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THE INVESTIGATION OF A MOR HUMUS DEPOSIT
IN
CUTHBERT'S WOOD, CO. DURHAM.

by Barbara E. Hart-Jones.

A dissertation submitted in partial fulfilment
of the requirements for the award of the Master of
Science degree at the University of Durham. August 1969.



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INTRODUCTION.

Several workers have recently been studying the pollen content of post-glacial deposits in County Durham but at the present time few pollen diagrams have been published. Map I shows the position of sites which are referred to below.

The diagrams published include Blackburn's study at Neasham (Blackburn, 1952) and two sites in Teesdale, Romaldkirk and Burtree Lane (Bellamy et al. 1966). Blackburn concluded that the deposit he investigated dated from Godwin's Zone I to Zone VII. In Teesdale the deposits were dated from the Late-glacial to Zone VI. Other published Post-glacial diagrams in the North East come from two lake deposits. One at Bamburgh, Northumberland (Bartley, 1966) and the other at Tadcaster, Yorkshire (Bartley, 1962). These both include Late-glacial and early Post-glacial pollen. There is also an unpublished diagram from Cranberry Bog, Co. Durham (Kershaw, 1967) and Ward is investigating a deposit at Stewards Shield in Seardale, while other work is being carried out in Teesdale.

The present study is of interest because it is carried out on a mor humus deposit, of over 1 metre in depth, in the centre of a wood. It can therefore be expected to indicate more local changes in the vegetation as compared with the regional changes shown in the diagrams previously mentioned. It was also thought that the deposit was of comparatively recent origin, starting probably in Zone VIIb or VIII, and that any changes would reflect man's activity in the immediate neighbourhood of the wood.

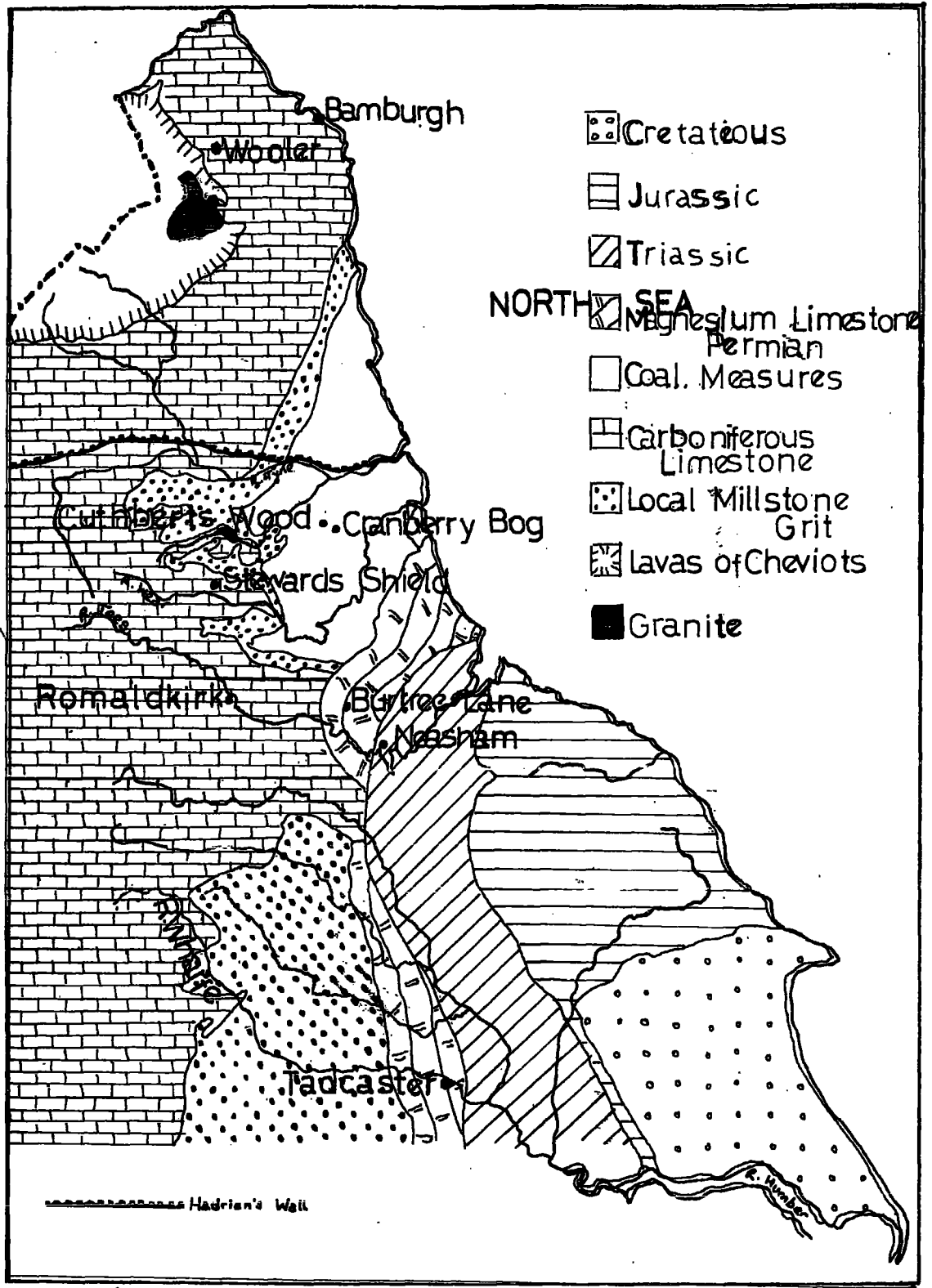
Pollen diagrams from mor humus have been obtained by Trautmann (1952) working in a spruce forest





(Picea abies) in Germany and by Iversen (1964) investigating mor underlying a Calluna heath and a mixed deciduous woodland in Jutland.


MAP 1

North-East England Showing Sites.




 Cretaceous


 Jurassic


 Triassic


NORTH SEA
 Magnesian Limestone

 Permian Coal Measures

 Carboniferous Limestone

 Local Millstone Grit

 Lavas of Cheviots

 Granite

----- Hadrian's Wall

0 10 20
 MILES

CUTHBERT'S WOOD, Co. DURHAM.

1. SITUATION.

Cuthbert's Wood, Grid Reference NZ 208555, is an area of 6.7 acres, which was until 1952 part of the Beamish Estate, situated 5 miles southwest of Gateshead and 1½ miles north of Stanley. (Map 2). The 450 foot contour passes east to west through the centre of the wood with higher ground to the north and a gentle slope to the Beamish Burn in the south.

2. GEOLOGY.

The solid geology of this area is Carboniferous coal measures. These coal measures are overlain by Pleistocene boulder clay and solifluction material. Approximately 8 miles to the west the local Millstone grit outcrops and 7 miles to the east there is Magnesian limestone laid down in the Permian. (See overlay for Map 1)

3. PRESENT DAY VEGETATION.

A map of the vegetation is given as an overlay for map 3. The main part of the wood is composed mostly of birch (Betula pubescens) but there are other areas, especially around the perimeter, where other species predominate, usually as a result of man's activity. In the main part of the wood many of the birches have been coppiced and some have been misshapen by the fungus Exoascus turgidus. Other common species are white poplar (Populus alba) and holly (Ilex aquifolium) but there are also examples of oak (Quercus petraea), yew (Taxus baccata), hornbeam (Carpinus betulus), wych elm (Ulmus glabra), elder (Sambucus nigra), rowan (Sorbus aucuparia), hawthorn (Crataegus monogyna),

hazel (Corylus avellana) and laurel (Daphne laureola). Alder (Alnus glutinosa), hogweed (Heracleum sphondylium) and goosegrass (Galium aparine) are found in the wetter areas.

The field layer of the wood is not well developed although there is abundant raspberry (Rubus idaeus) and bramble (Rubus sect. Eubatus) some bryophytes and pteridophytes with dog rose (Rosa canina), soft rush (Juncus effusus), foxglove (Digitalis purpurea), wood sorrel (Oxalis acetosella), wood avens (Geum urbanum), red campion (Silene dioica), bluebell (Endymion non-scriptus), dog's mercury (Mercurialis perennis), broad leaved dock (Rumex obtusifolius), and gramineae in places.

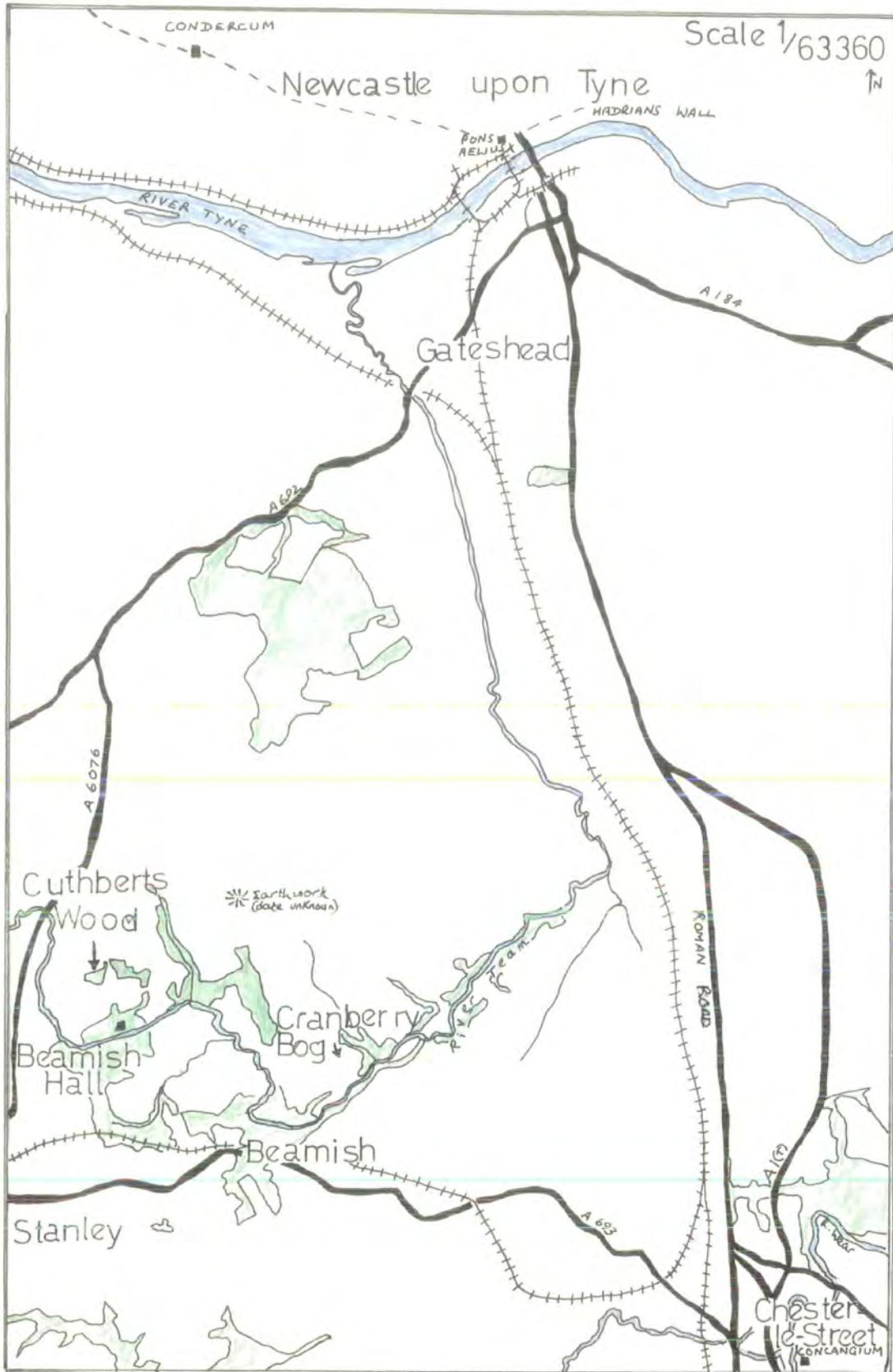
On the sandy well-drained slope at the northern and north eastern edges of the wood oak and sycamore (Acer pseudoplatanus) predominate. Along the field boundary on the south and southeast sides of the wood the trees are beech (Fagus sylvatica), ash (Fraxinus excelsior), hornbeam, sycamore and wych elm. Broom (Sarothamnus scoparius) and Rhododendron ponticum are also present with nettle (Urtica dioica), common hemp nettle (Galeopsis tetrahit) and woundwort (Stachys sylvatica) in the hedgerow. The open areas of the wood consist of pteridophytes, rose bay willow herb (Chamaenerion angustifolium), foxgloves, grasses and birch seedlings except for one small area which was sown with grass seed by the Boy Scouts who camp in the wood.

The wood is surrounded by fields which are either under cattle pasture or are sown with cereal crops.

The climate around Cuthbert's Wood is moist. At South Noor Colliery (Grid ref. NZ 190516) 2½ miles away at a height of 616ft. the average annual precipitation is 29.8 inches. (Met. Office, 1963).

MAP 2

LOCATION OF CUTHBERTS WOOD

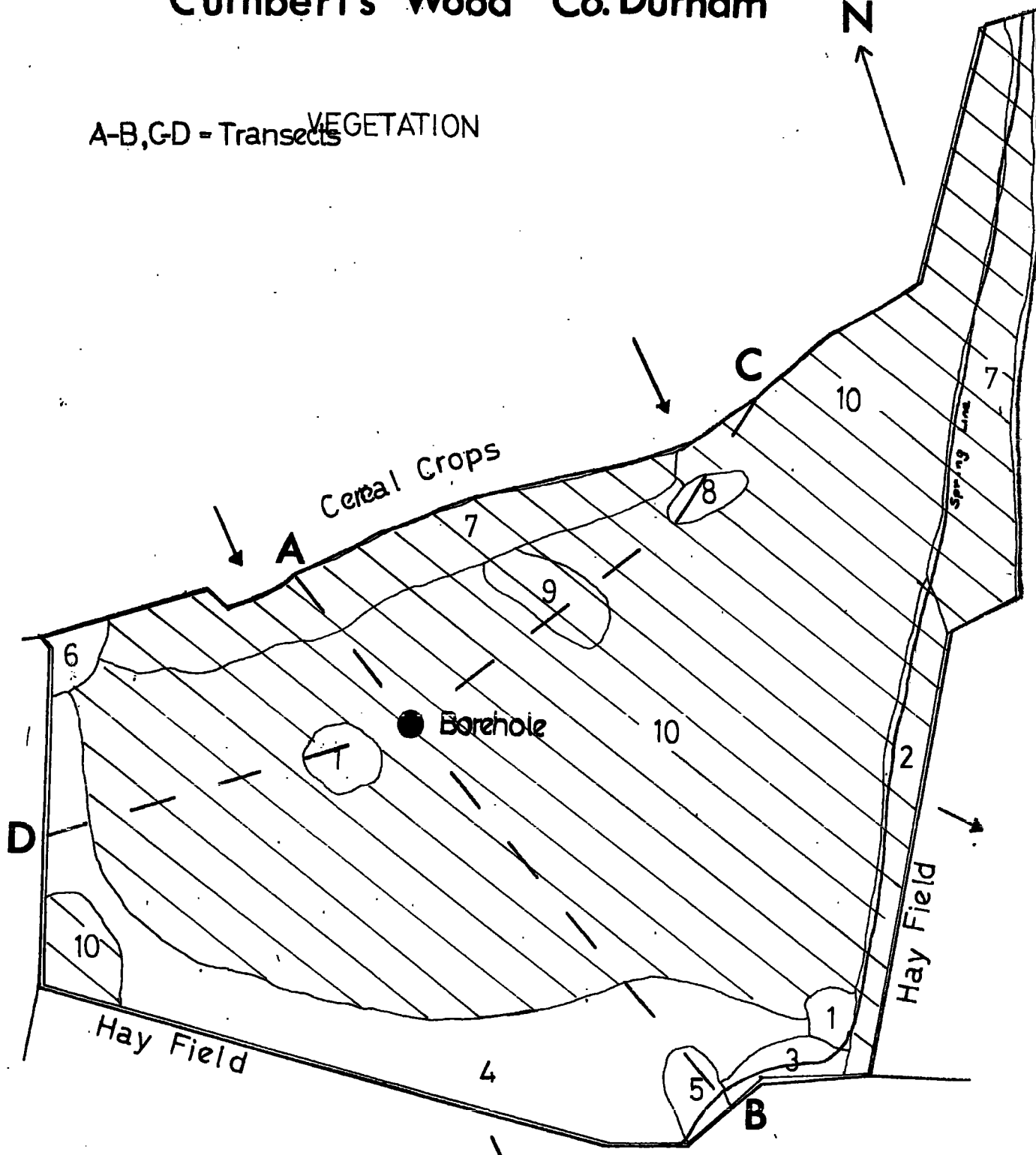


Cuthbert's Wood Co. Durham

A-B, C-D = Transects

VEGETATION

N



30 METRES

Shaded area is woodland

→ Direction of Slope of Land

4. HISTORY OF THE AREA.

The area has been occupied by man since the Mesolithic age. Evidence of this has been obtained from the coastal and river terrace sites of the Mesolithic period followed by artefacts and burials of the Neolithic and Beaker periods. It is of interest that fewer traces of Pre-Roman Iron age activity have been found than in ~~either~~ of the neighbouring counties of Northumberland and Yorkshire.

During the Roman period Co. Durham was a frontier zone. The position of Cuthbert's Wood in relation to Hadrian's Wall and the Roman fort, believed to have been called Concangium (Gillam and Tait, 1968) at Chester-le-Street is shown on Map 2. The Roman withdrawal at the beginning of the fifth century A.D. left the area open to invasion by Saxon and Scandinavian raiders.

The Anglian period saw Co. Durham as a forested wedge of land whose occupation was contested by both the Bernicia and Deira kingdoms.

During the pre-Norman settlement a gradual spread of population resulted in forest clearing and swamp drainage and the erection of feudal castles.

The Norman settlement resulted in the area becoming a land of scattered well organised villages whose chief asset lay in the ownership of cattle. This is shown in the Boldon Book produced in 1183. Subsistence farming was also practised by open field strip cultivation with oats, barley and peas comprising the chief crops. Waste land and forest areas which separated the villages were recognised as common grazing land for pigs, goats, cattle, hens and geese. Sheep rearing was virtually the monopoly of the bishop and prior at Durham.

From the fourteenth to sixteenth centuries repeated invasions by the Scots ravaged the land. The results of this unsettled period together with those of the Great Plague (1348/9 .D.) led to the neglect of cultivation in some fields.

Homberston's Survey (c.1570) gives details of the occupancy of small holdings and dwellings which clearly indicates a pastoral occupation of the Beamish Estate.

Population increased during the period of rapid industrial expansion during the seventeenth and eighteenth centuries which naturally gave an impetus to farming. The smelting of lead and iron by charcoal caused extensive deforestation. This continued until 1735 when Abraham Darby introduced coke as a fuel for smelting.

To-day the coal, chemical and steel industries are important sources of employment with mixed farming occupying only a small percentage of the population.

The Beamish Estate records which would have been of considerable interest were believed to have been destroyed in 1952.

An account of the estate owners of Beamish is given in the Victorian county histories for Durham (Fordyce, 1857). The estate is first recorded when Guiscard de Charron, Lord of Beamish died in 1268. In the fifteenth century the estate is said to have consisted of 150 acres of land 40 acres of wood (Hutchinson, 1787). In the sixteenth century the estate was forfeited to the crown and then granted to Sir Henry Gate, Kt. In 1763 the Beamish Colliery was opened.

AIMS.

The investigation was undertaken to determine the vegetational history of the area by analysing the organic deposit for pollen and macroplant remains. It was further hoped to determine the age of the deposit, its composition, and extent by a study of the wood's stratigraphy.

METHODS.

1. LEVELLING AND STRATIGRAPHY.

A preliminary survey of the wood by probing led to an approximate location of the centre of the organic deposit. Four transects each at right angles were laid out from this point (see Map 3) and the topography recorded by means of a level and "Sopwith" staff. The density of the shrub layer especially Ilex aquifolium caused the angle of two of the transects to be altered to obtain a clear line of sight.

The stratigraphy along the transects was determined by taking a core sample at every 5 or 10 metres with either a Hiller peat sampler or a screw auger as described in West (1968). Some difficulty was encountered in the drier areas when the borer could not be pushed far into the soil. The ^{strati}topography and sections are given in Fig. 1.

2. POLLEN ANALYSIS.

A Hiller sampler was used to obtain cores for analysis from the position marked on Map 3.

This type of sampler works by pushing a closed chamber into the deposit to the required depth and then turning it anti-clockwise to obtain a sample. The chamber is then closed by clockwise rotation before pulling up.

The sample chamber of the instrument is 50cm. in length. It is necessary to take a sample 0 - 50cm from one boring but to make a further adjacent boring to obtain a sample of 50 - 100cm. depth. The reason being that the screw at the base of the boring chamber disturbs the immediate underlying deposit. The sample for a depth 100 - 150cm. can be taken from the first boring. Boring to a greater depth was not necessary because the base of the organic layer was reached at 138cm.

The sampling chamber was fitted with liners to facilitate the removal of the cores to the laboratory.

Each sample within its liner was placed in a polythene bag immediately upon being brought to the surface to avoid contamination by contemporary pollen. Also each liner was labelled with the depths from which the enclosed sample was taken.

To test if the humus layer was currently accumulating and whether there were any differences in present day pollen representation in different areas surface samples were taken. One was from the litter layer in the area of the bore holes, one from a nearby Mnium hornum hummock and another from a wet area to the north of the bore holes. These samples were placed in polythene bags, labelled, and taken back to the laboratory.

In the laboratory samples at 2.5cm intervals were taken from the cores and placed in 2 x 1 inch glass tubes

with polythene stoppers and given a sample number. This number along with its depth was recorded. To minimise contamination samples were taken from the inner part of the core by a spatula which was washed after each sample was taken.

In order to count and identify the pollen grains any extraneous matter must be removed, the pollen grains concentrated, embedded in a suitable medium and mounted on a glass slide.

Each sample was broken down by boiling in a solution of 10% NaOH in a boiling tube and then poured through a fine mesh sieve into a 40cc centrifuge tube. The residue in the sieve which contains macroplant remains was washed and placed in tubes labelled with the depth. The filtrate was then centrifuged and the supernatant poured away. At this stage silica present in samples taken between 138 and 150cm was removed by boiling the sample for 4 minutes in a nickel crucible containing hydrofluoric acid. This was then transferred to a Pyrex centrifuge tube with 10% HCl, centrifuged and the supernatant poured away. More 10% HCl was added and the tube placed in a heated waterbath before centrifuging again. HF is extremely dangerous and this work was carried out in a fume cupboard whilst wearing goggles and rubber gloves.

All samples had cellulose removed by acetolysis in the fume cupboard. The procedure is as follows:-

- (a). Transfer material in 40cc centrifuge tube to 15cc centrifuge and add 7cc of distilled water to wash free of NaOH. Stir and centrifuge.
- (b). Dehydrate with glacial acetic acid and centrifuge.
- (c). Add mixture of 10cc acetic anhydride and 1cc of

concentrated H_2SO_4 and place in boiling water bath for one minute stirring all the time. Centrifuge.

- (d). Add 2 drops glacial acetic acid and 7cc distilled water. Stir and centrifuge.
- (e). Wash with distilled water. Centrifuge.
- (f). Mix with glycerine jelly and safranin stain, and mount under a coverslip on a labelled slide.

By means of a mechanical stage the slide can be moved from one side to the other under the microscope. All grains were observed and identified under high power, using oil immersion where necessary. The slide was then moved $1\frac{1}{2}$ diameters of the field of vision to the right before counting the next transect.

Pollen and spores were identified using the key in Faegri and Iversen (1964) and the photographs in Erdtman and Berglund (1961) and Erdtman, Pragowski and Nilsson (1963). Identifications were checked with the type slide collection. Counting was stopped on each slide after 150 tree pollen grains had been recorded, except at 12.5 and 17.5cm depth where a total of 500 pollen grains was counted before 150 tree pollen grains had been noted.

3. MACROFLANT ANALYSIS.

The residue of macroscopic remains in the sieve obtained during the preparation of the pollen slides was examined under a binocular microscope for plant material. Seeds were identified by comparing them with the drawings given in Beijerinck (1947) and the seed type collection. A moss was identified by Dr. Bellomy using Dixon (1954).

4. pH MEASUREMENT.

The pH through the 150cm core was measured to see if changes in acidity had any connection with the stratigraphical or pollen data. Samples at 5cm intervals were mixed with distilled water in a beaker and the pH reading obtained by using a direct reading pH meter.

RESULTS.

The humus layer has accumulated in the centre of the wood and overlies a leached soil. The extent of the deposit is approximately 70m north to south and 140m east to west. (See Fig. 1).

The stratigraphy at the bore hole is as follows:-

- 0 - 1cm leaf litter composed of Betula and Populus remains.
- 1 - 10cm waterlogged black humus.
- 10 - 110cm waterlogged brown humus with a drier mineralised band at 80cm and at 92cm.
- 110 - 138cm wellhumified brown deposit with fewer macro plant remains, becoming more mineralised from 120cm downwards.
- 138 - 150cm grey sandy material with larger mineral fragments towards the bottom. Some plant fragments preserved.

Coal dust was present throughout the profile. The mineralised bands may indicate that the deposit did not form at a uniform rate in time, or that clearing of nearby areas of land caused mineral fragments to blow in. Clearance of the land is undoubtedly responsible for the silica present at 92.5cm where a marked drop in the arboreal/non arboreal pollen has been detected in the pollen analysis.

— It is not possible to be certain whether or not the deposit is accumulating at the present time. The presence of Fagus, Carpinus, Populus and Acer pollen in the leaf litter, and its absence in the topmost consolidated sample may indicate that the deposit is not now accumulating.

The litter itself is not decomposing rapidly, however; its pH is low (4.3) and there is no evidence that the top part of the humus is drying out. Human activity has been concentrated in the wood for the last decade and this may be responsible for removal of top layers of the deposit creating what appears to be a break in deposit formation.

The results of the pH tests are shown in Pollen diagram 1, and table 2. It can be seen that the pH ranges from 3.9 to 6.2. The lower values occur at 132, 97.5 and 0 - 20cms and the highest values at 67.5cms and at the surface sample from the saturated area north of the borehole. Pollen was well preserved throughout and the high pH values did not affect the preservation of the pollen. It may be that the area around the borehole was waterlogged at 67.5cms like the area north of the borehole at the present time with the high pH caused by washing in of bases from the surrounding land.

Around the perimeter of the wood, where the organic deposit has not accumulated, there is a sandy soil.

The results of the macro remains analysis are given in Table 1. It should be remembered that these remains have been extracted from very small samples. Tree remains are the chief components of the deposit. The seeds of Juncus effusus which lives in wet areas are found abundantly throughout the profile except in the zone of higher pH from 82.5 to 52.5cms where they are found sporadically and in the litter layer from which they are absent altogether. The nearest Juncus plants at the present time are 5 metres away from the area of the borehole.

The results from the pollen analysis of the core are given in the form of two diagrams. Pollen diagram 1, includes pollen of trees and shrubs and the tree/shrub/herb ratio. Pollen diagram II shows the herb

TABLE 1.

MACROREMAINS.

Sample No.	Depth (cms.)	Seeds.							Park	Twig	Leaf fragment	Coleoptera remains
		Thuidium	Tamarischinum	Annulus of Pteridophyte	Rubus idaeus	Carex sp.	Rumex sp.	Juncus effusus				
Leaf litter								A	XB	X	XF	X
1	0.0						X					
2	2.5						X	X				
4	7.5						X	X	AB	X		
6	12.5						X			X	X	
8	17.5					X	X			X		
10	22.5						X					
12	27.5						X	XB	X			
14	32.5			A				X		A		
15	35.0			X			X	X	X		A	
16	37.5			X				X	AA	A		
17	40.0			X	X		X	X	X			
18	42.5						X	X				
20	47.5						X					
22	52.5						X	XB				
24	57.5									X		
26	62.5							X	AB	X		
28	67.5							XB	X	X		

A Alnus
 B Betula
 F Populus

Continued:-

TABLE 1. (continued)

MACROREMAINS

Sample No.	Depth (cms.)	Seeds.							Bark	Twig	Leaf fragment	Coleoptera remains
		<u>Thuidium</u> <u>tamarischinum</u>	<u>Annulus of</u> <u>Pteridophyte</u>	<u>Rubus idaeus</u>	<u>Carex sp.</u>	<u>Rumex sp.</u>	<u>Juncus effusus</u>	<u>Betula</u>				
Leaf litter												
31	75.0				X	X		XA	X	X		
34	82.5							XB	X			
36	87.5					X		XB	X			
37	90.0					X		XB		X		
38	92.5					X						
39	95.0				X	X		XB	X			
40	97.5					X						
42	102.5					X						
44	107.5	X				X		X	X			
46	112.5					X		X	X	X		
48	117.5					X		X	X	X		
50	122.5					X		X	X	X		
52	127.5					X						
54	132.5					X		X	X	X		
56	137.5					X		X	X			
58	142.5					X		X	X			
60	150.0							X				

A Alnus

B Betula

P Populus

pollen and spores. Pollen frequencies in both diagrams are given as percentages of total tree pollen. Where a total of 500 pollen grains was counted the total of tree pollen is given in brackets. Where the pollen frequency of Gramineae exceeds 100% the percentage figure is given.

When interpreting pollen diagrams it is important to take into account the differential pollen production and varying resistances to decay of the pollen of different species in order to obtain a more accurate picture of the vegetation. Some species produce large amounts of pollen which are better adapted to transportation over long distances e.g., Pinus, than others which produce smaller amounts of pollen which are ineffectively spread because their pollen drops to the ground with the flowers e.g., Tilia (Iversen 1964).

The tree pollen present indicates that the deposit was formed in Godwin's zone VIII, the Alnus, Quercus and Betula period. (Godwin 1956). Ulmus and Tilia frequencies are low, Betula shows an increase and Alnus a decrease towards the top of the top of the profile. The tree/shrub/herb pollen ratios are consistent, with three exceptions, throughout the diagram. The present tree/shrub/herb ratio is known to represent a woodland vegetation and where a similar ratio occurs in the diagram a wooded vegetation may be postulated.

The low herb percentages indicate that any grazing or thinning was minimal. A gradual decrease in arboreal/non arboreal pollen ratio occurs at 97.5 and 27.5cms and reaches its lowest point at 92.5 and 12.5cms. A gradual recovery to the original ratio occurs in subsequent samples. The tree pollen affected at the time of these decreases is that of Betula and Quercus. These decreases in tree pollen

are contemporary with increases in Gramineae, Plantago lanceolata and other herb pollen and therefore may be considered to indicate clearing of the land.

An increase in shrub pollen to 43% of the total pollen count at 37.5cm is explained by the steep rise in Salix pollen. There are two Salix peaks, one at 37.5cm and the other at 22.5cm. Salix pollen is present in low frequencies from 127.5cm to 42.5cm where the first increase is recorded. Above 17.5cm Salix pollen is found in small quantities and in the leaf litter none was recorded. Salix is not present in the wood today.

Corylus shows a marked increase in frequency at 17.5cm when the arboreal/non arboreal pollen ratio is decreasing.

As can be seen from Pollen Diagram I there are steady fluctuations in individual tree species pollen with no marked increases or decreases at any one level. However when considering the trends throughout the period covered by the diagram it can be seen that Alnus and Quercus pollen decreases in frequency towards the top of the profile whereas that of Betula increases and Fagus, Carpinus, Acer and Populus make their first appearance. Fraxinus, whose pollen grains are normally susceptible to decay, and are only produced in small quantities, is usually underrepresented in pollen diagrams. It does however appear at 102.5cm and is detected up to the present time but is missing from the zone where the pH was high presumably because these conditions did not favour its preservation.

The results of the pollen analysis of the three surface samples are shown in Table 2. The samples from the leaf litter above the bore hole and the moss

hummock show a difference of more than 10% in the pollen frequency of Fagus. These samples were taken less than 5 metres away from each other and as there is no Fagus closer than 40 metres this difference is presumably caused by the chance deposition of air borne pollen. With respect to other species the two counts are very similar. In the sample from the Wet Area Quercus, Alnus and Ilex are more abundant. These differences can be related to the proximity of these species at the present time.

The pollen counts reproduce the actual composition of the wood comparatively well. It must be remembered that recent pollen has not suffered the differential destruction of pollen grains which would have occurred in the fossilised pollen of the consolidated sediment. The presence of Fagus, Carpinus and Alnus around the field boundary of the wood and the presence of Populus strongly suggests planting in recent years.

TABLE 2.

RESULTS OF POLLEN ANALYSIS
of the
THREE SURFACE SAMPLES.

	1. Leaf litter at Bore Hole.	2. Moss Hummock	3. Net Area
H.	4.3	4.1	6.0
Tree/Shrub/Herb	76:5:19	75:4:21	65:6:29

POLLEN AND SPORES EXPRESSED AS %
TOTAL TREE POLLEN.

Betula	54.6	57.9	47.3
Pinus	0.6	2.6	
Ulmus	1.3	4.6	0.6
Quercus	2.6	11.3	31.3
Alnus	2.0	1.3	6.0
Fagus	21.3	4.6	3.3
Carpinus	2.6	9.3	1.3
Fraxinus	3.3	1.3	3.3
Acer	2.6	1.3	4.6
Populus	8.6	5.2	2.0
Corylus	2.6	2.6	2.6
Ilex	3.3	2.6	5.3

Continued:-

TABLE 2. (Continued)

POLLEN AND SPORES EXPRESSED AS
TOTAL TREE POLLEN.

	1.	2.	3.
	Leaf litter at Bore Hole.	Moss Hummock.	Net Area.
Gramineae	12.6	10.6	13.3
Cereals	2.0	5.3	6.6
Cyperaceae			0.6
Compositae	0.6	2.6	4.0
Caryophyllaceae	0.6	1.3	2.0
Chenopodiaceae		0.6	
Epilobium	0.6	0.6	0.6
Mercurialis	4.6	2.0	7.3
Plantago lanc.	2.6	1.3	4.0
Ranuncuaceae	1.3	1.3	
Rosaceae	0.6		
Rumex acet.	0.6	0.6	3.3
Succisa			0.6
Umbelliferae			0.6
Pteridium		3.3	0.6
Filicales	2.6	14.0	2.0

DISCUSSION.

A line drawn from the River Thames to the River Severn is traditionally accepted as the most southerly extent of the last glaciation, although of course, its effects were noticed further south. In lowland Durham, where Cuthberts Wood is situated, glacial erratics of Griffel granite from southwest Scotland, Borrowdale volcanic rocks from the Lake District, drift from the Pennines and rocks from the Cheviots have been found. (Eastwood, 1953). It may be assumed that the retreating ice left a boulder clay deposit. This was not reached when boring in Cuthbert's Wood although a late glacial clay was reached at a depth of 291cm at Cranberry Bog 2 miles away. (Kershaw 1967). The exact course of events following the retreat of the ice to the period represented at the base of the core is not known but over the greater part of England there was a gradual change from open vegetation to climax forest. Gradually a mature podsol developed and this was found below 138cm at Cuthbert's Wood. The vegetation on this podsol was of Woodland type with Alnus, Quercus and Petula present together with a substantial amount of Corylus. This part of the podsol can be given a relative date. The pollen diagram is post elm decline which marks the VIIa/b boundary and must therefore be VIIb/VIII.

A mor humus may be described as a soil in which discrete litter, fermentation and humus layers are present, as opposed to the mixing of humus and mineral soil which prevents the formation of distinct organic layers in formations referred to as mull. A mor humus normally consists of a substantial litter layer which remains relatively undisturbed while successive leaf falls

bury the previous layer thus producing stratification with the oldest most decomposed material at the base of the deposit (Burgos 1967). There are numerous animals in a mor humus but their size is small so that a minimal amount of disturbance takes place. This was borne out when studying the stratigraphy of Cuthbert's Wood for no earthworms (Lumbricus) were found in the humus whereas they were observed in the better drained mineral soils. In these areas any litter which had fallen on the surface was quickly decomposed and incorporated into the mineral soil through the action of the soil macro and micro faunas.

There has been much debate over the question of what conditions are required for the formation of a mor. Climate appears to be an important factor but not necessarily an overriding one because mull and mor soils can develop side by side in the same climate. Furthermore mull or mor may develop on soils which are uniform in character and origin of parent material. Quantity of litter is not seen to play a part in determining whether mull or mor would form. It has been suggested that one of the critical features in the formation of a mor humus is that phenolic materials in the leaf tissue tan the protein and form a protective coating over the cellulose of the leaf, thus inhibiting rapid decomposition. Mor formation is normally associated with a vegetation relatively rich in phenolic compounds and of low base content which gives rise to a relatively acid layer which in turn prohibits the activities of earthworms (Handley, 1954). The anthropogenic factor should not be ignored when considering the causation of a mor deposit. Man can affect the vegetation through burning, felling, planting and by changing the drainage of an area. It has been stated that mor is unstable and as it

increases in depth there comes a time when no autotrophic plants can grow and this results in erosion of the deposit (Handley, 1964). In time it appears that mull species would seed themselves on the mor and the system would change from mor to mull. Mull and mor humus types appear to be part of a reversible system.

In Cuthbert's Wood the deep humus layer started to form on top of the podsol when decomposition was no longer able to keep pace with the deposition of plant material. The factors causing the mor humus to form are not obvious although the most likely explanation appears to be a change of climate. The tree pollen represented in the diagram indicates that this change in climate was the sub-boreal to sub-atlantic one. At Cranberry Bog, 2 miles away, a recurrence surface, the 'Grenzhorizont', has been detected at 69cm which represents a climatic change to more atlantic conditions. This horizon is normally dated to 600 - 400 B.C. by radio carbon dating and it is probable that this climatic change is the same one which is responsible for the deposition of the mor humus in Cuthbert's Wood. The presence of Juncus effusus seeds and large amounts of Alnus pollen in the podsol indicate that the area was damp immediately prior to the mor deposition. This may be the result of impeded drainage caused by underlying boulder clay. Macroremains are usually considered to indicate the undoubted presence of a particular species in the immediate vicinity of the core. The presence of Juncus seeds in the profile is of importance for this reason especially in view of the fact that the exine of the pollen grain is extremely thin and is rarely preserved in the fossil state.

Tilia in Cuthberts Wood is not recorded above 142.5cm. It is known that this species does not regenerate readily in Britain today because increased wetness may have made the ground unsuitable. Godwin (1956) uses the Tilia decline as one of the indicators for the division between zones VIIb and VIII, thus assigning climate as the responsible factor. An anthropogenic explanation has been given for the Tilia decline where it is associated with increased pollen frequency of ruderal species (Turner, 1962). Increased wetness has resulted in the decline in Tilia in Cuthbert's Wood where no corresponding increase in ruderal species was noted.

Following the 'Grenzhorizont' there is usually a decrease in tree pollen relative to that of herbs. In zone VIII any such changes can be assigned to the activity of man. The pollen in the mor from Cuthbert's Wood may be considered to be of very local origin and therefore any changes in pollen frequencies relate to changes in the vegetation of the immediate surrounding land. That this is a reasonable assumption is shown by the high tree pollen frequency at the top of the profile where the vegetation is known to be that of a woodland. If the pollen was derived by long distance transport the top part of the diagram at Cuthbert's Wood would resemble diagrams from Cranberry Bog and other zone VIII diagrams where the pattern generally is one of decreased tree pollen and increased herbs towards the present time. Iversen's diagram from Draved illustrates a similar situation to that found at Cuthbert's Wood. The deposit at Draved is also of zone VIII and underlies a forest vegetation. The pollen consists of mainly tree pollen showing that it too was derived locally. The low Pinus pollen in Cuthbert's Wood shows that a little pollen derived

from long distances is being deposited by the pollen rain.

Human activity is visible between 100 - 90cm where there has been some felling of trees, particularly Quercus, Ulmus and some Betula and marked increases in Gramineae, Plantago lanceolata and other herb species. P. lanceolata is of value as an indicator because today it is associated with pasturage and cultivation and is intolerant of competition from woody plants (Godwin 1956). The decrease in elm may be because its twigs were used as cattle fodder. Alnus does not appear to be affected. Silica fragments have blown in as a result of the clearance. This is the first notable occurrence of human activity in Cuthbert's Wood. Similar post 'Grenzhorizont' clearings of forest are picked out at Cranberry Bog at about 55cm (Kershaw 1967) and also at Stewards Shield. Kershaw (1967) indicates that the drop in tree pollen at Cranberry Bog is due to the activity of Iron Age man in the area, possibly around 400 B.C. A later date would seem more likely for Cuthbert's Wood, perhaps one of the Romano/British periods in the first five centuries A.D. It may be that the construction of Hadrian's Wall along with the accompanying structures of mile castles, turrets and forts caused considerable tracts of forests to be felled. Furthermore increased production of crops would have been necessary to feed the legions stationed in the area. No cereal pollen grains were detected at this time however. The first appearance of Fraxinus pollen at 102.5cm, when drops in tree pollen were just beginning, may be of significance because it is known to be a pioneer species (Wardle 1961). The Anglo Saxons may have been responsible for this major clearance but with no archaeological evidence it is unfortunately not possible to give it a date.

Above this level tree pollen increases so that at 87.5cm Alnus is responsible for threequarters of the total tree pollen whereas Betula and Quercus frequencies are low. Alnus seedlings are known to have an advantage over Betula seedlings in wet soils when in competition as pioneer species. Alnus, however, is not adapted for the invasion of grassland but thrives in neglected grass in which drainage has become interrupted and given rise to seasonal surface wetness (McVean 1956). It is probable that the area of the wood became wetter at this time favouring Alnus and slowing down the regeneration of Betula. The slight increase in Corylus and Salix pollen together with abundant Juncus seeds adds support to this. Intensive grazing of the area at this time did not occur because the woodland was able to regenerate to its original density.

The increase of Salix pollen at 40cms is a very local effect which was not detected 2 miles away at Cranberry Bog. Ward has, however, found an increase in Salix pollen at Stewards Shield, which is presumably also very local. ^{High} Salix frequencies are not normally found in zone VIII. With the increase in Salix there is a slight decrease in Alnus and Quercus which may indicate some felling of trees. Betula shows a slight increase. The Salix peak drops before rising again at 22.5cm. Increased wetness may be the cause of the Salix increase, but as this was not detected at Cranberry Bog and as there are no corresponding changes in other species the climatic factor may be ruled out and planting of Salix suspected. Salix was used for many crafts and pollarding of the trees was practised to provide repeated crops of small poles (Edlin, 1956). A demand for poles for fencing and hurdling would have been created by the enclosure

of land. After the first Salix peak there is a reversion to the original tree/shrub/herb ratio and then at 27.5cm a gradual decrease in AP/NAP ratio occurs. Here there is a remarkable correlation between Cuthbert's Wood and Stewards Shield where there is also a phase of clearance soon after the Salix peaks. A similar clearance phase is not detected at Cranberry Bog which again illustrates that it is the vegetation, immediately around the area from which the core was taken, that is being picked out in the pollen diagram. Alnus and Betula pollen decreases whereas Corylus takes over as the predominant shrub from Salix and grasses and other herbs increase. During this clearance phase cereal pollen of Secale, presumably blowing in from surrounding tilled land, increases. Cereal pollen is not abundant in the leaf litter layer, despite the surrounding arable fields, which indicates that it does not blow in in large quantities while the wood is as dense as it is at present. Hydrocotyle is present which indicates flooding of the land or a rise in the water table. The dating of this phase of clearance is difficult in the absence of documents. It may relate to the demand for timber during the two wars of the twentieth century because some felling in the wood is known to have occurred during the last war (Hunter 1969). The decaying stumps of Quercus and Betula trees (of ages up to 70 years) are present in the wood today especially around the perimeter as evidence of this felling. The depth of this clearance phase however, would seem to indicate an earlier date of perhaps the late eighteenth and early nineteenth century. If such an early date is accepted the later clearance (25 years ago) is missing from the profile.

A fire which occurred in the wood in 1947 ~~may~~

may be responsible for burning of the top layer of the deposit destroying any pollen evidence for the felling in the last war. No evidence of fire was however, detected in the centre of the wood.

The top of the diagram shows that regeneration of the wood occurred after this clearance phase and was therefore not grazed. Betula increases at the expense of Alnus which may be the result of a lowered watertable, or better drainage. Certainly Alnus at the present time is restricted to the very wet areas of the wood which are more basic; a feature favourable to this tree (McVean 1956).

Following the first clearance phase there is rise in pH possibly caused by the washing in of bases from the surrounding cleared land. A similar rise in alkalinity does not occur after the second clearance and it is thought that the effect of atmospheric pollution resulting from industrial activity in the area may have masked any such effects.

The surface samples are interesting because they illustrate the sort of variation in pollen percentage which can exist over a very small area. They show that by studying deposits of this type a more detailed picture of the actual vegetation of an area can be built up.

Some deer are known to visit the wood at the present time. These animals escaped from the deer park when the estate changed hands in 1952. These deer, together with rabbits, may be responsible for the open areas of the wood remaining open. At the south side of the wood there is an extensive tract of open land dominated by Chamaenerion angustifolium, the 'fire weed'. If this area is open

because of the effects of the 1947 fire some trees would have been expected to have grown in the last 20 years. Betula seedlings which are present are all less than 6 inches high which does suggest grazing. It is interesting to note that the pollen diagram itself does not indicate that such open areas exist. Traces of Epilobium pollen are found in the surface samples but this once again shows, as would be expected, that it is the vegetation immediately around the borehole which is contributing the pollen and that only a little pollen from pollen rain is settling.

Rhododendrons and laurels are growing in the wood at the present time but no evidence was obtained for a time of planting. These bushes were frequently planted in the Victorian era to provide a thick cover for game birds and for decorative purposes. It may be that the pollen of these species does not preserve well or is not dispersed far from the shrubs themselves.

The herb pollen diagram has many pollen types represented by single pollen grains only. It must be remembered that the presence of these grains may be due to deposition by pollen rain or animals. Where abundant pollen of a particular type occurs it is probable that the plant was actually growing in the vicinity. For instance at 17.5cm the Cruciferae pollen shows a marked increase perhaps because of the presence of Cardamine spp., Capsella or other weed type. Increased Filicales spores are associated with the Salix peak.

Cuthbert's Wood therefore suffered two major clearances and one phase of Salix planting. All through the history of the Beamish Estate wood would have been required for construction, fencing, tools, fuel etc. and it may be presumed that felling and coppicing was occurring at frequent

intervals. The clearance phases may be related to times of building, perhaps improvements to the manor house, but the extraordinary correlation of events in Cuthbert' Wood with those of Stewards Shield indicate that these clearances may be related to times of more extensive timber demand. It is known for instance that there was extensive destruction of forest during the Civil War and that the iron and tanning industries put heavy demands on woodland. (Tansley, 1939).

In the absence of any dating evidence a possible time scale may be postulated. The first clearance may represent Romano-British clearing, followed by several centuries when the area was covered with alder/birch wood with some oak. Enclosure of the land around the eighteenth century may have called for fencing material causing Salix to be planted. Increased industrial activity may have caused a further demand on timber resulting in the second drop in tree pollen. It is to be hoped that there will be some documentary evidence for Stewards Shield which will provide a suitable time scale for Cuthbert's Wood as well.

SUMMARY.

1. A background to pollen diagrams in the northeast of England is given together with a location map.
2. The location of Cuthbert's Wood, Beamish, Co. Durham is given and there are also two maps.
3. A mor humus deposit in Cuthbert's Wood was studied in order to determine its age, extent and the vegetational history of the area.
4. A description of the wood at the present time is given and there is also an account of the human history in the area.
5. The topography and stratigraphy of the wood was examined and sections are drawn in Fig. 1.
6. A core of 150cm was taken in the centre of the wood to examine the organic deposit overlying a podsol for pollen analysis and macroplant analysis. The pH of the core at 5cm intervals was determined. Three surface samples were also taken for pollen analysis. The results of these analyses are presented in the forms of two pollen diagrams and in two tables. These diagrams indicate that the deposit is of zone VIII throughout.
7. The discussion contains a definition of a mor humus and a suggested time for the formation of the mor humus in Cuthbert's Wood.

Continued:-

SUMMARY. (continued)

8. The evidence suggests that most of the pollen in the core was locally derived possibly from a radius of 10 - 20metres from the bore hole.

9. At the bottom of the profile the area was wooded. The pollen analysis reveals that there were two major clearance phases of the woodland with a sharp rise in Salix pollen immediately prior to the second one. The first clearance is possibly of Romano-British age; the Salix peak is associated with the enclosure of farmland and the second clearance associated with the increased industrial activity of the area

10. It is regretted that neither documentary nor archaeological evidence is available for this site but it is hoped that the close similarity of the Cuthbert's Wood diagram to that of Ward's at Stewards Shield may allow an interpretation based on her findings in the presence of documents, when available.

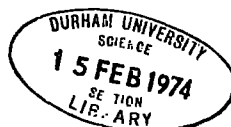
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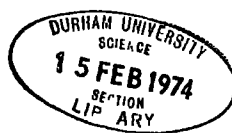
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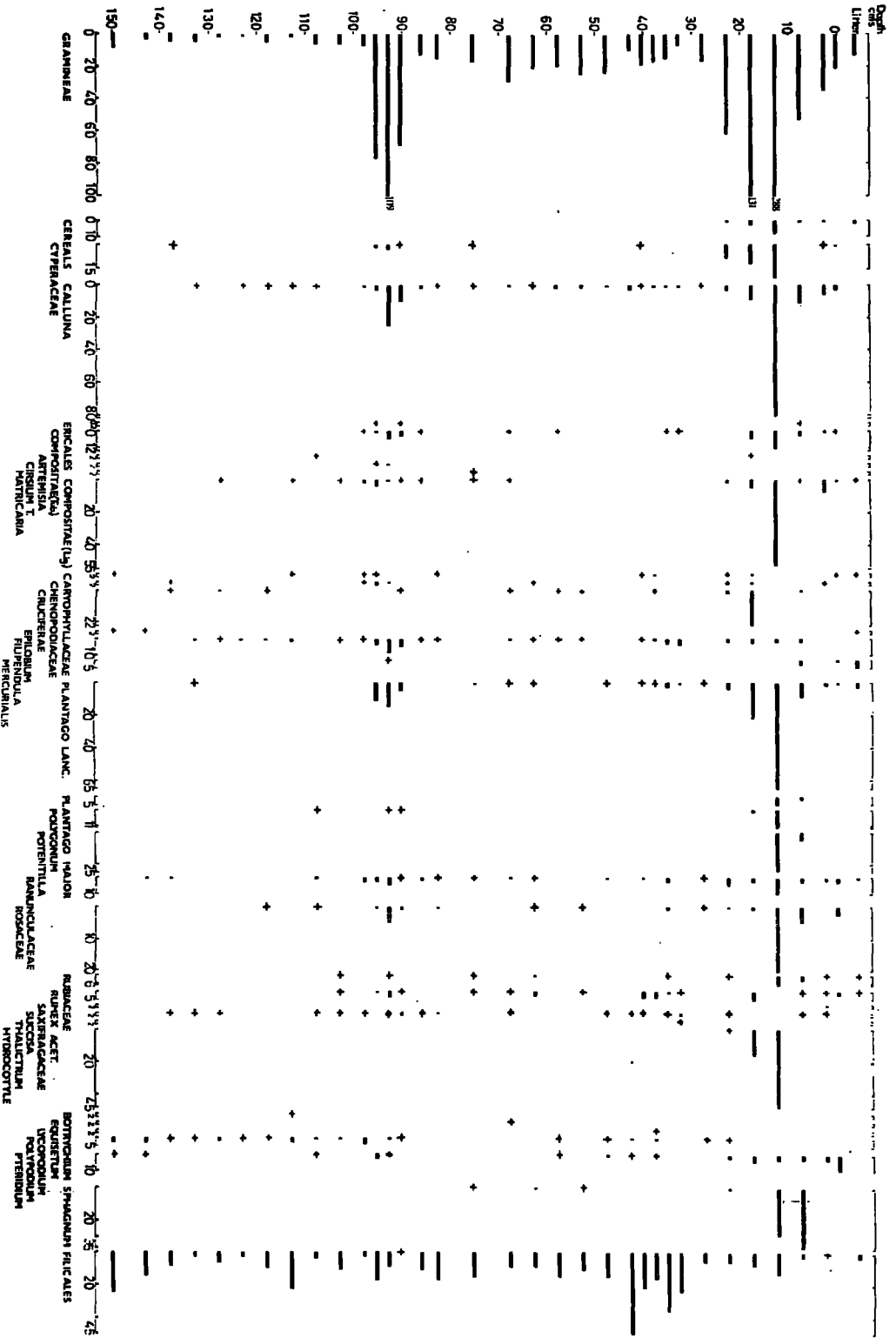
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POLLEN DIAGRAM II

HERB POLLEN AND SPORES EXPRESSED AS % TOTAL TREE POLLEN



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POLLEN DIAGRAM I

