
19	93	3816	45	148	1482
23	151	3136	46	162	1331
27	164	2150	47	135	1578
31	169	2721			
35	163	1881			
39	164	2051			
40	171	1852			

B.2. White Gill 'A'

Sample	AP	≤P
1	158	1618
2	160	2044
3	150	2038
4	144	1638
5	152	1619
6	115	1306
7	108	1062
8	89	1145

C. Blakey Landslip

Sample	AP	ΣP	Sample	AP	ΣP
2	31	1707	255	165	473
15	54	473	275	168	362
35	34	1063	295	184	784
55	49	1348	305	161	503
75	74	470	315	184	690
95	24	569	335	168	442
115	153	1500	345	188	838
135	95	757	355	173	1323
155	65	1437	375	157	1645
175	93	955	395	156	560
195	40	380	480	185	529
205	46	703	485	229	498
215	22	794	493	168	1070
225	36	1001			
230	107	1111			
235	79	461			
237	71	636			
240	73	843			
245	152	936			

D, Loose Howe

Sample	AP	ΣP
2	26	2295
10	26	925
20	54	2457
30	50	2079
40	60	1891
50	42	1115
60	57	1860
65	104	1441
70	51	1843
80	150	1869
90	102	1300
95	97	1098
100	82	627
105	109	939
110	125	1191
120	152	1357
130	159	1613
140	75	765
150	64	1150
155	117	1796
160	155	1486
165	147	1091
170	152	1142
175	158	1300
180	149	1047
185	152	1112
190	80	1924
192	167	1772
194	150	1351
198	30	2252

E. Yarlsey Moss

Sample	AP	ΣP
3	77	1259
11	77	3648
21	62	3822
31	80	2723
41	132	1208
43	99	799
44	75	651
47	91	1111
49	65	768
51	63	872
61	137	1737
71	96	1794
81	133	2092
91	152	1897
101	169	1419
111	142	1831
121	150	1943
126	48	995
131	81	1326
136	40	1241
141	143	2895
146	59	1031
151	173	2636
156	59	1401
161	181	3351
166	67	846
171	198	2658
176	90	1527
181	210	2566
191	200	1788
201	200	1828
211	204	1540

F. Howdale Hill

Sample	AP	ΣP
2	41	1141
10	44	790
15	23	1117
20	21	817
25	67	966
30	34	1168
35	39	1307
40	53	800
45	69	1025
50	116	1923
55	61	1272
60	126	1498
64	171	1422
68	148	1459

G. Glaisdale Moor

Sample	AP	ΣP
5	84	1410
10	85	1778
15	74	1092
20	112	2305
25	67	959
30	142	2161
35	111	1357
40	158	1488
45	158	1345
50	155	1653
55	156	1043
60	161	1185
65	157	1586
70	164	1538
73	176	816
75	163	1209
77	152	866
80	148	1180
85	154	934
90	136	849
95	154	1239
100	148	1299
105	163	1025
107	155	809
110	172	759
112	194	750
115	178	715
120	140	526
125	185	457
129	184	405
129.3	158	393
129.7	172	421
130.2	158	456

H. Wheeldale Gill

Sample	AP	ΣP	Sample	AP	ΣP
12	27	2634	55	165	2464
16	21	1494	58	77	1098
20	60	1922	60	138	1852
25	64	1194	63	101	1957
30	37	1541	65	116	1926
33	40	2727	67	161	2010
34	46	2628	70	155	1627
35	64	2435	75	95	1583
36	64	2570	80	53	683
37	76	3142	85	156	1406
38	72	2624	90	153	1357
39	101	1568	95	157	1647
40	162	2144	100	137	1638
45	156	1469	105	92	1174
50	141	2233	110	102	1096
			115	147	1785
			120	89	892
			130	33	219

I. 1. Collier Gill Head

Sample	AP	ΣP	Sample	AP	ΣP
225	160	1005	239	168	1025
229	156	985	241	157	1003
233	156	1069	247	165	1238
235	159	1143	253	174	843
237	154	1286	259	162	805
			265	164	914
			271	201	512

I. 2. Trough House

Sample	AP	ΣP	Sample	AP	ΣP
150	148	1392	185	156	1415
155	150	1181	190	176	1588
160	159	859	193	148	1465
165	151	844	195	156	1785
170	151	804	197	154	1746
175	167	1021	200	181	1101
180	148	778	202	179	817
			204	168	866

I. 3. Pike Hill Moss

Sample	AP	ΣP
86	8	1084
90	35	1443
95	86	2158
100	65	1083
105	86	1929
107	10	302
109	27	1096