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ABSTRACT

POLLEN ANALYSIS OF PEAT DEPOSITS NEAR EDLINGHAM, NORTHUMBERLAND.

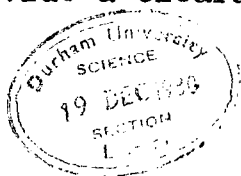
by David William Moyle

The clearance history of vegetation in Northumberland has been subject to very limited research. The present study is principally concerned with the impact of man on vegetational development in the vicinity of Edlingham in central-eastern Northumberland. The area has a diverse physical environment including both arable lowlands and heath covered sandstone uplands. Archaeological evidence indicates the likelihood of continuous human settlement since Mesolithic times.

Two peat deposits of contrasting size and pollen catchment were surveyed and sampled for pollen study purposes. A small lowland mire adjacent to Edlingham Castle provided a limited record of post-clearance vegetational history estimated to date from the 17th century. The second site at Black Lough consists of a large body of peat contained within a depression in the underlying glacial drift located on the interfluvium of a Fell Sandstone ridge overlooking Edlingham. A 7 metre core from this site produced a continuous pollen and stratigraphic record extending from the Late Devensian to the present.

Twelve pollen assemblage zones (BL I - BL XII) are identified from the Black Lough core. Comparison of these zones with the Flandrian Chronozones established at Din Moss (Hibbert and Switsur 1976) demonstrates a close correlation. On this basis a time scale has been placed on the major vegetational changes occurring in the Black Lough pollen diagram.

The impact of man on the vegetation at Black Lough is first detected at the Flandrian I/II transition dated at Din Moss to 6710 ± 100 b.p. Mesolithic activity led to minor openings in the forest cover and possibly contributed to the very sudden decline of Pinus pollen recorded at Black Lough. Detailed study of the Flandrian II/III transition challenges the traditional view of the Elm Decline as an isolated event involving the selective decline of elm pollen only. An anthropological explanation is supported. Following the decline of elm it would appear that for a period of 2500 years covering the Neolithic, Bronze Age and Early Iron Age, occupation was relatively continuous involving progressively more permanent agricultural communities and gradually increasing clearance. The great upsurge of clearance following this period is associated with the pre-Roman Iron Age and appears to be relatively uniform across north-east England. From Romano-British times to the present the Black Lough diagram provides a detailed sequence of clearance and regeneration phases which is tentatively related to historical events and appears to provide a clearance sequence of reference value for the region.



POLLEN ANALYSIS OF PEAT DEPOSITS
NEAR EDLINGHAM, NORTHUMBERLAND

by

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Thesis submitted for the degree of Master of Science,
through the Department of Geography,

University of Durham,

May 1980



I hereby declare that none of the material contained in this thesis has been accepted for the award of any other degree or diploma in any university and that, to the best of my knowledge and belief, the thesis contains no material previously published or written by another person, except where due reference has been made in the text.

D.W. Moyle
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D.W. Moyle
May 1980

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- CHAPTER I -

INTRODUCTION

1.1 GENERAL INTRODUCTION

The village of Edlingham (National Grid Reference NU 113090) in northern Northumberland is a "shrunk medieval village" (Alexander and Roberts 1978) consisting now of only a scatter of houses adjacent to a Norman church and derelict 14th Century castle. The village is sited on the gentle western valley slopes of Edlingham Burn, a tributary of the River Aln (photos 1,2,3). Facing across the valley is a steep escarpment of Fell Sandstone rising to a general elevation of 230 metres O.D. from which relatively flat heathery moors dip gently to the south east. A stretch of water known as Black Lough (NU 133084) is located immediately over the ridge top approximately 2 km south-east of Edlingham (fig.1, photo 4).

The origins of Edlingham are briefly discussed in J.C. Hodgson's A HISTORY OF NORTHUMBERLAND (1904). It is stated that Edlingham (or Eadulfingham) was "among the places given to Saint Cuthbert, in 737, by King Ceolwulf." (Hodgson 1904, p.14). The form of the town-name and other historical evidence suggests that "the site may almost certainly be regarded as the ham, the homeplace, of a community of Angles, the relatives and dependants of a man called Eadwulf". (Hodgson 1904, p.15) (hence Eadulfingham). In later Medieval times the township area



included both arable and pastoral farming, with the existence of a corn mill on Edlingham Burn suggesting considerable grain production. At this time the pasturage of stock on the upland "wastes" (presumably the Fell Sandstone uplands immediately east of Edlingham Burn) was also a normal part of livestock husbandry in the region (Hodgson 1904).

There is a strong likelihood that the site of Edlingham, or at least its general location, also saw settlement in Roman and earlier periods: "Edlingham must have been occupied in pre-historic days, for it possesses advantages for settled habitation in all respects equal to those of the surrounding districts, where the discovery of stone and bronze weapons and implements, and the occurrence of fortified strongholds and of places of burial bear testimony to an abundant population in those times." (Hodgson 1904). If pre-historic occupation did indeed occur, the resultant impact on the vegetation should be reflected in the pollen record preserved in organic deposits in the immediate locality. (Ref. 1.2)

The impetus for the current study results largely from the interest in obtaining palaeobotanical data to complement archaeological studies currently in progress at Edlingham in establishing the history of clearance, settlement and arable farming in the district. The contribution which can be made by pollen analytical studies

to an understanding of man's impact on vegetation, particularly when related to an archaeological site, has been well established. The series of papers from the Somerset Levels (Coles et al 1975, 1976, 1977, 1978) and the integrated bioarchaeological investigations at Star Carr (Clark 1954, 1972) are excellent examples of the manner in which palaeobotanical information has been integrated into an overall bioarchaeological investigation. In addition, there are now numerous published papers which employ pollen analytical methods to investigate the impact of man on vegetation (for example Godwin 1978, Tinsley 1975 Iversen 1973, Davies and Turner 1979, Pilcher 1975, Bartley 1975). The growth in such pollen studies over the last decade has played an important part in the revised understanding of British prehistory (Renfrew 1974) and in particular the environmental interactions of early man (Evans 1975, Simmons and Tooley, in press).

For the present investigation, pollen study sites were sought as near as possible to the village of Edlingham to maximise the opportunity for eventual bio-archaeological correlations in the locality. Two peat deposits were located relatively near to the village site, one at Black Lough and the other a small mire adjacent to the Castle (fig.1, photo 5). It was decided to conduct a stratigraphic survey of both sites and to select suitable

cores on which pollen analytical studies might be carried out.

1.2 RESEARCH OBJECTIVES

The two pollen study sites selected provide a strong contrast in physical characteristics and presumably also in the nature of their pollen catchments (site details are discussed in sections 5.1 and 6.1). The Black Lough site is a large upland raised bog which might be expected to provide a long pollen record of regional significance (see discussion in 6.3). The Edlingham Castle site, by contrast, is a small valley bottom mire with a predominantly local pollen catchment (ref. section 5.3). The original research objective was based on this difference in character between the two sites to provide an opportunity to correlate local and regional vegetational changes.

The specific objectives for the study were:

- a) to establish an outline of the regional environmental history since the Late Devensian which could be related to Flandrian chronozones.
- b) to conduct a detailed study of the changing impact upon the vegetation of different cultural groups living in the vicinity of Edlingham, and by comparison with Black Lough, to establish the degree to which local effects were reflected in the wider region.

A detailed stratigraphic survey of Edlingham mire, however, revealed that the stratigraphic sequence showed very little consistency between the 5 metre spaced sampling sites, and it demonstrated that the mire had been subject to a very variable formation history, possibly involving erosion and redeposition (ref. section 5.2). It thus became necessary to reformulate the research objectives to concentrate attention more strongly upon the Black Lough site although preserving the original direction of the research study. It was decided to construct an outline pollen diagram from the Edlingham site to be used in a supporting role in the interpretation of human impact in the area.

Black Lough now became the principal site and was to be sampled in greater detail than originally envisaged, concentrating attention on the late-Flandrian II and Flandrian III periods when human activities might be expected to become an important influence on the vegetation. While Black Lough has a relatively large pollen catchment and may be less sensitive as an indicator of minor local clearance activities, it should, nevertheless, register more extensive clearance phases in the district.

The revised objectives may be summarised:-

- a) to establish the nature and sequence of human impact on the vegetation of the Black Lough district;
- b) to establish the regional environmental history since the Late Devensian, and

- and relate it to Flandrian chronozones;
- c) to correlate the human impact phases established at Black Lough with other sites in the general region, as the basis of a tentative chronology for the site.

As is described in Sections 1.3 and 6.1, Black Lough occupies a site of moderate upland character, which, although exposed and generally poorly drained, would not have been entirely unattractive to early pastoral and agricultural peoples. Indeed, with the presence of a steep Fell Sandstone scarp nearby and a permanent water supply in Edlingham Burn, it is an area of considerable habitat diversity providing a variety of living environments, not only for plant and animal communities but also for man. This is reflected in the general landscape character of the region.

1.3 THE PHYSICAL SETTING

The Edlingham/Black Lough area lies 13km. inland from the Northumberland coast, in a region of scarplands and low intervening valleys, flanking the granite dome of the Cheviot Hills some 20km. away to the north-west (ref. figure 1). The steep escarpments have a general elevation of 250-300 metres O.D. over the rolling hills and valleys which are generally below 100 metres O.D. The form of the present landscape closely reflects the underlying solid geology (ref. figure 2), although import-

ant superficial features result from the glacial advances of the Pleistocene and subsequent erosion and deposition of the glacial deposits (ref. figure 3).

The principal relief-forming strata in the vicinity of Edlingham are the Fell Sandstone and Cementstone Groups, both formed during the Early Carboniferous. The resistant Fell Sandstones constitute the high ridge lines with their steep north-west and west-facing escarpments and more gently inclined beds extending to the south-east and east. The Cementstone Group consists of a variety of shales, mudstones, siltstones, thin limestones and sandstones which are generally less resistant to erosion and form the low rolling hills and vales between the Cheviot Hills and the Fell Sandstone ridges. The alignment of the scarplands and valleys, which has such a dominant effect on the physical character of the landscape as well as the human use of the region, results from geological events largely occurring during the Carboniferous. A series of level-bedded sedimentary strata accumulated during the Carboniferous after a period of extensive volcanic activity during which the Cheviot granite massif was intruded. The Scremerston Coal Group, overlying the Fell Sandstones, resulted from peat beds formed during the warm, humid terrestrial conditions of the Upper Carboniferous, and was then in turn overlain by various limestones and sandstones. The Group itself is very variable with thin coal seams providing limited coal extraction possibilities. At Corby's Crag, in the near vicinity of Black Lough, faulting has allowed the coal seams to be worked at "a very early date",

(Carruthers et al 1930) although little information is available on the history of the extraction shafts. Uplift, tilting and faulting during the early Mesozoic inclined the Carboniferous strata against the uplifted Cheviot massif in a series of stepped levels inclined gently to the south and east. Continuing terrestrial erosion during the remainder of the Mesozoic and Tertiary gradually removed the deep Carboniferous deposits covering the Cheviot massif and created the landscape basically as it exists today.

The characteristic broken relief of the scarplands has a significant effect on the local climate. The relief amplitude between ridge-top and valley bottom is usually in the order of 200-250 metres over a horizontal distance of approximately 1 km, creating a sharp environmental gradient between sheltered valley and exposed higher zone of moorland. Newton (1972) notes that snow lies much longer on the uplands over 800 ft. than in the surrounding vales, and this effect was certainly noticeable during field work at Black Lough in March 1979 (photos 6, 7). Data on the climate of north-eastern England (British Association 1949) suggest that on the lowlands under approximately 60 m. snow falls on average for about 12 days in the year, and on elevated land over approximately 240m. on about 20 days. Similarly, on the coast, snow lies on average for about 7 days compared with about 12 days in valleys such as the Aln, and 40 days on elevated

sites such as Black Lough. The influence of the relief on local rainfall is also considerable with the sheltered valleys of the Aln having as much as 5-10 inches less rainfall than the surrounding uplands, which average approximately 35 inches annually, (British Association 1949). In general, the climate of the valley bottoms is far more moderate than that of the exposed wind-swept ridge tops which in the winter months are particularly subject to extremes of temperature, wind and snow.

Rivers originate from the high precipitation area of the Cheviot Hills in a regular radial pattern across the less resistant Cementstone rocks, but due to the blocking effect of the Fell Sandstone ridges, the Rivers Breamish and Till are displaced north to join the River Tweed. The River Aln and River Coquet have utilised fault lines to cut through the Fell Sandstone directly to the east, but their general course and those of their tributaries (such as Edlingham Burn which flows into the Aln) closely parallel the alignment of the Fell Sandstone scarps.

The onset of glaciation did not greatly modify the basic landscape features, the ice being of local (Cheviot) origin and limited in volume and erosive power (King 1976). It did, however, cause a general infilling of lowland areas with boulder clay and glacially derived sand and gravel, which has since been partially eroded (ref. figure 3). The presence of the glacial deposits has increased the

variety of soil types in the region and thereby the range of habitats. (Details of the superficial geology relating to the two study sites are discussed in sections 5.1 and 6.1). The village of Edlingham is located on the boundary zone between an outcrop of the Cementstone Group and boulder clay, whilst Black Lough is located on the immediate backslope of a Fell Sandstone Ridge in a variable faulted zone encompassing outcrops of the Scremerston Coal Group and boulder clay (ref. figure 3).

The soils derived from the various rock types and surface deposits are likely to have considerable bearing on the use made of the region by early man, who in turn may have initiated soil deterioration as a result of clearance activities. The Fell Sandstone weathers to a podzolized sandy soil of low base status (Robson 1965) which, since earliest settlement, would have left the high ridges as uncultivated rocky moors. These soils now support pine plantations. A map published in 1794 (ref. figure 4) as part of a comprehensive agricultural survey of Northumberland (Bailey and Culley 1805) clearly shows the pattern of Fell Sandstone ridges plotted as "Heathy Mountains" surrounding the Cheviot Hills. The authors compare the "extensive, open solitary wastes, growing little else but heath, and affording a hard subsistence for the flocks that depasture them" with the "deep, narrow, sequestered glens" of the intervening valleys. Many small peat bogs, and larger raised bogs such as

Black Lough, have formed in depressions over boulder clay on the poorly drained interfluves of the Fell Sandstone ridges but there is no general formation of blanket peat.

By comparison, soils derived from both the boulder clay and the various Carboniferous shales, sandstones and coal bearing groups show great variability, but are generally of greater fertility and better texture than those derived from the Fell Sandstone. The variability of these soils revolves around the inherent variability of the parent material and the soil drainage conditions operating at a particular site. Much of the boulder clay contains a considerable proportion of silt and sand from the Cementstone bedrock and weathers in conditions of moderate to good drainage into a light brown soil suitable for arable farming. In pre-clearance times these soils would have developed in association with the mosaic of mixed deciduous woodland and forest, producing various forms of brown forest soil. Associated with the forests would have been a variety of wet-land habitats resulting from springs and drainage depressions in the boulder clay, as is found today along Edlingham Burn and on the Fell Sandstone uplands. It is to these better drained brown forest soils with nearby fresh-water springs that early agricultural man may well have been first attracted. At the present time the high fells are used mainly for forestry and rough grazing, with limited areas

of cropping on the better drained soils associated with the Scremerstone Coal Group. The valley bottoms and intervening hills are given over to mixed sheep/livestock/arable farming with considerable areas of wheat, oats and barley on the lighter soils, although pastoral land use is dominant.

The sandstone scarps clearly have a dominant influence upon the physiography of the region, influencing river courses, micro-climate and the pattern of soil development. In more recent times they have also influenced the location of transport routes and the forms of settlement, agricultural and extractive land use in the region. It is no less likely that the economy of early man was also closely related to the pattern of upland and lowland according to his varying needs for protection, hunting and gathering resources, water, pastoral lands and productive soil. The variety of habitats available in the immediate vicinity of Black Lough and Edlingham would allow many of these needs to be met. In addition, ready lowland access is available to the east, utilizing the alignment of Edlingham valley and the passage of the River Aln through the barrier of Fell Sandstone at Alnwick. The present road system largely follows this route. The existence of a Saxon settlement at Edlingham reflects these environmental resources and suggests also the likelihood of other early agricultural groups living in the area.

1.4 PREVIOUS RESEARCH

Prior to 1970, very few detailed pollen studies were available from sites within north-east England (a region bounded in the north and south by the Rivers Tweed and Tees and in the west by the Pennine/Cheviot uplands). While the north-west of England had been the subject of numerous pollen studies before 1970 (e.g. Walker 1955, 1965, 1966; Pennington 1947, 1964, 1965, 1970; Oldfield 1963, 1965; Oldfield and Statham 1963) it has only been in recent years that north-east England has been the subject of more intensive palaeoecological research. The relative paucity of palaeoecological data in Northumberland, in particular, has prevented the development of a regional vegetation history, although recent publications (Bartley et al 1976, Davies and Turner 1979, Turner 1979) have gone some way to amending that situation. Further progress towards a more comprehensive regional synthesis of vegetation history will depend on the greater availability of detailed pollen diagrams from the region. Some of the earliest pollen diagrams produced in Britain after Erdtman's initial research (1927, 1928, 1929) were constructed from sites in Northumberland and the Lakes District by K.B. Blackburn and A. Raistrick. Raistrick and Blackburn (1931 a, 1931 b) established through precise analysis of some 23 sites in southern Northumberland and northern Durham, the basis of the major vegetational zones later

to be recognised as a general pattern in England (Godwin 1940). Their work was clearly influenced by the contemporary writings of von Post (1916) and Sernander (1910), although no formal system of zonation was applied to the diagrams. Attempts were made to relate similar events across the various diagrams which led to the observation that site, and particularly topographic factors, have a strong influence on vegetation history in the region. The difference between upland and lowland sites has since become a recurring theme of pollen studies in the region. Later work by Blackburn (1953) at a highland site (Broadgate Fell) near Ridsdale, Northumberland, led to the conclusion that while the general features of forest development in Northumberland can be matched with Godwin's East Anglian type zone, the proportions of pollen of the various taxa are different. For example, birch never dropped below 20% of total tree pollen and staged a strong recovery during Godwin zone VIII. For the first time the marked decline in elm is recognised at the Atlantic/Sub-Boreal boundary although no particular climatic or anthropogenic significance is attached to the event. Oak, lime and beech are also recognised as having lower percentages than in diagrams from southern England. The greatest problems with zoning were associated with the upper part of the diagram at the VII-VIII transition, largely as a result of the virtual absence of Fagus and a preponderance of grass and heather species, together with

a rise in birch, hazel and alder. Blackburn suggested that a hazel-alder-birch zone VIII would be more appropriate although the strong rise in heather species, which at other sites had been associated with a "Grenz-horizont", was clearly of importance in the final positioning of the zone boundary.

The early papers of Raistrick and Blackburn have been examined, since in many ways they recognised features of northern pollen diagrams which have continued to attract the attention of workers down to the present day. They also made a largely unrecognised contribution to the early development of pollen analytical techniques and the knowledge of forest history in Britain.

Two further upland sites at Muckle Moss (Pearson 1960)¹ and Coom Rigg (Chapman 1964) produced pollen diagrams very similar to Blackburn (1953). A series of lowland sites, near Bamburgh, (Bartley 1966), Trickle Wood (Turner 1968), Wooler Water (Clapperton et al 1971), and Akeld Basin (Borek 1975), provided an effective contrast to the earlier upland studies, and in the case of Bartley (1966) gave the first detailed account of Late Devensian and Early Flandrian vegetation in the region.

The two most recent studies of environmental history in the area reflect modern developments in pollen analytical methods, although the essential patterns and problems identified remain similar to those recognised some 35 years previously. Hibbert and Switsur (1976) link

1. Study sites discussed in North-east England are located and referenced in figure 1. After initial reference in the text, sites will be referred to by geographical name without reference details.

radiocarbon dating with a detailed (4cm) sampling interval from an upland bog site at Din Moss in Roxburghshire near the Northumberland border and provide the only comprehensive series of dates for zone boundaries in the immediate region. Some 10km. south of Din Moss also in Roxburghshire, Mannion (1978) has applied absolute pollen counting techniques to an infilled lake deposit at Linton Loch to determine the late Quaternary environmental history of the area.

Studies concerned principally with the impact of man on vegetational development have been far fewer in number and generally concerned with sites in Co. Durham (Roberts et al 1973, Donaldson and Turner 1977, Bartley et al 1976). All three studies provide radiocarbon dates to establish a relatively firm chronology for clearance events during Flandrian III at the various sites. The only such study conducted in Northumberland, and the most recent in the region generally, has examined evidence for clearance activities from four sites, and established dated clearance episodes at two of them (Davies and Turner 1979).

The resultant chronology of clearance events has enabled a tentative regional picture of clearance history to be established for north-east England. Bartley et al (1976) has emphasised the local variability of clearance activity in south-east Durham due apparently to edaphic factors favouring particular sites for arable farming.

Whereas the best drained and most fertile sites near Bishop Middleham were cleared in c.1400B.C. (Middle Bronze Age) and remained permanently cleared, the worst drained site at Neasham Fen remained only partially cleared until c.700A.D. Other sites went through variable periods of clearance and regeneration. Turner (1979) has brought together data from nine radiocarbon sites in Durham and Northumberland and concluded, with some caution, that clearing of any significance generally did not begin until the late pre-Roman Iron Age. A site such as Bishop Middleham is seen as an exception because of its light well-drained soils which would attract settlement from an early time. Generally, the Bronze and Iron Age landscapes were well-wooded with breaks in the canopy being the result of temporary pastoral or agricultural activity. The nine sites produced a set of dates for extensive clearance ranging from 180-190B.C. to A.D.190-240 (tree ring corrected dates). Reversion to woodland did not generally occur until A.D.480-650 with one site (Steward Shield Meadow) being delayed until A.D.1110-1200. Turner notes that the delay in forest regeneration until well after the period of Roman rule suggests a measure of political stability well into the sixth century A.D. Over an area as variable and large as north-east England there is clearly a need for further detailed research before a comprehensive picture of human impact since Mesolithic times can be obtained.

- CHAPTER 2 -

EVIDENCE OF EARLY HUMAN OCCUPATION IN THE REGION

2.1 THE NATURE OF THE EVIDENCE

Any inferences concerning the nature and distribution of a particular early culture, made on the basis of fragmentary archaeological evidence, must remain tentative. Nevertheless, such evidence does constitute a positive indication of the presence of a particular group in a region and may be of value in the correlation of biostratigraphic evidence for human impact. For this reason, records or archaeological data, derived principally from the Gazetteer of Sites published with Archaeology in the North (Clack and Gosling 1976) have been plotted onto 1:25,000 O.S. maps, covering the area of the ancient parish of Edlingham and adjoining districts (ref. figures 5,6,7). The data in the Gazetteer have been collated from all available verifiable sources including the O.S. Archaeology Record Cards, the Schedule of Ancient Monuments and published data. Finds since 1976 have not been included on the map.

The terminology and chronology for the groups listed below follow those used in Clack and Gosling, 1976. This chronology is based on the available radiocarbon assays for archaeological sites in the region and represents the most reliable overall assessment of this material currently available. Uncorrected radiocarbon dates

(Libby half-life of 5568 years) are indicated with the lower case convention (b.p.) and calendar years with upper case (B.C./B.P.). It is recognised that the actual boundaries between cultures may extend over a lengthy transition period and that considerable overlap between cultural groups may exist in separate parts of the region. The "false dichotomy" between hunting-fishing-gathering and food producing societies for the Mesolithic for example, has been discussed by D.Clark (1978 p.15). This also applies to later cultures.

2.2. MESOLITHIC EVIDENCE (c.8000 - c.3500B.C.)

2 sites

Evidence for Mesolithic occupation is limited to two flaking floor sites, at Rothbury and Corby's Crag. The Corby's Crag site is of particular significance to the present study since it is located only 1km north-east of Edlingham on the Fell Sandstone scarp overlooking Edlingham Burn. Recent excavation of the rock shelter (Beckensall 1976) produced clear evidence of Mesolithic, Bronze Age and Iron Age occupation levels in the shelter, further underlining the attraction of the region to human settlement. The Mesolithic material consisted of over 30 fragments of flint including a microlith, a thumb scraper and a borer. The site established unequivocally the presence of Mesolithic people in the immediate area, and by inference the likelihood of associated environmental changes.

Outside the mapped area, numerous Mesolithic artefacts have been recorded on the present coastal plains and river valleys between the Rivers Tyne and Tees. One site at West Hartlepool has an antler dated to 8700 ± 180 b.p. (BM80) (Barker and Mackey 1961). The relative paucity of finds in northern Northumberland compared with those on the lowlands to the south of the Tyne, is not necessarily evidence of a lower level of Mesolithic activity in the northern river valleys and plains. It may well be the case that, "the present distribution reflects not so much the activities of Mesolithic man as of modern field-workers" (Clack and Gosling 1976, p.16). There is little apparent reason for Mesolithic peoples to avoid the region to the north of the Tyne when they clearly occupied at least the lowland areas to the south. Clark (1978) points out that the very sites attractive to Mesolithic and early Neolithic cultures, namely those of high ecological productivity in river valleys, near lakes and on the coast, are also those most likely to be obliterated by erosion and deposition, and modern farming. He notes, for example, that the Mesolithic levels in the lower Po delta are now buried at a depth of more than 10 metres (Clark 1978). A possible rise in sea level in the North Sea of some 11 metres since the Mesolithic would similarly submerge many Mesolithic sites on the original coastal plains (M.J. Tooley, personal communication). It is most

unlikely then, that extensive Mesolithic sites will be discovered in the region. There can be little doubt, however, that the river valleys and tributaries of the Coquet, Aln and Tweed, extending from the coast with diverse upland habitats nearby, were attractive to Mesolithic and early Neolithic cultures and were settled as heavily as the valleys of the Wear and Tees to the south.

2.3 NEOLITHIC EVIDENCE (c.3500 - c.2000B.C.)

12 sites

Ten of the twelve sites recorded occur in a cluster in the south-west corner of the region on remnant surfaces of the dissected Fell Sandstone plateau at an elevation of approximately 700m. O.D. The other two sites in the north-east of the area are located on lowland boulder clay. All sites consist of standing stones which have probable ceremonial significance rather than indicating places of actual settlement. The cluster of sites near Rothbury forms part of a number of Neolithic sites inland from the coast in northern Northumberland. It suggests a considerable spread of Neolithic farmers along the rivers of the Coquet, Aln, Breamish, Till and Tweed, although the actual evidence is limited.

The skeleton of an early Neolithic man was discovered in intertidal peat beds at Hartlepool Bay (Tooley 1975). Cleaned but untreated bones from the

skeleton gave a radiocarbon date of 4680 ± 60 b.p. (HV. 5220) (Tooley 1978). Analysis of pollen at this site shows a major recession of forest, in which elm and lime pollen decline, dated to 5215 ± 80 b.p. (HV. 5217) (Tooley 1978). At this, and other sites nearby, the forest recession is associated with charcoal layers and an increase in the pollen of weed species. The conclusion is made that the elm and lime declines result from clearance and lopping by Neolithic groups whose presence in the area is evidenced by the burial remains. While such direct evidence for the presence and environmental impact of Neolithic peoples has not been found in northern Northumberland it is likely that similar levels of Neolithic settlement occurred in the northern coastal plains and valleys.

2.4 BEAKER AND BRONZE AGE EVIDENCE

Beaker 3 sites (Beaker Period c.2100 - c.1400B.C.)

Bronze 54 sites (Bronze Age c.1400 - c.700B.C.)

The Beaker/Bronze occupation is represented by two concentrations of sites, one across the northern section of the map north of Alnwick, and the other in the vicinity of Rothbury in the south-west. Corby's Crag rock shelter near Edlingham contained a Bronze Age Burial Urn decorated with grain impressions, and "cup and ring" marked stones have been found both at this site and near Black Lough. As with the Neolithic, the sites are

associated with burial and religious rites rather than settlement. The relatively high concentrations of Beaker/Bronze Age sites in northern Northumberland indicate a strong presence of this cultural group in the region, but it is problematical whether any significance for intensity of land-use in particular areas can be attached to the detailed distribution of sites. The low number of finds along the River Aln is probably not a reliable indicator of low settlement pressure in this area, but rather a case of poor preservation of remains. The Corby's Crag and Black Lough finds certainly suggest Bronze Age settlement in the locality.

2.5 IRON AGE AND ROMANO-BRITISH EVIDENCE (c.700B.C. - c.400A.D.)

Iron Age 28 sites (Hill forts 25, Settlements 3)

Iron Age/Romano-British settlements 11

Romano/British settlements 19

Iron Age sites show an apparent tendency towards location at places of higher elevation. In the north-west a cluster of hill-forts is located on the foothills of the Cheviot Hills, and in the south, on the upland ridges and plateaus formed by the Fell Sandstones Group. This distribution possibly reflects the favourable preservation of sites on the less heavily settled uplands where the hill-forts (which form the great majority of Iron Age remains) would be located for defensive reasons. By comparison, the 3 Iron-Age settlement sites are located

on low-land areas to the east and north-east of Edlingham. An Iron Age hill-fort is located on the Fell Sandstone escarpment c.2km north-east of Edlingham. The Iron Age/Romano-British and Romano-British settlements are generally located on river valley and hilly sites probably related to the agriculturally productive lands, although some, such as the settlement on Corby's Craggs (Fell Sandstone) c.1.5km north-east of Edlingham, are located in defensive positions.

The relationship between settlement sites and native population levels in Northumberland in Iron Age and Romano/British times, unfortunately, remains unclear. There is some suggestion of a growth in population during the Roman period indicated by the physical growth of individual settlements onto more marginal agricultural lands (B.K. Roberts, personal communication). This may be indicative of an overall growth in settlement during Roman times in Northumberland and possibly also reflects an amelioration of climate. The high density of Iron Age hill-forts beyond the immediate area extending along the foothills of the Cheviots towards the River Tweed and along the valley of the River Coquet suggests a considerable population density during this period. It is possible that the evidence for more extensive low-land settlement during the Iron Age has been obscured by subsequent arable farming and modern settlement superimposed over Iron Age remains.

2.6 EVIDENCE OF ROMAN OCCUPATION (c. 80A.D. - c. 400A.D.)

Roman remains in the area mapped are limited to 2 Roman roads and an associated fort and camp site at the point of intersection about 3km north-west of Edlingham. The north-south road known as the Devil's Causeway represents the eastern branch of Watling Street, and it continues on to a terminus at the River Tweed near Berwick. An easterly link road from High Rochester meets the Devil's Causeway just north of High Learchild. The direct impact of the Roman presence on northern Northumberland is difficult to determine. As a military frontier zone, it was subject to disturbance from north and south at different times, but for lengthy periods it was also subject to peace and stability during which population and productivity probably increased. While the net result for the region as a whole remains unclear, it is likely that settlements closely associated with the Roman garrisons and transport routes would have been considerably influenced.

Examination of the route of the Devil's Causeway through the mapped area indicates a marked eastwards diversion towards Edlingham Burn then returning to the direct north-south route at its intersection with the High Rochester link road near High Learchild (ref. figure 6). There seems little topographic reason for making this diversion, and in fact the opposite would seem to be the case. Continuing directly north (as the present

road does) would avoid a drop in altitude and the resultant climb out of Edlingham valley. It would seem quite possible that the road diverted to pass near an existing settlement and potential supply base immediately prior to meeting the link road from High Rochester where a fort and camp were established. The probability of an existing Iron Age village at Edlingham is thereby increased and the direct influence of a nearby Roman garrison on the agricultural economy of the area might be considerable.

2.7 MEDIEVAL EVIDENCE (c.400A.D. - c.1500A.D.)

Deserted Medieval villages	46
Castles	5
Pele Towers (defensive towers)	18
Bastles (fortified manors)	6
Other Medieval remains (mainly Churches, Wells, Mills, Bridges)	68

The archaeology of the Medieval period suggests population instability and conflict. Unfortunately, Medieval archaeological evidence does not as yet provide a clear chronological picture of land-use change and rural population variations. The archaeological remains of this period probably largely relate to the later Medieval period after about the 9th century. There is very little archaeological evidence of extensive rural settlement prior to the 9th century, although once again

this may be largely due to poor preservation of remains. The royal villa and associated settlement at Yeavinger confirms the continuation of political stability and technological skills from the time of Roman occupation into the 4th and 5th centuries when British rulers maintained a series of frontier kingdoms. This stability came to an end during the 6th and 7th century when plagues and continuing internal conflict apparently reduced economic and cultural activity to a low level and probably led to general rural depopulation.

The large number of deserted Medieval villages clearly suggests a drastic rural depopulation at some stage, but the actual timing and process of depopulation has not yet been established by detailed archaeological investigation. Indeed, the number and age of deserted and "shrunk" Medieval villages (such as Edlingham) may well increase as research in this region continues. Apart from a temporary "flowering" during the 8th century, political and economic stability did not return to the north until after the Norman conquest of the late 11th century. The castles, bastles and pele towers mapped, date largely from the post-Norman Medieval period with most castles being constructed between the 11th and 15th centuries, and most pele towers and bastles during the 15th to 17th centuries (Cramp P.J. in Clack and Gosling 1976). The Norman church at Edlingham has a square tower of strong construction including slit windows which

Hodgson (1904) considers to have clear defensive purposes and to have been added to the church during the 13th century, probably as a response to northern raids (photo 3). Edlingham Castle is first mentioned in contemporary records during the 14th century (Hodgson 1904). The proliferation of defensive structures dated to the post-12th century reflects the constant period of warfare between raiding Scots and defending English in the post-Norman period in northern Northumberland. In the Durham Account Rolls of 1401-1402, quoted by Hodgson, "Thomas de Lyth the sacrist, ----enters 73s.4d. as received from the corn tithes of Edlingham and no more, because the rest was destroyed by Scots" (Hodgson 1904 p.149). Clearly the effect of constant raiding during the 12th, 14th and 15th centuries, separated by periods of relative quiescence, would be reflected in the progressive expansion and contraction of rural population and associated agricultural activities. The onset of a period of plagues during the late part of the 15th century is likely to have resulted in a severe depression of rural population, and a contraction of agricultural land-use.

2.8 CONCLUSION

Archaeological evidence for human occupation in the Edlingham region exists for all major cultural periods since the Mesolithic. The evidence is largely fragment-

ary and indirect but does, nevertheless, establish the presence of elements of the major groups at various times in the region. The evidence is quite inadequate to provide any quantitative guide to the distribution or intensity of human occupation, and for the pre-Roman period in particular, does not necessarily establish any continuity of settlement in a particular district. There is a strong suggestion of marked population fluctuation during the Medieval period, which might be expected to be reflected in periods of vegetation clearance and regeneration as rural population fluctuated.

Fowler (1978) pursues this theme in the development of the proposition that the level of population is the principal determinant of cultural impact upon the landscape in Britain. His resultant population curve for later pre-historic and early historic times is based on population estimates for key periods in southern Britain¹. If environmental impact is principally a function of population level as Fowler claims, the history of vegetation in the Eldingham region should reflect the fluctuations in human population since Mesolithic times. The degree to which human impact will actually become apparent in a study of vegetational history depends to a large extent upon the study site (ref. section 1.2) and the nature of the techniques of analysis used.

1. The Fowler population curve and its relationship to environmental impact is discussed more fully in Chapter 9.

- CHAPTER 3 -

RESEARCH METHODS

3.1 STRATIGRAPHIC ANALYSIS

At both Edlingham and Black Lough borehole lines were laid out along the central position of the deposit and then at right angles to the base line from the point of greatest depth of organic deposit. Initial borehole intervals at Edlingham were 10 metres which were reduced to 5 metres in the central area of the deposit. Borehole intervals at Black Lough were 50 metres except at borehole B.L.9 where a pine plantation prevented the full 50 metre interval.

All borehole sites were levelled into Ordnance Datum using a Kern Autoset level. The ground heights at sampling level were obtained from a single bench mark at each site by means of open levelling traverses. Bench mark for Edlington was located on St. John's Chapel near the village (97.99m O.D. Grid Ref. NU 11430912) and for Black Lough on a hilltop approximately 1km to the north-west (250.73m O.D. Grid Ref. NU 14130937).

Cores for stratigraphic description were all obtained using a Russian type peat corer with chamber dimensions 50cm x 4.5cm producing a half diameter core. Sediments were such that penetration and removal of the corer was possible by two people and resultant cores were cleanly

and evenly sampled. Vertical control of the depth of penetration was maintained against a marker strip placed across the sediment surface at the surveyed level. The surface level was fixed from the top of wooden pegs driven into the sediment.

Cores which were not analysed at the site were placed immediately on removal into 50cm lengths of half diameter plastic casing and sealed in polythene. In the laboratory they were stored in the dark at 4°C until required. The core for pollen sampling at Black Lough (BL 12(a)) was taken next to borehole BL 12 at the same surveyed level.

Sediments were described using the methods, nomenclature and symbols proposed by Troels-Smith (1955) although symbol spacings for Turfa, Substantia humosa and Argilla were altered to facilitate drawing (key to symbols, figure 10(a)). Difficulties were experienced in applying certain aspects of Troels-Smith's scheme, particularly when analysing cores in the field. Most difficulty centred around the maintenance of consistency in assessing the level of humification of a deposit (humositas) as opposed to its Limus humosus or Limus detrituosus content. Since all three materials consist of completely disintegrated or decomposed organic substances with a dark homogeneous appearance it is often quite difficult to maintain consistency in the description.

The distinction is of importance since Limus is derived from lake deposits and its presence will indicate a distinct sedimentary environment. At Black Lough the alternative descriptive system suggested by Troels-Smith (1955) using a level of Substantia humosa (Sh) to indicate humified material together with a proportion of unhumified Turfa or Detritus, was applied. Th^0_1 Sh₃ then is equivalent to Th^3_4 , provided the humified material was decomposed Turfa. While painstaking efforts were made to describe all cores in a consistent and accurate manner it is possible that a degree of error is present in this aspect of the description. In spite of this difficulty the Troels-Smith scheme was found to be a practical and comprehensive means of describing sediments both in the field and laboratory. Descriptions based on the system make no assumptions concerning the type or origin of deposit (fen, fen wood, fen carr) but concentrate solely on assessing the characteristics of its composition. A description independent of genetic assumptions is thereby obtained.

3.2 POLLEN ANALYSIS

Samples for pollen analysis were obtained from cored samples following completion of stratigraphic description in the laboratory. Material for pollen analysis was taken from a central position in the cleaned core at each

level to avoid contaminated surface material. A volumetric displacement method (Bonney 1972) was used to sample identical volumes of material for absolute pollen counting purposes. Material was added to a 10ml measuring cylinder containing 5ml of distilled water until 0.5ml of water had been displaced. The water and material were then carefully washed into a beaker into which 5 standardised tablets of Lycopodium spores were added (10,000 spores \pm 200 per tablet). Preparation for pollen analysis followed the steps described in Appendix 1.

Slides were prepared using 22x40mm No. 1 $\frac{1}{2}$ coverslips. Pollen grains and spores were identified and counted using a Vickers M 15c microscope. Counting was carried out at a magnification of x400 and difficult identifications were viewed at x1000 under an oil immersion objective. Slides were counted by horizontal traverses at 1mm intervals until at least 400 Lycopodium spores or 150 tree pollen had been counted. A small number of exceptions to this counting pattern related to levels where pollen was very sparse or where tree pollen was sparse but pollen of shrubs and herbs was prolific.

Pollen and spores were identified according to the keys of Faegri and Iversen (1975) and Moore and Webb (1978) and checked against a comprehensive departmental pollen reference collection. Critical identifications were

discussed with colleagues before a firm identification was concluded. Considerable assistance in pollen identifications was also derived from Erdtman et al (1963), Erdtman (1952) and Nilsson et al (1977).

The pollen data were transferred to computer punch cards and processed by the computer programme NEWPLOT written in Fortran IV by Mr. I. Shannon, Geography Department, University of Durham. Pollen percentages and pollen concentrations were calculated on a variety of pollen sums which were plotted separately and used as working diagrams. The computer programme calculated statistical confidence intervals at a 99% confidence limit and plotted them as short vertical bars on either side of the mean value. For the purposes of general discussion and the construction of other summary diagrams the mean value has been used, with reference being made to confidence levels at critical points.

The pollen sum used in all diagrams in the thesis has been that of Total Land Pollen (TLP) including all pollen except aquatics and spores. To overcome the problem of Calluna pollen from the bog surface obscuring other percentage calculations (Faegri and Iversen 1975), a separate summary chart of TLP excluding ericoid pollen has been constructed alongside the summary TLP chart at levels where ericoid pollen became significant. The

use of absolute pollen data also assisted in making appropriate allowances for bog species in the analysis of the percentage data (ref. section 6.3). In the identification of plants and the naming of pollen types the nomenclature established by Clapham, Tutin and Warburg (1962) has been used. Corylus and Myrica pollen have been grouped as Coryloid pollen and excluded from the trees grouping. It is likely that most pollen of this type represents Corylus, and at times in the discussion it has been referred to as this taxon and discussed as a member of the woodland flora. Considerable difficulty was also experienced in separating Empetrum from Ericaceae pollen, especially in upper levels of the diagram where the frequency of tetrad pollen type was very high. At these levels most of the Ericaceae pollen (referred to as Ericoid pollen in the diagram) was clearly Calluna and this assumption is often made in the discussion. The Empetrum division was maintained but the figures should be viewed with caution.

It was decided not to apply R-value correction factors (Davis 1963, Anderson 1970) to the pollen data. It is doubtful whether the complex of factors which result in a non-proportional representation of particular taxa in the pollen rain can be reduced reliably to an R value which will apply equally in all regions (Moore and Webb 1978). Instead, the likely levels of over or under

representation have been taken into account when analysing the pollen diagrams and adjustments made in relation to the particular conditions of the site.

The pollen diagrams have been zoned largely using the concept of Pollen Assemblage Zones (PAZ's) and Sub-zones advanced by West (1970). Each PAZ is characterised by a distinct assemblage of taxa and is named after the dominant pollen taxa present. No account was taken at this stage of other regional or standard zoning sequences. Following division into local PAZ's the diagram was then correlated with Flandrian chronozones largely as determined at the nearby site of Din Moss (Hibbert and Switsur 1976). Correlation was based on careful comparison of the pollen zones at Black Lough and Din Moss. Radiocarbon dates from Din Moss were used as the major guide to the chronology of vegetation history at Black Lough.

- CHAPTER 4 -

EDLINGHAM

4.1 SITE DESCRIPTION

The mire under investigation at Edlingham is located immediately adjacent to the north-eastern boundary of Edlingham Castle on gently sloping land a short distance from Edlingham Burn (ref. figure 9, Photos 5,8). The mire measures approximately 120m x 40m and is at an elevation of approximately 83m O.D. It is located on an active spring line at the foot of hill-slopes currently under cereal cultivation. The detailed topography of the area suggests that the present river-ward extent of the mire results from lateral migration of the stream course. Abandoned meander loops can be seen at the south-western and eastern margins of the mire (photo 9). Surface drainage from the hill-slopes to the north-west is channelled directly onto the lower south-western section of the mire through a series of erosion hollows. It is likely that sheet wash from the ploughed hill-slopes also finds its way onto the mire surface. In many ways the mire acts as a sump taking drainage from the castle and surrounding slopes.

It is almost certain that the surrounding hill-slopes have been cultivated since at least Saxon times and probably much longer. Current soil phosphate tests being conducted on the hill-slopes with the object of

determining the site of the original Saxon settlement, have produced a complicated pattern of phosphate enrichment zones over the hill-slope above the mire. The meaning of this pattern is not clear but it does suggest a long history of agricultural and possibly settlement use (M.J. Alexander, personal communication). Detailed surveying of the surrounding hill-slopes has also determined the existence of ridge and furrow plough marks of probable medieval age which extend right up to the mire margins (B.K.Roberts, personal communication (photo 6)). The key to this long history of arable farming lies in a combination of the genial micro-climate of the valley, and the quality of the hill-slope soils. These soils are derived from an outcrop of the Cementstone Group and are, as a result, relatively deep, well drained and fertile loams. The boundary between the Cementstone and boulder clay soils passes immediately to the west of the castle. The area of the mire represents a mixing of boulder clay, which underlies the immediate area, and alluvial sands and gravels from the nearby stream.

The surface of the bog is itself quite variable. Four active springs produce very wet, reed-swamp conditions in the immediate vicinity of the water flow. Recent attempts to drain the mire have produced deep channels which carry the water away rather more rapidly than would be normal, such that much of the surface is at least periodically dry (photo 9). These areas are being colonised by alder and a variety of herbs and shrubs of open

habitat. Mosses are common on the wetter sections of the mire surface together with dense stands of Carex sedge. Along the banks of Edlingham Burn alder is common, and cultivated fields extend right up to the edge of the mire (photos 5,8,9)

The alignment of the railway embankment does not appear to have encroached on the mire surface. Its construction does, however, contribute another source of possible disturbance to the mire surface in recent times. The site is clearly one with both advantageous and disadvantageous qualities. It is perfectly placed to provide a record of local vegetational change since agricultural settlement in the vicinity of Edlingham. As a permanent source of running water, a local drainage sump and the target of recent drainage attempts, it must also have a high chance of stratigraphic disturbance. It was decided that the basic attraction of the site rendered a detailed stratigraphic survey worthwhile in the hope that an undisturbed coring site could be found.

4.2 STRATIGRAPHY (ref. figure 10)

A main transect was located in a central position along the length of the mire taking care to locate between parallel trench lines recently cut into the eastern end (ref. figure 9). Boreholes were placed at 10m intervals to determine the deepest part of the basin (photo 10). At this

stage it became evident that the original basin had been truncated by impenetrable sand and gravel deposits at the western end in the vicinity of boreholes ED 3-6. A pit was dug at ED 5 revealing river washed stones and gravel at 74cm similar to those currently found in Edlingham Burn. Detailed examination of the surface topography established the course of an abandoned meander loop curving through the western end of the current wet mire centred on boreholes ED 3 and 6 (photos 8,9). The position of the old river bed is evidenced by the even lowering of the surface levels between ED 3-6 (ref. figure 10). Attention was accordingly shifted to the elevated eastern portion of the main transect and boreholes were put down at 5m intervals in the region of the strongest showing of peat in the first series of boreholes. Transects were also run at right angles to the main line. It became increasingly apparent that no consistent deposit of peat existed in the mire. The variability between cores was quite extraordinary. Encouraging records of monocot. peat of up to 40cm in depth in one core would be completely absent 5 metres away in the next. Within any one core a complex intercalation of sand, silt clay, organic clay, organic silt, Detritus and Turfa in various combinations defied strenuous attempts to establish some order in the stratigraphy. After completing 27 boreholes without any change in the situation, the conclusion was inescapable that the basin

had been subject to a variable history of erosion, deposition and redeposition such that no extensive body of undisturbed peat representing a considerable and continuous period of time existed. It was also likely that the sand, silts, and clays and the more organic deposits between them had been formed fairly rapidly under the high energy conditions associated with continuous spring flow and sheet wash from the adjacent hill-slopes.

The prospect for meaningful pollen-analysis from such deposits was not encouraging. Nevertheless, the core with the greatest depth of organic deposits (ED 13) was selected for preliminary pollen study. The stratigraphy of this core is as follows:¹

0-17cm	Dark brown monocot peat. Traces of silt and sand. Th ^① ₃ Ld ^① ₁ Ag+ Ga+ Nig 3, strf 0, elas 3, sicc 2, lim 0
17-30cm	Brown organic silt Th ^② ₂ Ag1 Ld ^② ₁ Ga+ nig 3, strf 0, elas 2, sicc 2, Lim 0
30-41cm	Grey organic silt Dh1 Ld ^③ ₁ Ag2 Ga+ nig 2, strf 1, elas 1, sicc 2, lim 0
41-77cm	Brown silty clay Ag2 As1 Dh1 Ld ^④ ₄ Ga+ Dg+ Nig 1, strf 0, elas 0, sicc 2, lim 0
77-105cm	Dark brown organic gyttja Th ^⑤ ₂ Ld ^⑤ ₂ D1+ nig 3, strf 2, elas 4, sicc 2, lim 1

1. The system of sediment descriptions after Troels-Smith (1955).

- 105-110cm Smooth wet grey organic silty-clay
Ag2 As1 Dh+ Ld^④₁
nig 1, strf 0, elas 0, sicc 2, lim 1
- 110-177cm Detritus peat (earthenware chips 118-123cm)
Dh2 Ld^③₂ D1+
nig 3, strf 3, elas 3, sicc 2, lim 0
- 177-200cm Brown woody silt with black Limus streaks
Ag2 Dh1 Ld^④₁ D1++ Ga+
nig 2, strf 1, elas 0, sicc 2, lim 0
- 200-218cm Soft grey sandy silt/clay with detritus wood
Ag2 As1 Ga1 Ld^④₊ D1+
nig 1, strf 0, elas 0, sicc 2, lim 0
- 218-247cm Pink-brown silt/clay with wood detritus
Ag2 As2 D1+ Dh+ Ld^④₊ Ga+
nig 1, strf 0, elas 0, sicc 2, lim 0
- 247-312cm Firm pink-brown silt/clay
Ag3 As1 Dh+ D1+ Ld^④₊
nig 1, strf 0, elas 0, sicc 2, lim 0
- 312-350cm Orange sandy, silt/clay. Increasing gravel
with depth.
Ag2 As1 Ga1 Gg(min)+ Gg(max)+ Dh+
nig 1, strf 0, elas 0, sicc 2, lim 0

The sequence demonstrates the typical intercalation of organic and minerogenic deposits found in all cores at Edlingham. The basal deposits appear to be boulder clay which underlies the basin. Detritus wood is a common although minor component of the succeeding layers up to 110cm. High energy depositional conditions appeared to have prevailed from the base up to 177cm resulting in a sequence of sandy silt/clays with little organic content. Between 177cm and the surface a series of organic silts, detritus peat and silty clays suggest an alternating history of calm and more turbulent depositional environments. It is also possible that the stratigraphic sequence is not

a continuous one, although the generally diffuse (lim 0) boundary zones between layers does not support this. The alternative explanation is that a complex pattern of mineral and organic sedimentary micro-environments has existed over the mire surface since its formation. This type of pattern of surface deposits is found at the present day. The occurrence of what appear to be earthenware pipe fragments at 118cm in ED 13 implies a relatively recent history for the site and an accordingly rapid rate of sedimentation.

4.3 THE POLLEN DIAGRAM²

A framework pollen count at intervals of approximately 20cm was conducted on a core from borehole ED 13. It was found that pollen was too sparse to count below 180cm. The pollen data resulting from the remaining 10 levels provided a surprising degree of consistency in terms of gradations between levels. The environmental variability evident within the stratigraphy between 177cm and the surface is not reflected in the pollen diagram. This gives some confidence in making deductions on the basis of the diagram, although its use must remain essentially secondary to the Black Lough pollen diagram.

4.4 POLLEN ASSEMBLAGE ZONES (ref. figures 12, 13)

Pollen assemblage zones at this site will have an

2. All pollen percentages refer to percent total pollen excluding aquatics and spores, unless otherwise stated.

essentially local character. Being a small catchment area it will derive pollen mainly from dispersal through the trunk space and from deposition in running water washing off surrounding hill-slopes and into the mire (Tauber 1965). Two pollen assemblage zones have been defined.

ED I (180-115cm) · Alnus-Corylus-Gramineae Zone

Alnus and Corylus together represent over 50% of pollen up to 155cm, from where they decline steadily to c.20% at 115cm. Gramineae increases steadily through the zone from 21% to 42%. Limited amounts of Quercus, Ulmus, Pinus and Betula pollen, rarely exceeding 1%, suggest that none of these tree taxa had more than a minor local presence during this zone. Alnus and Corylus have very high pollen concentration values in the lower part of the zone suggesting heavy growth on the actual mire surface. This is supported by the regular detritus wood noted in the stratigraphy between 312-77cm. Fern spores reach quite high levels during this period (maximum of 22.2% at 180cm) also suggesting growth on the mire surface. Cyperaceae maintains 10-15% during the zone and Sphagnum remains at low levels throughout. The overall impression is one of a damp, base-rich minerogenic in-wash deposit, supporting a heavy growth of alder and hazel, with ferns in the understory and sedge plants in associated pools. As the alder declines quite steeply at 130cm, possibly due to increased dampness or

human activity, herbs of open habitat rise to 25%. They include Plantago lanceolata, P. coronopus, Rosaceae, Senecio-type, Matricaria-type, Taraxacum-type, Ranunculus, Umbelliferae, Polygonum, and Caryophyllaceae. No cereal pollen is recorded during the zone.

ED II (115-2cm) Gramineae Zone

The summary diagram indicates how totally herbs dominate this zone, dropping below 90% only once at 2cm. Cereal pollen is present at four levels indicating regular arable farming on the nearby fields. Plantago spp. maintain a continuous curve as do the herbs of open habitat listed in the previous zone. Grasses remain near or over 50% for the entire zone. A.P. remains at very low concentration levels, although Pinus rises steadily to 7.1% toward the top of the zone. This suggests an increasing regional Pinus pollen rain probably associated with the establishment of plantations in historic times.

The local environment during this zone is clearly largely tree-less and dominated by grasses, herbs of open habitat and agricultural crops. Many of the herbs would be actually growing on the mire margins and surface, which by the continued very low values of Sphagnum and variable Cyperaceae values, would suggest a neutral to base-rich status with acid conditions confined to the limited wetter zones. The continued in-washing of minerogenic sediments,

as recorded in the stratigraphy, would prevent the wide-scale development of acid conditions and the formation of continuous peat deposits.

4.5 SUMMARY

The consistent pollen record discussed above would lend support to the continuous nature of the stratigraphic sequence recorded at ED 13. If this is the case, the entire period of the pollen diagram relates to a post-clearance period in view of the generally low tree values recorded. It will also tend to confirm the earlier suggestion (ref. section 4.2) that the variable stratigraphy of the mire is largely the result of a great complex of variable conditions operating over the mire surface at any one time.

- CHAPTER 5 -

BLACK LOUGH

5.1 SITE DESCRIPTION (ref. figures 1, 14)

Black Lough is an area of standing water measuring approximately 300m x 130m, enclosed within the eastern margin of a large body of peat measuring approximately 500m x 400m (photo 4). The lake is rectangular in shape with noticeably angular dimensions and vertical drops of about 1.5m to the lake floor around the southern and western edges. It is most likely that the present lake results from peat cutting in relatively recent times. The peat and lake are contained within a depression in the underlying glacial drift, possibly formed by glacial deposits blocking natural drainage to the east. It is located on the interfluvium of a north-easterly trending Fell Sandstone ridge at a height of 213m (700ft.) O.D. The ridge extends prominently above the surrounding lowlands to the west and east and reaches a maximum height of 252m (825ft.) O.D. approximately one kilometre north of Black Lough. The site is clearly very exposed to the prevailing westerly and south-westerly winds, and as discussed in section 1.3, is subject to climatic extremes quite different from the protected valley bottom of Edlingham Burn approximately two kilometres to the west.

The relatively gently sloping interfluvium is generally

poorly drained compared with the steep sandstone escarpment and ridge top immediately to the west. Soils within the immediate vicinity of the basin vary according to both parent material and drainage conditions (ref. section 1.3). The superficial geology map (figure 3) indicates the close proximity to Black Lough of four different soil forming materials. The small patches of glacial sands and gravels result in lighter, better drained soils, as do the Scremerston Coal Group and Fell Sandstone Group to the west. The poorly drained areas of boulder clay are generally not suitable for arable farming but these conditions are very variable and a considerable area is currently cropped on higher slopes approximately 700m north of Black Lough. Considerable areas of the previously heather covered uplands have now been drained and planted to improved pasture, although the sandstone areas generally remain as "heathy mountains". A young pine plantation extends from the Edlingham road up the scarp and onto the western side of the current bog surface (photos 4, 7, 11).

The surface vegetation of the bog reflects the varying hydrological conditions at the site. The section east of the pine plantation and south of the lake, in which boreholes BL 12 to 15 are located, has a relatively dry surface and is very densely vegetated with Calluna vulgaris to the exclusion of most other taxa (photos 7, 11). In the wet depressions, tussocks of Eriophorum vaginatum

and Sphagnum spp. become locally dominant. Around the actual margin of the lake Scirpus, Phragmites and Carex spp. are abundant. The drier conditions in this part of the bog appear to be related to drainage ditches cut around and through the pine plantation which would have the effect of lowering the water table of this portion of the bog. There is also very limited natural catchment to the south and south-east of the lake.

The portion of bog to the north-west and west of the lake has a variable land-surface apparently the result of peat cutting. To the south-west of borehole BL 6 the bog surface is lowered by approximately 2 metres (ref. figure 15) resulting in reed-swamp conditions in the vicinity of BL 7 and a pool and tussock landscape in the surrounding cut areas (photos 12, 13). The resultant vegetation complex consists of a recurring series of mounds dominated largely by Eriophorum vaginatum, but with occasional stunted Calluna vulgaris on the drier sections, and pools with spreading Sphagnum spp. On the bog surface to the north of BL 6 a more regular 'regeneration complex' exists with small pools and damp areas favouring mosses and liverworts, and Calluna and particularly Eriophorum dominating the drier tussocks (photo 14). Around the margins of the bog a wet lagg area promotes the growth of reed and sedge species. There are no trees or tall shrubs now growing on or near the site although

the presence of tree stumps and wood in peat excavations attests to their former presence on the bog surface (photos 13, 15, 16).

5.2 STRATIGRAPHY (ref. figures 15, 16)

The presence of the lake and pine plantation dividing much of the peat deposit, prevented a complete transection of the basin. Two transects, approximately at right angles, were run along lines that provided the most complete coverage of the present open bog surface (ref. figure 14). Boreholes were placed at 50m intervals, and as noted in section 3.1, cores were either described in the field or transported to the laboratory for analysis. Following the completion of the stratigraphic survey, a further core BL 12(a) was taken immediately next to BL 12 for detailed description and provision of material for pollen analysis. Coming at the completion of a protracted period of stratigraphic survey, and having the benefit of close laboratory examination, BL 12(a) is the most reliably described core and is used as the basic reference site in describing the stratigraphy. (Section 3.1 discusses problems faced in maintaining consistent stratigraphic descriptions.)

All boreholes were continued into minerogenic sediments until further penetration without mechanical assistance became impossible. A fairly reliable indication

of the basal topography is thereby obtained. It would appear that the present peat deposit was originally divided into an upper and lower basin separated by an island or ridge in the approximate area of borehole BL 5. Further lines of boreholes would be necessary to define the detail pattern of the basins. It is likely that organic sedimentation developed independently in the two basins and gradually coalesced in the vicinity of borehole BL 5.

The surface appearance of the peat immediately west of the lake strongly indicates a recent history of peat cutting. In this area numerous Pinus stumps are exposed and it is possible that the heavy wood layer and change in character of the peat defined the lower limit of peat cutting. The peat-cut depression slopes into the present lake (photo 15). It is estimated that approximately 2 metres has been removed from the area of borehole BL 7. No other area of the present bog surface shows any similar evidence of peat-cutting. This is supported by the generally even levels of the peat surface in the vicinity of boreholes BL 1 - BL 4 and BL 8 - BL 13. A slight doming of the peat bog surface is evident at BL 2.

The greatest depths of biogenic sediments were obtained from the lower basin centred on boreholes BL 8, BL 11 and BL 12 and the basal silts and clays were also deepest here. It was decided to locate the core for

pollen analysis at BL 12 in view of the greater likelihood of surface peat disturbance at the BL 8 end of the main basin.

The stratigraphy at BL 12(a) is as follows:

- 0-26cm Dry, dark-brown, felted, crumbly monocot. peat. Well humified. Calluna roots. Traces of sand.
Th[⊙]₁ Sh₃ Ga₊
nig 3, strf 2, elas 3, sicc 3, lim 0
- 26-65cm Moist, dark-brown well humified monocot. peat, felted with some Calluna roots. Traces of sand and Sphagnum.
Th[⊙]₁ Sh₃ Ga₊ Tb₊
nig 3, strf 1, elas 1, sicc 2, lim 0
- 65-90cm Moist, slightly humified, mixed monocot./
Sphagnum peat.
Th[⊙]₁ Tb[⊙]₂ Sh₁
nig 3, strf 1, elas 2, sicc 2, lim 0
- 90-100cm Slightly humified, fibrous, Eriophorum peat.
Th[⊙]₃(E) Sh₁
nig 3, strf 0, elas 1, sicc 0, lim 1
- 100-142cm Moist, slightly humified Sphagnum peat.
Wood between 123-135cm
Tb[⊙]₃ Sh₁ D₁₊
nig 2, strf 1, elas 2, sicc 2, lim 1
- 142-358cm Well humified, moist monocot. peat with a significant trace of Sphagnum. Minor fragments of wood throughout.
Th[⊙]₁ Sh₃ Tb₊ D₁₊
nig 3, strf 2, elas 1, sicc 2, lim 1
- 358-365cm Well humified mixed Eriophorum/monocot. peat. Small fragments of wood.
Th[⊙]₁ Sh₃ Tb₊ D₁₊
nig 3, strf 0, elas 1, sicc 2, lim 1
- 365-388cm Well Humified monocot. peat with Sphagnum trace. Minor wood fragments.
Th[⊙]₁ Sh₃ Tb₊ D₁₊
nig 3, strf 2, elas 1, sicc 2, lim 1

- 388-395cm Well humified mixed Eriophorum/monocot. peat.
wood trace.
Th^⓪1 Sh3 Tb+ D1+
nig 3, strf 0, elas 1, sicc 2, lim 1
- 395-408cm Well humified monocot. peat with Sphagnum
trace. Wood trace.
Th^⓪1 Sh3 Tb+ D1+
nig 3, strf 2, elas 1, sicc 2, lim 1
- 408-465cm Mixed, well humified, Eriophorum/monocot. peat.
Wood fragments.
Th^⓪1 Sh3 Tb+ D1+
nig 2, strf 0, elas 1, sicc 2, lim 0
- 465-489cm Firm, moderately humified detritus peat, with
numerous small twigs and wood fragments
including Betula. Trace of Eriophorum and
Sphagnum.
Dh2 Ld^⓪1 Dg1 D1++ Tb+
nig 3, strf 3, elas 1, sicc 2, lim 0
- 489-500cm Firm, moderately humified, woody detritus peat
including Betula remains. Slight trace of
Sphagnum.
Dh2 D11 Ld^⓪1 Tb+ Dg+
nig 3, strf 3, elas 1, sicc 2, lim 0
- 500-523cm Firm, moderately humified, detritus peat with
twig and wood fragments including Betula.
Increasing presence of reeds below 506cm.
Dh2 Ld^⓪1 Dg1 D1++ Tb+
nig 3, strf 3, elas 1, sicc 2, lim 0
- 523-551cm Finely textured dark greasy material (prob-
ably gyttja) with reed remains and prolific
Potamogeton seeds. Traces of sand.
Ld^⓪2 Dh1 Dg1 Th+ Ga+
nig 3, strf 2, elas 0, sicc 2, lim 2
- 551-565 Moist, soft, grey silt with low organic
content. Non calcareous.
Ag3 Ld^⓪1 Ga+
nig 2, strf 0, elas 0, sicc 3, lim 3
- 565-631cm Rough brown organic sandy-silt with consid-
erable reed remains. Non calcareous.
Ag2 Ga1 Ld^⓪1 Dh++
nig 2, strf 2, elas 0, sicc 3, lim 0
- 631-659cm Firm grey-brown, slightly organic sandy-silt.
Non calcareous.
Ag2 Ga2 Dh+ Ld+
nig 2, strf 1, elas 0, sicc 3, lim 0

659-700cm Moist blue-grey sandy silt. Large fragments
of carbon (coal?) at 692cm and 700cm. Non
calcareous.
Ag2 As1 Ga1
nig 1, strf 0, elas 0, sicc 2, lim 0

The minerogenic horizons below 551cm show a generally low organic content, and the general lack of very fine clay particles and the common presence of sand suggest a high-energy depositional environment. Boreholes BL 3, 7, 10, 13, 14 and 15 also encountered gravel in association with the sand and silt fraction. These basal minerogenic layers probably represent in-wash materials derived from the surrounding largely un-vegetated boulder-clay covered hill-slopes during the Late Devensian. The development of a shallow lake and reed-swamps is indicated by the increasing Limus content and the presence of reed-like plant remains above 631cm. Sharp boundary zones at 565cm (lim 3) and 551cm (lim 2) suggest marked environmental changes at these points. At 565cm a shallow reed-swamp condition appears to change to deeper limnic conditions as the sediments become markedly finer and softer and macroscopic plant remains largely disappear. At 551cm productive conditions again reappear with a high Limus humosus (Ld^④₂) content, reed remains and prolific numbers of Potamogeton fruits. The changes in stratigraphy at this point possibly represent a progressive raising and lowering of the lake level. The cause of such a fluctuation could be related to climatic change leading to a

drop in the watertable. All of the boreholes record either a high degree of Substantia humosa or the presence of Limus at the immediate post-minerogenic level. Seven boreholes record the presence of Detritus at this level. Allowing for the difficulty of separation between Substantia Humosa and Limus in the Troels-Smith scheme (section 3.1) and the greater reliability of stratigraphic description from BL 12(a), it is likely that some form of lake or reed-swamp conditions applied at most of the borehole sites during the Late Devensian - Early Flandrian period.

The disappearance of reed remains over 506cm, and the first appearance of tree-wood fragments (including Betula) during the level 523-500cm, indicates increasingly terrestrial conditions and the development of swamp and fen-carr communities. This trend is continued in the following level with considerable amounts of detritus wood and the first record of Turfa in the form of fibrous Eriophorum and a trace of Sphagnum. The progression of the tree growth from the bog margins can be seen in the increase in basal tree wood remains moving from borehole BL 12(a) to BL 13, 14 and 16. This effect is also evident in the basal stratigraphy of the upper basin on either side of BL 2. This point represents the beginning of acid bog conditions at BL 12(a) which continue unbroken for the remainder of the core. Between 408cm

and 142cm well humified Turfa peat with clear bands of Eriophorum are recorded amongst the generally monocotyledonous remains. The degree of humification of the Turfa made estimation of the proportion of Sphagnum within the peat difficult. Examination of the material retained in the sieves after KOH treatment during pollen preparation, confirmed that Sphagnum was generally a minor, but consistent, component of peat within these levels. Only two sampling levels within this zone (352cm and 202cm) produced high concentrations of Sphagnum remains. Minor fragments of tree wood continue to appear through this section, although never in large quantities. It suggests tree growth on the bog surface, but perhaps not in the immediate vicinity of the core site. The sequence of stratigraphic changes up to 142cm is indicative of an hydroseral plant succession progressing from unproductive open water through reed swamp and fen carr to ombrogenous bog onto which tree growth extended during drier periods. A more systematic study of plant microfossils and an examination of the chemical composition of the stratigraphic layers would be necessary to determine the detailed history of the succession.

At 142cm a major change occurs in the stratigraphy. Over a relatively short distance (1m) the dark monocot. Turfa changes to a moist, fresh Sphagnum peat. A band of tree wood is encountered between 125-135cm, but otherwise

the Sphagnum continues unaltered until 100cm. No more wood occurs in the core above 125cm. This marked change of humification is of the nature of a "recurrence surface" or "Grenzhorizont" first observed by C.A. Weber. The Grenzhorizont appears to have two phases. A particularly dark, highly humified peat occurs between 170-160cm, although it was not considered sufficiently humified to be categorised as Sh⁴ since some rootlets remained. At 142cm the second change occurs. An examination of stratigraphic data from other boreholes at Black Lough does not establish a bog-wide continuation of the humification levels, although there are a number of breaks from Sh³ to Sh² or Sh¹, in upper parts of several cores. A detailed re-examination of these levels specifically in terms of establishing uniformity in humification changes may clarify the situation. However, the variable levels of the site and resultant differences in hydrological conditions between different parts of the bog, may well prevent the development of such uniform strata. Indeed, even if the Grenzhorizont extended uniformly across wide areas of the bog, it would not necessarily mean that all points were synchronous (Frenzel 1966). In spite of a number of inconsistencies in the dating of recurrence surfaces, there are numerous recurrence surfaces in Britain which have been consistently dated to around 2500 BP coinciding with climatic deterioration at the end of the

Sub-Boreal period (Godwin 1975). One of the difficulties with using the recurrence surface as a chronological indicator, is that rapidly increased peat growth may result from other than climatic causes. Turner and Kershaw (1973) consider that the initiation of rapid peat growth over a Grenzhorizont at Cranberry Bog resulted from forest clearance in the catchment area leading to increased run-off. This effect is more likely to occur with a small bog such as Cranberry Bog than with larger bogs. Nevertheless, local hydrological effects need to be carefully considered before accepting an age implication for a Grenzhorizont.

Between 90cm and the surface the Sphagnum peat first grades into a mixed Eriophorum/Monocot./Sphagnum Turfa and then, at 65cm, into a humified Monocot. Turfa with considerable Calluna remains. The top 25cm is dry, crumbly and well humified reflecting the current environmental conditions of the bog surface. At the moister sections of the bog surface the upper peats are less humified and have a higher Sphagnum content.

5.3 POLLEN ASSEMBLAGE ZONES

The pollen assemblage zones distinguished in the Black Lough 12(a) pollen diagram have been designated BL I - BL XII and are described below. It is considered that the character of the zones is essentially regional rather than local in view of the size and site of the pollen

catchment at Black Lough and the relative independence of the pollen curves from the stratigraphic history (West 1977). The BL 12(a) core site is some 150 metres from the present nearest boundary of the bog and generally over 200 metres from other parts of the boundary (ref. figure 14). In Tauber's (1965) model, a catchment area of such dimensions would have its central area subject to considerable above-canopy and rain-out components of pollen deposition, and a pollen source area extending some kilometres from the site. The stratigraphic analysis of Black Lough demonstrated that the size and character of the catchment surface has varied considerably over its history. As a large lake, its pollen catchment would have extended over a wide region. At other times, the littoral vegetation has advanced across the bog surface presumably in response to changing hydrological conditions. The presence of Pinus and Betula trunks and roots within the central area of the present bog confirms this. During such times of advance the pollen record would be dominated by local elements of the flora derived from pollen dispersal in the trunk space or directly to the ground. It is therefore not possible to be definitive with regard to the pollen source area for the whole diagram, although the stratigraphy suggests that at most times it is likely to have extended for some kilometres from the actual site.

The assumption of an essentially regional character to the pollen zones is supported by the relatively smooth nature of the curves for most pollen taxa. The aquatic taxa and Sphagnum which do fluctuate to a greater extent have been excluded from the pollen sum. It is recognised that in using a raised bog as a source of pollen, the pollen derived from the actual bog surface may obscure vegetative changes occurring in the areas around the bog. Faegri and Iversen (1975) note that: "Such diagrams are easily recognised by the excessive dominance of one pollen type and by violent changes in the curves" (p.134). Neither characteristic is particularly evident in the present diagram until the beginning of the final zone (BL XII) when Ericoid pollen (mainly Calluna) exceeds 50% of T.L.P., and at 44cm reaches a very high pollen concentration level. Gramineae pollen does not exceed 28.4% at any stage, although, with Ericoid pollen excluded from the sum, Gramineae would also exceed 50% T.L.P. above 100cm. At these levels. the vegetation has been subject to considerable clearance and it might be expected that Calluna and Gramineae have also achieved considerable regional importance.

Anderson (1970) demonstrated that clumped pollen grains, such as those from Ericoid taxa, would be carried considerably shorter distances (100-500 metres in a 2 m/sec. trunk space wind velocity) compared with single

grains (600-2000 metres). Although Calluna is a prolific bog coloniser, it also has a strong regional significance on the Fell Sandstone uplands of the region. Dimbleby (1962) has postulated an anthropogenic origin for many British heathlands and Godwin (1975) suggests an expansion of Calluna into sandy upland soils as a result of early Sub-Atlantic climatic deterioration. In view of the potential regional importance of heath species to the present study, and the likelihood of more effective transport in the open exposed uplands of the region, it was decided to include Ericoid pollen within the pollen sum. The absolute pollen concentration data and a comparison summary diagram excluding Ericoid from the sum, provide effective means of judging any domination of the percentage T.L.P. graph by pollen produced from the bog surface.

5.3.1. Descriptions of the Pollen Assemblage Zones

(ref. figure 24, 17-22)

BL I (675cm-638cm)

The recognition of this zone and its transition into BL II remains tentative in the absence of more detailed sampling. It is characterised by very low pollen concentrations and a high proportion of folded and corroded pollen grains. Pollen percentages are based on too few grains to be meaningful from the one level counted. The only tree

pollen counted was one Betula grain, which was probably B. nana in view of its small size and rounded shape (Birks 1968)

BL II (638cm-552cm) Herb-Juniper-Betula Zone

The boundary between BL I and BL 2 represents a transition to a zone with high pollen concentrations of Gramineae, Cyperaceae and herbs of open habitat such as Rumex, Artemisia, Polygonum and Plantago. The zone is dominated by herbaceous genera which reach 83.3% at 625cm, decreasing rapidly to 60.6% at the close of the zone. Shrub percentages exceed those of trees for the entire zone. Juniperus is present throughout and reaches a peak of 11.9% near the end of the zone (552cm). Empetrum reaches a peak of 3.7% at 575cm, and Salix maintains a low presence of 1-2%. Betula and Pinus are the dominant trees but remain at low concentration and percentage levels throughout, with Betula rising slowly to 15% and Pinus to 3.1% at 552cm. Two pollen grains of Betula nana were identified at 625cm. Aquatic taxa rise to 42.2% during this zone reflecting the expansion of the lake environment. Pediastrum colonies became particularly prevalent during this zone. The landscape during this period appears to have been generally open with copses of birch and possibly some local pine and scrubby clusters of juniper and willow amid the generally herbaceous communities.

BL III (552cm-502cm) Betula-Salix-Corylus Zone

The opening of this zone is marked by a sharp rise in the

pollen concentration of Betula, which continues to reach a peak at the close of the zone. The highest Betula percentage (45.5%) for the entire diagram is reached at 525cm, although the immediate sharp decline of Betula percentage after this level is entirely a function of the increasing concentration of Coryloid pollen (ref. figure 17). Pinus continues to be present at less than 5% although the pollen concentration curve indicates a gentle rise beginning at the start of the zone. Salix rises to a peak of 9.3% before declining towards the end of the zone. Juniperus pollen drops to very low levels, while pollen of Ulmus and Alnus appears for the first time. Ulmus remains at less than 1% but Coryloid pollen increases rapidly through the zone to reach 66.2% by 502cm. Pollen of herbs declines steadily from 60.6% to 4.7% through the zone. Aquatic pollen fluctuates from 4.4% to 28.5% but disappears by the close of the zone. Overall, the zone is characterised by a rapid rise to dominance of birch and hazel paralleled by an equally rapid decline of grasses and other open-habitat herbs as the tree canopy closes.

BL IV (502cm-451cm) Corylus-Betula Zone

Coryloid and Betula pollen strongly dominate this zone, together accounting for 80-90% of total pollen at each level. Both taxa generally maintain the high levels

of pollen concentration reached at the close of zone BL III with the apparent decline of Betula on the percentage diagram being a function of the percentage calculation. During this zone Pinus concentration continues to increase steadily although the effect on the percentage curve is largely obscured due to the very high values of Betula and Coryloid pollen. Similarly, Ulmus concentration reaches a high value by the close of the zone although percentage representation remains at 2.3%. The opening of the zone is marked by the appearance of Quercus pollen which remains at low values throughout. Grass pollen makes a slight recovery from the low levels reached at the close of zone BL III, and Ericoid pollen also increases to a moderate concentration peak at 451cm. Salix and Juniperus disappear at the close of the zone.

BL V (451cm-399cm) Betula-Pinus-Corylus Zone

The opening of this zone is marked by a steady rise in the percentage of Quercus and Pinus and a marked parallel decline in the concentration curves for Betula and Coryloid pollen. Quercus reaches 6.3% by the end of the zone. The combined Betula-Coryloid percentage declines steadily to 54.3% by 399cm as Quercus, Ulmus (3.4% at 399cm) and particularly Pinus increase in percentage through the zone. Pinus rises steadily to 18.2% at 425cm which it then maintains. The A.P. percentage steadily increases through

the zone to 43.2% as both Coryloid and herb pollen percentages decrease. Ericoid pollen increases slightly to 12.2%.

BL VI (399cm-364cm) Betula-Pinus-Corylus Zone

The opening of the zone is drawn at the point where Alnus frequencies become continuous. Alnus values rise slowly through the zone from 0.4% to 2.5%. The Pinus curve reaches a marked peak for the diagram of 34.3% at 387cm from where it declines to a steady level of c.15%. Ulmus values also rise at 387cm to 4.6% but then return to about 2% for the remainder of the zone. Betula decreases through the zone from 14.7% to 9.9% reflecting also a strong drop in concentration. Quercus continues its steady rise to reach a zone peak of 8.8% at 375cm. Coryloid pollen makes a strong recovery to 62.0% at 375cm coinciding with the first significant rise of Sphagnum which jumps sharply to 81.6%. Ericoid pollen remains steady at c.10%. During this zone herb pollen drops to below 1% for the first time and A.P. reaches its maximum value since BL I of 55.6%. Shrub pollen rises to 70.1% but this is largely composed of Coryloid pollen and might be seen as a part of a total tree percentage of 99.1% at 375cm.

BL VII 364cm-332cm) Pinus-Quercus-Alnus-Coryloid Zone

The opening of this zone is drawn at the point at which

Alnus values begin to rise steeply. The zone is characterised by a steadily increasing percentage of A.P. composed of taxa of the Mixed-Oak Forest reflecting a change from Boreal to Atlantic climatic conditions. Alnus pollen rises to 22.9% and Quercus to 11.8%. The first Tilia grain is recorded at 364cm. Ulmus remains at similar levels to the previous zone ranging between 1.8% and 3.5%. Betula declines to its lowest level of 5.2% since the opening of BL II. Coryloid pollen remains generally high reaching a peak of 49.0% at 340cm and declining to 39.4% at the end of the zone. Ericoid pollen declines to a low of 3.8% and Sphagnum declines to 12.0% from a peak of 53.7% early in the zone when conditions appear to have been particularly moist. While the percentage of A.P. plus Coryloid remains over 83% there is evidence of a slight opening of the canopy at 352cm. The first Plantago grain since 525cm (P. coronopus) is recorded and other herbs of open habitat show a definite rise which is maintained to the close of the zone.

BL VIII (332cm-268cm) Ulmus-Quercus-Alnus-Corylus Zone

The opening of the zone is drawn at the point where Pinus declines to very low values from which it does not recover for the remainder of the diagram. This zone is characterised by a maximum development of the Mixed-Oak Forest with A.P. reaching its maximum figure of 63.2% at 275cm.

Quercus reaches a peak of 21.0% and generally averages about 15%. Ulmus rises to a peak of 7.0% and Alnus is steady at c.20% with a peak of 33.4% at 290cm. Isolated Tilia and Fraxinus grains appear at several levels but neither taxon establishes a continuous curve. Betula rises through the zone to a general level of 10% but Pinus remains at very low levels throughout. Sphagnum reaches a very high level early in the zone but declines rapidly and remains at low levels thereafter. Ericoid pollen generally fluctuates around 10-15% and herbs of open habitat are completely absent throughout the zone. It appears to be a zone essentially of closed forest, with Gramineae and Cyperaceae pollen from the bog surface accounting for peaks of herb percentage at 275cm and 270cm.

BL IX (268cm-249cm) Quercus-Alnus-Corylus Zone

This is a zone of some upheaval in the pollen record. Its opening is defined on the first major decline in Ulmus pollen. Ulmus falls from 6.3% at the close of BL VIII to 1.2% at 266cm, which is its lowest value since its appearance in BL III. Ulmus then recovers to 5.0% but declines finally to less than 1% at 260cm. Betula also declines significantly at the opening of the zone and remains generally low thereafter. Quercus rises to a peak of 24.0% at the same level as the Ulmus recovery (264cm) but then declines through the zone to a low of 5.5% at 252cm. Closely parallel with this decline there

is a steady rise in Alnus pollen reaching a peak of 29.1% at 249cm. Coryloid pollen remains very steady at c.30% but Ericoid pollen varies widely between 8.9% and 31.3%, with its lowest levels during the period of Ulmus recovery. Sphagnum is similarly variable but with an opposite pattern of peaks and lows. Tilia establishes a discontinuous presence during the zone but remains at very low values with only one or two grains appearing at any level. Fraxinus is completely absent and Pinus remains very low. Spores of Polypodium and Filicales reach some of their highest levels. The first appearance of Plantago lanceolata and a reappearance of herbs of open habitat such as Caryophyllaceae, Rosaceae and Polygonum during the zone suggest limited opening of the canopy. This is reflected in a levelling of the curve and a period of increased fluctuation in tree/shrub/herb percentages. The close of the zone is defined on the point at which Gramineae reaches a maximum and the herb percentage begins a marked decline along with the concentration values of all tree and shrub taxa.

BL X (249cm-144cm) Alder-Corylus Zone

This zone is characterised by a very gradual downward trend in A.P. and equivalently slow rise in shrub and herb pollen percentages. Periods of disturbance to the forest and resultant increases in herb percentages become more pronounced as the zone progresses. Ericoid (mainly

Calluna) pollen gradually becomes a more important component of the pollen sum although still generally remaining under 25%. Peaks in Sphagnum generally coincide with lows in Ericoid pollen suggesting a movement of heath species onto the bog surface during drier periods. Tree pollen is mainly composed of alder and hazel both of which gradually decrease from about 25% to 20% during the zone. Quercus rarely exceeds 10% and also gradually decreases through the zone to end at 1.1%. Betula generally fluctuates between 5-15% with an upward trend reaching 26.3% at the close of the zone. Pinus and Ulmus become discontinuous through the zone and rarely reach 1%. Isolated grains of Tilia and Fraxinus appear at several levels.

The zone has been broken into three sub-zones on the basis of changes in the A.P./Herb pollen ratio reflected most clearly in the summary diagrams and indicating periods of limited opening of the forest canopy.

Sub-zone BL X(a) (249cm-184cm) Minor Temporary Forest Openings

The early part of this period is one of relative forest recovery and stability following the disturbance of BL IX. A.P. recovers to a maximum of 53.2% at 230cm and herb pollen declines to levels of around 2% from 6.9% at the start of the sub-zone. There is evidence of a limited opening of the canopy at 230cm, 202cm and 193cm with the appearance of grains of Plantago lanceolata, P. coronopus,

Chenopodiaceae and Fraxinus although most of the rise in herb pollen is composed of Cyperaceae presumably from the bog surface. Following these levels A.P. rises to a final maximum for the zone of 58.6% while at this same level herb pollen completely disappears.

Sub-zone BL X(b) (184cm-170cm) Forest Opening

The pollen spectrum during this period suggests a more significant opening of the forest canopy. A.P. drops to a zone low of 31.6% and herb pollen reaches 20.4% of which 8% is composed of Cyperaceae. At 175cm Plantago lanceolata reaches its highest level of 1.8% when there is also a Gramineae value of 6.5%, and various open habitat herbs such as Matricaria type, Ranunculus, Rosaceae, Saxifragaceae, Polygonum and Urtica are found. Quercus levels drop to a low of 3.7% during this period and Corylus and Betula also show some decline.

Sub-zone BL X(c) (170cm-144cm) Continuous Minor Forest Openings

Following the more significant opening of BL X(b), some forest recovery occurs during this zone, although there is a continuing minor presence of taxa indicating open conditions. Gramineae levels are maintained at a more continuously higher level than prior to BL X(b) and Plantago species are continuously represented at low levels. During this sub-zone A.P. remains fairly constant at c.35% and herb pollen at c.10%. It is noticeable that Ericoid pollen rises to over 25% at the start of the

sub-zone and remains relatively steady at about that level for the remainder of the zone. Sphagnum levels during this period are generally low, suggesting a drier bog surface.

BL XI (144cm-48cm) Betula-Corylus Zone

This zone is characterised by increasing fluctuations in the percentages of A.P. and herb pollen as openings in the forest become pronounced. A.P. exceeds 50% at only one level and declines to 19.1% at the end of the zone. Betula rises to a general level of 25% but declines to less than 10% at the close of the zone. Coryloid pollen follows a parallel pattern with similar percentages. Other tree pollen taxa remain at generally low values, with only alder occasionally rising over 10%. Fraxinus develops a largely continuous curve with values under 5% until it disappears at the close of the zone. Ericoid pollen varies widely, and for the first time rises briefly to over 50% of the total pollen. The inverse relationship with Sphagnum values is maintained suggesting a continued concentration of heath species on the bog surface. Plantago species, grasses, other herbs of open habitat and Pteridium all become regular components of the pollen rain although only rising briefly to high values.

The zone is divided into three sub-zones on the basis of the degree of opening of the vegetation as

indicated by the presence of open habitat taxa and fluctuations in the A.P./herb pollen curves.

Sub-zone BL XI(a) (144cm-106cm) Increasing Forest Disturbance

The sub-zone opens with a marked peak in Ericoid pollen rising to 53% and gradually decreasing to 11% at 106cm. Sphagnum concentration is low for the entire sub-zone. Grasses, Plantago and other open habitat taxa gradually increase without rising to strong peaks. This is reflected in a gradually increasing herb pollen curve. The one major rise in herb pollen at 125cm is largely a reflection of higher Cyperaceae and Gramineae values probably derived from the surface of the bog. A marked and brief regeneration of forest occurs at 114cm when Quercus exceeds 10% for the only time in the zone to reach 24.3%, Tilia appears and there are slight rises in Betula and Ulmus. A.P. at this level reaches a maximum for the zone of 57.4%.

Sub-zone BL XI(b) (106cm-89cm) Forest Clearance

The summary pollen curves indicate a marked rise in herb pollen and equivalent reduction in A.P. during this sub-zone. A.P. drops to its lowest value (13.7%) since BL II and herb pollen rises to 45.1%. Sphagnum appears to rise to very high values, but the concentration data suggests a more limited rise. Pollen of Betula, Quercus, Alnus and Corylus drop to very low values, while at the same time there are peaks in Plantago lanceolata (7.8%),

Gramineae (28.4%) and Pteridium (13.7%). At the close of this sub-zone the first cereal-type pollen is recorded confirming the clearance character of the sub-zone. Earlier in the sub-zone relatively high values of Rumex and Rosaceae pollen occur. Ericoid pollen remains low at 15-20%.

Sub-zone BL XI(c) (89cm-48cm) Forest Recovery

The heavy clearance pressure of the previous sub-zone appears to be relieved at this point resulting in a progressive increase in A.P. and equivalent decline in herb pollen to a minimum value of 1.4% at 62cm. Alnus, Quercus, Betula and Corylus recover to their pre-clearance values of the previous sub-zone. At 62cm a gradual increase in Gramineae and Plantago begins and all tree taxa start to decline towards the close of the sub-zone. Ericoid pollen now rises again to c.50% as Sphagnum drops to generally very low levels. No further cereal-type pollen grains occur during this sub-zone.

BL XII (48cm-2cm) Gramineae-Calluna Zone

A sudden decline in all tree taxa (including Corylus) to values of about 1% or less marks the opening of this zone. At the same time there is a steady rise in Ericoid pollen (mainly Calluna) and a more variable rise in Gramineae pollen. Cereal-type pollen becomes more regular in appearance and Plantago and other open-habitat herbs are maintained at low but regular frequencies.

Three sub-zones are identified based on the degree of disturbance to the vegetation.

Sub-zone BL XII(a). (48cm-36cm) Heavy Clearance

This sub-zone is characterised by a reduction in A.P. to a virtual total clearance value of 3% and a rise in herb pollen to 41.1% (or with Ericoid pollen excluded to 86.8%). At one level during this sub-zone (44cm) Ericoid pollen rises to 80.1% indicating a dominance of Calluna probably extending beyond the bog surface. Cereal-type pollen establishes a continuous curve for the first time and Plantago and Gramineae pollen rise to maximum values of 4.6% (40cm) and 27.4% (36cm) respectively. Other open habitat herbs appearing during the sub-zone include Artemisia, Senecio-type, Matricaria-type, Chenopodiaceae, Umbelliferae, Polygonum, Rumex and Urtica.

Sub-zone BL XII(b) (36cm-12cm) Limited Regeneration

The opening of this sub-zone is marked by a disappearance of cereal-type pollen, a general reduction of Gramineae and Plantago, and a marked rise in the pollen of Betula, Alnus and Corylus. Pinus, Ulmus and Quercus remain at very low values. With Calluna now maintaining over 50%, a clearer picture of tree/herb relationships is obtained from the Ericoid-excluded summary diagram. On this basis, A.P. recovers to 34.9% and herb pollen declines to 26.2%. Various herb taxa associated with arable or open habitat conditions continue to appear during the

zone, including a single grain of Cannabis pollen. The general recovery of A.P. is disrupted at 20cm with a strong peak of Gramineae (27.4%) associated with Polygonum, Filipendula, Plantago lanceolata, Umbelliferae and Rumex. Towards the close of the sub-zone cereal-type pollen reappears and herb pollen again rapidly increases.

Sub-zone BL XII(c) (12cm-2cm) Heavy Clearance

The reappearance of cereal-type pollen coinciding with high Gramineae and low tree pollen marks the beginning of another period of virtual total clearance. Sphagnum drops to less than 1% during this sub-zone and Calluna totally dominates the pollen spectrum rising to a maximum value at 2cm of 88.6%. The major open habitat herbs appearing are Plantago lanceolata, P. coronopus, Senecio-type, Matricaria-type and Umbelliferae.

Towards the top of the sub-zone there is a slight rise in pollen concentration of Pinus and Ulmus although this is barely discernible in the diagrams. Both summary diagrams suggest a levelling off at a relatively high level of clearance towards the close of the period represented in the diagram.

5.4 POLLEN ASSEMBLAGE ZONES AND BOG HISTORY

As noted earlier, the pollen curves are relatively independent of the stratigraphic history. At two points, however, there is an apparent correlation between significant changes in the stratigraphy and P.A.Z. boundaries.

It is considered that because of the Black Lough catchment, these correlations most probably reflect overriding environmental changes taking place at the time. The two areas of correlation are discussed below in relation to borehole records from BL 12(a).

5.4.1 Minerogenic/Biogenic Transition (700cm-500cm)

The wide sampling interval at this point in the BL 12(a) pollen diagram prevents a very close correlation, however, the general relationship is clear. An additional diagram is presented (ref. figure 23) from a core taken approximately 50m north of BL 10 (BL 10(a)). This core was taken specifically to examine the nature of the minerogenic-organogenic transition at Black Lough. A 10cm counting interval centred around the boundary zone in BL 10(a) displays a remarkably similar series of pollen curves to those at BL 12(a). It also confirms the wide extent of limnic conditions during the early history of Black Lough. The BL II/BL III boundary coincides remarkably closely with the sharp lithological boundary at 474cm in BL 10(a) and 551cm in BL 12(a). (The P.A.Z's were established quite independently of the stratigraphic data (ref. section 3.2)). At this particular point in both diagrams, aquatic species drop to very low values presumably due to a temporary drop in lake level. The disappearance of major quantities of sand a little above

this level and the appearance of clay, coincides in both diagrams with the first rise in Betula and Corylus. It would appear that as the basin surrounds became more vegetated the intensity of run-off decreased, resulting in the transition from sands and silts to clay. A rise in Sphagnum and fern spores above 474cm and 551cm, respectively, attests to the onset of more terrestrial conditions on the bog margins. The peak of Betula during BL III in BL 12(a) combined with higher detritus wood, Limus and prolific Potamogeton fruits, suggests the onset of rich fen-carr conditions and the expansion of Betula onto the bog surface. Aquatic taxa finally disappear at 500cm in BL 12(a), possibly the combined result of hydroseral succession and decreased run-off. The period of time represented in this segment of the BL 12(a) diagram appears to reflect the environmental changes associated with amelioration of climate in early post-glacial times. The changes in lithology relate closely with the pollen record since they both reflect the change from a thinly vegetated, herb dominated landscape to one increasingly dominated by trees and shrubs, with an associated reduction in minerogenic sedimentation.

5.4.2 Grenzhorizont/BL X-XI

The Grenzhorizont character to peat deposits at 142cm has already been noted (ref. section 5.2). The almost

exact correlation of P.A.Z. boundary BL X-XI with this stratigraphic marker is of considerable interest. An initial sharp rise followed by a continuous decline of Coryloid pollen, together with a slight rise in Quercus and slight decline in Corylus, Alnus and Betula, coincide with the layer of fresh Sphagnum peat between 142cm and 100cm. Intruding over purely climatic effects within this zone are the increasing effects of human clearance. It is therefore not possible to interpret changes in pollen curves purely in terms of climatic deterioration. However, the progressive decline in Calluna, together with rises in Sphagnum, Cyperaceae and Gramineae indicate a moister bog surface possibly associated with a cooler, wetter climate.

5.5. CORRELATION WITH FLANDRIAN CHRONOZONES (ref. figure 31)

The pollen assemblage zones at Black Lough and Flandrian chronozones at Din Moss (ref. figure 1) (Hibbert and Switsur 1976) show a close similarity. Din Moss is located on a flat plateau at a height of 170m (555 ft) O.D. approximately 40km north-west of Black Lough. It is the closest site to Black Lough at which the biozone boundaries have been dated and related to existing Flandrian chronozones. In dating the P.A.Z. boundaries from three sites in Britain and comparing the results with similar dated levels from Red Moss (Hibbert et al

1971) and Scaleby Moss (Godwin et al 1957), Hibbert and Switsur (1976) conclude that the corresponding zones exhibit a broad synchronicity at the five sites. This is a similar finding to that of Smith and Pilcher (1973) for sites that are approximately at the same height above sea-level. On the basis of the above evidence, radiocarbon dates from Din Moss have been related to equivalent levels on the Black Lough diagram and are used to provide a general chronology for the vegetation history at the site. In discussing the sites, exact equivalents for percentage values cannot be compared since Din Moss is based on a pollen sum of trees plus group and Black Lough on T.L.P., nevertheless, the general relationships remain clear.

5.5.1 Late Devensian/Flandrian I a (BL I/II)

At Din Moss there would appear to have been continuous biogenic deposition throughout the Late Devensian while at Black Lough this period is represented by organic silts and clays with sparse pollen. It would appear that at Black Lough minerogenic sediments were washed from a largely unvegetated landscape into the basin and sedimentation rates were rapid.

A Late Devensian diagram from the vicinity of Bamburg (ref. figure 1) (Bartley 1966), approximately 30km north-east of Black Lough, demonstrates a similar

landscape pattern. The diagram from Longlee Moor shows very open herbaceous vegetation in which A.P. does not exceed 10% and Juniper remains at less than 15% extending through the Late Devensian well into the early stages of Flandrian I a. The eventual formation of closed woodland is delayed until late in Flandrian I a. The sediments reflect the open conditions with high proportions of mineral inwash.

While the lower part of the Black Lough diagram has not been studied in detail, it would appear that the Flandrian opens at the point where the pollen of open-habitat herbs reduces to less than 25%, Juniperus pollen starts to rise and tree pollen begins a steady rise. This is approximately equated with the opening of BL II although the sampling interval is too large at this point to be specific. At least the upper part of BL II would appear to equate with Flandrian I a. BL I and perhaps the lower part of BL II therefore encompass much of the Late Devensian although it is impossible to be more specific without closer sampling.

5.5.2 Flandrian I b (BL III)

This zone is directly equivalent to BL III. Its opening is marked by the first appearance of Corylus pollen which remains at continuous but low levels throughout the zone. Betula rises to a peak value and N.A.P. reaches

low values by the end of the zone that are generally maintained for the remainder of Flandrian I and II. Juniperus pollen becomes discontinuous during the zone and Salix rises to a maximum value and declines towards the close of the zone. Pinus pollen is present at low percentage.

The high Betula values during Flandrian I b are common to a number of sites in north-east England as listed below:

Thorpe Bulmer	60-80% T.L.P. (Bartley <u>et al</u> 1976)
Din Moss	75-80% A.P.
Linton Loch	50-70% T.L.P.
Black Lough	45.5% T.L.P. (max. value)

The Linton Loch percentages are supported by a uniformly high pollen concentration curve maintained up to the close of Flandrian I. The Black Lough pollen concentration data also indicates high values continuing beyond Flandrian I b until the opening of Flandrian I d (BL V).

5.5.3 Flandrian I c (BL IV)

BL IV is equated with this zone. The opening is marked by the rational limit of Corylus and empirical limit of Quercus. Corylus pollen rises rapidly to maximum values through the zone and Betula decreases from its maximum value of the previous zones but still maintains approximately 25% at Black Lough and 40% at Din Moss. Salix

continues at very low percentage, slowly increasing to the close of the zone. Pinus retains a low but continuous record. Ulmus pollen appears for the first time at Din Moss while at Black Lough it appeared earlier during the previous zone.

5.5.4 Flandrian I d (BL V)

BL V is equated with this zone. It is marked at both sites by the expansion of Quercus, and at Black Lough by a large rise in Pinus pollen. Hibbert and Switsur (1976) note the consistently low values of Pinus at Din Moss which differed from Nant Ffrancon and Tregaron where a rise in Pinus similar to that at Black Lough is found. Ulmus increases to 10% at Din Moss but at Black Lough it remains under 4%. Ulmus never reaches consistently high values in the Black Lough diagram reflecting its limited distribution on the boulder clay covered Fell Sandstone of the ridge top. Corylus remains at high but decreasing values while Betula continues its steady decline.

Pinus percentages generally in north-east England during Flandrian I vary widely between sites only a short distance apart. For example, Din Moss, Linton Loch and Trickle Wood record uniformly low Pinus percentages of less than 10% A.P. for Flandrian I, whereas Akeld Basin nearby has pine values extending up to 75% A.P. A number of other highland sites in the region

(Broadgate Fell (Blackburn 1953), Coom Rigg and Muckle Moss) have recorded consistently high pine values of 20-40% during Flandrian I. The explanation for the variation most probably lies in particular site factors such as the efficiency of local soil drainage (Bartley et al 1976). Turner (personal communication), however, has found that Pinus does not show a statistical relationship with any soil or altitude groups in early post-glacial forests in the northern Pennines, although possibly at sites with lower precipitation Pinus becomes more sensitive to conditions of soil drainage. Pennington (1970) also found that Pinus percentages were very variable in north-west England and concluded that edaphic rather than climatic factors were responsible. The low nutrient sandy soils associated with the Fell Sandstone ridge at Black Lough would provide such an edaphic factor favouring the growth of pine.

5.5.5. Flandrian I e (BL VI)

This zone has been set up at Din Moss on the basis of the marked differences between the empirical and rational limits for Alnus. It is a feature absent from Scaleby Moss, Nant Ffrancon, Tregaron and Red Moss. The Linton Loch diagram also shows no sign of this feature although a zone equivalent to Flandrian I e has been recognised. BL VI demonstrates an Alnus curve almost identical to

that at Din Moss and it also coincides with a secondary peak in Corylus towards the Flandrian I/II boundary. Pinus reaches a maximum value during this zone at Black Lough. At both sites other tree taxa remain stable although Betula continues to slowly decline. Ericoid pollen begins its first noticeable rise during this zone at both Din Moss and Black Lough.

5.5.6 Flandrian II (BL VII, BL VIII, part of BL IX)

The opening of Flandrian II is universally marked by the rational limit of Alnus which at Black Lough coincides with the opening of BL VII. The pattern of vegetation changes following the expansion of Alnus at Black Lough, however, necessitates the recognition of a further zone, BL VIII during Flandrian II. The opening of this zone is based on the point where Pinus declines suddenly to very low values and Alnus reaches consistently high values. This point at Nant Ffrancon and Tregaron coincides with the Flandrian I/II boundary, but at Black Lough the decline of Pinus and rise of Alnus are much more prolonged possibly reflecting edaphic conditions. During this period Quercus rises steadily, Betula reaches low values and ericoid pollen also declines. During BL VIII, Quercus, Ulmus and Alnus reach maximum values and N.A.P. declines to generally less than 2%. Tilia and Fraxinus occur only sporadically as isolated grains. This pattern is very similar to that of the Flandrian II at Din Moss.

5.5.7. Flandrian III (part of BL IX, BL X, BL XI, BL XII)

The decline of Ulmus is clearly defined at Black Lough, Din Moss and all other sites referred to. It has been shown to be broadly synchronous at the five sites discussed by Hibbert and Switsur (1976), and other sites in the region indicate a marked synchronicity at 5300-5400 years b.p. (ref. section 7.1). The opening of Flandrian III is therefore clearly defined and at Black Lough is found at 260cm, approximately mid-way through P.A.Z. BL IX. The significance of BL IX in relation to the elm decline is discussed in section 6.2. The Flandrian III is notable for the increasing impact of man which precludes the recognition of consistently equivalent vegetation zones across wide areas. The zones BL IX to BL XII result largely from the effects of variable human impact, and in the following chapters (6 and 7) are discussed in terms of their possible relationship with movements of cultural groups and historical events.

5.5.8 Conclusion

The similarity between the vegetation records at Black Lough and Din Moss is striking. The only major difference is found in the behaviour of Pinus which has been shown to be extremely variable at different sites in northern England. Apart from this, the match is particularly close suggesting a parallel development of

vegetation during the Flandrian. It is therefore with some confidence that the radiocarbon dates from Din Moss are transferred to the equivalent levels at Black Lough as the basis of a chronology of vegetational history at Black Lough.

- CHAPTER 6 -

THE HISTORY OF FOREST CLEARANCE AT BLACK LOUGH
AND EDLINGHAM

The evidence for human impact on the vegetation at Black Lough is considered within the framework of four principal periods during which the vegetation becomes more open in character. These periods are contained both within and across P.A.Z's previously discussed. Sections of the overall pollen diagram (ref. figure 24) have been extracted and enlarged to illustrate key or characteristic elements of the four clearance phases. The four major clearance phases are: (ref. figure 31)

- 6.1 Flandrian I/II transition
- 6.2 Flandrian II/III transition
- 6.3 Pre-cereal clearance
- 6.4 Post-cereal clearance

6.1 FLANDRIAN I/II TRANSITION - LATER MESOLITHIC
CLEARANCE (ref. figure 25)

P.A.Z's BL VI, VII and VIII are notable for the extremely low values of herb taxa recorded. During the period of these zones temperate deciduous woodlands reach their maximum development. A pollen catchment the size of Black Lough would intensify the dominance of regional tree and shrub pollen in the pollen record during a period of general woodland dominance. It is likely

that dry-land herb pollen is under-represented since it would derive from smaller patches of more open character probably separated from the bog surface by peripheral tree and shrub zones which would have a filtering effect on the pollen rain. The minor appearances of dry-land herb taxa during the Flandrian I/II transition may therefore have greater significance than their low numbers suggest.

During BL V (mid Flandrian I) no Pteridium spores and only isolated pollen grains of open-habitat taxa are recorded. During this period the A.P. percentage steadily increases and Gramineae maintains a low but continuous presence. At 399cm an increase in open-habitat herbs (Rumex, Rosaceae, Saxifragaceae, and Polygonum) coincides with the first peak in the Calluna curve, although there is no discernible effect on A.P. which continues to increase in percentage. Betula concentration begins a steady decline at this point suggesting the possibility of a link with the increased values of open-habitat herbs, especially since the highest value of macroscopic charcoal in Flandrian I was recorded at the previous level. After 399cm herbaceous pollen again contracts and no further dry-land herb pollen is recorded until 352cm.

Between 352cm and 318cm a number of changes occur in the pollen record which suggest some disruption to the local forest cover (ref. figure 25). One of the most

significant of these is the first appearance at 352cm of a Plantago species (P. coronopus) since the open conditions of the Late Devensian and early Flandrian.

Hedera is also recorded at this level. Between 352cm and 332cm pollen of Rosaceae, Ranunculus, Artemisia, Mercurialis, Fraxinus and Salix suggest the existence of open habitat and light woodland conditions nearby. Pteridium rises from 364cm to reach a peak of 14.3% at 325cm, and fern spores show a marked rise at 352cm and increase to a peak at 318cm. Macroscopic charcoal is generally present at medium to high levels up to 332cm.

A.P. values show a slight down-turn at 340cm but this is partially explained by a temporary sharp rise in Coryloid pollen affecting the percentage calculation. Except for Pinus, no other tree taxa decline in pollen concentration at this level. At 325cm, however, coinciding with the sharp Pteridium peak, all tree taxa decline markedly in concentration although this is not reflected uniformly in percentage values. Pinus suffers a dramatic decline in both concentration and percentage, dropping from 17.3% at 346cm to 0.4% at 325cm from which it never recovers.

Discussion:

The pollen records described above indicate that some form of forest recession, probably involving fire, occurred near Black Lough at the Flandrian I/II transition.

Mesolithic communities undoubtedly frequented the area as evidenced by the microlithic remains excavated from Corby's Crags only 1km to the north-west on the same ridge line (ref. section 2.2). The marked decline of Pinus, which probably represents the complete disappearance of the genus from the immediate region, is one of the most dramatic changes in pollen frequency recorded in the entire diagram. The potential destructive capability of Mesolithic groups through the use of fire (Simmons 1969, 1975 a, b, Mellars 1976), and the transept axe (Smith 1970) has been strongly argued. Simmons (1975 b) points out that the "hyper-forest zone" of upland areas (bog margins and scrub) would provide excellent browse conditions for red and roe deer. Regular burning increases the quality of browse and brings it to the reach of smaller herbivorous animals. Intentional burning of scrub and bog-side zones by Mesolithic man to attract game would open the forest and lead to the growth of heath plants and various open-habitat herbs. The upland areas would be attractive to the Mesolithic hunter as a summer hunting zone because of the more open and variable vegetation leading to a greater variety of animal habitats.

Whether the activities of Mesolithic groups could lead to the wide-scale recession of forest remains uncertain. Smith (1970) quotes from an account by De la Pryme (1701) where he records the excavation of

a large body of fossil trees in which pines in particular had been heavily burnt and split with axes. Smith also notes other sites where charred pine, birch and hazel wood has been found in association with Mesolithic settlement on the Boreal/Atlantic transition. Simmons (1964) identifies in his Blacklane diagram a forest recession at the Boreal/Atlantic transition in which Pteridium rises to a sudden peak, and open-habitat herbs including Plantago lanceolata, Artemisia and Rosaceae appear. He also notes the early presence of Fraxinus and the beginning of a rise in Alnus coincident with the recession level. An anthropogenic explanation is tentatively proposed for the vegetative changes observed.

The Mesolithic clearance evidence described at Black Lough is very similar to the events Simmons describes at Blacklane, although the levelling off in alder at Black Lough is shown to be a temporary marked decline in concentration. The decline of Pinus is also lacking at Blacklane. It would seem very likely that at Black Lough a regular burning and perhaps limited felling of the more open pine/birch/hazel woodland of the bog margins and uplands during the summer months to encourage game led to a local Calluna-Pteridium heath developing in the vicinity of the Lough. Alder, birch, hazel and pine suffered marked reductions in pollen production as a result, while oak and elm, growing in patches of more closed forest, were less affected and their relative

abundance actually increased. With the reduction of firing, alder, hazel and birch made a rapid recovery but pine, already weakened, succumbed to autogenic changes already in progress. With the increasing warmth and wetness of the Atlantic, alder was able to colonize those areas previously occupied by pine, and together with hazel, shaded out birch from all but the more broken or precipitous sandstone sites. The possibility that Mesolithic activity led to the complete demise of Pinus also cannot be dismissed.

Following the clearance episode discussed above, Pteridium and the open-habitat herbs disappear for a number of levels and the woodland taxa become dominant. Ericoid pollen, however, does not return to its previously low levels of the mid-Flandrian I but maintains a fluctuating value of about 15% up to the Flandrian II/III boundary. It would appear then, that the early beginnings of Calluna heath at Black Lough may be found at the Flandrian I/II transition related possibly to the firing of vegetation by Mesolithic man and the development of acid bog conditions. Dimbleby (1962) has persuasively argued that the disappearance of the pine/birch forest and the initiation of heath and bog development is closely linked with Mesolithic human activity and in particular the use of fire. The evidence contained in the Black Lough diagram tends to support that hypothesis although more detailed sampling is needed to establish

the relationship clearly.

Smith (1970) refers to the significance of a secondary Corylus maximum at the Boreal/Atlantic transition and suggests its possible relationship to human activity. The secondary Corylus maximum is clearly demonstrated at 375cm (immediately preceding the F I/II boundary) in both the concentration and relative diagrams from Black Lough (ref. figures 17, 20). At the nine sites considered by Smith, only two show evidence of an opening of the forest by human activity and at these it is considered that the rise of Corylus is probably due to human activity. At the other sites, as at Black Lough, the particular level at which the Corylus reaches a peak is almost devoid of herb pollen. However, Black Lough does indicate an opening of the canopy immediately below (399cm) and above (364cm-318cm) the Corylus peak, and as opposed to Smith's non-human activity sites, Calluna, and to a lesser extent Pteridium, have already risen to moderate levels which are maintained through the Flandrian I/II transition. The macroscopic charcoal level is also high at 375cm even though no open-habitat herbs are recorded. A change in vegetation through human activity is thus a possibility.

An alternative explanation involves a time lag in the autogenic transition in which Corylus initially replaces Pinus from increasingly damp sites and in turn is replaced by Alnus as the water-table continues to rise (Smith 1970). At Black Lough

this explanation appears unlikely in view of the continuation of high Pinus values beyond the time of both the secondary Corylus rise and the initial sharp rise of Alnus. The completion of the decline of Pinus does coincide exactly with the completion of the rise of Alnus, suggesting that whether the cause was human or autogenic or a combination of both, Alnus did largely take over the sites vacated by Pinus although as Smith (1965) notes the actual spatial readjustments of the tree species was probably extremely complex. The presence of fossil Pinus roots within the Black Lough stratigraphy does suggest this type of process was operating. Indeed, the high Pinus values at 387cm declining so completely to 0.4% at 325cm suggests a high source of Pinus pollen in the immediate area which by combined human and environmental pressure is rapidly eliminated. It is difficult to imagine climatic change alone acting with sufficient magnitude or rapidity to cause such a rapid and complete decline. When linked with human-induced burning or felling, however, such a change would be quite possible. The secondary rise of Corylus preceding the fall of Pinus and rise of Alnus, seems best explained by postulating an opening of the canopy resulting from the activities of Mesolithic hunting groups resulting in an expansion of local Corylus communities. Such an explanation would account for the less than universal occurrence of a secondary Corylus maximum

around the time of the Flandrian I/II transition.

A comparison with other diagrams in the region confirms the variable occurrence of the secondary Corylus rise and associated changes in Pinus and Alnus (ref. figures 1, 30). Three of the seven sites, viz Muckle Moss, Coom Rigg and Bishop Middleham (Bartley et al 1976), demonstrate a marked Corylus peak and those same sites also record a very close correlation between the Corylus peak, the swift rise of alder and an equally swift decline of pine. While the changes in the pollen curves from these sites demonstrate a similar scale of changes to those at Black Lough, none resemble the much later sudden decline of pine after the rise of alder. Since no indications of human activity are recorded from the sites at this time it would seem that autogenic processes are the most likely cause of the change in vegetation. The only diagrams which resemble the late decline of pine at Black Lough are those from the high fells of the northern Pennines at Valley Bog and on Widdybank Fell (Turner et al 1973), where the final Pinus decline is delayed as late as the Flandrian II/III boundary, presumably due to the competitive advantage derived from the cooler, wetter climate of the high fells and the existence of areas of limestone bedrock. Once again, no indications of human activity are identified from this point in the diagrams. There would not appear

to be a general pattern of human impact emerging from this point in pollen diagrams in north-east England. However, the possibility of such influence, which has been observed at Black Lough, may depend on studies specifically designed to isolate the low level of indicator species and charcoal content generally associated with Mesolithic clearance.

6.2 FLANDRIAN II/III TRANSITION - THE DECLINE OF ELM (ref. figure 26)

After the brief episode of Mesolithic clearance recorded at the F I/II transition, there are no further records of specifically open-habitat taxa appearing during Flandrian II apart from very low values of Gramineae pollen probably derived from the bog surface, and variable (5-15%) frequencies of Ericoid and Pteridium. The only apparent variation to a domination of the pollen record by woodland taxa comes at 275cm when the herb pollen curve rises to 10% (ref. figure 26). This, however, is probably a reflection of a wetter bog surface and more rapid peat growth since Sphagnum and Cyperaceae values also rise, and concentration values for all other taxa decrease. It is noticeable, however, that charcoal values are consistently high during mid-Flandrian II levels and although open-habitat herbs are not recorded, there are consistent appearances of Salix and Fraxinus

(and heath and grass species noted above). This suggests more open woodland conditions and implies a continuing low intensity impact of later Mesolithic cultures maintaining areas of heath and open woodland. The first open-habitat herbaceous pollen since the Mesolithic clearance at 332cm, occurs at 268cm and marks the opening of a period of renewed clearance and considerable upheaval in the pollen record. This period corresponds with P.A.Z. BL IX during which elm declines to very low levels and other tree, shrub and herb taxa demonstrate considerable instability. The period has been divided into three phases to facilitate description.

6.2.1. Phase A (268cm-266cm): Initial Elm Decline

The clearest indication of the upheaval in the pollen record initiated at the opening of Phase A is seen in the tree/shrub/herb summary diagram. The previously even tree curve suddenly declines coinciding with a sharp rise in shrub pollen (mainly Calluna) which reaches a maximum value of 58.2% at 266cm. Gramineae, Pteridium and particularly Filicales rise from very low values and the first open-habitat herb (Polygonum) appears. This genus is of particular interest, since it is often associated with farming as a weed of disturbed sites such as roughly cleared land or ploughed fields. Iversen (1973) regards a frequent occurrence of pollen of Polygonum

as an indicator of agriculture. The sole record of Polygonum at this level may not be significant, but in view of the nature of the site (ref. section 5.1) and the naturally poor pollen dispersal of Polygonum, it may be of some importance.

The tree and shrub taxa during this phase demonstrate considerable contrasts. Elm appears to decline suddenly on the relative diagram from 6.3% at 268cm to 1.2% at 266cm but the concentration curve indicates a more gradual and less severe decline beginning at 272cm. Oak increases both absolutely and relatively while alder and birch increase in concentration but decline relatively. This relative decline is due to large rises in the proportion of Coryloid and Ericoid pollen between 268cm and 266cm. The most meaningful picture of vegetation changes during this phase is derived from the absolute pollen curves which indicate the following pattern of changes. Elm continues a slow decline to 266cm but to a level only a little lower than the average for Flandrian II. Oak, alder, birch and hazel begin a marked increase after generally declining values towards the close of Flandrian II. Heath species (Calluna and Pteridium) continue an expansion already in progress by the beginning of the phase. In summary, it would appear that the lowest point for tree pollen except elm occurs just prior to phase A between 270cm

and 268cm, from which point heath species, grasses, open-habitat herbs and most trees begin a strong recovery continuing into phase B. Elm continues to decline until 266cm.

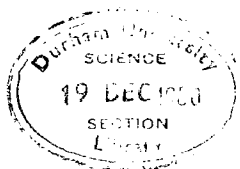
6.2.2. Phase B (266cm-260cm): Temporary Forest Recovery

The forest continues to recover until 264cm when both oak and elm concentration and relative values return to their mid-Flandrian II levels, hazel levels off and Calluna, Pteridium and Gramineae return to low values.

At 262cm a new character is evident in the pollen record. Alder, birch and Coryloid pollen concentration rise to levels not exceeded again in the diagram and oak and elm also continue a less dramatic rise. Pteridium, Filicales and Ericoid values also reach high levels. The explanation for such a universal rise in pollen concentration might be sought in a particularly favourable period of climatic conditions. Increased dampness of the bog surface may have led to greater Sphagnum growth and the development of local alder/birch carr communities. Higher temperatures and humidity may also result in increased oak and elm pollen production, and a large increase in Corylus pollen. A more probable explanation, however, appears to lie in an increased rate of pollen deposition as a result of slower peat growth during a period of drier conditions. This would result in high pollen

concentration values for all taxa as in fact is the case at this level. However, the generally dark, humified Turfa (Th^⓪1 Sh3) between 358cm and 142cm does not show any evidence of a change in sedimentation rate at this point. The evidence for increasing continentality in climate up to the elm decline in Britain remains inconclusive (Smith in press). The period of either high pollen influx or high pollen production did not extend beyond the particular level, since by 260cm all tree pollen concentration values had returned to a figure below that immediately preceeding the sharp rise. During this period it is probably more reliable to look at relative pollen figures as a guide to the actual changes in the vegetation. The most notable change after the apparent peak of forest recovery at 264cm is the decline of elm from 5.0% at 264cm to 0.5% at 260cm and this is also paralleled in the concentration figures. It is significant that elm pollen rose only marginally between 264cm and 262cm when other taxa were increasing very rapidly. Oak concentration also rose far less than other tree or shrub taxa during this period. The actual relative decline of both oak and elm from 264cm is therefore probably a true representation of the vegetative changes occurring. The relative decline of oak during this period is actually greater (24.0% to 8.4%) than that of elm, (5.0% to 0.5%) although elm is virtually removed

from the vegetation of the region. Elm at no stage appeared to be a major component of vegetation in the vicinity of Black Lough, rarely rising over 5% during Flandrian II which, after correction for over-representation, results in a very minor presence. It was probably growing on the richer soils of the valleys with patches on the Scremerston Coal Group-derived soils near Black Lough. Oak similarly would probably have reached its maximum development on the lowlands although it clearly achieved some importance nearer Black Lough rising to an uncorrected figure of 20% during Flandrian II. The marked reduction of oak and elm pollen at the close of phase B most probably represents a considerable clearance of high forest in the general vicinity of Black Lough with a more selective total clearance, or prevention of pollen production, of elm. At the close of phase B alder, birch and Coryloid pollen remained relatively stable having increased slightly during the period of oak and elm decline. Calluna increased strongly between 262cm and 260cm, rising to a diagram peak up to this point of 30.5%. Gramineae values remained low although an important indicator family of disturbed habitats, Caryophyllaceae, is recorded at 260cm, Godwin (1975) brackets Caryophyllaceae with Cruciferae as an indicator of arable farming during later Flandrian times.



Cruciferae were regarded by Iversen (1973) as a strong indicator of agriculture. A very high charcoal level is recorded at 262cm during the period of maximum decline of oak and elm and preceding the strong rise of Calluna.

6.2.3. Phase C (260cm-249cm): Further Clearance and Forest Recovery

At 258cm no elm pollen at all was recorded and subsequent to this point in the diagram elm rarely rose above 1%. Oak, however, recovers briefly at 258cm to 15.1% before declining again to its lowest level for the zone of 5.5% at 252cm. The brief recovery of oak is reflected in a stabilization of hazel and a marked decrease of birch from 8.6% to 3.6%, presumably as a result of increased shading from the regenerating woodland. Ericoid pollen also decreases temporarily to 24.1% at 258cm. Alder has the most constant pollen record of all tree taxa during this period, generally increasing gradually in percentage since the beginning of phase B, although the high pollen productivity of this genus may exaggerate its importance in the vegetation. Its probable location along stream lines and on the bog margins would place it at less risk from agricultural clearance and enable a more consistent pollen production to be maintained.

The major period of clearance activity during P.A.Z. BL IX appears to occur between 256cm and 252cm.

The pollen record is complex but explicable in terms of a dynamic landscape mosaic of areas of regeneration mixed with freshly (but roughly) cleared woodland and stable forest. There is no consistent, overall pattern of ecological succession following a single major clearance event represented in the diagram as, for example, Iversen (1941) recognised at Korup Sø and Ordrup Mose in Denmark. As a further complication there is a marked peak in Sphagnum spores at 252cm rising to 88.1% and corresponding with a depression in Ericoid pollen. Apart from the possibility of increased rainfall leading to a moister bog surface, a higher water-table may be linked with increased run-off from the surrounding catchment as a result of woodland clearance. Smith (in press) notes a number of recent studies which suggest increasing wetness in Neolithic times although he also stresses the difficulty of separating climatic from anthropogenic effects. Barber (1978, and Barber in press) has concluded from detailed palaeoecological studies conducted at Bolton Fell Moss, Cumbria, that there is a distinct link between peat stratigraphy and climatic change. In proposing his "Phasic Theory" of peat bog growth, in place of Post and Sernander's and Osvold's cyclic regeneration theory, Barber claims that "bog growth occurs in phases closely related to climatic variations" (Abstract). If this is the case, the consistent Calluna/Sphagnum

relationship noted through the Black Lough diagram can be interpreted in terms of wetter and/or colder climatic phases such as the period noted above at 252cm. Moore (1975), however, assembled evidence demonstrating the manner in which clearance leads to a rising water-table which he used to argue for Mesolithic and Neolithic groups initiating renewed peat growth at about the time of the elm decline. At this stage, it is not possible to be conclusive concerning the climatic or anthropogenic causes of rising water-tables in peat bogs. Either cause could operate in the short term and produce similar effects although an association with general clearance activity would suggest an anthropogenic influence.

The appearance of Plantago lanceolata at consecutive levels (254cm, 256cm) marks the opening of extensive clearance of a more prolonged nature at Black Lough. It is the first appearance of P.lanceolata in the diagram. It is on the presence of this particular species that Iversen (1941) based much of his argument in favour of a "landnam" or "land taking phases" immediately after the elm decline. In all his diagrams the first appearance of P.lanceolata came at approximately the same point soon after the elm decline, thereafter gradually developing a continuous curve up to the present day. Iversen quotes Linkola (1916, 1921) in proposing that the species is "anthropochorus" i.e. that it was brought to the

region by man as opposed to natural migration. He would also extend the argument to claim that P.lanceolata first arrived as an agricultural weed, although it occurs sporadically in association with Mesolithic clearance in British sites (Simmons 1964, Innes 1979). Iversen (1973) described P.lanceolata as the most important indicator of "old-fashioned rough pasture" since it demands full sunlight and therefore will not grow in grazed woodland in which the canopy is still largely intact. In addition to P.lanceolata, grains of Ranunculus and Chenopodiaceae are recorded at 252cm and 249cm respectively. Ranunculus is usually associated with grassy environments and has been used as an indicator of pastoral activity (e.g. Donaldson and Turner 1977). Similarly the Chenopodiaceae require very open conditions with a high nitrogenous level (Iversen 1941) and have also been used as cultural indicators (e.g. Hicks 1971). While it is recognised that the presence of this so-called "cultural vegetation" is no more than indirect evidence for the presence of Neolithic man in the immediate vicinity, it gains in significance when viewed in the perspective of the overall diagram and other changes occurring at the time.

The depression of trees during the first half of phase C is clearly visible in the summary diagram, particularly at 254cm where the non-Ericoid curve also dips noticeably. This depression is largely a result of the

severe decline in elm and oak noted above. Following the temporary forest recovery at 258cm, the curves of birch and hazel fluctuate in opposite pattern at a time of increasing charcoal content. This might be interpreted in the light of the type of regeneration sequence observed in the Draved Forest landnam experiment (Iversen 1956) and the Ordrup Mose diagram. It was found that two of the early prolific colonising plants were birch and bracken which took immediate advantage of the open, high nutrient conditions and rose to an early peak. The birch rise and declining hazel at 256cm might well correspond to a period of initial regeneration following clearing by burning. As birch declines after 256cm hazel rises to a zone maximum of 36.6% at 254cm but then rapidly declines to 252cm as birch rises again. At this level Pteridium has reached a zone peak and grasses have risen sharply towards a peak of 4.5% reached at 249cm. At 249cm the charcoal content of the sample is very high although generally high levels are maintained for the entire zone. During this period Ericoid pollen fluctuates widely probably reflecting alternating periods of clearance and recolonisation associated with the fluctuating birch and hazel curves.

Above 249cm there is a general smoothing of the percentage curves, although it is noticeable that birch and hazel continue to oscillate in opposite pattern. Oak

maintains a very steady value around 10% until 225cm when it again declines. There is evidence of continuing pastoral clearance through this zone although apparently of a more limited nature. At 230cm pollen of Plantago lanceolata and Chenopodiaceae coincide with a very high charcoal level and a rise in Pteridium, Ericoid and Betula pollen. Generally however, there is indication of a period of limited regeneration above 249cm during which oak, alder, and to a very limited extent, elm, slowly recover from the low levels reached during BL IX.

6.2.4. Discussion

The three phases discussed above do not correspond in a simple way with Iversen's three stage Landnam sequence (1949, 1973). Iversen visualised a major clearance event based on fire followed by relatively short term farming occupation and seral succession complete perhaps within a hundred year period. The evidence from Black Lough suggests a more prolonged and complex process involving numerous local clearances culminating after the decline of elm and followed by only limited regeneration of high forest. In this it resembles more closely the three stage pattern described by Pilcher, Smith and Pearson (1971) from sites in Northern Ireland and the Primary Elm Decline of Oldfield (1963) in the southern Lakes District. Phases A and B at Black Lough are

approximately equivalent to Pilcher et al. Stage A which begins with a fall of forest tree pollen (usually elm) and is characterised by increased grass and occasional plantain pollen. At Black Lough grasses rise but plantain does not appear until the following stage, although pollen of Polygonum and Caryophyllaceae indicate cleared land. Phase C is approximately equivalent to stage B in which there is a marked increase in plantain pollen and hazel pollen rises. Stage C, involving forest regeneration, corresponds to the close of phase C and the period beyond it up to approximately 230cm when tree pollen reaches its maximum value.

This latter period at Black Lough between 249cm-230cm would appear to involve a period of more rapid peat growth indicated by universally low concentration figures. The Sphagnum percentage is high for this period although no significant reduction in humification is evident in the stratigraphy. Previous reference has been made to the possibility of increasing wetness during Neolithic times (ref. section 6.2.3) and the above data would further support that conclusion. Whether this increasing wetness in any way influenced the reduction in clearance activity and general regeneration observed between 249cm and 230cm is difficult to say. It is apparent, however, that the reappearance of pastoral clearance and high charcoal levels at 230cm, and a further

decline of elm at 225cm, correspond exactly with a return of pollen concentration levels to their pre-decline level. Such an association between climatic deterioration, clearance activity and forest recovery would not seem an entirely unlikely possibility.

The time scale determined by C 14 dating for the Northern Ireland landnam stages would appear to have some relevance to the Black Lough sequence. Pilcher et al summarise the time periods for the three stages as follows:

Stage A	100-400 years
Stage B	150 years
Stage C	50 years

An overall time span of at least 500 years would seem to be necessary to allow for the range of vegetative changes recorded at Black Lough during phases A, B and C. In this respect it would seem likely that the Black Lough Neolithic land clearance chronology resembles that determined by Pilcher et al for Northern Ireland. The final determination of the time span involved will await radio-carbon dating.

Other aspects of the sequence at Black Lough are also similar to those reported by Pilcher et al. There is a distinct impression of pastoral farming becoming important in phase C with the appearance of Plantago lanceolata, as it does in stage B in Northern Ireland.

While no cereal pollen grains were detected at Black Lough, the presence of Polygonum during phase A is suggestive of limited arable farming. Iversen (1941) notes the general absence or low frequency of cereal pollen in diagrams for the Neolithic. He accounts for this by noting that all wheat, barley and oats cereals are self-pollinating and the pollen is therefore only carried a short distance from the parent plant. Since the only wind pollinated cereal (rye) does not appear until the Roman period in Britain and the Iron Age in Europe generally it is unusual to obtain high cereal pollen values prior to this cultural period. At a site of the nature of Black Lough, it would be virtually impossible to record cereal pollen of wheat, oats or barley at any time except in the unlikely event that they were grown on the bog margins. The onset of continuous cereal pollen records at Black Lough is therefore likely to be associated with the introduction of Secale (rye) during the Roman occupation. The possibility that in spite of an absence of cereal-type pollen limited arable agriculture was associated with the early clearance activities is therefore quite real. In Northern Ireland cereal-type pollen was present in two valley bog sites during the stage A but as at Black Lough, absent from the raised bog site. It is argued by Pilcher et al that arable farming in stage A changes to predominantly pastoral

farming in stage B as a general pattern in Northern Ireland. The limited herbaceous pollen recorded at Black Lough would suggest a similar sequence operating in North-East England.

The phenomenon of the elm decline and associated land occupation is usually interpreted as the result of immigrant cultures arriving in an area with new knowledge of land clearance techniques and technology, and with an economy based on farming. Such a revolutionary change from a nomadic hunting and gathering life-style could indeed account for the dramatic and sudden onset of forest clearance and the later appearance of agricultural and pastoral indicator species. The reasons for the apparently selective and near-synchronous destruction of elm at this time, however, poses considerable difficulties, the discussion of which has generated a considerable literature since 1941. The most recent and most complete discussion of this literature (Smith, in press) notes that with the use of modern methods of pollen analysis involving absolute pollen counting and close sampling, a rather different picture is emerging of the nature of the elm decline. The traditional view involving a single, rapid and selective decline of elm may in reality be a more complex process involving other species in a series of vegetational and land-use changes.

The current study supports this assessment of the

nature of the elm decline. It has been noted earlier that elm concentration values had decreased steadily for several levels before an initial decline of elm recorded in the percentage curve at 266cm. There are no open-habitat herbs recorded during this period but charcoal and grass levels are generally similar to those recorded during the more intensive period of land occupation following the final elm decline. Pteridium levels are actually higher then than after the elm decline. It would seem likely that the gradual decrease of elm and to a lesser extent oak pollen leading up to the elm decline results from clearance activities of more advanced Mesolithic or pioneer Neolithic cultures involving limited animal herding and plant cultivation. There is no evidence in the Black Lough diagram of a revolutionary change in land-use during Flandrian II, but rather a gradual intensification of pressure on the forest in the latter stages of the period. The concept of elm suffering under persistent lopping for fodder, advanced so cogently by Troels-Smith (1960) and Heybroek (1963) has considerable appeal in accounting for the preliminary decline of elm observed in the Black Lough diagram. After elm reached its initial low point at 266cm the pressure seems to have been suddenly removed and it recovered along with oak and alder to a mid-Flandrian II level. This is very reminiscent of

Oldfield's (1963) preliminary elm decline followed by complete forest recovery at his Lakes District sites. Then a steep and final decline of elm and particularly oak occurs associated with high charcoal levels, and rises in Pteridium and grasses. It is at this point that the major change in the diagram occurs, when both elm and oak are drastically reduced to a point from which neither recover in the remainder of the diagram. At Black Lough, the "Elm Decline" is very much an "Elm and Oak Decline" with oak actually suffering a relatively greater reduction than elm. The pattern of limited recession followed by temporary regrowth and then heavy impact would be in accord with the likely effects on vegetation of the arrival and departure of a relatively low impact cultural group and its replacement by a new immigrant culture with a higher population and advanced agricultural technology. The continued appeal of elm as a stock food to this group and the general clearance pressure on the limited areas of better soil favoured by elm, would then be sufficient to cause its selective removal from the vegetation of a region. The value of actually retaining areas of oak and hazel for the provision of swine mast has been argued by Iversen (1973) and may account for the levelling-off of the oak decline at 5-10%. There is no stratigraphic or general botanical evidence to suggest a climatic change at this time.

Indeed, the rise of cultural indicators and the decline of elm and oak are so closely associated in the Black Lough diagram that it is difficult to look beyond a direct anthropogenic cause.

The leaves of Tilia and Fraxinus are also readily eaten by cattle and it has been argued by Turner (1962) that the Tilia decline observed in many British pollen diagrams may also be the result of human activity. Both Tilia and Fraxinus have a very limited occurrence in the Black Lough diagram which suggests that the site is at the limit of their environmental ranges. It is noticeable, however, that although generally sparse, Tilia establishes a more regular presence actually during the period of maximum land occupation after the elm decline disappears at the close of phase C for some considerable time. Fraxinus appears intermittently up to the time of the initial decline of elm and disappears prior to phase A also for a considerable time. It is possible that the pioneer Neolithic/Mesolithic herding group was responsible for the disappearance of the limited amount of Fraxinus at this time under the pressure of its use for animal fodder. The explanation for the increased Tilia presence during the occupation phase would seem to involve the encouragement or even management of Tilia by the immigrant group. The region is marginal for Tilia but the regular recording of its pollen during this

period would appear to confirm its presence especially when a degree of under-representation is taken into account. The tree is certainly useful as a source of stock fodder and also attracts honey bees which may have been highly valued by the Neolithic farmers. The disappearance of the tree towards the end of stage C may reflect the increased pressure being placed on fodder resources during the period of soil stress which probably preceded the emigration of the bulk of the group.

The reduction of clearance pressure after phase C is most probably related to soil deterioration resulting from two hundred years or more of intensive exploitation of the forest soils in the region. The Draved experiment (Iversen 1956) demonstrated how the initially high crop productivity of the burned-over site quickly deteriorated after the first year. A continuing series of small clearances would therefore be required to maintain agricultural productivity for the Neolithic community which would eventually be forced to move to adjacent areas as local soils became exhausted. The complex pattern of continuing clearance and regeneration has been noted in phase C of the pollen diagram and also the relatively sudden point at 249cm where the curves even-out and regeneration begins. It would seem likely that at this point the bulk of the local community began a migration to new areas, possibly repeating the process

that caused them to arrive at Black Lough in the first instance. The possibility that a period of wetter climate intensified the deterioration of soil or rendered further land clearance impossible should also not be dismissed as a contributing factor in the period of reduced impact on the vegetation that now followed.

6.3 CLEARANCE PRIOR TO THE RECORDING OF CEREAL-TYPE POLLEN (230cm-106cm)

In the absence of C 14 dates the relationship between clearance episodes and cultural periods becomes uncertain above the Flandrian I/II boundary. Possible relationships are considered in more detail in the following chapter. It is most likely, however, that the period under present discussion includes the later Neolithic, Beaker/Bronze Age and Iron Ages. The appearance of the first cereal-type pollen grain associated with a heavy clearance period marking the close of the period under discussion suggests that it may extend up to the late Iron Age and the introduction of Secale. No absolute certainty, however, can be attached to this tentative estimation of cultural periods.

6.3.1 Zone BL X (249cm-144cm) (ref. figures 18, 27, 31)

The character of the period up to the close of BL X at 144cm is one of generally limited impact on a substantially wooded landscape with short periods of more substantial clearance activity depressing the tree curve

and increasing the herb percentage of the vegetation. After each such clearance the tree curve fails to recover fully with the overall effect being a very gradually receding woodland and increasing heath component of the vegetation. The changes are transitional and gradual rather than sudden, and suggest a progressively intensifying land-use. During zone BL X, herb values generally return to very low levels after each clearance although the gradually increasing severity further delays this return. The close of BL X coincides with the last complete return of herb pollen to very low levels, after which clearance impact increases noticeably. The clearance history during BL X fits closely Turner's (1965, 1970) model of small temporary clearances of Neolithic and Bronze Age times in which the life-style is considered to be one of shifting pastoralism and limited arable farming. It might be seen as a series of "landnam" type occupations as groups are forced to move from an exhausted environment to a new woodland area. However, while the clearances during BL X certainly appear to be relatively small and temporary, the overall effect, so clearly registered in the Black Lough regional pollen record, is sufficient to depress completely oak and elm values from the time of the first major Neolithic activity. This suggests a considerable overall impact on the vegetation of the region even

though it would tend to be patchy, leading to a mosaic of vegetation at various stages of regeneration (shown as C/R periods on figure 31). The general dominance of hazel, birch and alder during BL X, and the variable but steadily increasing percentage of Ericoid pollen, Pteridium and Gramineae, support this general assessment of the landscape character. There is little evidence of arable farming during this period, beyond the regular appearance of agricultural indicator species such as Polygonum, Artemisia, Chenopodiaceae, Rumex and Ranunculus. The occurrence of these species is concentrated mainly into the short phases of limited clearance during zone BL X (a). This zone between 249cm and 184cm has considerable uniformity of character involving generally low Gramineae values and a consistent woodland component largely composed of alder and hazel. The clearance episodes become more intense towards the top of the zone although the herb percentage on each occasion returns rapidly to near zero value and tree pollen recovers completely. The most significant of these temporary clearances occurs at 202cm where a rise in Gramineae, Plantago lanceolata and Ericoid pollen coincides with a reduction in hazel, alder and oak (ref. figure 18). Recovery is complete, however, by the following level at 197cm. It is tentatively proposed that zone BL X (a) corresponds with the period of

Neolithic cultural occupation and the increasing intensity of clearance reflects the developing technology, increasing population and more settled way of life of the people.

The pattern of clearance between 184cm and 144cm has a different character from the preceding period, principally characterised by the more continuously high Gramineae levels maintained between the major clearance peaks. The clearance illustrated in figure 27 between 188cm and 166cm (zone BL X (b)) demonstrates the significantly increased intensity of clearance operating at this time. It is suggested that this clearance possibly marks the arrival of Beaker/Bronze Age or even Iron Age groups in the region following a way of life still principally based on semi-nomadic pastoralism. The gradual increase in grasses and Ericoid species suggests a more effective and prolonged woodland clearance than previously and perhaps a more settled life-style. It is a difference in degree, however, and reflects a relative continuum in land-use patterns from the more advanced Neolithic stage into Bronze Age cultures. The likelihood of significant Bronze Age clearance being recorded at Black Lough is suggested by the nearby Bronze Age cremation urn excavated from Corbys Crags and a cup and ring marked stone near the present lake. Bronze Age groups clearly occupied the immediate vicinity of Black Lough possibly using it for

summer grazing and ceremonial activities.

The clearance episode between 188cm and 166cm was quite intense but centred closely on the 175cm level. At this point Gramineae is near its peak value, Plantago lanceolata attains 1.8% of total pollen and a variety of plants characteristic of open or disturbed habitats occur. Betula and Quercus pollen suffer marked declines to a general low point at 175cm after which Quercus partially recovers and Betula values rise quite steeply to 16.8% at 162cm. Hazel and heath species begin to increase between 175cm and 170cm as agricultural indicator herb species decline. It would appear that the entire land occupation episode is completed within the 20cm section of sediment which would suggest an approximate time span of some 400 years if calculated on an average sedimentation rate of 5cm/century (Walker 1970).¹ The actual period of occupation between approximately 170cm and 179cm would be nearer 200 years based on this calculation. During the clearance period charcoal levels are moderate to high, reaching a peak at 175cm and declining to 166cm. Above 166cm the woodland does not fully recover and herb values generally remain at about 5% approaching the recurrence surface at 142cm.

1. See also section 6.6

6.3.2 Zone BL XI (a) 144cm-106cm

The character of the clearance impact changes more markedly beyond 144cm although it is still a progressive development of land-use pressure. Plantago lanceolata pollen begin a virtually continuous curve and Gramineae increase steadily through the sub-zone. Other open-habitat herbs are present at most levels instead of being concentrated almost entirely into short periods of intense clearance as previously. Heath species in fact decline steadily after an early increase to 55.8% at 140cm, suggesting a more continuous grazing pressure on the heathy openings in the upland woodland and an extension of grassy communities. Tinsley (1975) noted a similar effect in the plants from Nidderdale Moors zone N-E, which she explained as a response to increased grazing pressure, noting the comments of Boulet (1939) on the profound effect of sheep grazing in restricting the spread of Calluna vulgaris in the Welsh uplands. A similar effect is seen on the present Black Lough surface in which Calluna vulgaris is restricted to those sections of the bog which are fenced off from sheep and cattle grazing.

The overall impression is one of a more settled community, based heavily on pastoral farming but not subject to the continuous migration and reclearance associated with the earlier period. It is likely that

this period encompasses much of the Iron Age. The tree percentage in fact tends to increase very slightly overall during this stage suggesting that existing open areas were used more effectively rather than opening new sections of forest. Charcoal levels tend to be lower overall, with one major exception at 121cm when a very high concentration is recorded. The lower charcoal possibly suggests heavier reliance on implements for clear felling or it may indicate non-local clearance. The charcoal peak was followed at 118cm by a temporary peak in Ericoid pollen of 37.8% and a reduction in tree pollen to 23.4%. Oak pollen records its sole recovery since the elm decline during the later stage of this period when it rises at 114cm to 24.3%. Birch and hazel also maintain a regular level of around 25% and elm increases from a nil recording at 144cm to 0.8% at 110cm.

The close of BL XI (a) is marked by the onset of a particularly intense period of clearance quite out of character with any previous recession of the woodland and is associated with the first recorded cereal-type pollen grain. It would seem likely that this clearance is associated with the more advanced technology of the later Iron Age and the arrival of the Roman legions. It will be discussed in more detail in section 6.4.

The sequence of levels between 144cm and 106cm represents a continuation of the trend towards increased

grass pollen but interestingly, not at the expense of further deterioration of the forest. The impression is gained of a more ordered landscape with better defined and maintained agricultural zones and more permanent settlements. In section 2.5 it was noted that there was an Iron Age Hill Fort on the sandstone escarpment above Corby's Crags and three Iron Age settlement sites on the lowlands to the east and north-east of Edlingham. The existence of these settlements would probably suggest continued agricultural use of the region in the vicinity of Edlingham and Black Lough but with the considerable difference from earlier periods that the settlements were relatively permanent. The nearly continuous presence of Plantago lanceolata and increasing Gramineae values indicates a continuing pastoral base to the economy. While no cereal-type pollen grains are recorded, the scattered occurrence of pollen often associated with cultivation such as Artemisia, Plantago Major/Media, Ranunculus, Compositae, Polygonum and Chenopodiaceae suggests a continuing limited grain production on the better drained soils of the valley sides. The depression of Ericoid percentage suggests an increase in sheep grazing, particularly on the upland regions in the vicinity of Black Lough where heath species might be expected to mainly occur. It is also noted that alder decreases during the middle of

this period indicating a period of increased clearance and utilisation of river side and bog margin sites.

There is no suggestion of the alder decline being linked with a drier period at this stage, since the stratigraphy between 142cm-100cm consists of a lightly humified Sphagnum peat.

6.4 CLEARANCE HISTORY AFTER THE APPEARANCE OF CEREAL-TYPE POLLEN. (106cm-0cm)

This section of the pollen diagram marks the onset of heavy forest recession and the appearance of cereal-type pollen. It was argued in 6.2.4 that the nature of Black Lough as a pollen catchment would prevent cereal-type pollen from the self-pollinating cereal species being recorded unless grown on the immediate bog margins. The recording of cereal-type pollen should therefore mark either the approximate point at which the wind pollinated rye (Secale) was introduced or a massive local expansion of grain cultivation around Black Lough. Since the Black Lough site is not currently used for cereal cultivation and has little appeal for this type of agriculture compared with the richer, better drained valley slopes below, it is considered that the former possibility is more likely. The appearance of cereal-type grains at 89cm is therefore of considerable significance and is seen as indicative of more widespread arable farming on the valley slopes near Edlingham from late Iron Age and Roman times.

6.4.1 106cm-84cm (BL XI (b)) Probable Late Iron Age/
Romano-British Clearance. (ref. figures 28, 31)

The period opens with the onset of intense clearance which at its peak at 94cm reduces the tree percentage to 13.7%. Pollen of herbaceous taxa rise at this level to 45.1% which is its highest value for the entire diagram. Birch, hazel, alder and oak are heavily reduced. While birch, alder and hazel recover to some extent above 80cm, oak generally remains at very low values. As opposed to the depression in woodland taxa, Ericoid pollen begins a generally continuous climb from 11.8% at 94cm to 88.6% at 2cm. It would appear that the changes in vegetation and probable deterioration in soil initiated during this clearance period led to the expansion of heathy upland moors over extensive areas and created a pattern which has largely continued to the present day.

The herbaceous pollen record would suggest that the overall clearance episode can be subdivided into an earlier pastoral phase, reaching a peak between 110cm and 94cm, followed by more predominantly arable farming between 94cm and 80cm. Figure 28 illustrates the changes in the pollen record indicating these phases. It is suggested that the change from a pastoral to an arable emphasis reflects the arrival of Roman legions in the district.

Pastoral phase (110cm-94cm) Late Iron Age

Gramineae pollen rises steeply from 106cm to a maximum value of 28.4% at 97cm, from which point it declines equally steadily to 2.0% at 84cm. Coinciding with the peak of grasses, Coryloid pollen declines to its first minimum of 13.7% from which it recovers to 23.5% at 94cm. Ericoid pollen remains at a generally even level of around 15% until 94cm when its rapid expansion begins. Plantago lanceolata rises to a maximum of 7.8% at 94cm from where it decreases rapidly to a nil record at 80cm, Pteridium values largely parallel Plantago lanceolata rising to 13.7% at 97cm and decreasing to 0.4% at 84cm.

Arable phase (94cm-80cm) Romano/British

Direct evidence of cereal cultivation in the form of two cereal-type pollen grains is found at 89cm. At 80cm one Cannabis grain was recorded. At this point in the diagram Plantago lanceolata has dropped to low values, grassland is decreasing rapidly, heath is increasing rapidly and Coryloid pollen has dropped to its second low point of 16.8%.

Discussion

The pattern of agricultural indicator herbs demonstrated in figure 28 suggests two principal periods of agricultural activity. Between 106cm and 97cm P. coronopus,

Chenopodiaceae, Artemisia, Saxifragaceae, Polygonum, Rumex, Ranunculus and Rosaceae are recorded. No open-habitat herbs are recorded at 94cm. Between 89cm and 80cm Plantago coronopus, Potentilla type, Mercurialis, Rumex and Ranunculus are recorded. The break at 94cm coincides with a recovery of hazel between its two low points and a slight rise in the Quercus curve. The charcoal records also demonstrate a division between very low levels up to 94cm and medium levels at 89cm and 84cm. The cause of this division remains unclear since heavy clearance was conducted during the period of low charcoal records. It is possible that clearance in the immediate vicinity of the bog was complete prior to this point and that the extended recession of tree taxa reflects the regional pattern. The burning of stubble and grasses prior to crop replanting, however, may have been more local and led to charcoal deposition during the arable phase.

The significance of the two agricultural phases within one general period of heavy clearance is possibly explained in terms of the arrival of Roman legions during the late Iron Age. The significance of the diversion of the Devil's Causeway (Roman road) towards Edlingham and the nearby establishment of two Roman forts has been discussed in section 2.6. Hicks (1971) has established that in North Derbyshire arable cultivation became

important for the first time during a period (AD 40-410) which correlates with the Roman occupation of the region. Hicks suggests that the local presence of Roman Forts would provide a stimulus to grain growing in the region in which pastoralism had previously been the basis of the economy. The first heavy clearance at this site in North Derbyshire is dated to the late Iron Age (425 BC to AD 30) and it is suggested that the Iron Age pastoralists continued their former way of life, but increased the areas under grain cultivation on the better soils of the hill slopes and valleys. It is also noted that Secale and Cannabis were introduced during the period of the later Roman occupation. The parallel between Hicks' findings and the sequence from Black Lough is striking and lends support to the cultural division proposed for this section of the clearance history.

6.4.2 84cm-48cm (BL XI (c)) Post-Romano-British
Woodland Regeneration (ref. figure 19)

In section 2.7 the period of economic and political disruption following the Roman period, from approximately the 6th century and continuing intermittently until the Norman period, was discussed. On the assumption that the previous period of heavy clearance is correlated with the time of Roman occupation, it would appear that the following period of forest regeneration reflects the

time of early Medieval economic recession. During this period tree and herb percentages return to a situation similar to that associated with the early Iron Age, although Ericoid pollen remains at higher values. Herb pollen steadily reduces from 84cm to reach its lowest value of 1.4% at 62cm. Tree pollen increases quite rapidly from its minimum value of 13.7% at 94cm to reach 47.2% at 80cm, from which level it then recedes again to maintain a general level of approximately 25-30% until 58cm. The regenerating trees are mainly birch and alder, with oak remaining generally under 5%. Hazel recovers to 26.1% at 66cm and remains over 20% until 58cm. No cereal-type pollen grains are recorded between 84cm-48cm.

The pollen record suggests that the landscape of this period is one of secondary vegetative succession, with previously cultivated fields gradually being colonised by thickets of birch and hazel which progressively shade out the grasses and other herbs. The initial wide-scale abandonment of previously cultivated land, reflecting a considerable decrease in rural population, is reversed at 80cm and a new equilibrium is maintained at a relatively low level of agricultural activity. The disappearance of cereal-type pollen suggests a general reversion back to an Iron Age style of mixed pastoral farming with limited grain cultivation on the better soils. Pastoral farming, however, appears to have been maintained at

sufficient level of intensity to control the further spread of heath vegetation during this period. It is possible, however, that heath had already achieved a maximum extension over the sandstone uplands and the fluctuation of Ericoid pollen percentages in the pollen diagram reflects the periodic expansion and contraction of Calluna on the bog surface perhaps related to sheep grazing pressure as at present. Plantago lanceolata retains a continuous curve except at the level of maximum forest revival (80cm). This level appears to mark the maximum point of agricultural recession and may well correlate to the period of warfare, famine and plague between AD 550 and AD 650 (Morris 1973). Following the low point of herb pollen at 62cm a gradual recession of woodland and increase in herb pollen is again set in motion leading up to a period of almost total clearance above 48cm.

6.4.3 48cm-36cm (BL XII(a)) "Total" Clearance:
Norman Period

Figure 29 illustrates the rapid agricultural recovery and almost total clearance of woodland following the early Medieval depression. Cereal pollen establishes a continuous curve and Plantago lanceolata steadily drops to low values. Gramineae pollen concentration rises to very high levels, but because of an even higher concentration of Ericoid pollen, is limited to 27.4% at 36cm.

The difference between the summary tree/shrub/herb diagrams, with and without Ericoid pollen in the sum, indicates the domination of the pollen spectrum by Ericoid pollen. It rises to 80.1% at 44cm and generally averages about 50%. This reflects to some degree the drying of the bog surface and resultant probable colonisation by Calluna. However, this expansion of Calluna is probably also a wider reaching one extending over much of the upland moor and hill regions. It probably also reflects a decreased emphasis on upland pastoralism at a time of prosperous grain farming. All tree taxa as well as hazel are practically removed from the pollen record at this stage, particularly at the peak of clearance activity between 36cm and 42cm. Alder, hazel and birch make a slight recovery beyond 36cm. The peak of clearance and heath growth corresponds closely with high charcoal levels at 42cm and 40cm suggesting active clearance and agricultural activity within the immediate vicinity of Black Lough.

The landscape during this period was probably converted from a patchy mosaic of overgrown fields and deserted dwellings into a heavily cultivated and virtually treeless agricultural landscape. The prolific range of arable and pastoral indicator herbs clustered between 48cm and 32cm on Figure 29 indicates the intensity of mixed cereal/livestock agriculture in the region. The

continuous level of cereal-type pollen between these levels suggests a distinct emphasis on grain cultivation. Rural population levels clearly must have recovered steadily prior to and during this period of arable farming. Villages such as Edlingham would have become flourishing settlements housing the rural workers and providing agricultural services. Local fields would be under intensive cultivation and thickets of alder, hazel and birch would be coppiced or cleared away. Demand for hurdle fencing, fuel and construction timber would place a heavy clearance pressure on remaining woodland. It is apparent that clearance reached its greatest intensity at this time for the entire diagram, with less tree pollen being recorded then than at any other time before or since.

The implications of such a clearance for population growth, cultural development and environmental impact are great. B.H. Slicher Van Bath (1963) describes the period from AD 1150 - AD 1300 as the "Precocious Flowering" (p132) of European agriculture. He describes advances in theology, philosophy, architecture and material well-being and an associated rise in population and productivity. However, the rapid economic expansion was achieved at an environmental cost which led directly to its own downfall a mere 150 years later. He quotes the English historian Postan (1950) concerning the period after the rapid expansion of

the 13th century. ---"the honeymoon of high yields was succeeded by large periods of reckoning, when the marginal lands, no longer new, punished the men who tilled them, with recurrent inundations, dessications and dust storms." The favourable economic conditions of the 13th century (price of wheat increased almost 3x) led to the cultivation of increasingly marginal lands, and it might well be imagined that the areas in the immediate vicinity of Black Lough were included. This might explain the very high level of herbaceous and shrub pollen recorded at this time relative to trees. The result of the expansion into marginal lands was that the manuring from limited farm animals could not be maintained, soil nitrogen rapidly became exhausted, harvests failed and settlement retreated. The depleted soils were then colonised by grasses, heath and birch further extending the open moorland and low scrub. The general demand on the environment for fuel (peat and tree wood), construction timber, gathered foods (nuts, fruits) and the increased pressure of arable and pastoral farming generally, overstretched the ability of the economic and environmental system to maintain itself. Agricultural areas of the continent (Slicher Van Bath) and in northern England (B.K. Roberts, personal communication) actually record a denser population and higher number of recorded tenants in the 13th century than today. The agricultural decline resulting from this excessive

fragmentation of small holdings and environmental mismanagement was in progress before the arrival of the Black Death from about 1348. The climatic deterioration of the early decades of the 14th century possibly accelerated a decline that was already in motion, and which was further deepened by the plagues continuing spasmodically up to about 1405.

6.4.4. 36cm-12cm (BL XII (b)) Limited Woodland Recovery

Following the previous period of quite intense agricultural activity the tree pollen curve does recover slowly to 15.3% at 25cm. During this period cereal-type pollen again disappears and the agricultural indicator species reduce in frequency. Gramineae pollen concentration decreases to 6.6% at 16cm and the growth in Ericoid percentage is held in check at c.50% probably as a result of some expansion of hazel, birch and alder and a return to sheep grazing on the uplands.

The regeneration during this period is relatively limited although the rural depression does appear quite marked. The disappearance of cereal-type pollen and a low but continuous level of Plantago lanceolata and other agricultural indicator herbs suggest a considerable rural depopulation and reversion to a basically pastoral economy similar to the early Medieval period. The limited regeneration evident in the pollen diagram is probably a

reflection of the almost total clearance achieved during the previous period of economic buoyancy.

This period of rural depression would seem to be correlated with the years of plague, famine and warfare of the early 14th century extending to the mid-15th century discussed above. Lamb (1966) discusses the onset of climatic deterioration during the early 14th century which culminated in a series of harvest disasters and famine. Zeigler (1969) claims that the Black Death alone accounted for a rural depopulation during the 14th century of 25-30% and led to fields and entire estates lying waste for decades. It is surprising then that regeneration of this region was not more marked since there is no evidence to suggest that it escaped the ravages of the period. Davies and Turner (1979) quote from the inquisitio post mortem after the death of the second Lord Percy in 1351 in reference to the ravages of the Black Death in the Township of Chatton a few kilometres to the north of Edlingham in Northumberland. "Of 27 bondage holdings, 11 were lying waste for lack of tenants, and out of 13 cottages, 8 were waste and uncultivated" (Davies and Turner 1979 p.801). In addition Chatton and the neighbouring Chillingham petitioned the king for relief from taxation in 1344 due to the ravages of the raiding Scots. The difficulties faced by Edlingham at this time were also evident and are discussed in

section 2.7. Nevertheless, while the most likely explanation for the limited regeneration would seem to be related to the degree of preceding clearance, it is also possible that rural depopulation was not as severe in the Edlingham region as that recorded in other districts. As a result, agricultural activity may have been maintained at a moderately high level although reverting to a pastoral base. Slicher Van Bath (1963) notes that the Black Death showed great regional differences with some villages being depopulated and others not affected. He also observes that larger farms grew at the expense of unprofitable smaller holdings during the 14th century, which would effectively maintain a reasonable level of agricultural production and prevent wide-scale revegetation.

6.4.5. 12cm-0cm (BL XII (c)) Renewed Heavy Clearance

Political and economic stability returned to the north gradually from the early 1500's and became complete with the Union of the Crowns in 1603. It is likely that the marked rise in Gramineae pollen, return of cereal-type pollen and renewed heavy clearance of tree taxa above 12cm relates to this period. Arable farming clearly returned strongly, but at a level below that of the earlier intense arable farming of Norman times. This is illustrated most clearly on the non-Ericoid summary

graph (ref. figure 19) in which the level of tree clearance is seen to be less than previously and only maintained briefly at that level. (The extremely high Ericoid concentrations at these levels obscures the true percentage relationship between tree and herb taxa. Ericoid percentage generally exceeds 80% indicating its dominance on the bog surface.) The lower clearance level possibly reflects a more limited rural population as a legacy of the 14th and 15th centuries. It may also reflect the disruption of Civil War during the 1640's although this effect would probably be too short term to show up on the pollen diagram. Of greater likelihood is the gradual spread of agricultural improvement after the 1700's in which enclosure of fields and the establishment of shelter belts, hedgerows and plantations became more common. The numbers of pollen grains of Pinus and Ulmus did in fact increase at the top levels of the Black Lough diagram (5cm and 2cm), while birch and hazel practically disappeared. This possibly represents the beginning of the estates movement and general farm improvement epitomised in the work of Bailey and Culley (1805) (ref. figure 4). The top sample also marks the disappearance of cereal-type pollen which possibly suggests an agricultural landscape changing to the mixed pastoral emphasis of the present day. This effect is also noted by Davies and Turner (1979) who consider that it probably dates

from the early 19th century. They quote from Hodgson (1827) who considers that northern Northumberland could not compete profitably as a grain growing area with the Scottish grain growing regions, whereas the growth of pastoral agriculture was well suited to its climate and soils.

6.5 CORRELATION OF THE EDLINGHAM AND BLACK LOUGH DIAGRAMS.

It is at the BL XII (b-c) boundary that the Edlingham pollen record appears to show the closest correlation. P.A.Z. ED I (ref. figure 13) is characterised by increasing values of Gramineae and open-habitat herbs and decreasing values of Alnus, Quercus, Betula and Coryloid pollen. By the early stage of ED II at 98cm, no Quercus or Pinus pollen, and only 1.1% Betula, 1.7% Alnus and 5.7% Coryloid is recorded. Cereal grains are first recorded at 80cm and agricultural indicator or weed taxa such as Senecio type, Matricaria type, Taraxacum type, Ranunculus, Rosaceae, Umbelliferae, Polygonum, Rumex, and Plantago are recorded in increasing numbers. Polygonum was particularly numerous suggesting an emphasis on arable farming. Plantago lanceolata established a continuous curve from 80cm to the surface. The clear impression is of a landscape undergoing the latter stages of clearance (ED I) leading to a period of intensive, predominantly arable farming (ED II). The

level at 2cm also reflects a similar increase in Pinus to the 2cm at Black Lough, although no Ulmus pollen appears. Coryloid and Betula pollen also increase slightly at this level perhaps reflecting local colonisation of the mire margins.

There is every indication that the ED 13 pollen record from Edlingham mire dates from about the 17th century coinciding with the final intensive clearance associated with the revival of rural land-use after about 1600. This conclusion is supported by the occurrence of fragments of earthenware material similar to that used in drainage pipes at a depth of 118cm at the ED I/II boundary. The material consisted of chips of earthenware that appeared to have been laid on the original surface and become enveloped within the growing detritus organic matrix. It formed a smooth imprint within the encasing of peat and gave the distinct impression of having been laid down in-situ rather than as the result of excavation from a higher surface. It is tentatively equated with early drainage attempts at the wet and rapidly accumulating mire surface during the early 18th century. The overlying layers of silty clays and organic silts attest to the following inwash of minerogenic materials from the cultivated fields adjacent during the re-establishment of arable farming in the region (ED I).

6.6 PEAT DEPOSITION RATES AND THE CHRONOLOGY OF CLEARANCE HISTORY.

The rate of growth of peat bogs fluctuates quite widely depending principally upon the dampness of the bog surface, which in turn is related directly to the level of the water-table and/or level of precipitation. A varying water-table may result equally from climatic change, or the influence of man in causing increased run-off through clearance of a drainage basin. Walker (1970) estimated an average rate of peat growth for British peat bogs of c.5cm/century which was generally confirmed by Hibbert and Switsur (1976). The determination of sedimentation rates is based on a series of radiocarbon dates placed evenly through the deposit resulting in a series of average growth rates for the various dated sections. With sufficient dates the varying sedimentation rates should be reflected in the degrees of humification ascribed to the various stratigraphic levels. A high rate of calculated peat growth which coincides with a well humified monocot peat would suggest that either the radiocarbon dates are suspect or the stratigraphic description was in error. In this way the stratigraphic description may provide a check on the general reliability of the radiocarbon dates. This relationship has been used to provide an indirect means of testing the tentative cultural sequence discussed above.

In the place of radiocarbon dates for the determination of sedimentation rates, the sequence of proposed cultural boundaries has been allocated an estimated date based on existing knowledge of the cultural periods. Whereas these dates are relatively precisely known from the arrival of the Roman legions to the present day, they are rather imprecisely known beyond that. Fortunately, the broadly synchronous event of the elm decline provides a reasonably accurate base date for the main period of cultural impact and allows an overall sedimentation rate to be calculated. The following date estimations have been used in the calculations.

2cm	AD 1950	Top level sampled
12cm	AD 1700	Agricultural improvements begin
46cm	AD 1100	Start of later Middle Ages agricultural boom
89cm	AD 500	Post Romano-British decline begins
106cm	0	Late Iron Age clearance begins
144cm	BC 500	1st Iron Age clearance indicated
260cm	BC 3300	Elm Decline

(The dates for the elm decline, Iron Age clearance and Iron Age/Romano-British period are based on a consensus of dates from existing studies in north-east England discussed in chapter 7.)

The resultant sedimentation rates are shown in comparison with the humification assessments on figure 32.

Sedimentation rates range between 7.6 and 3.4cm/century which is within "normal" ranges for British raised bogs. The principal divisions between the zones of high (Sh3),

low (Sh1) and high (Sh3) humification, are reflected in the sedimentation rates. The correlation between high humification and low sedimentation rates at the surface (Sh3 and 4.8cm/century) and the contrast to be seen in humification and sedimentation rates at the recurrence surface level (142cm) is marked. The Sh3/Sh1 boundary at 65cm is also reflected in a transition in sedimentation rates from 6.0 to 6.7cm/century, with a break between 89cm and 106cm, although the dated levels do not coincide with the stratigraphic boundary. The stratigraphy between 65cm and 100cm is a mixed zone in which Eriophorum peat occurs in a band between 90cm and 100cm. Eriophorum presents considerable difficulty in the assessment of humification levels, especially when contained within a zone of mixed peats. Coming as it does between Sphagnum peat below and mixed Sphagnum-monocot peat above, it probably represents a period of drier conditions and slow peat growth. While the fibrous matrix did not appear to be heavily broken down, it almost certainly should have been classified at a higher level of humification than the peats above and below. The period of low sedimentation rate (3.4cm/century) coinciding closely with this stratum would be quite in order in terms of the type of drier bog surface in which Eriophorum would dominate. In general it is considered that the results of the sedimentation calculation offer

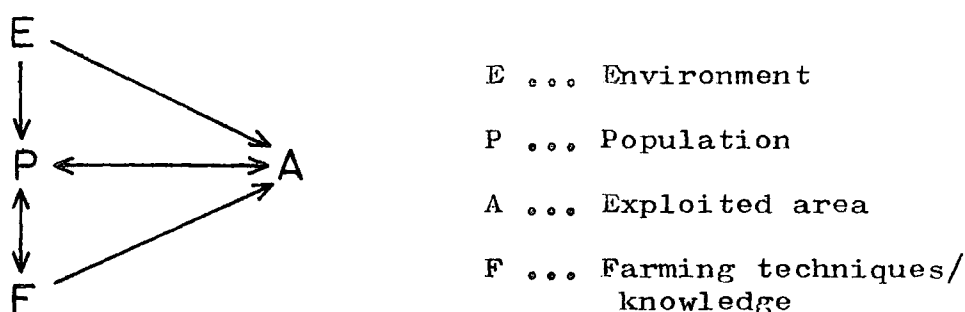
some support to the scheme of cultural divisions proposed, although the intrinsic lack of precision involved rules out any more than a tentative conclusion.

6.7 A RELATIONSHIP BETWEEN PEAT STRATIGRAPHY AND CLEARANCE HISTORY

It is noticeable that the onset of the two major periods of increased clearance leading to heavy arable farming coincides closely with stratigraphic zones indicating drier bog conditions. The first of these involves a band of Eriophorum peat at 90cm-100cm (discussed above in 6.6) which coincides with the first period of heavy clearance associated tentatively with the late Iron Age and Roman period. The second is at 65cm coinciding with the beginning of the steep rise in herb pollen and decline in tree pollen leading up to the massive clearance tentatively associated with Norman times.

It is purely speculative to suggest a causal association between the upsurge in clearance and the environmental conditions leading to a drier bog surface, but the coincidence is striking. A purely environmental explanation for major changes in the rural economy is undoubtedly an oversimplification of complex political, social, economic, technological and environmental processes. Nevertheless, in times of limited technology and local

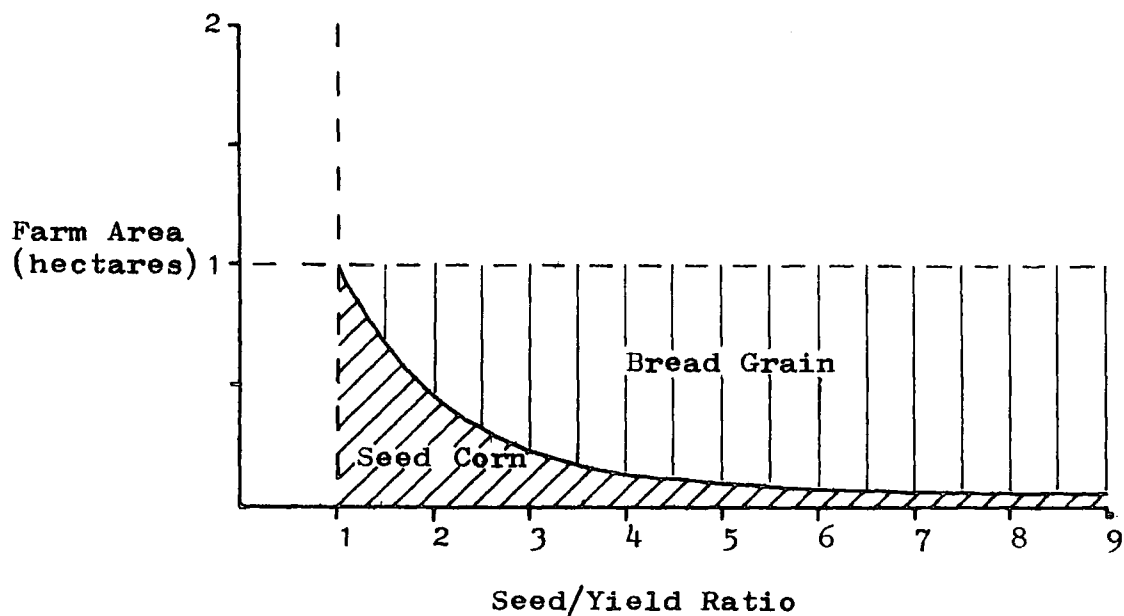
systems of political, social, and economic management, the environmental factor must become an important one. Slicher Van Bath (1963) points out that agricultural production before the 19th century was concentrated almost exclusively on self-sufficiency, i.e. providing food for the immediate household group. The balance between area of land used, the intensity of farming technique and size of the population was critical and fragile. Van Bath illustrates this relationship diagrammatically as follows: (p.9)



With settled cultural groups the area available for arable cultivation (A) was severely limited because of the need to manure the ground with either cattle dung or turf to maintain productivity. Farming technique was inherently conservative being passed-on through generations and changing only slowly. Since population level is mainly a function of the other variables it follows that the environmental factor is the major uncontrolled influence on the intensity of farming and related population levels. It is noted by Van Bath that a relatively small increase in seed sown relative to yield, (seed/yield ratio),

provides proportionately larger returns in the form of surplus production which in turn results in a growing population, increased investment in farming and a further increase in farming intensity. The effect is cumulative as illustrated below, with the greatest increase being after the initial increases in seed/yield ratio.

modified after B.H.Slicher
Van Bath (1963) p.20



Since early agriculture was constantly at the lower limit of the graph with much of the seed production being used for seed corn and the remainder consumed, the response to any ameliorating or deteriorating factor which increased or decreased yield would be rapid. In this way it is considered possible that climatic changes reflected in the

bog surface vegetation could have an important triggering effect on the intensity of early agricultural activity.

The actual balance between environmental, political, social, economic and technological factors in prehistoric farming remains a matter for speculation. The present data suggests, however, that the environmental factor connected with late Iron Age and Norman agricultural advances may be of considerable significance.

6.8 SUMMARY OF BLACK LOUGH CLEARANCE HISTORY

The periods of clearance (C), regeneration (R) and mixed clearance and regeneration (C/R) are shown diagrammatically in figure 31. The mixed C/R period represents a complex mosaic of regenerating and temporarily cleared areas approximately equivalent to Turner's (1965) concept of small temporary clearances. It is mainly associated with the Neolithic and Bronze Age periods. The tentative association of the clearance and regeneration phases with cultural periods is based on data discussed more fully in chapter 7.

- CHAPTER 7 -

REGIONAL CORRELATION OF THE BLACK LOUGH FLANDRIAN III
CLEARANCE HISTORY (ref. figures 1, 33)7.1 CORRELATION WITH OTHER POLLEN DIAGRAMS FROM THE REGION

Only one other study concerned principally with the impact of human activities on the vegetation, has been conducted in Northumberland (Davies 1978, Davies and Turner (1979). Davies (1978) examined four sites located near areas of prehistoric remains and established a series of radiocarbon dated clearance phases for three of the sites (Fell End Moss, Steng Moss and Camp Hill Moss). Camp Hill Moss is located on a Fell Sandstone ridge very similar in nature and elevation (205m O.D.) to the Black Lough site, and some 20km to the north near the village of Chillingham. In contrast with Black Lough, however, it is a relatively small bog occupying a depression in the boulder clay and would largely receive a local pollen catchment. Unfortunately, at this site the upper two dates in the period beyond the Iron Age are unreliable so it is not possible to establish an approximate chronology for Black Lough from this site. The essentially local record at Camp Hill Moss would also complicate any direct correlation. Of the other sites, Steng Moss would appear to offer the nearest comparison to Black Lough, being a large upland moss (305m O.D.) located approximately 30km

to the south west.

Other studies are based on sites well south of Black Lough in County Durham except for Bolton Fell Moss in Cumbria. Sites for discussion were selected on the basis of being sufficiently close to have some relevance to the clearance history at Black Lough and having sufficient radiocarbon dated clearance levels to allow chronological relationships to be examined. The variations in size, elevation and type of site analysed, and in local soil differences, are likely to produce considerable variation in local clearance history but the number and spread of sites is such that dominant regional patterns should become evident. The relationship between the principal clearance phases of the various sites is shown in figure 33.

7.1.1 The Elm Decline and Neolithic Clearance

Dates for the elm decline from lowland and moderate upland sites in north-east England appear to be closely synchronous around 5300b.p. to 5400b.p. (ref. figure 8). The one exception is the highland site at Valley Bog which stands out at some 500 radiocarbon years later than the lowland sites. This has been interpreted as the time taken for a new cultural group to spread from the lowlands to the highlands (Bartley et al 1976, Chambers 1978). Since the highlands would be influenced by increasing cold or wetness before the lowlands, rather than after, the

late date for the elm decline at Valley Bog largely eliminates climatic factors as a cause for the decline. There would seem little doubt then that the elm decline at Black Lough occurred around 5300b.p. in accord with sites to the north and south of the region.

The impact of Neolithic groups from the time of the elm decline is considered to be minimal at all sites examined. Except for the decline of elm, which is quite distinct in most diagrams, there is little evidence reported of significant clearance. The first Plantago lanceolata pollen appears soon after the elm decline at Hutton Henry and at Bishop Middleham at 5180 ± 110 b.p. A similar occurrence is found at Valley Bog together with a cereal-type pollen grain soon after the elm decline but little appears thereafter until a level estimated at 3300b.p. At Mordon Carr a continuous curve for P. lanceolata is recorded from 4543 ± 70 b.p. Agricultural indicator species are recorded in discontinuous curves from about the same level as the appearance of P. lanceolata, suggesting that minor and temporary agricultural clearances are being created in the forests, but with little general impact on the level of tree pollen.

No detailed study of the elm decline similar to that at Black Lough has been conducted at other sites in north-east England so it is difficult to establish whether the trends determined have a wider significance. There

would appear to be a definite decrease in oak pollen at the time of the elm decline at Bishop Middleham, Valley Bog and Hutton Henry but more detailed analysis would be needed to confirm this. The post-elm decline pollen record at Black Lough is generally similar to the other sites, with Plantago lanceolata appearing immediately above the elm decline, but then only intermittently together with other weed taxa for a considerable time. Peaks of charcoal and Gramineae, however, suggest continuing clearances of a temporary nature concerned principally with pastoral activity.

7.1.2 Bronze Age Clearance

Apart from scattered occurrences of weed type herbaceous taxa and minor fluctuations in the tree/shrub/herb ratios, there is no record of significant clearance activity that could be defined as a "phase of clearance" until about 3600b.p. Between 3688 \pm 60b.p. at Fell End Moss and about 2800b.p. at Neashem Fen most of the diagrams record limited short term clearances with herbs such as Rumex, Plantago lanceolata, Ranunculus and the occasional cereal-type pollen grain suggesting a shifting pastoral economy with limited grain cultivation.

The following table summarises the periods of limited clearance prior to about 2800b.p. recognised in the diagrams.

Specific clearance episodes - Bronze Age

Fell End Moss	3688 \pm 60b.p.
Steng Moss	3594 \pm 45b.p. 3015 \pm 45b.p.
Neashem Fen	3242 \pm 70b.p.

Periods of short temporary clearance - Bronze Age

Bolton Fell Moss	1440 BC to 840 BC (extrapolation from C. 14 dates)
Camp Hill Moss	3510 \pm 70b.p. to 3110 \pm 80b.p.
Hallowell Moss	3645 \pm 60b.p. to 2432 \pm 60b.p.

These clearances are all dated from early Bronze Age times suggesting that farming intensity did increase measurably at this time, possibly reflecting an improved technology and certainly resulting in an increased although variable population (ref. section 6.7). The changes tended to be gradual, with the specific periods of clearance at Fell End Moss and Steng Moss being limited to about 200 years duration (Davies and Turner 1979).

The impression of an increasing intensity of farming is heightened by the two notable exceptions to the patterns already discussed. At Bishop Middleham and Hutton Henry, major agricultural clearance begins at 3660 \pm 80b.p. and 3544 \pm 80b.p. respectively, and at Bishop Middleham in particular the landscape remains in a cleared form until the present day. While initial farming is mainly pastoral the emphasis at Bishop Middleham changes to cereal cultivation from 3360 \pm 80b.p. These two sites cast considerable doubt over the common conclusion that the forest

remained relatively undisturbed during Bronze Age times and that the small population of shifting pastoralists had little impact beyond temporary clearings. While the great majority of sites do indicate limited impact, it is likely that at particularly favourable locations, such as the well-drained sands and gravels and outcropping Magnesian limestone of Bishop Middleham, permanent agricultural settlements were established with relatively high local populations. Turner (1970) draws a contrast at the beginning of the Bronze Age, between the heavily cleared south-western chalklands of England, "and the whole of the rest of the country"(p.98). It would seem now that the contrast in Bronze Age clearance activities might be drawn more locally between particularly favourable sites in which agricultural settlement was relatively permanent and low intensity shifting agriculture in the surrounding regions. This question must now remain open until further research establishes a clearer pattern.

The coincidence of dates in the vicinity of 3500b.p. for the initiation of more significant clearance both of a temporary and more intense nature would suggest a general cultural movement, or period of technological innovation, at about this time. Comparison of this date with the range of Bronze Age radiocarbon dates listed in Burgess (1974) places it at the beginning of the transition between Beaker and later Bronze Age cultures. Walker (1966),

as quoted in Bartley (1976), also claims a period of more settled agricultural activity on the Cumberland lowlands between 1750 BC and 1400 BC which coincides closely with the observed situation in north-east England. On the basis of the above evidence it would seem reasonable to ascribe the period of increased clearance noted in the Black Lough diagram between 188cm and 166cm, (BL X (b)), (ref. figure 31) to this period. It is the first major clearance phase following the elm decline, which in all other diagrams begins from between approximately 3680b.p. and c.3300b.p. This coincidence of dated clearance events in the region, and its apparent correlation in Cumberland, would appear to represent an important Bronze Age cultural influx into northern England.

7.1.3 Early Iron Age Clearance

A coincidence of dates between about 2400-2800b.p marks the onset of a renewed period of progressively increasing clearance although still generally of limited proportions. Bishop Middleham remains the exception with high values of Plantago lanceolata and Gramineae and continuous curves for cereal-type pollen and various agricultural weed taxa extending from 3360 \pm 80b.p. to the top of the diagram. Most other diagrams indicate small scale farming from this period differing in scale rather than nature from the preceding Bronze Age. Dates for the onset of these early

Iron Age clearances are as follows:

Dates for Onset of Initial Small-Scale Iron Age Clearance

Bolton Fell Moss	840 BC to 160 BC (extrapolation from C.14 dates)
Neashem Fen	between 2488 \pm 75b.p. and 2850 \pm 60b.p.
Camp Hill Moss	2670 \pm 70b.p.
Steng Moss	2586 \pm 45b.p.
Hallowell Moss	2432 \pm 60b.p.

At Valley Bog and Hutton Henry during this period there are fluctuating clearance and regeneration periods with mixed cultivation and pastoral indicator herbs and occasional cereal-type pollen grains but no specific levels are dated. The main exception to the pattern of gradually increasing agricultural impact is at Fell End Moss where very little agricultural activity occurs after the early Bronze Age pastoral clearance. Herbaceous pollen remains at very low frequencies, no cereal-type pollen is recorded and Plantago lanceolata becomes discontinuous. This reflects the limited archaeological finds in the area suggesting that the south-west corner of Northumberland was less densely populated during the late Bronze Age and early Iron Age than other parts of the country (Davies and Turner 1979).

The Black Lough diagram indicates a distinct upsurge in clearance following the peak of proposed Bronze Age activity between 188cm and 166cm. The upsurge does not come as a single peak suggesting major change but rather a series of gradually increasing peaks resulting

in progressively increasing herbaceous vegetation and variable tree vegetation. This largely occurs after 144cm which coincides with the marked change in peat stratigraphy towards a damper bog surface. Ericoid pollen makes a dramatic rise at this point to over 50% and then progressively declines to low levels again. The rise is so closely associated with the change in stratigraphy that it would seem certain to be the result of autogenic processes linked with the changing bog environment, rather than with human influences. After 166cm Plantago develops a largely continuous curve and Gramineae and Pteridium percentages increase steadily. The continuously oscillating birch and hazel curves suggest a period of variable regeneration and clearance associated with agricultural activities, based on increasingly more permanent settlement. In this it reflects the pattern established at most other sites in the region.

7.1.4 Conclusion: Neolithic to Iron Age Clearance in North-east England

Except at Bishop Middleham and to a lesser extent Hutton Henry where exceptional agricultural conditions appear to have led to very early heavy clearance pressure, the approximately 3500 years between the early Neolithic and later Iron Age exhibits a surprisingly even development of farming intensity. The transition between Neolithic, Beaker, Bronze Age and Iron Age cultures is not marked

by massive increases in clearance pressure that the development in technology might be expected to produce. The increased agricultural activity seen generally between approximately 1700 - 1400 BC and 500 - 800 BC appears to represent an intensification of the same type of agriculture rather than a revolutionary change. The Black Lough vegetation record suggests a certain cyclic development of agricultural intensity, with periods of growing impact followed by a lull prior to the next upsurge (ref. figure 31). This could possibly be equated with the effects of developing agricultural technique and growing population during periods of cultural stability followed by depopulation and vegetative regeneration during periods of cultural displacement and then renewed clearance pressure as conditions stabilise. The fragility and sensitivity of the prehistoric farming-population-environment system (see section 6.7), would result in a rapid drop in both productivity and population following upon any disruptive influence on a particular aspect of the system. Such a disruption might be expected to result from the arrival of a new cultural group, especially if the acculturation process involved considerable conflict. It is tentatively suggested that the cyclic pattern of clearance referred to above is associated with the arrival of immigrant Neolithic, Bronze Age, Iron Age and a later Iron Age cultural groups into north-east

England leading to gradually increasing agriculture intensity.

7.1.5 Later Iron Age and Romano-British Clearance

The coincidence in time for the onset of the first heavy clearance at all sites except Bollihope Bog, Bishop Middleham and Hutton Henry, to the period 200 BC - AD 50, is striking. Hutton Henry has a second distinct period of heavy clearance associated in time with those above, and Bollihope Bog begins 100 years later. The dates for the onset of heavy Later Iron Age clearance are listed below:

Duration of Later Iron Age/Romano-British Clearance

	<u>Opening Date</u>	<u>Closing Date</u>	<u>Duration</u> (approx. C14yrs)
Valley Bog	2175 \pm 45b.p.	not established	--
Bolton Fell Moss	(est) 164 BC	(est) AD 465	629 (cal. yrs)
Stewart Shield Meadow	2060 \pm 20b.p.	840 \pm 100b.p.	1220
Thorpe Bulmer	2064 \pm 60b.p.	1148 \pm 60b.p.	916
Steng Moss	1970 \pm 60b.p.	1490 \pm 60b.p.	480
Hallowell Moss	1956 \pm 70b.p.	1355 \pm 50b.p.	601
Fell End Moss	1948 \pm 45b.p.	1330 \pm 40b.p.	618
Hutton Henry	1842 \pm 70b.p.	not established	--
Bollihope Bog	1730 \pm 100b.p.	not established	--

The two dated Northumberland sites show a remarkable similarity in the time of onset and duration of clearance,

beginning at about the time of Christ and extending for some 500-600 years. This clearly extends either side of the period of Roman occupation between approximately AD 80 and AD 410. The onset of clearance, therefore, must be the result of late Iron Age influence. This is demonstrated more clearly at Valley Bog, Bolton Fell Moss, Stewart Shield Meadow and Thorpe Bulmer where the onset extends back to at least 100 years BC.

The extent of clearance at this time is generally far in excess of that recorded for any previous period. It is clearly associated with an upsurge in population based on relatively permanent settlements and probably possessing more advanced agricultural skills and technology. Both arable and pastoral farming are involved in the period although a pastoral emphasis appears to be more general. The major exceptions are again Hutton Henry and Thorpe Bulmer where arable farming was important. At Thorpe Bulmer a remarkable rise in Cannabis pollen from 2064 \pm 60b.p. to reach 19% of total pollen by 1730 \pm 120b.p., together with cereal-type pollen, Centaurea cyanus, Artemisia, Polygonum aviculare, Cruciferae and Chenopodiaceae, indicates intensive arable farming in the area well before Roman occupation. At Stewart Shield Meadow at about the same time, tree pollen decreases to a level similar to the current day and there is a great rise in herbaceous species, as well as Calluna

and Pteridium. This suggests the first expansion of Calluna heath in the region. The herb taxa include high percentages of Gramineae, Plantago lanceolata, Compositae, and Ranunculus with some isolated cereal-type pollen. Pastoralism appears to be the main land-use together with limited grain cultivation. A similar pattern is seen at Hallowell Moss, Bolton Fell Moss and Valley Bog, where the rise in Calluna is extremely high reflecting both bog surface growth and a probable extension of regional heathland after clearance. The Northumberland sites of Steng Moss and Fell End, and apparently equivalent clearances at Broad Moss and Camp Hill Moss, show a heavy decrease in tree pollen, a sharp rise in Calluna and Pteridium, and increased percentages of Gramineae, Plantago lanceolata and Rumex all suggesting a predominant pastoral land-use. Minor occurrences of cereal-type grain were also recorded.

Davies and Turner (1979) suggest that much of the increased agricultural activity at this time is related to the political and economic stability resulting from the Roman military presence. Certainly Steng Moss and Fell End Moss have the latest dated onset of agricultural activity, but even allowing for the standard error of the dates the onset predates the arrival of Agricola's legions. Only Hutton Henry (approx. AD 108) and Bollihope Bog (approx. AD 200) could be explained in terms of a direct

Roman influence. All other sites clearly predate Roman influence by as much as 250 years at Bolton Fell Moss and Valley Bog, and 150-200 years at Stewart Shield Meadow and Thorpe Bulmer. A more likely explanation for such a sudden and extensive change in the pattern of clearance activity would seem to be the arrival of a new Iron Age culture with a more sedentary life style and advanced agricultural techniques. Turner (1979) arrives at a similar conclusion in explanation of greatly increased Later Iron Age agricultural activity. Bartley et al (1976) find this a likely explanation for the early upsurge of Cannabis cultivation at Thorpe Bulmer and note that Piggot (1958) suggests that refugee populations of southern Iron Age cultures arrived in northern England during the 1st century BC.

The general cyclic pattern of clearances observed in the Black Lough pollen diagram (ref. section 7.4) again suggests a short period of exceptional regeneration immediately prior to the rise in herb pollen associated with the first major clearance of the diagram. At 114cm Quercus rises from a general level of approximately 6% to 24.3%, Ericoid pollen drops to 5.9% and plantains and open-habitat herbs disappear (ref. figure 19). It is tentatively suggested that this represents a period of agricultural disruption resulting from the arrival of an immigrant Iron Age culture in the region, after which the

onset of greatly accelerated clearance activity begins.

On the basis of such a uniform pattern of heavy Late Iron Age clearance in north-east England it would seem almost certain that the equivalent rise in clearance activity at Black Lough is of this age. On the basis of the nearest dated sites at Steng Moss and Fell End Moss, this would suggest an onset date of about 2000b.p.

The nature of the clearance at Black Lough differs from that observed at other sites in that a distinct two phase pastoral/arable division is identified (ref. section 6.4.1). An early rise in Gramineae and Plantago lanceolata gives way at 94cm to a general rise in heath taxa and the first pollen grains of cereal-type and Cannabis, together with a range of agricultural weed taxa and low values of grasses and Plantago (ref. figure 28). The two phases are separated by a short period of regeneration principally of hazel and oak. It is tentatively proposed that the change in emphasis from a predominantly pastoral land-use to one involving greater grain cultivation after a brief period of regeneration is related to the arrival of Roman occupation in the area. The stimulus to grain production resulting from a nearby Roman garrison is likely to be considerable. It has earlier been suggested that the village of

Edlingham was the cause of a distinct diversion in the

Devil's Causeway (ref. section 2.6) and it would seem probable that provisions for the distant garrison were supplied locally (Barber 1978 p.119). A similar transition from pastoral to arable land-use associated with Roman occupation has been noted by Hicks (1971).

The period of high Romano-British agricultural activity in north-east England extends well beyond the time of departure of the Roman legions. This is particularly evident at Stewart Shield Meadow and Thorpe Bulmer where clearance levels are maintained until about AD 1100. The emphasis changes at Thorpe Bulmer from cultivation to pastoral land-use during this period indicated by rising values of Gramineae and Plantago lanceolata and decreasing Cannabis and cereal-type pollen. Roberts et al (1973) suggest some caution with the Stewart Shield Meadow diagram because of the extremely low rate of sedimentation (1cm in 150 years) calculated. They consider that a section of the core may have been eroded, although there was no stratigraphic evidence for this. The Thorpe Bulmer site would seem to have been exceptionally favourable for early agricultural activity which would explain its continuing heavy cultivation up to about AD 1100. Bartley et al (1976) note that the close of the period coincides with the punishing Norman raids on the northern regions which caused widespread devastation and a temporary cessation in agricultural activity.

All other diagrams date the close of the period of intense clearance to the period AD 500-600 some 100 to 200 years after the departure of the legions. Turner (1979 in press) considers that this implies a continuing economic and political stability well into the 6th century AD. On the basis of the above evidence, the close of the heavy clearance at Black Lough is tentatively placed at AD 500, following the date at Steng Moss. The actual date of abandonment of the garrison near Edlingham is not known but it is most likely to be well before the final withdrawal of Roman legions from England in the early 5th century.

7.1.6 Early Medieval Vegetation Regeneration

The number of radiocarbon dates available for sites from north-east England becomes quite limited after the Romano-British period. Bolton Fell Moss provides the only comprehensive record, although the opening of most periods at this site is estimated on the basis of extrapolation from radiocarbon dates. Steng Moss and Fell End Moss have a number of dated clearance phases after the Roman period and dates are estimated for the upper clearance levels at Hallowell Moss, Stewart Shield Moss and Bollihope. At Bollihope two radiocarbon dates are also available just below the final level of clearance.

Period of Early Medieval Regeneration:

	<u>Opening</u>	<u>Closing</u>
Bolton Fell Moss	(est)AD 465	(est) AD 1050
Steng Moss	1490 \pm 60 b.p.	1085 \pm 35 b.p.
Fell End Moss	1330 \pm 40 b.p.	945 \pm 40 b.p.

The dates above suggest that for between 400 and 600 years following the Romano-British period, agricultural activity and therefore also population levels, diminished significantly. Tree pollen at Bolton Fell Moss recovers to 70% of non-mire pollen, and grasses drop below 20%. Agricultural indicator herbs such as Artemisia, Plantago and Compositae reduce in percentage although a discontinuous cereal-type curve is maintained. At Steng Moss and Fell End Moss cereal-type pollen disappears, grasses and weed taxa reduce, tree pollen increases and Calluna declines markedly. The series of changes at the three sites are essentially similar suggesting that agricultural depression was widespread over northern England between about AD 500 and AD 1000.

Historically, the period in northern England was a time of continuing social and political instability involving plagues, internal warfare and the constant threat of raids by the Picts and Scots. The one period of relative stability came during the 8th century when Anglian authority became established and there was evidence of internal peace and a period of cultural

development. It was not until after about AD 1100, following the ruthless imposition of Norman authority during the so called "Harrying of the North", that a rapid economic and social recovery came about. From about that time right across western Europe there was an extraordinary agricultural recovery which continued for approximately 200 years.

There can be little doubt that the period of regeneration in the diagrams discussed above reflects to varying extents the period of economic and political instability of the early Medieval period. This same pattern is seen clearly in the Black Lough diagram between 84cm-48cm (BL XI (c)) following the first period of intensive clearance. It is therefore tentatively dated to the period AD 500 to AD 1100 in accord with the historical evidence and dates from other sites in the region. The details of vegetative recovery during this period are discussed in section 6.4.2, but it is of interest to note that a distinct temporary clearance peak occurs in the centre of the zone at 66cm (ref. figure 19). Gramineae and open-habitat herb values rise temporarily and Betula decreases. In contrast to this the following sample at 62cm shows herb pollen reduced to a zone minimum of 1.4% and trees recovered to 33.7%. A similar pattern is seen in the Bolton Fell Moss diagram 5cm above a level dated to 765 ± 60 AD.¹

1. Radiocarbon terminology as used by Barber 1978.

The possibility exists that these changes in the pollen record relate to the period of internal peace during the 8th century followed immediately by an upsurge in disruption due to the Viking and Scottish raids after AD 850.

7.1.7 Clearance and Regeneration AD 1100 to the Present (ref. figure 34)

The small number of dated levels available from sites in the region after c. AD 1100, restricts the development of a meaningful regional correlation. Nevertheless, there is some evidence of two significant periods of clearance centreing around AD 1100 and AD 1800, separated by a further period of regeneration.

	<u>Clearance-AD 1100</u>	<u>Clearance-AD 1800</u>
Bolton Fell Moss	(est)AD 1050-AD 1380	(est)AD 1640-AD 1895
Hallowell Moss	-----	(est)AD 1600-AD 1800
Steng Moss	-----	est. peak 1825
Fell End Moss	(peak)945 \pm 40b.p.	434 \pm 45b.p. to present
Stewart Shield Meadow	-----	est. peak 1815
Bollihope Bog	-----	prior to 170 \pm 80b.p. 80 \pm 80b.p. to present

At Bolton Fell Moss and Fell End Moss a distinct and brief period of clearance takes place from about AD 1050. At Bolton Fell Moss tree pollen drops to c.35% and the pollen of Gramineae, Cereal-type, Plantago, Rumex,

Compositae and Artemisia rise to levels equivalent to the Romano-British period. A similar pattern is seen at Fell End Moss. Following this brief period of intensive mixed arable/pastoral agriculture, tree pollen again recovers to its previous level and Gramineae, Plantago lanceolata, Rumex, Artemisia and Compositae decrease. Cereal-type pollen disappears from both diagrams.

The period of agricultural advance after c.AD 1100 noted at Bolton Fell Moss and Fell End Moss, is almost certainly related to the more stable political and economic conditions following the Norman conquest and reflected in a general period of stability and agricultural prosperity across western Europe (ref. section 6.4.3). The strongly contrasting period of regeneration following the renewed clearance would also seem to correlate with the widespread famine and death resulting from poor harvests and plague during the 14th century. In the north of England the 14th century was also a time of internal conflict with raids from the Scots and constant threat from moss troopers and rievvers. This is reflected in the concentration of fortified peles and bastle houses which reached their peak during the later 14th and 15th centuries (ref. section 2.7).

The period of agricultural readvance which appeared to begin about AD 1600 and reached its peak at approximately

AD 1800, is reflected in several of the pollen diagrams from the region. Bolton Fell Moss records a minimum tree percentage for the diagram at a level estimated to AD 1785 and at Hallowell Moss tree pollen falls to approximately 3% at a level estimated to the 17th century. From this point in both diagrams tree pollen increases, probably reflecting increased plantings on estates during the 18th and 19th centuries. Pine in particular rises from about 1800, and this particular level is so well defined that it is employed as a marker by Barber (1978). At the same time grasses, Calluna, cereal-type pollen and agricultural weed taxa rise to maximum values. At Bolton Fell Moss this level is dated to AD 1800. At the Northumberland sites, Bolton Fell Moss and Hallowell Moss, there is a decline in cereal pollen towards the top of the diagram, while grass levels remain high. This has been interpreted as a gradual change in regional land-use from an emphasis on grain cultivation during the 18th century to the mixed pastoral arable agriculture of the present day, in response to changing market conditions (Davies and Turner 1979, Donaldson and Turner 1977).

The Black Lough pollen diagram displays a similar pattern to the alternating series of vegetative changes between the 12th century and the present day described above (ref. figure 34). The period of clearance at

Black Lough tentatively related to the agricultural expansion of the Norman period, (BL XII (a) 48cm-36cm ref. section 6.4.3 figure 29), would appear to have considerably greater impact on the vegetation than that observed at Bolton Fell Moss and Fell End Moss. This may reflect the more easterly, near-coastal location of the Black Lough region, and its closer association with the great upsurge in agriculture experienced generally in western Europe at this time. The period of vegetation regeneration following is not as strongly developed compared with Bolton Fell Moss and Fell End Moss, (ref. section 6.4.4) although agricultural indicator herbs do decline and cereal-type pollen disappears. At Black Lough, tree pollen fails to rise over 15.3% during this period although the high level of Calluna pollen, derived at least partially from the bog surface, probably depresses the tree percentage. A more meaningful maximum figure for tree pollen of approximately 35% is derived from the non-Ericoid pollen sum. This is still well below the 80% of non-mire pollen recorded at Bolton Fell Moss and approximately 43% at Fell End Moss. The final major rise of herbaceous pollen and decrease of tree pollen at Black Lough, (BL XII (c) ref. section 6.4.5), follows a similar pattern to that recorded at several other sites in the region. An initial minimum tree percentage coincides with the last high cereal pollen

level, after which tree pollen, in particular pine and elm, increases towards the surface and indicators of cultivation decrease.

7.2 CORRELATION WITH HISTORICAL DATA

As a further means of testing the tentative chronology placed on the Black Lough clearance history it was decided to compare the A.P. curve with a "curve" representing variation in socio-economic factors since the Roman occupation. This is based on the assumption that the pattern of agricultural expansion will be closely tied to the prevailing socio-economic conditions. Since clearance pressure is related to agricultural expansion a match between the clearance curve and the socio-economic curve should represent a confirmation of the clearance chronology. The validity of the exercise depended on the accuracy of the determination of the socio-economic curve. In this aspect I am indebted to Dr. B.K. Roberts who kindly agreed to draw up an economic expansion/contraction chart since AD 80 based on his own extensive experience and the available literature. It is emphasised that, while extensive discussions were held between Dr. Roberts and myself concerning post-Roman land-use history, the economic expansion/contraction chart was drawn-up entirely independently and without any prior knowledge of the pollen diagram. The two charts were compared only after the

cultural sequence already described had been determined.

The resultant correlation (ref. figure 35) proved to be surprisingly close with only minor areas of disagreement between the two curves. All major increases and decreases in the A.P. curve relate closely to major contractions and expansions in the socio-economic chart. The essential incompleteness of the economic data disallows an actual curve to be drawn for economic conditions. Nevertheless, taken at the appropriate level of generalisation, the match is quite remarkable and far more complete than was thought likely to result in view of the possible sources of error. It adds support to the cultural scheme proposed for the Black Lough diagram and at the same time provides a possible insight into the factors leading to clearance and abandonment of agricultural land in the region.

7.3 CONCLUSIONS

1. The present availability of radiocarbon dated pollen diagrams from north-east England is sufficient to establish a regional correlation of clearance history for the Flandrian III up to the end of the Romano-British period. This correlation is summarized in figure 33.

2. After the Romano-British period, the limited number of radiocarbon dates and detailed pollen

analytical data, prevents the development of a comprehensive regional synthesis of clearance history. A tentative regional correlation based on available dates and historical evidence is presented in figure 37.

3. The close match between the Black Lough clearance history and the regional clearance history of north-east England allows a tentative chronology to be placed on the major clearance periods represented in the Black Lough diagram. This chronology is summarized in figure 33.

4. The degree of correlation between the A.P. curve and an independent assessment of social and economic forces acting since AD 80, provides further support for the Black Lough clearance chronology.

- CHAPTER 8 -

CONCLUSION

The Black Lough pollen diagram provides a continuous record of regional environmental history from Late Devensian III to the close of Flandrian III. The vegetational history closely parallels that of Din Moss and Linton Loch, suggesting a relatively uniform region of vegetational development in north-east England and the Borders during the Flandrian. Correlation with the chronostratigraphic units of Din Moss has enabled an approximate chronology to be placed on the major vegetational changes recorded at Black Lough.

The impact of man on the vegetation at Black Lough is first detected at the Flandrian I/II transition which is dated at Din Moss to 6710 \pm 100b.p. Since the pollen record at Black Lough is largely regional, it is likely that Mesolithic communities were active over a considerable area of the upland region around Black Lough. This is supported by the excavation of a Mesolithic microlith, scraper and borer together with 30 flint fragments from a ridgetop rock shelter approximately 1km from the sampling site. The initial rise of heath coincides with evidence for the first opening of the forest cover and is attributed to Mesolithic activity. The very sudden decline of Pinus pollen is also considered to be at least

partially the result of Mesolithic firing and felling in the vicinity of the Lough. It coincides with high charcoal levels, a general decline in tree concentration and a rise in Ericoid and Pteridium values.

The continuing influence of Mesolithic activity in the region extends up to the Flandrian II/III transition. Detailed analysis of the boundary zone indicates that the period probably represents the complex interaction of late Mesolithic and/or pioneer Neolithic communities. This is reflected in a steady decrease in elm pollen concentration and to a lesser extent other tree species, and a steady rise in herb pollen towards the end of Flandrian II. This pattern is interpreted as the result of limited clearance and selective lopping of elm branches by an early pastoral group not directly equated with a Neolithic economy. The subsequent temporary recovery of elm and other tree taxa prior to the final decline of elm is interpreted as the period of displacement of the late Mesolithic/pioneer Neolithic community by a more advanced immigrant culture.

The traditional view of the Elm Decline as an isolated event involving the selective decline of elm pollen only is not supported. Oak, in fact, declines in parallel and to a greater extent than elm, although elm is apparently eliminated from the local vegetation community. The decline of elm at Black Lough is

associated with a series of complex vegetational changes extending over an estimated period of at least 500 years. These changes are set in motion during late Flandrian II and extend into early Flandrian III. They fall into three phases which do not correspond in a direct way to Iversen's Landnam stages. The characteristics of the three phases are as follows:

Phase A: Initial elm decline, increase of heath, first open-habitat herbs.

Phase B: Initial forest recovery and subsequent rapid decline of elm and oak. Rise of heath to high values. Open-habitat herbs increase and charcoal is recorded at a high level.

Phase C: Maximum area of clearance represented by generally low tree pollen, in which oak drops to its lowest value, and first appearance of Plantago lanceolata. Fluctuating birch, hazel and Gramineae levels indicate a regeneration complex. Mainly pastoral land-use. Generally high charcoal levels. Partial forest recovery towards the close of the zone.

There is some indication of a period of low sedimentation rate during the early phase B evidenced by uniformly high pollen concentrations. While this contains the possibility of climatic change immediately prior to the decline of

elm and oak, it is considered that the overall pollen evidence strongly supports an anthropogenic explanation for the vegetational changes.

The vegetational history between the elm decline and the first major clearance, represents a period of gradual and continuous land-use intensification. While there is a suggestion of cyclic clearance activity which has been tentatively associated with the arrival of Bronze Age and Iron Age cultures, the overall pattern is one of continuity of land-use. It would appear that over a period of approximately 2,500 years, occupation of the Black Lough region was relatively continuous, involving progressively more permanent agricultural communities and a gradually increasing level of farming intensity and population. The great upsurge in clearance associated with the pre-Roman Iron Age, and continuing through and beyond the time of Roman occupation, represents the first major change to the pattern of clearance established at the opening of Flandrian III. This Iron Age upsurge in clearance is broadly synchronous across north-east England, although earlier heavy Bronze Age clearance occurs at sites in two particularly favourable agricultural areas. At Black Lough the first major clearance period appears to consist of a phase of pastoral agriculture succeeded after a short period of regeneration by mixed farming with increased emphasis on grain

cultivation. This sequence is tentatively associated with the impact of the Roman legions arriving in the region and the increased local demand for grain associated with the nearby Roman fort and growing civil settlement. Population levels during the approximately 500 year period of intensive agriculture could be expected to reflect the great rise in agricultural productivity since the bulk of production was used to maintain the farm/household unit.

A clear regional picture of clearance history is lacking after the Romano-British era in north-east England. The Black Lough diagram provides a sequence of clearance and regeneration phases which relates closely with historical trends and matches with the limited pollen data for this period available from other sites. It appears to provide a clearance sequence for the post-Romano-British period which is of reference value for the region. A lengthy period of agricultural recession, indicated by marked vegetation regeneration, followed the extensive clearance of the Romano-British period. This was probably related to the political, social and economic instability of the early Medieval period. The agricultural recession abruptly ended at a point equated with Norman times, approximately AD 1100. Cereal pollen reappeared and tree pollen dropped rapidly to its lowest level for the entire diagram. Historical data indicate

that the number of rural tenants and general density of rural population reached levels at this time higher than at the present. This is reflected directly in the degree of clearance recorded and suggests a close relationship between rural population and the level of agricultural clearance indicated in the pollen diagram. This pattern is reflected in the following period of rural depopulation associated with the Black Death, famine and further border trouble when revegetation again proceeded, although at a level somewhat lower than might be expected. It is concluded that this represents a lower level of rural depopulation in the Black Lough/Edlingham region than neighbouring districts, and also reflects the effect of extreme clearance during the 200 years preceding.

The modern period is represented by a relatively moderate depression of the tree pollen curve, due largely to the growth in tree plantations since the 18th century. The tree pollen curve reaches a minimum level before the top of the diagram at a point where Gramineae and cereal pollen are at a peak. This point is equated with the early 19th century when arable farming reached its peak as a result of the Napoleonic wars and general agricultural improvements. The top levels of the diagram record a rise in tree pollen and a disappearance of cereal pollen which probably relates to the change in the rural economy

of northern Northumberland towards a pastoral base and the continual increase in the area under tree plantations.

Population and Environment

The history of cultural impact on the vegetation of the Black Lough region over the last 7000 years is essentially the record of the increasing ability of man to exploit his environmental resources and support his population. This is particularly true up to at least the 18th century when the bulk of the population remained dependent upon the immediate production of the farm on which they lived or worked. The concept of a delicately balanced equilibrium between environment, population, farm area and technical skills advanced by Van Bath (1963) is helpful in understanding the manner in which population must have varied constantly in response to changing conditions. It is clear that population would not increase independently except as a response to improvement in one of the other variables, such as climatic amelioration or technical innovation, which would allow greater agricultural production. Once a major movement of population and increased exploitation got under way it is likely that it generated a degree of self-sustaining inertia which was only checked when population exceeded the ability of the farm to continue exploiting the environment. Such a situation appeared to have been reached at the close of

the period of Norman agricultural expansion, when use of marginal lands and over-fragmentation of land holdings led to rapid rural depopulation as soils deteriorated and harvests failed. This preceded the main effect of the Black Death which continued the reduction in population.

In his essay on the impact of cultures upon the landscape, Fowler (1978) considered that the level of population is basic to the degree of environmental impact. The essence of the Fowler hypothesis is that population level is a direct indicator of environmental impact. Using existing population estimates for the 4th-2nd millennia BC (Atkinson 1968, 1972), and the "absolute" level of 1086 AD established by the Domesday Survey, Fowler makes estimates for the intervening periods to establish a population curve for southern Britain from 3000 years BC to the present. He considers that there is now evidence to estimate a peak Romano-British population of around 3 million which drops (in southern England) to $1\frac{1}{2}$ million by 1086, when it again begins to increase. The resultant graph (ref. figure 38) provides a demographic model against which the history of landscape impact might be compared.

Using Fowler's assumption that the level of impact is directly related to population, a curve has been drawn using the A.P. (excluding Ericoid) curve and estimated cultural periods from the Black Lough pollen diagram. The vertical

scales of the two graphs have no relationship to each other, other than to indicate higher or lower values at particular dates.

The interesting feature of the graphs is the very similar general trends shown in both. Since one is derived from population data directly and the other from changes in arboreal pollen percentages, it is quite remarkable that the curves are so similar. This suggests that there is indeed a close relationship between population level and clearance history as Fowler claims. The main conclusion to be drawn from the comparison is that population trends, and presumably clearance and regeneration trends, are similar at a general level between southern and northern England. There is a suggestion that the major peaks of clearance and regeneration in northern England are delayed by some 200 years from those in the south and that the contrasts between periods of clearance and regeneration are greater. The period of regeneration following the Romano-British clearance appears to be particularly well-developed suggesting major economic recession in northern England in early Medieval times. This may be a reflection of the northern location of Black Lough which rendered the area most susceptible to border warfare during this period. The onset of regeneration following the Norman agricultural period is also very rapid suggesting a very sudden rural

depopulation but to an ultimate level less than half of that reached during the early Medieval period.

8.1 PERSPECTIVE, CONSPECTUS, FUTURE RESEARCH

The current study is concerned with the vegetational history of an area of northern Northumberland within the context of the vegetational history of north-east England. In analysing the pollen record it became clear that for approximately the last half of the period under investigation it was the impact of man which was becoming the major control on vegetation development. Whereas this impact is relatively limited until about 500 BC it progressively becomes the most dominant influence from that point on. The nature of the Black Lough site, being a regional pollen catchment, meant that detailed clearance history or small scale events, were difficult to detect. But in filtering out the detailed effects it served to bring into focus the more general impact of man on the regional vegetation of the area. This is perhaps a more valid viewpoint from which to assess clearance history since it is the summation of individual clearance events which is being recorded, rather than one, perhaps exceptional, local clearance episode. For this reason the results of the study have relevance of a more general nature and provide insights into the manner in which landscapes are modified by the actions of man.

The techniques of analysis used in the study were generally adequate to achieve the desired aims. Ideally, much larger pollen counts at closer intervals would provide better data but the length of the core and the time available prevented any improvement in this area. The use of absolute pollen data in the form of pollen concentration values was quite indispensable in achieving the depth of analysis required to clarify many parts of the diagram. The basic means of analysis has remained the percentage diagram but at many points this obscured rather than clarified the actual relationship between taxa. Caution needs to be shown, however, when using concentration values to establish relationships over a number of levels since sedimentation rates may vary considerably. Pollen influx data are the only effective solution to this problem. The use of a computer programme to carry out rapid initial sorting, multiple pollen sum calculations and to plot summary pollen diagrams was a valuable aid, particularly when embarking on the initial analysis of results.

As the study progressed a number of areas of future research became evident:

1. Mesolithic clearance history

This theme has been completely neglected in Northumberland pollen diagrams. A close sampling interval is required and ideally a pollen catchment of more local

character than at Black Lough. Nevertheless, it is likely that the Black Lough site, being close to a Mesolithic rock shelter, would produce more information on Mesolithic land occupation with close sampling below the level of the Elm Decline. Of particular interest is the section of core between approximately 400cm-266cm where minor indications of forest opening were detected (ref. section 6).

2. Local vegetational history in the Black Lough/
Edlingham region.

The original intention of this thesis was to compare the local and regional vegetational history in the vicinity of Edlingham. The present study has established the prolonged period of human occupation in the region and the nature of regional vegetational change. It would be of great interest now to determine local vegetational change within this general region particularly in association with a known or likely location of ancient settlement.

3. Post Romano-British clearance history.

This period of clearance history is generally inadequately documented in north-east England. There is a need for more detailed, dated pollen diagrams of this period before a meaningful regional synthesis of human

impact can be developed.

4.

Late Devensian

Only two specifically Late Devensian studies have been conducted from sites in north-east England. There is a need for greater palaeobotanical documentation of this period.

5.

Survey of study sites

As a matter of considerable importance, a survey of the location, type and research potential of sites suitable for palaeocological research should be conducted in north-east England. Many sites are actively being drained and little is known of their potential for research.

6.

Absolute pollen data

Very few pollen diagrams are available from sites in north-east England using absolute pollen data. The present study confirms the considerable benefits to be obtained from the use of such data in determining vegetational history and in particular the effects of human impact.

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