An investigation into the recent vegetation history of Great Wood, near Eggleston Co. Durham using fine resolution pollen analysis of Mor humus and relevant historical evidence.

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An Investigation into the Recent Vegetation History of Great Wood, near Eggleston Co. Durham using Fine Resolution Pollen Analysis of Mor Humus and Relevant Historical Evidence.

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A Dissertation Submitted in Partial Fulfilment of the Requirements for the Degree of Master of Science.

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ABSTRACT

This study investigated the recent vegetation history of an ancient woodland, Great Wood, near Eggleston Co. Durham which has been part of the lands of Eggleston Hall since at least 1614. Mor humus was extracted from two sites within the woodland canopy and consecutive 1cm samples were analysed from each sediment. The reasons for this fine resolution sampling was firstly, because the soil profiles were only between 14-20cms and only represented a time scale of a few hundred years, and secondly to provide fine temporal resolution to correspond with the fine spatial resolution obtainable under a closed canopy.

Sediment analysis was undertaken to investigate the stratification of the soil in order to identify signs of disturbance. Mor # 1 proved to be highly stratified, whereas as mor # 2 was less stratified, possibly disturbed and had signs of charcoal at the lowest levels. It was therefore concluded that mor # 2 only represented part of the time scale that mor # 1 illustrated, as it was a more recently formed humus, the earlier part having been burnt away.

An absolute time scale was not used but a relative time scale was assigned using documentary and anecdotal historical evidence. This took into account the development of the nearby village and the social and economic changes of the region, and also the association of the woodland with Eggleston Hall and the consequent utilisation of the woodland for timber and recreational purposes.

The pollen record of mor # 1 was thought to represent the vegetation history from approximately 1750 to the present time, whereas the pollen record of mor # 2 shows the vegetation history from the late nineteenth century onwards. This time scale was deduced from the following:

1. There were signs of a more open canopy, due to a greater proportion of herb pollen to tree pollen, and evidence of pollen representing a more regional source area such as *Triticum* and possibly *Calluna.* This was thought to represent 1750-1820 when tillage increased in importance and there were reports of arable activity in the adjoining townfield probably causing a reduction in grazing pressure in the wood and allowing regeneration. This was promoted by the Enclosure Act in 1785, an attempt to establish mineral rights and to make the dales more commercially viable for agriculture and was a result of marginal land being used for tillage during the Napoleonic wars. However, signs of succession and canopy closure began to develop and there were also some signs of management deduced from *Fagus*

pollen appearing and documentary evidence of the path construction through the woods.

2. The herb pollen to tree pollen ratio began to fall and canopy closure continued but was not thought to be complete, due to selective management and extraction of timber. The disappearance of *Triticum* was believed to be due to a change in agricultural trends. *Fagus* pollen which was quite significant, disappeared abruptly due to the trees in the vicinity of the site being removed.
3. Complete canopy closure shown by a consistently high tree pollen to herb pollen ratio with *Quercus* dominating, arose when management of the wood was abandoned in the 1920's.

The fine resolution obtained, both temporally and spatially, demonstrated that mor humus was a useful medium for pollen analysis and with consideration of the underlying principles and mechanisms, meaningful interpretation of the pollen record was possible. Problems encountered with extraction of samples and during processing were discussed.

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1. INTRODUCTION

1.1. The Overall Aims of the Study.

The objectives of this study were to determine, using fine resolution palynological techniques, the recent vegetation history of a woodland site and to look for the occurrence of anthropogenic indicators and other evidence indicative of human activities. Local and regional documented historical evidence and recent regional vegetational history were utilised to determine a relative time scale. In addition, this study aimed to evaluate the use of mor humus as a medium for fine resolution pollen analysis.

To achieve these aims, firstly a suitable site was selected. Great Wood situated in Teesdale on the steep banks of the River Tees, down stream from Eggleston proved to be very suitable. It is an ancient woodland with SSSI status. A review of the history of the adjacent village (Alexander, 1972) indicates that at least since 1614 the wood has been part of the demesne lands of Eggleston Hall.

After careful examination of the wood, two sites were chosen where mor humus had accumulated to a depth of 15-20cms. Pollen analysis included the extraction and examination of pollen from both sediments at consecutive 1cm intervals. Results were then analysed using the software package Tilia 1.10 and Tilia*graph 1.17 (Designed and written by E.C. Grimm). Sediment analysis was also undertaken following the Troels-Smith sediment description system and in the form of loss on ignition (L.O.I.) tests and macrofossil analysis.

Interpretation of the results showed that previously this part of the wood appeared to have a more open canopy than today and that it went through a number of successional stages involving changes in the relative proportions of tree species. There was evidence of management and it was possible to equate features in the pollen diagrams with historical events. Therefore, this wood which is considered to be an ancient woodland, has not escaped human interference. It was possibly grazed in the past and was managed from around the mid eighteenth century until approximately 70-80 years ago. The results also illustrated the importance of analysing more than one sediment from the woodland site, and how analysis of the sediment goes hand in hand with pollen analysis in order to verify the pollen record.

The mor humus was difficult to work with but showed good resolution and reasonable preservation of the pollen grains. Some improvements in the methodology have been suggested.

1.2. Description of the Sample Site: Great Wood, Upper Teesdale.

Great Wood which adjoins the village of Egglestone in Teesdale Co. Durham (Figure 1), is considered to be an ancient woodland and has SSSI status (first notified in 1975).

Ordinance Survey sheets:	1: 50,000 - 92
	1: 10,000 - NZ 02 SW
Grid reference no.	NZ005217

It lies at an altitude of between 170m-220m (550ft-720ft) and has an area of 63.35ha (156.5 acres) and a mainly west aspect.

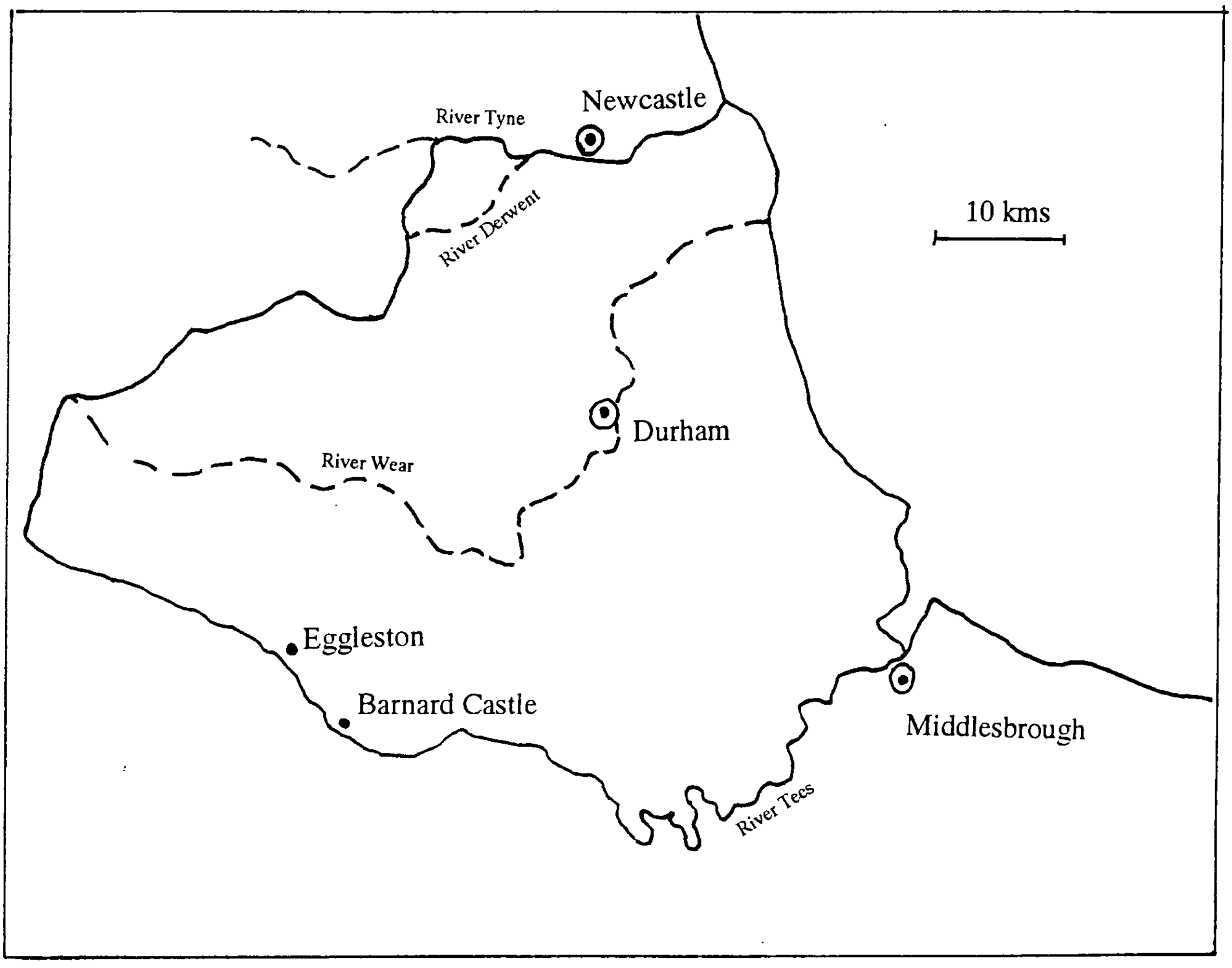


Figure 1: The Location of Eggleston in County Durham.

The wood is situated on the eastern bank of the River Tees, on the steep slopes, cliffs and boulder screes of a ravine cut by the river through the underlying limestones, sandstones and gritstones. It is protected from surrounding farmland by a stone boundary wall and forms part of the demesne lands of Eggleston Hall. The majority of the wood has been recorded as demesne haughs or riverside meadows since 1614 (Alexander, 1972).

Physical Description.

GEOLOGY

The underlying geology of the area consists of Millstone grit. This is described as "sandy deltaic beds with thin limestones" (Johnson 1970). It is a combination of limestone bands with thick shale and sandstone sequences and also coal seams, in a roughly cyclical sequence. The alternating beds have produced a number of structural terraces which are illustrated at Eggleston and utilised for settlement and cultivation. Also, where the river passes over more resistant beds there is a return to a gorge profile which restricts access to the river and has prevented the development of any sizeable area of river meadow. (Geological Survey, Barnard Castle 1969; Dunham and Hopkins, 1958; cited by Alexandra, 1972). At Great Wood, there are steep slopes of limestone in the northern part of the wood forming small cliffs and patches of stabilised block scree, whereas the southern part of the wood is dominated by sandstone and to a lesser extent boulder clay (Figures 2 & 3 - After the Geology Survey of England and Wales (1974), Ordnance Survey Sheet 32 (1: 2 500)).

SOILS

The nature and the distribution of the soils in northern Britain has been most severely influenced by the Weichselian or Devensian glaciation. Glaciation opened out the dales and also accentuated the differential nature of the material of the underlying rocks (Dwerryhouse, 1902; cited by Alexandra, 1972). The distribution of soil types is related to not only solid geology but also to deposited glacial drift. Frequently in upper Teesdale, glacial drift masks the solid geology and therefore the parent material of the soils is not solid rock but is glacial drift composed of a variety of the aforementioned rocks. Thus the distribution of soil types depends to a large extent on topography as this determines whether the surfaces have been eroded or subject to deposition (Johnson 1978). As the geological maps indicate, the solid geology of the majority of the site is not overlain by glacial drift and the geological variations this produces gives soils with a wide range of base status and drainage (Kirby, 1983). The Soil Survey of England and Wales (Sheet 1: The Soils of Northern England, 1983. 1: 250,000) describe the soils in the area occupied by Great Wood are described as "typical brown earths", which are non alluvial loamy soils with a non calcareous sub soil, without significant clay enrichment. A larger scale map may be more precise and provide better resolution, but was not available.

CLIMATE

The climate in Teesdale is closely related to its topography (Raistrick, 1968). By virtue of it's location, at right angles to the north-south axis of the Pennines, County Durham receives a sheltering effect from the Pennines but is directly effected by the influence of the North sea. Therefore the overall climate of the north-east is colder and drier. However, there are marked differences in local climate along an east-west gradient from coastal areas to the Pennine uplands due to the change in altitude (Smith, 1970).

As stated, County Durham is generally sheltered by the Pennines from the prevailing western circulation, but hills and coasts tend to be very breezy. There are higher wind velocities in the Pennines than in the lowlands but the wind on the coast is of a more constant nature (Smith, 1970).

The amount of precipitation is very variable from year to year and in terms of the number of rain days. However, there is an average of 686mm (27 inches) of rain in coastal areas increasing gradually to an average of 1650mm (65 inches) at high altitude western locations (Graham, 1988). The precipitation in the proximity of Eggleston has been estimated at 875-1125mm (35-45 inches) (Hydrological Survey, 1961; cited by Alexandra, 1972).

County Durham has a low mean annual temperature (122 year mean temp of 8.3 °C), due to the marked decrease in temperatures with an increase in altitude in the west and the cooling influence of the North Sea (Smith, 1970). The growing season at the altitude where Eggleston is situated, (the period where consecutive daily mean temperatures are above 5.5 °C) is approximately 200 days from the beginning of April to the second week in November (Raistrick 1968). In addition, at this altitude there is less affect from the "haar" or mists which in coastal regions decrease the amount of sunshine hours appreciably (Smith, 1970).

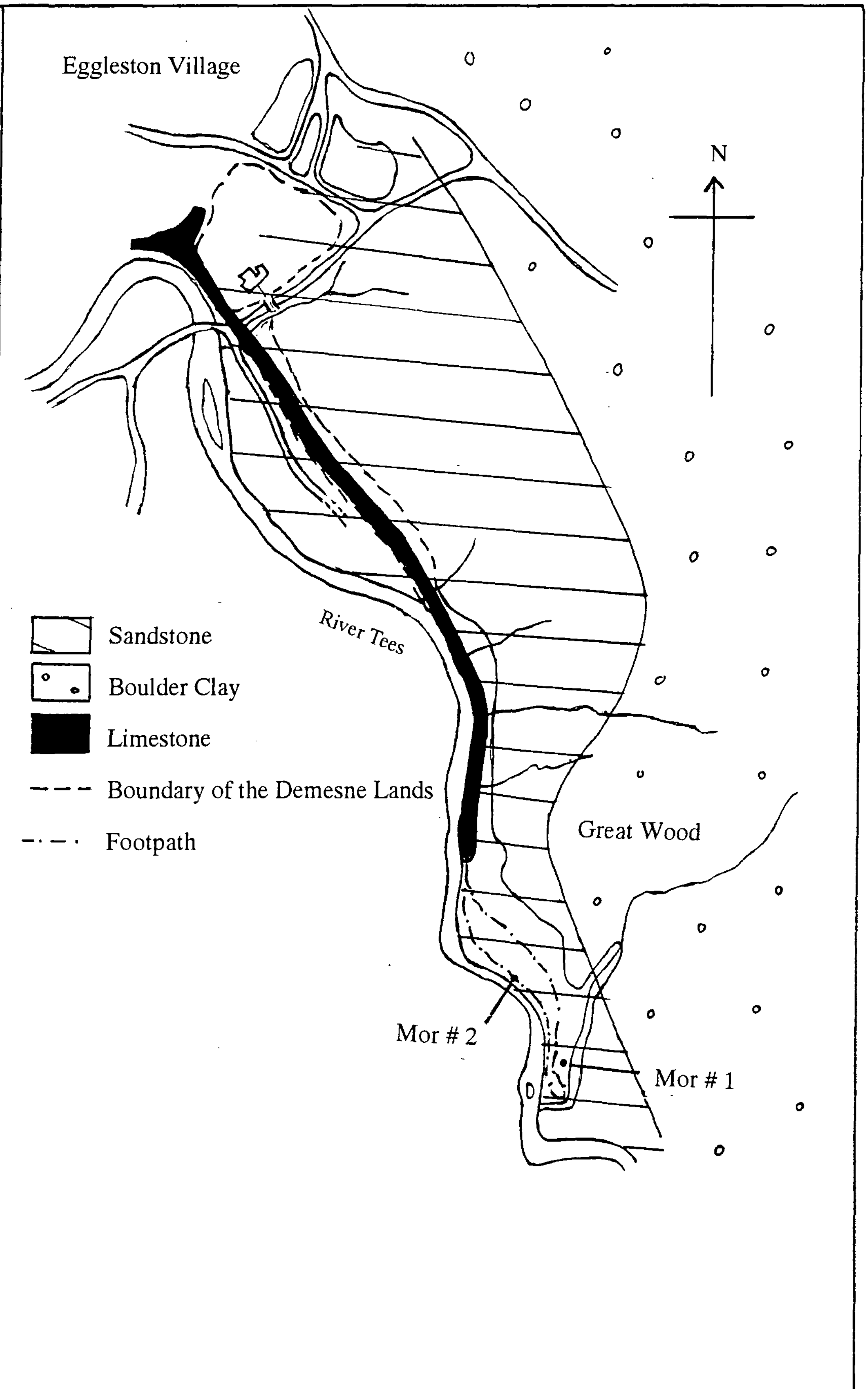


Figure 2: The Solid Geology of Great Wood 1: 15 000

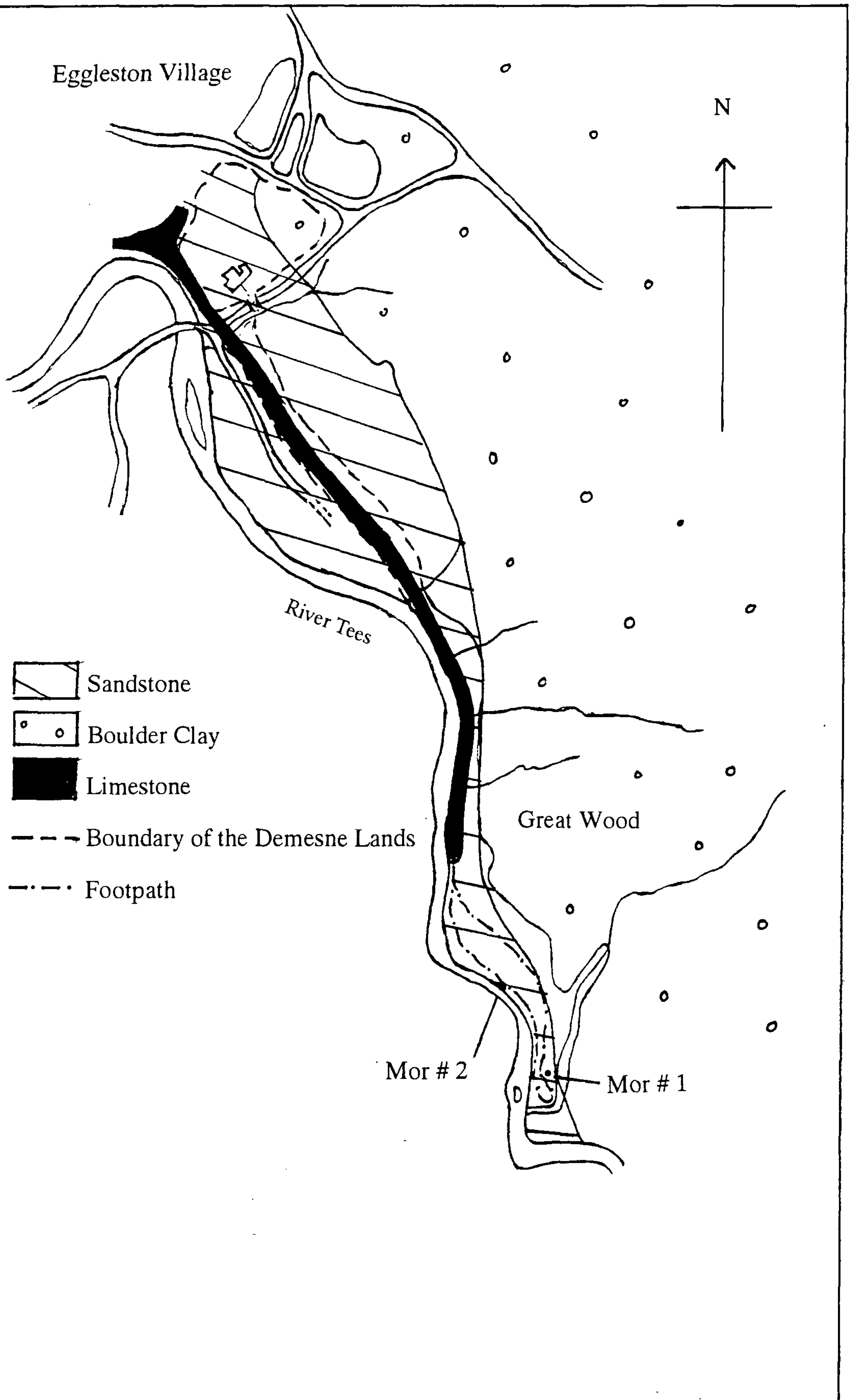


Figure 3: The Drift Geology of Great Wood 1: 15 000

General Contemporary Vegetation.

Along with the adjacent wood, Shipley Wood; Great Wood is reputed to be one of the most important woodland sites in the north east of England. It supports the richest assembly of woodland lichens in north east England and, as previously mentioned, the geological variations within the site give soils with a range of base-status and drainage. This is reflected by the variety of woodland types and in the numbers of woodland vascular plants (Kirby, 1983).

Graham (1988) classifies the wood with respect to the National Vegetation Classification (N.V.C.) scheme and proposes that the wood is a mixed deciduous canopy with a range of ground flora communities. Figure 4 illustrates the results of the Nature Conservancy Council's (now English Nature) woodland survey undertaken in 1983 (Kirby, 1983). It is suggested that there are three vegetation assemblages, *Ulmus glabra/Fraxinus excelsior* on the calcareous sites (1,2,5,6,13); a wet *Alnus glutinosa* stand (7); *Quercus petraea* (9,10,11,12,). The authority followed for naming the plants is Rose (1981).

1 *Ulmus, Acer pseudoplatanus* stand over *Mercuralis perennis, Dryopteris* spp, *Geum urbanum, Primula* spp, *Chrysosplenium oppositifolium* with occasional *Corylus avellana, Crataegus monogyna,* and young *Acer. Ulmus, Fraxinus* on the calcareous sites. Small stream (Photographs 1&2).

2 *Ulmus, Fraxinus, Betula pubescens, Acer* over *Mercuralis* with local patches of *Holcus, Endymion non-scriptus,* and *Anemone nemorosa. Ulmus, Fraxinus* on the calcareous sites.

3 Inundation areas with some young *Alnus* also *Crepis paludosa, Geum rivale, Allium ursinum, Dactylorhiza fuchsii, Succisa pratensis, Brachypodium sylvaticum, Deschampsia cespitosa.* Also some small islands with scrubby *Salix* spp.

4\. Slumped area with much *Filipendula ulmaria, Allium ursinum.* Some scree areas with *Mercurialis, Urtica dioica, Poa trivialis, Galium aparine.*

5\. Mature maiden *Fraxinus, Ulmus,* with less *Acer* than up stream. Rich mixed ground flora and also scattered dead *Ulmus* (Photographs 3&4).

6\. Small patches of *Fraxinus* regeneration with a few mature *Quercus* on the upper slopes amongst the *Fraxinus* and *Ulmus* on the calcareous sites. A ground flora of *Mercurialis, Luzula sylvatica, Endymion, Pteridium aquilinum, Dryopteris* spp.

7. A spring with a couple of *Alnus* and a ground flora of dense *Filipendula, Crepis, Mentha aquatica, Valeriana officinalis,* and occasionally *Rhododrendron ponticum.*
8. Mature *Fagus sylvatica* by top wall. with *Fraxinus* and conifer poles and a species poor ground flora of *Mercurialis* and *Dryopteris* spp. This area is possibly an old plantation. Lower down there is dense *Acer* regeneration (Photograph 5) and mature *Quercus* nearer the river with *Rhododendron* locally abundant.
9. On this shelf area there are mature *Quercus* with *Rubus fructicosus* agg, *Dryopteris* spp, *Lonicera periclymenum, Endymion, Pteridium aquilinum* and going to *Deschampsia flexuosa* and again *Rhododendron* locally abundant. (Photograph 6). In this area there are patches of *Fagus, Quercus* and *Betula* regeneration.
10. Scrubby open *Betula* area, with a fairly open mature *Quercus* canopy. There are signs that these may possibly be old coppice stems.
11. The upper slopes are covered with dense young *Betula* and *Acer* within scattered mature *Quercus* and an occasional *Ulmus*. The ground flora consists of *Blechnum spicant, Deschampsia flexuosa, Rubus, Agrostis tenuis, Oxalis acetosella, Ajuga reptans, Dryopteris* spp and *Luzula sylvatica* (Photograph 7).
12. Mature *Quercus* and occasional conifers over a dense ground flora of *Luzula sylvatica.* There is very much young *Betula* and occasional *Fraxinus* and *Crataegus* thickets. (Photograph 8)
13. *Fraxinus, Ulmus, Acer* in the side valley with a ground layer of *Allium, Geranium robertianum, Epilobium montanum, Chrysosplenium oppositifolium.* The lower slopes have mature *Quercus* with much *Calluna vulgaris* and *Vaccinium myrtillus* (Photograph 9).

The assessment emphasised that the wood was disturbed by the intrusions of *Acer pseudoplatanus* and *Rhododendron* It stressed that the canopy in the oak areas was fairly open almost like parkland and also mentioned that the *Betula* regenerating in these oak areas was not more than 10-15 years old and suggested a change in grazing regime there, with one dead sheep seen. Mr. Beadle the current game keeper, with 43 years of service for Eggleston Hall, suggested that this was due to previous grazing by sheep and rabbits, which had been prevented by the gaps in the boundary walls being repaired and therefore keeping the sheep out, about 15 years ago (pers comm). It was estimated that the timber was mainly 80-120 years old (in 1983) with a second generation of approximately 40-50 years (in 1983) and then the most recent growth, and it was suggested that the upper plateau may have been more open in the past.

Site details

The localites of the two sample sites are shown on figure 4. They will be refered to as Mor # 1 and Mor # 2.

Mor # 1 (Photographs10 & 11)
This sample was collected from a site situated at the top of the steep valley sides where the ground began to level out and become less stony. The surrounding vegetation consisted of large mature *Quercus petraea,* with an under storey of predominantly young *Betula* sp.. There were a number of *Taxus baccata* in the locality, also *Picea abies.* The ground layer was dominated by *Luzula sylvatica.*

Mor # 2 (Photograph 12)
This sample site was located on a wide shelf between the bottom of the steep valley sides and the river It was clear of inundation areas and about 300m north of mor # 1. It was surrounded by adjacent mature *Quercus petraea,* an individual *Taxus baccata* and young *Acer pseudoplatus* with an understory of mainly *Rhododendron ponticum* and a ground layer dominated by *Luzula sylvatica.*

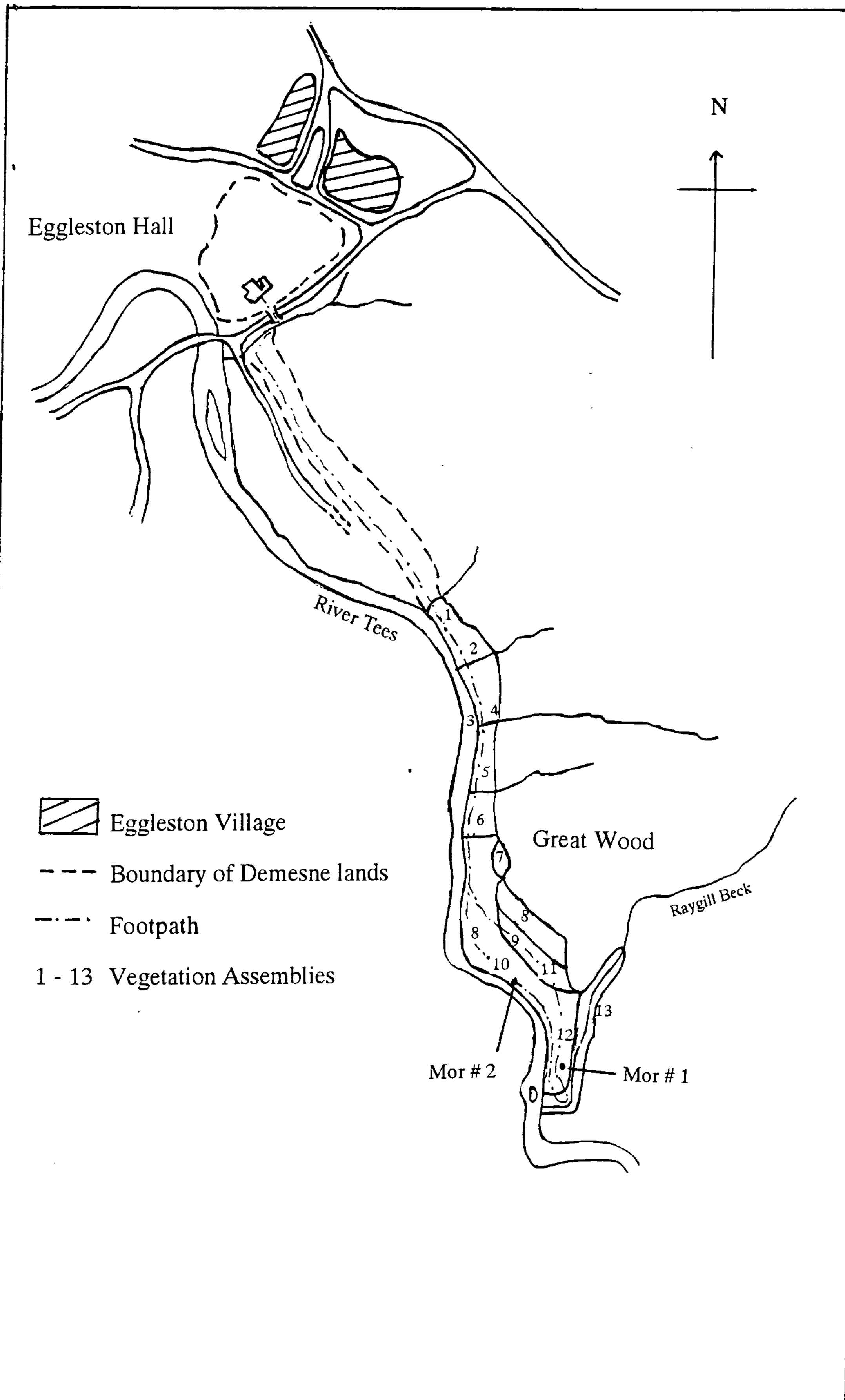


Figure 4: The Vegetation Assemblies of Great Wood 1: 15 000

Photograph 1: Dead Coppiced *Ulmus*

Photograph 2: Dense *Acer Pseudoplatanus*

Photograph 3: Dead *Ulmus* with *Fraxinus* at Calcareous Sites

Photograph 4: Relative size of Mature *Fraxinus* with Tape Measure (20cm diameter).

Photograph 5: Dense *Acer* Regeneration.

Photograph 6: Mature *Quercus* and *Rhododendron*.

Photograph 7: Scattered Mature *Quercus* and *Acer*.

Photograph 8: Mature *Quercus* and *Betula* Thickets.

Photograph 9: *Quercus* with *Vaccinium myrtillus*.

Photographs 10 & 11: Site from which Mor # 1 was Extracted.

Photograph 12: Site from which Mor # 2 was Extracted.

1.3. A Historical Review of Eggleston.

"Eggleston is a microcosm of historical process and form within the Pennine Dales".
(Alexander, 1972).

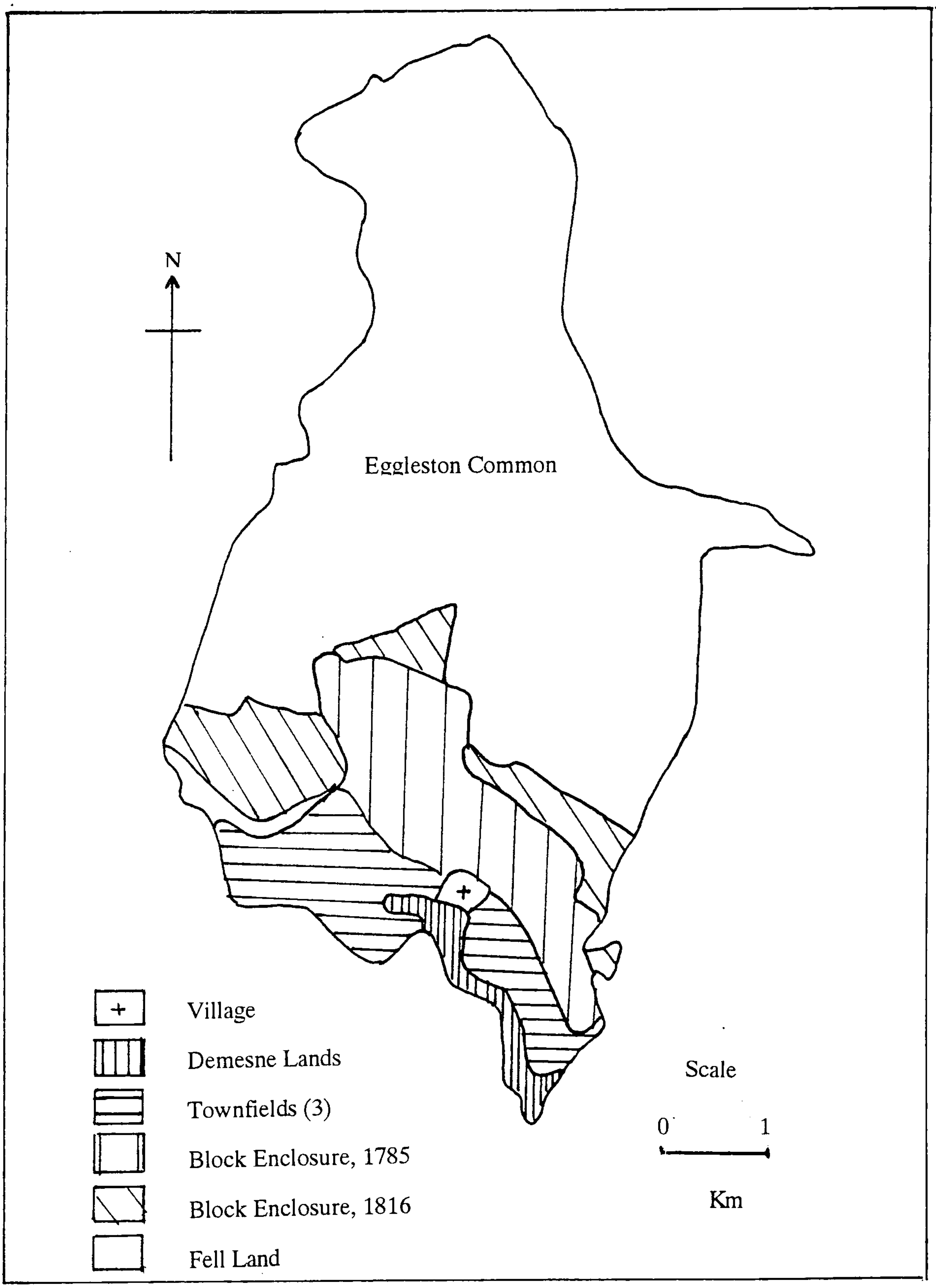
Rural Settlement and Population

Eggleston township is located in Teesdale on the north banks of the River Tees, about six miles to the north-west of Barnard Castle. It occupies a total area of over 3239ha (8,000 acres) of which approximately 2024ha (5,000 acres) are fell land and it currently has a population of 438 (Eggleston Advertiser, April 1993). The site of the village occupies a glacially excavated indentation within the valley side, formed of a series of gently sloping drift covered benches, which have greatly influenced the settlement and agrarian pattern of the township (Alexander, 1972), (Figure 5).

Alexander cites Conzens (1949), that a settlement is a "geographical record of its own evolution", and stresses the importance of the continuum of change within the settlement and in the surrounding areas. Alexander suggests that factors which caused the settlement to arise initially such as the availability of fresh water and suitable location are merely contributary, with respect to social and economic trends, in the development of the settlement.

It is widely believed that the earliest human occupancy of the dales was approimately 8,000 years ago (Roberts and Atkinson, 1968; cited by Alexandra 1972) and that they have been occupied since these pre-historic times. The earliest documented recording of Eggleston township was dated 1197 (Mawer, 1920). However, archaeological evidence exists indicating a settlement cluster of Bronze Age origin at Foggerthwaite approximately 1.5 miles from the village centre of Eggleston (Alexander, 1972). It is suggested that Eggleston may have Romano-British origins, as Roman pottery has been found in the grounds of Eggleston Hall (Roberts, 1978), and Hutchinson (1786) reports that "Romans wrought mines there, as tools and implements were found, where in the use of which was not known to experienced miners of this age", although, this statement can hardly be conclusive! It's place name which has Old English origins, translates as Ecel's village (Roberts, 1978).

Figure 5: The Settlement of Eggleston Delimited by the Parish Boundaries.



The evidence and information concerning Eggleston before 1570 is rather sparse (Alexander, 1972). Throughout the period between the twelfth and the fourteenth century most of the colonisation took place in the dales. Alexander (1972) describes how monks and feudal owners played a major part in pushing back the frontiers of colonisation through a policy of land management involving direct exploitation, prior to the impact of large landownership towards the end of the sixteenth century.

In addition to descriptive historic references, there are several cartographic representations of the dale. These include the anonymous map of Teesdale from circa 1569; Christopher Saxton's map of 1610; and John Speed's map in 1620 (Alexander, 1972), all of which indicate the location of the Eggleston township. However it was not until 1614 that the first detailed map was drawn up of Eggleston township by Richard Daines (Figure 6). This representation of the original map shows the village consisting of two rows of farmsteads and out buildings, facing each other across a green. The manor house and its grounds occupied the same site as it does today. It also shows the beginings of the process of enclosure occurring throughout the surrounding land, where improved pasture provided communal arable fields and meadows. The adjoining fell land was used for a variety of purposes by the village. The area now occupied by Great Wood is shown here as being part of the demesne meadows or haughs (a colloquial term for riverine meadows) and was also part of the communal East Field and described as "Barrenlawe" land, which is enclosed land or intakes.

After 1614, there is little detailed information on Eggleston until the late eighteenth century (Figure 7). The manor house, which was first documented as Eggleston Hall in 1750, maintained its position but had been rebuilt. The then present owners, the Hutchinsons, experienced boundary disputes with neighbouring landowners, the Rabys and the Bishop of Durham, but maintained the boundaries until the nineteenth century boundary revisions (Halmote Court Records; cited by Alexander, 1972). By 1790, the Hall grounds had expanded at the expense of several village tenements in the east row and part of the Middle Field, to create a park of 25 acres surrounded by a boundary wall. Demesne lands now included all the land along side the River Tees within the East Field, as far as Raygill Beck. The east row of the village had changes made to the length of the holdings as a result of road construction. The west row had maintained its length but reduced its number of dwellings, and the Middleton road ran across the two rows of farmsteads. Land in the East Field had been consolidated and amalgamated to form eight holdings, and the common or fell land had been enclosed (Figure 7).

Figure 6: Eggleston Township - 1614

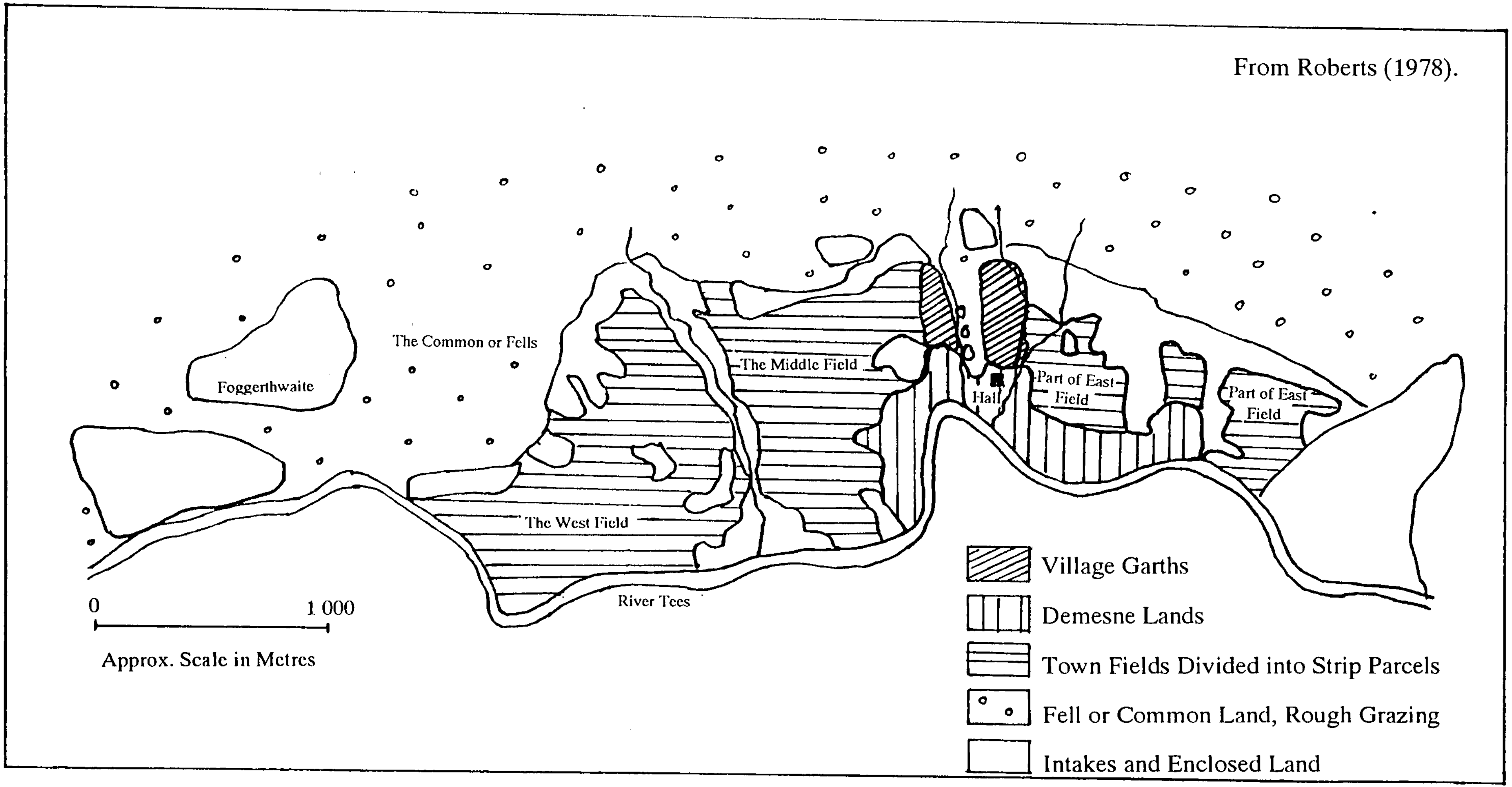
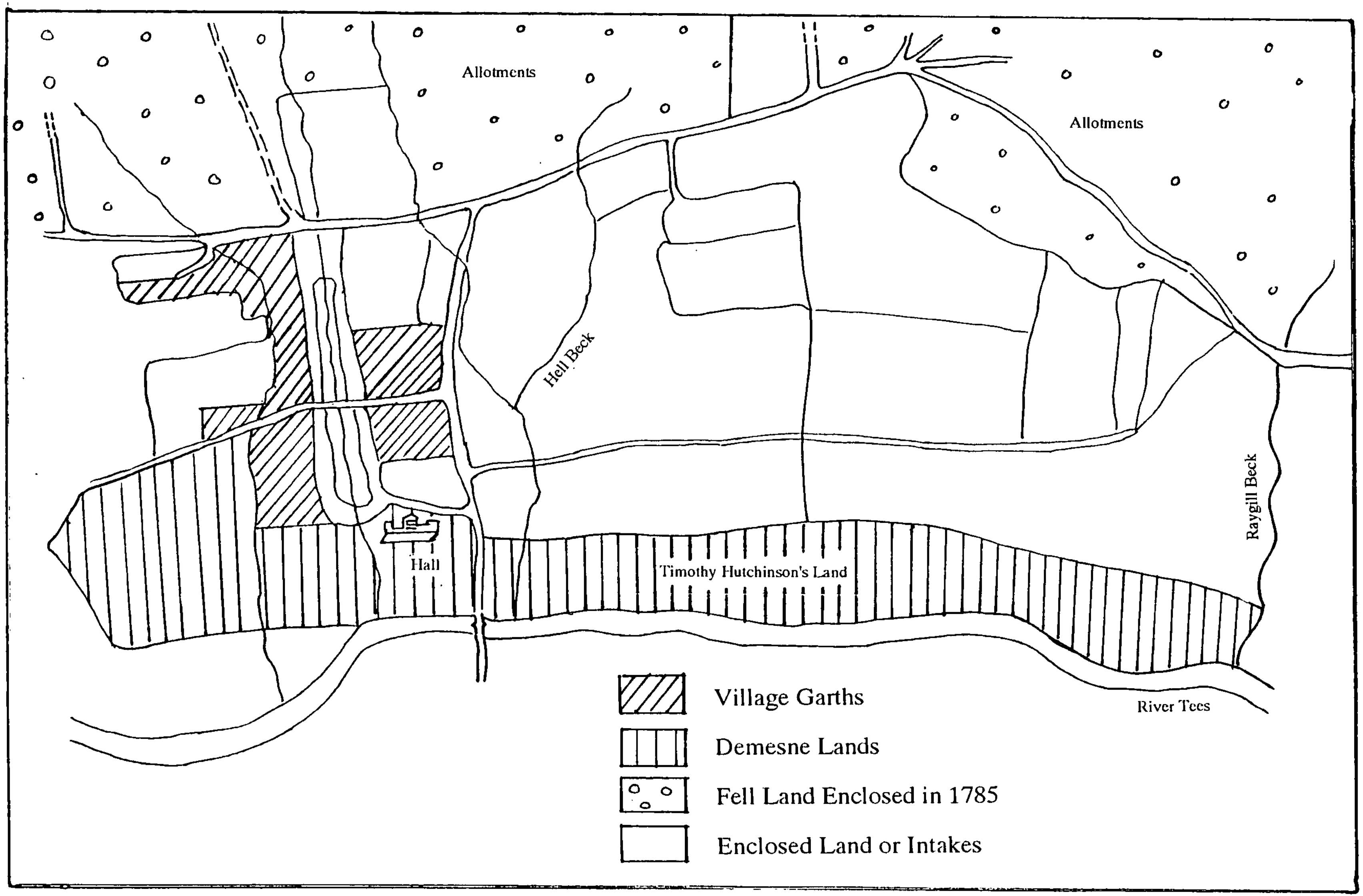


Figure 7: A Reconstruction of Eggleston Village and East Field from *ca.* 1790



At the beginning of the nineteenth century Eggleston Hall was rebuilt again, with increasingly extravagant landscaped gardens and lands. The eighteenth century had seen a significant growth in the popularity of landscape design with the likes of John Lancelot "Capability" Brown. It was in the settings of their houses that aristocracy spared no expense in the use of trees and woods to beautify their scenery. Parkland and trees were not necessarily viewed as economic investments, but more as amenities (Miles, 1967).

The population of Eggleston itself stood at 306 in 1801. Subsequently, the township experienced a rapid increase in population (Fordyce 1857; Kelly's Directorys 1890, 1894, 1902, 1914, 1921, 1938; Alexander, 1972; Eggleston Advertiser, 1993).

Table 1: The Population Figures of Eggleston from 1811 until 1993.

DATE	POPULATION
1811	335
1821	462
1831	623
1841	617
1851	636
1861	**788**
1881	747
1891	645
1901	546
1914	461
1921	461
1938	420
1966	420
1993	438

Fordyce states that this population trend was directly related to the erection of Blackton mill, and also as a consequence of the completion of enclosure thus making agriculture more commercial (Alexander, 1972). However the population declined rapidly with the demise of lead mining in the dales towards the end of the nineteenth century, and has remained at a relatively constant level into contemporary times.

Landownership

Teesdale in the middle ages was run under the feudal system, which was complicated by additional ecclesiastical ownership. This remained until the early fourteenth century when there was a decline in the feudal system (Saunders, 1959; cited by Alexander, 1972). Landownership now predominated but the ecclesiastical influence remained (Bell, 1857; cited by Alexander, 1972).

In 1317 Eggleston was held by the Nevilles (the Earls of Warwick) according to the *Calender of Inquisitions post mortem* (5 Edw.2 1307-1327; HMSO 1908; cited by Alexandra, 1972). According to Surtees (1923) it then became the possession of "Wilberfosse whom descended it to Walgrave". In 1397 the Nevilles became the Earls of West Moreland but fell from grace in 1571 as a result of the Rising of the North in 1571. Their lands passed into the hands of the Crown and were then given to the Vane family in the early seventeenth century. With the exception of Eggleston these estates have remained intact until the present day. Eggleston was conveyed to Tobias Ewbank of Staindrop in 1632 (Fordyce, 1857).

Around 1650, the Sanderson family purchased the Hall and owned it until in 1727 when William Hutchinson purchased Eggleston (Surtees, 1923). In 1769, it was passed on to his son Timothy. The Hall was subsequently given to Timothy Hutchinson's eldest son William, who rebuilt the hall in 1810-11. William died in 1826 and the Hall then became the property of his namesake brother William. His nephew Timothy Hutchinson took it over until 1844, when the last member of the Hutchinson family Cecil William Hutchinson, was the owner until 1919 (Fordyce, 1857). The hall was then bought by the Gray family who have held it until the present time.

During the nineteenth century there was a demise in the manorial structure and associated changes in land ownership. Lay ownership predominated with ecclesiastical ownership of glebe lands and tithe payments. A Tithe Commutation Act which substituted a money rent or modus for unpopular payments in kind, took place in 1849 (Alexander 1972). The township, village and ecclesiastical parish were formed in 1859, from the parish of Middleton-in-Teesdale (Kelly's Directory, 1890).

Agrarian Landscape

The origin of field patterns is closely related to the origins of settlement (Alexander, 1972). This is illustrated in Teesdale by a basic three field pattern. Generally this consists of the township core with a cultivated area surrounding it consisting of subdivided townfields. Beyond these were meadows and intakes which reflected irregular expansion of the township out onto the fell land, this land being the third component of the township's fields. The final pattern is the result of seventeeth century piecemeal enclosures and late eighteenth and nineteenth century block enclosures.

Strip lynchetts or terraces occur in the Middle Field of Eggleston township. This was an effort to counteract the problem caused by the degree of slope and thus to produce a series of flat surfaces for cultivation. It is believed that they are of mediaeval origin. (Taylor, 1966; cited by Alexander, 1972).

By 1608 the field structure in Eggleston comprised of three sub divided fields and a considerably growing number of meadow closes (Figure 6).

Throughout Durham in the late sixteenth and early seventeenth century and in marginal corn growing areas there was a movement away from tillage. It was reported that "500 ploughs have decayed in a few years and corn has to be fetched from Newcastle, whereby the plague is spread in the northern counties.......of eight thousand acres currently in tillage, now not eight score are tilled; those who sold corn have to buy......tennants cannot pay their rent" (Thirsk, 1961; cited by Alexandra, 1972).

This was attributed partly to climate and also to the contemporary social and economic forces. According to Lamb (1959), in western Europe there was a climate optimum between 400 and 1200 A.D. which peaked at 800-1000 A.D. and this mild period is thought to have contributed to the expansion and colonisation of Teesdale in that time (Alexander, 1972). In the period between 1200-1400 A.D. climatic decline set in again and this period was marked by climatic instability throughout western Europe. A period of partial recovery is then proposed between 1400-1550 A.D. before the onset of the "Little Ice Age" from 1550-1850 A.D.. Lamb reported that "in England upland estates and farms on the pennines became poorer", but that there were mild periods in the 1630's, 1730's 1770's and 1840's.

After 1750, an expanding industrial and commercial period saw Teesdale undergoing the superimposition of regular "grid iron" field patterns over much of the fell land.

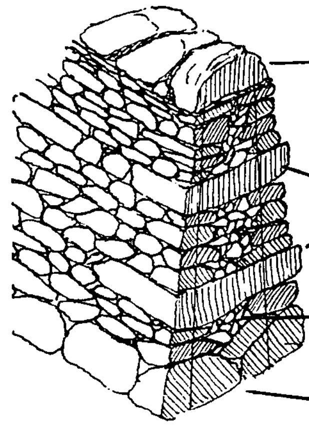
Consequently there was a reduction in acreage of common land but an increase in land suitable for commercial agriculture. It established indisputable mineral rights for lead, silver and coal and ultimately positioned the fells in a more commerical position (Alexander, 1972). Associated with enclosure was land improvement, such as drainage, all of which lead to the expansion of flexible crop rotations based on the Norfolk four course system and convertible husbandry (Loudon, 1825; cited by Alexander, 1972). County Durham rapidly improved its agricultural reputation.

However, it should be noted that the overwhelming motive behind enclosure was the gain of mineral rights and only secondary was the developement of agricultural estates based on cattle and sheep rearing. Some land was intended for tillage, and determination to grow grain on these marginal lands reflected both population growth and the high price of cereal crops in England after 1750. Prices rose even higher during the Napoleonic Wars and early in the nineteenth century (Micington, 1968; cited by Alexander, 1972).

By the late eighteenth century amalgamation and consolidation was evidently becoming important in Eggleston. In 1785 a private Act was passed for the enclosure of fell land at Eggleston "not exceeding 2,500 acres" (Eggleston Enclosure Award, 25 George 3, Private act 13, 1785; cited by Alexander, 1972). This was thought to be implemented by 1790. For instance the East Field had been reduced from 36 parcels of land in 1614 to 8 holdings in 1790 (Alexander, 1972), (Figure 7). A second enclosure award was implemented in Eggleston in 1816.

Stone was used for the construction of walls to delimit field boundaries. When the Enclosure Act was passed through Parliament guide lines were developed on the construction of the walls which gave them characteristic features. For instance in Yorkshire (and apparently in Upper Teesdale), the walls were characterised by two rows of through stones; and in Derbyshire, three rows (Raistrick, 1946; Armstrong, 1966), (Figure 8)

Figure 8: Characteristic Features of the Walls Built as a Result of the Enclosure Act (1785) in Teesdale.



Inventory material has been utilised as a guide to past crops in Eggleston and a brief summary can be compiled outlining the dominant crops in chronological order using the fragmented evidence available. This will hopefully give a general picture of the predominant patterns.

In the late sixteenth and early seventeenth century, oats and bigg (Northern winter barley) were cultivated with poor harvests in this period. An increase in permanent acreage was occuring which would suggest a growing number of stock (Probate inventory records 1589, 1596, 1624, 1687; cited by Alexander, 1972).

1622-23 and 1629 were years of poor harvest when rye had to be shipped in to Newcastle from Danzig and occasionaly from corn growing counties in southern England (Thirsk, 1967; cited by Alexander, 1972).

The following references are from the diary of Christopher Sanderson, who was lord of Eggleston Manor from 1662 until 1681 (Alexander, 1972).
1662 - rye cultivated.
1672 - wet harvest with oats in the towns fields until mid October.
1673-Little hay cut before September and the corn was unsound, also cultivated were oats, rye, bigg and malting barley.
(1672-73 was a similar situation to 1622-23).
1676-A fine harvest produced with subsequent low prices producing rye, bigg, oats, and wheat (indicating it was a good year as it was grown all the way up the dale as far as Eggleston).

1681 - A year of drought.

This account clearly shows the unpredictablity of the harvests and the associated fluctuation in prices in the dales towards the end of the seventeenth century before the beneficial effects of the Agricultural Revolution was felt (Alexander, 1972). In addition, Thirsk (1967; cited by Alexander, 1972) maintained that pastoral farming was predominant with arable as a subsidiary in Teesdale in the early seventeenth century.

There is little known about the intricacies of cultivation in Eggleston during the eighteenth century. However, it was observed that no good tillage crops were grown until three to seven years after enclosure (which was carried out as stated before by 1790) as the soil structure was undergoing process of improvement following drainage

1760-90 - reduction in cereal prices

1763-Arable cultivation in the Middle Field as illustrated by a map by John Greenwell showing 150 parcels of land (Alexander, 1972).

1771 - Great flood, inundating fields (Plumb, 1961; cited by Alexander, 1972).

Late eighteenth century- Highly fluctuating exports of wheat, rye and barley from Stockton.

1792 - Foreign grain imported (Bailey 1810; cited by Alexander, 1972).

1801-1815 - Napoleonic Wars-Increase in cereal prices and land up to 330m used for cultivation (Roberts *et al*, 1973).

1803-Garland recognised arable cultivation in Eggleston. However it is postulated that enclosure in 1785, effectively saw the decline of cultivation.

1820-reduction in cereal prices but to a lesser extent than in 1760-90 (Chapman, 1966; cited by Alexander, 1972).

1849-Five acres in tillage in the former middle field (Ecclesiastical Tithe records, 1849; cited by Alexander, 1972).

Since this time agriculture at Eggleston has been dominated by pastoral farming, however the land was brought back into tillage during the Second World War (Mr. Beadle, pers comm).

Consequently it can be seen that as regional specialisation increased as a result of improvements in transport and communication, arable cultivation was no longer an important proposition in the marginal areas of the dales, instead pasture and meadow land were valued for sheep and cattle grazing. Even so, since 1600 the area of cultivated and improved land in Eggleston had increased nearly eight fold (Alexander, 1972).

Mineral extraction

Mining and refining of lead and to a lesser extent silver within the mineral deposits of the Lower Carboniferous series has made a major impact on the cultural landscape of the dales (Garland, 1834; cited by Alexander, 1972). In Teesdale it was concentrated above Eggleston (Joy, 1968; cited by Alexander, 1972).

Lead mining is believed to have been carried out in Teesdale since Roman times (Lee, 1965; cited by Alexander, 1972). However, documentary material relating to mining was not readily available until the sixteenth century. Richard Daines map of 1614 showing the presence of the "Lady Brown Leade Mylls" situated on Eggleston Beck, which probably serviced a mine at Flakebrigg. It was redeveloped by the Hutchinson's in the eighteenth and nineteenth centuries (Alexander, 1972).

As the mining tended to be very primitive it was a very transitory and shifting activity, and little is recorded in the Pennines until the late seventeenth century (Smailes, 1961; cited by Alexander, 1972). Christopher Sanderson at Eggleston, is recorded as leasing the mines in 1663 on a short lease (Ramsden, 1947; cited by Alexander, 1972).

In 1727 When William Hutchinson bought Eggleston there was reference to a lead mill or smelting mill, probably the successor to the 1614 mill and also an additional mill (Cotesworth Manuscripts, 1727; cited by Alexander, 1972). A growth in smelting capacity in Eggleston is indicative of rising demand and there are references to lead mining between approximately 1726-1749 (William Hutchinsons lead account ledger 1726-49; cited by Alexander, 1972). In 1771 the London Lead Company leased the mines and smelt mills at Eggleston, making it the smelting center of Teesdale

(Ramsden, 1947; cited by Alexander, 1972) and the complex of Blackton Beck mills were leased in 1789.

In the nineteenth century there was an intensification and commercial developement of lead mining and smelting which reflected the Industrial Revolution as a whole, and by 1850 the impact of lead working on the township of Eggleston was considerable. The London Lead Company had initiated major road and bridge building programmes (Raistrick, 1938; cited by Alexander, 1972) and provided facilities for the miners. The population in Eggleston rose rapidly in the nineteenth century to a maximum of 788 in 1861. However a decline in lead mining was experienced towards the close of the nineteenth century as with other industries throughout Britain, due to competition from abroad and the increasing use of substitute metals (Jackson, 1957; cited by Alexander, 1972).

An investigation into the history of the region and of the adjoining settlement provides crucial information from which it may be possible to deduce how Great Wood might have been affected by human activities and the developement of the settlement. A historical perspective of this wood developed from the above information, and related to the pollen record is outlined in the discussion.

1.4. A Background to the Recent Regional Vegetation History.

In order for broad comparisons to be drawn if necessary, and to introduce the recent vegetation history, several previous studies have been examined to hopefully illustrate briefly the spatial and temporal vegetation dynamics at a regional scale.

Roberts *et al* (1973) have produced detailed pollen diagrams from sites in Weardale of a similar altitude to Great Wood. One of these sites in particular is thought to represent vegetation from within a few kilometres as well as local pollen, and is therefore suitable for demonstrating the vegetation dynamics derived from an extra-local or regional pollen source area.

The pollen diagram for the small bog which is in close proximity to Steward Shield Meadow represents data from about 1200 B.C. when climate deterioration caused peat to form over large areas of the lower parts of the northern Pennines (Roberts *et al*, 1973). Tree pollen and tree/shrub/ herb ratios show that on a regional basis until about 2000 years ago there was a moderate amount of woodland consisting of mainly *Betula, Alnus* and *Corylus* with some *Pinus* and *Quercus*. Tree pollen then declines during the Iron Age/ Romano-British period, so that the tree pollen frequency closely resembles that of today, indicating a similarly open landscape. There was however, very slow peat deposition at this time, therefore the validity of that pollen diagram representing this period is open to question (Roberts *et al*, 1973). In the twelfth century, tree pollen frequencies increase especially *Alnus* and *Salix* although this is considered a local phenomenon. It is thought that an agricultural recession in the fourteenth century was the underlying causal factor for this increase, and the impact of deteriorating weather conditions also favoured the regeneration of these trees. However by the mid fifteenth century the woodland of upper Weardale was mostly cleared due to demand from mining and as a result of increasing agriculture. Since then, the pollen record indicates that the remaining woodland is similar to contemporary woodland.

This site lies in an adjacent river basin, so the climate and possibly the geology may be similar. Therefore when local events are taken into account, it is feasible that this may be used to broadly represent regional, long term vegetation dynamics in Teesdale.

A pollen diagram produced with less fine resolution has been constructed from sediment extracted from a peat bog at Simy Folds (Donaldson in Coggins, Fairless and Batey, 1983). This site is west of Great Wood situated at a slightly higher altitude in the River Tees basin. In very broad terms it agrees with the previous pollen data in that during the last two and a half millennia the vegetation has been dominated by herbaceous pollen. Continuing from this period until modern times, with regards to the tree pollen frequencies *Betula*, and after a slight lag *Pinus* marginally dominate the pollen record, later *Ulmus* also becomes important. At this site *Salix* pollen eventually ceases, which corresponds with a decline in *Alnus* pollen frequency, this taxon maintains a constant but low level, as do *Quercus* and *Corylus*. *Acer* appears towards modern times.

There appear to be some local variations in the vegetation represented in this diagram in comparison with that of Steward Shield Meadow. Such differences were observed by Turner and Hodgson (1991) when investigating the variations in the composition of the late Flandrian forests in the northern Pennines from about 5000-2500 years ago. They concluded that the spatial variations in the composition of species in woodlands was related to topography, local geology and especially climate, until they were replaced by blanket peat and grassland over 2000 years ago. They pointed out that spatial diversity is as important as temporal change at a regional scale and should be considered when zoning pollen diagrams.

Therefore, it is apparent that while offering a general guideline to the regional vegetation dynamics influenced over time by climatic variations, spatial diversity through variations in geology and topography, is also important. Super-imposed on the differences caused by these factors, is the effect of interference by man. It is thought after most of the bog communities had formed, the better drained soils which still carried woodland would have been periodically subjected to man's activities, such as for grazing animals, wood and timber needs and later possibly for as a fuel supply for smelting. These activities tended to favour grassland, especially when the populations were high, and allowed regeneration when populations declined. Contemporary farming still maintains these areas as grassland preventing the re-growth of trees (Turner *et al*, 1973).

2. METHODOLOGY.

2.1. The Principles of Pollen Analysis.

Palyonology is the study of pollen grains and spores from higher plants and from cryptograms respectively (Moore and Webb, 1983). One aspect of palynology deals with fossil pollen and spores in stratified sediments. It has become the most widespread and established technique used to generate historical vegetation data, and is referred to as pollen analysis.

Pollen data can be utilised at a variety of temporal and spatial scales. It can be used as a source of information about vegetation dynamics on a large scale, for instance to show the behaviour of plant assemblages and individual taxa in relation to past major environmental and climatic fluctuations or recording the effect of human activities in pre-historic and historic times. On a progressively smaller scale it can illustrate regional and local vegetation dynamics or specific microclimatic or anthropogenic influences.

The fundamental assumption that pollen data reflects vegetation change (Green, 1983), has been partly verified by the use of modern pollen deposition studies or surface sample studies. These have illustrated firstly, that there is a relationship between the relative proportion of the different taxa in the vegetation and their pollen percentages (Anderson, 1970) and secondly that modern pollen data is representative of general modern vegetation assemblages (Prentice, 1988). As a result pollen diagrams can be considered as broadly accurate reflections of vegetation change. The use of pollen diagrams can be extended to draw up maps to show vegetation patterns at a particular time and sequential maps to show the migration of species over time.

It is important to note that there are many variables that have to be considered in order for precise and accurate data to be generated. These include recognition of differences in pollen productivity and dispersal which will determine the relative quantities of pollen of various taxa in the sediments; an idea of the size of the pollen source area; the quality of the sediment; the careful processing of the sediment samples to extract the pollen, and the accurate identification and recording of the pollen, all of which will be outlined later.

As previously stated pollen data can be represented within a range of spatial and temporal scales. This study considers mor humus deposits from a woodland site and a summary of the degree of resolution expected is outlined below.

Spatial resolution.

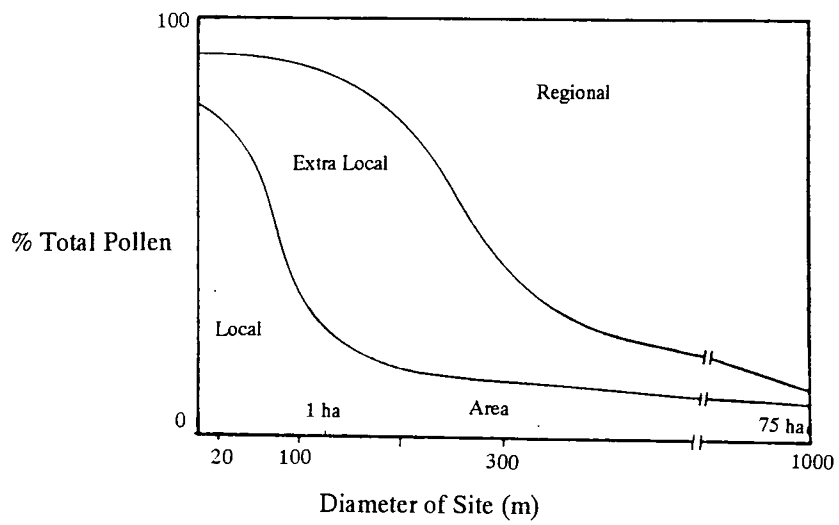
As Bradshaw (1988) stated, small hollows and other "closed canopy" sites, record vegetation change over a few hundred m^2 and resolve vegetation changes of 10 years duration or less. For spatial precision it is necessary to use sample sites which have only collected pollen from a close vicinity to the place of production. Work carried out by Tauber (1965, 1977) has been instrumental in illustrating the mode of transfer of pollen grains from source trees to the ground or lake, and also the extent of the areas effectively represented in pollen diagrams. He deduced that the majority of pollen to be deposited at small sites close to forests, was in fact pollen from within the forest carried in air currents through the trunk space. He also stated that at heights below 2m wind velocities in a forest rapidly decrease to zero, thus pollen emitted below that height will therefore be dispersed very badly. Anderson (1970) noted that this was particularly true of herbaceous forest plants. Tauber also noted two other components in pollen deposition, the component carried above the canopy of the forest and the rain out component. He suggested that the share of the different components in the pollen deposition varied with the size of the basin, the topographic setting and the structure and density of the surrounding vegetation. Jacobson and Bradshaw (1981) devised a model relating site size to the relative proportions of pollen originating from different distances around the site (Figure 9).

Further verification is provided by work showing that within closed forests, pollen does not travel beyond 20-30 metres from its source (Bradshaw, 1981; Anderson, 1970). Anderson (1970) estimated that although pollen falling from trees may be carried several hundred metres before falling to the ground, the majority is deposited beneath or very near the source. Also that pollen collected in the canopy by filtration and washed to the ground by rain is mainly derived from trees a few tens of metres away. In addition, foreign pollen may either be carried by wind into a forest and deposited close to the forest edge, or caught in the tree tops by wind turbulence and washed out.

From this information Jacobson and Bradshaw (1981) concluded that for fossil sites such as mor humus profiles within closed canopies, the major source area for the pollen will be the surrounding 20-30m. They suggested that although some pollen grains come from greater distances, they will be swamped by the pollen from the local vegetation.

Bradshaw (1988) stated that closed canopy sites provide spatial and also temporal resolution that enables pollen analysis to illustrate successional sequences and local scale phenomenon. He also emphasised that these studies should not be seen in isolation as they link to regional pollen studies, as the small pollen source areas are a component of the larger regional sources.

Figure 9: The Relationship Between the size of a site and the Relative Proportions of Pollen Originating from Different Areas Surrounding the Site (after Jacobson and Bradshaw, 1981)



Temporal resolution.

Originally pollen analysis was used on large time scales over many thousands of years, mainly for studying climatic history and vegetational change and comparing sediments. More recently in addition to this, fine temporal resolution analysis has been undertaken which will generate data over short periods. This includes a decrease in the size of the sample interval and the use of finer than 1cm consecutive samples for particularly detailed purposes.

However, the problem when dealing with such fine resolution samples is the difficulty of assigning a time-scale. This problem can be partly alleviated by selecting specific levels in the diagram and radio carbon dating them, which would give you the time covered by that part of the diagram. These estimates can then be used if a constant accumulation of the sediment is assumed and thus there a time period per sample between dated levels can be assigned (Roberts *et al*, 1973). However, accumulation rates can vary in very short distances (Turner and Peglar, 1988) and so another approach can be taken whereby pollen influx is assumed to be constant and thus the pollen concentration can be used to give an estimate of the relative rates of accumulation of each sample in the diagram. Having reached this stage dates can be attached. Finally, the linkage of particular features of the fine resolution pollen diagram with known historical events, both on a very local scale and a larger scale basis, has been attempted (Huntlety, 1989; Roberts *et al*, 1973).

2.2. Factors to Consider when Interpreting Percentage Pollen Data.

As already stated, the objective of many pollen analysis studies is to reconstruct vegetation at a certain temporal and spatial scale. To achieve this pollen data is usually expressed in any of three forms: as percentages (based on a pollen sum, which may consist of all the grains counted in a sample or a subset of them); as concentrations (grains per unit volume or mass of sediment, determined by adding a known volume of exotic pollen into the sample during preparation); or as accumulation or influx rates as outlined earlier.

In 1963, Davis stated that "a consideration of the theoretical relationship between vegetational percentages and the percentages of pollen in sediments makes it obvious that where species differ in the amounts of pollen they contribute to sediments, pollen diagrams cannot be interpreted quantitatively by means of traditional methods". As previously mentioned, surface samples have been utilised to verify assumptions made when interpreting pollen diagrams. Broadly speaking it has been found that although the pollen data reflects patterns in the vegetation, percentages are biased towards certain taxa, with high pollen productivity and/or slow deposition from the atmosphere. Certain tree taxa in forest situations are commonly over represented in pollen data, usually wind pollinated light pollen grains such as *Pinus*. Other taxa, usually insect pollinated such as *Acer* or with particularly heavy grains such as many cereals, are less well represented (Grimm, 1988). As Davis (1963) pointed out these differences have to be corrected, before the true proportional representation of a species in vegetation can be determined from the pollen percentages.

Anderson's work on surface pollen analysis under a closed canopy (1970) relates partly to pollen dispersal from the parent plant, and partly to plant productivity which will be examined later. Further work showed that pollen released in closed canopy situations fell vertically or was washed by rain, thus was distributed a very small distance (Anderson, 1974; cited by Moore, Webb and Collinson, 1991). Therefore the distance that a grain travels will depend on the microclimate of the site and the aerodynamics of the grains (Table 2).

Table 2 : Volume, Weight and Settling Velocity of Several Pollen Types in Still air (After Erdtman 1969; cited by Moore, Webb and Collinson, 1991).

Pollen Type	Volume (μm^3)	Weight($g \times 10^{-9}$)	Settling Velocity (cm/s)
Picea	132 000	72.8	6.0
Fagus	51 770	37.0	5.0
Pinus	47 030	18.4	3.0
Corylus	10 150	10.2	2.3
Alnus	9070	6.8	1.6
Betula	7540	6.1	1.5
Taxus	7130	4.1	1.0
Juniperus	9460	3.8	0.9

The differences in pollen productivity have been studied directly (Ertdman, 1969; cited by Moore, Webb and Collinson, 1991) by investigating the numbers of pollen grains produced by each taxon. This method tends to be unreliable but does confirm that wind pollinated taxa produce more pollen than insect pollinated. As mentioned the surface pollen studies by Anderson (1970), have been more useful in determining pollen productivity. As he regarded the pollen source area within a closed canopy to be no larger than 30m, he calculated the crown area of the different tree species within this radius, and compared them with the different pollen percentages he had obtained. The data was expressed in relative terms with *Fagus sylvatica* as a reference species. Table 3 shows a sequence of decreasing pollen productivity for Northern European Trees.

Table 3: Pollen Productivity and Correction Factors for Northern European trees.

Northern European trees in decreasing order of pollen productivity.	Correction Factors based on P_{rel} and R_{rel} values
Pinus, Betula, Quercus, Alnus	1:4
Carpinus	1:3
Ulmus, Picea,	1:2
Fagus, Abies	1 x 1
Tilia, Fraxinus, Acer	1 x 2

Anderson (1970) also noted the difference in pollen production by *Corylus avellana* in well lit and shaded situations - production decreased with shading. As a result of the differences in productivity and dispersal, correction factors have been devised and applied to data (Anderson, 1970; Bradshaw, 1981). Davis (1963) presented her "R value" model as a way of relating pollen percentages to tree percentages for each tree taxon. It expresses the over or under representation of a species. This value is not constant but depends on the species composition. The relative representation value of a species, the R_{-rel} value is the ratio of its R-value to the R-value of a standard chosen species such as *Fagus* (Anderson, 1970). Correction factors are calculated based on the R_{-rel} values and also relative pollen productivity P_{rel}, which in most cases resemble the R_{-rel} value (Table 3); and it has been found that correction factors are similar for tree species in other areas, with slight variations being put down to slight differences in climate, soils and forest structure (Anderson, 1970).

It should be noted that the data for these surface samples were taken from within closed vegetation, which as Anderson points out has a very local pollen source. When dealing with the standard types of pollen studies, such as mires or lakes ranging from 1-1000ha, the pollen will originate from regional source areas. Recent quantitative studies have shown that there is a relationship between pollen percentages and regional vegetation patterns (Prentice, 1988)

Prentice and Webb (1986) state that studies in modern pollen deposition in closed forests supports the assumption that changes in pollen percentages for each taxon are monotonically, or even linearly related to changes in relative abundance although as mentioned the proportions of taxa are not assumed to be equal to the relative abundances for the reasons previously outlined. Also they are not assumed to be proportional to tree abundances within any finite radius, due to background pollen (there is a leptokurtic curve to pollen deposition, that is there is a high likelihood of pollen falling close to the source). However, in theory there is a non-linear relationship of pollen percentages with tree percentages as demonstrated by Fagerlind in 1952 (Prentice and Webb, 1986). This is called the Fagerlind effect. Fortunately, with a diversity of pollen types, the Fagerlind effect is slight to moderate and a roughly linear relationship can be assumed but if more precision is required the effect requires correction (Prentice and Webb, 1986). Another aspect when dealing with percentage data is that percentages of different types of taxa are not totally independent of each other (Moore, Webb and Collinson,1991), compared with pollen influx data which is independent of abundance but more site dependent.

However, percentage data have been found to be useful for regional and local studies and also for investigations into vegetation dynamics basically because only percentages can be determined for modern samples, for comparison with fossil samples.

2.3. Mor Humus and Fine Resolution Pollen Analysis

Palynologists have in recent years demonstrated that it is possible to reconstruct vegetation history from pollen data obtained from a mor humus profile (O'Sullivan, 1973; Bradshaw and Hannon, 1992; Huntley, 1989; Mitchell, 1988). However, it has been stressed that the validity of mor humus profiles is very much dependent on a number of factors which operated during the formation of the soil, all of which need to be taken into consideration when interpreting the pollen data (O'Sullivan, 1973).

Mor humus has been described as a dry, acidic accumulation of partially decomposed leaf litter of low biological activity. It is associated with acidic free draining soils such as podsols, and is found under trees producing a leaf litter of high polyphenolic compounds (Davies, Coulson and Lewis, 1964; cited by Bradshaw, 1988)). Handley (1954, cited by O'Sullivan, 1973) stated that the presence of certain proteins in the mesophyll tissues of particular species of plants inhibit bacterial activity, and lead to an accumulation of unassimilated plant material. An influx of fungi is the result of a lack of bacterial activity, which encourages anaerobic conditions in the organic layers of the soil.

A number of complications have been noted which operate during the formation and deposition of the soil which may influence the pollen data.

Firstly, some pollen may be destroyed or damaged during the formation of the mor profile. As the soil is liable to oxidation and microbial action, compared to peat or lacustrine deposits, there may be problems with preservation. Early palynologists dealing with terrestrial soils were aware of this (Dimbleby, 1957). It was noted that when anaerobic fen peats were aerated, the pollen was destroyed leaving only resistant grains, such as fern spores. From these results it was deduced that oxidising conditions in more mineral soils must destroy pollen. Later it was decided that low pH was a very important factor in preserving pollen in mineral soils and that grains may become incorporated into humic aggregates (Erdtman, 1943; cited by Dimbleby, 1957).

Long term studies have been carried out to determine the susceptibility of various pollen and spore types to corrosion in various soils (Havinga, 1984) and to the problem of differential deterioration which produces bias. It was found that pollen and spore deterioration proceeded slowly in various peats and podsolised sand soil, as no change in composition in the pollen and spore mixtures was noted over a period of twenty years. Deterioration was used as a measure of the process of decay. It was found that deterioration was higher in podsolised soil, with *Lycopodium* and *Taraxacum* appearing very resistant in all soil types. This compounds the idea that high values of these pollen grains are an indication of pollen corrosion and subsequent decay. *Quercus* was found to be a very susceptible species in podsolised sand. Table 4 illustrates the relative deterioration rates (of which thinning was the predominant feature) of pollen and spores after 20 years in podsolised sand soil (after Havinga 1984).

Table 4: Relative Deterioration Rates of Pollen and Spores in Podsolised Sand Soil.

Pollen or Spores listed in relation to their increasing susceptibility to deterioration in podsolised soils
Lycopodium (most resistant)
Pinus, Taraxacum, Tilia
Carpinus
Alnus
Myrica
Fagus
Corylus
Acer
Juniperus
Ulmus
Betula
Fraxinus, Populus
Polypodium
Quercus
Salix
Taxus (least resistant)

Bradshaw (1988) suggests that a preservation index (derived by calculating the percentage of deteriorated but identifiable pollen at a site) can act as a guide to the overall preservation properties of a particular site.

Other destruction of pollen grains may be caused by fungi (Goldstein, 1960; Elisk, 1966; cited by O'Sullivan, 1973), which may also act selectively, destroying pollen differentially. In addition, soil fauna such as mites may physically destroy pollen (O'Sullivan, 1973).

A second type of complication might arise by disturbance of the stratification of the Mor humus profile, and hence that of the pollen. Wind throw of trees at a site or disturbance by fire may disrupt the profile. Bradshaw (1988) pointed out that the base of mor humus profiles may contain charcoal indicating that earlier humus has been burnt away. Mixing activities of soil fauna may also destroy stratification. Godwin (1958) discusses the problems with movement in soils. Although, as Bradshaw (1988) suggests mixing is at a minimum and down wash is prevented by the pollen being trapped in aggregates of humic material (Manaut, 1967; cited by Jacobson and Bradshaw, 1981). He states that pollen diagrams derived from mor humus can show very fine detail and sharp changes in pollen stratigraphy, indicating that no down wash or mixing has occurred.

Finally, despite the low biological activity in mor soils, material is continually being removed or reassimilated. Tamm and Holmen (1968; cited by O'Sullivan, 1973) suggested that disturbances of the soil profile are distinguishable from either the stratigraphic nature of the pollen diagram, or through distinctive changes of pollen content. When coinciding with soil boundaries these stratigraphic changes may indicate changes in accumulation of soil, which includes discontinuities in deposition.

Bradshaw (1988) suggested that the time period covered by mor humus profile will usually be confined to the last couple of hundred years and that temporal resolution can be high depending on the sampling interval. The use of mor humus has been particularly important in closed canopy studies where the pollen source area is small and therefore good spatial resolution can be obtained, and thus the reconstruction of stand level dynamics are possible.

2.4. Pollen Preparation and Counting.

Preparation of samples followed the protocol described in the "Standard Methodology for Obtaining, Preparing and Counting Pollen Analytical Samples" (Huntley and Allen, 1992) and included instructions on mounting of residues and counting procedures. Therefore, only a brief summary of the procedures will be outlined here with references to any necessary adjustments that were made. Great care must be taken to record correctly all the necessary details (sample number, site, location and sediment type), to follow the instructions accurately and to avoid any form of contamination.

A monolith of the mor soil of between 15-20cm, was collected from each of the two sample sites, wrapped in cling film and foil, labelled appropriately and stored in a cold storage room at 4 °C. These monoliths have to be handled carefully as material was required from them for pollen and sediment analysis. Each sediment was sampled at consecutive 1cm intervals. Due to the nature of the material, it was impossible to use a standard cylindrical sampler to extract each 1cc sample, so having removed the outer 2-3mm of the sediment an estimated $1cm^3$ block was cut out of the sediment. This was repeated over the entire depth of the sediment The individual samples where stored in glycerol, in stoppered vials until preparation.

Initially, preparation to extract pollen was undertaken on samples at 4cm intervals to obtain an overall picture of the pollen diagram. However, the final sample interval was at consecutive 1cm stages for greater resolution.

Added to each sample before preparation commenced was 1cc of a calibrated suspension of exotic pollen. Initially, a batch of *Eucalyptus* pollen in a glycerol/water/phenol medium was prepared which would be of sufficient volume to accommodate all the work to be done.

The initial step involved boiling the samples plus the exotic pollen in 10% NaOH to remove humic colloids, after which the colour of the supernatant was recorded as a measure of the extent of humification. Each sample was then washed through a fine sieve of approximately 125-200μm, and the sieve residue retained for further examination. The material that passed through the sieve was subsequently treated with 10 % HCl before flotation on saturated $ZnCl_2$ in order to separate mineral matter from the pollen. After this procedure the material which had been retrieved from the surface of the $ZnCl_2$ was treated with 10 % HCl.

In order to remove cellulose debris from the samples it is necessary to carry out acetolysis This involved an initial wash with glacial acetic acid (CH_3COOH) to dehydrate the samples followed by boiling in acetic anhydride and concentrated Sulphuric acid (H_2SO_4). After a final wash in CH_3COOH which removes the soluble acetate products of acetolysis, the samples were stained with a dilute solution of aqueous safranin.

The final stage of preparation involved dehydration of the samples in tertiary butyl alcohol (TBA, 2-methylpropan-2-ol) and then transfer of the final residue into small vials where an equal volume of silicone oil (2000 cs viscosity) was added. The samples were then placed uncorked in a 60 °C oven for *ca* 12 hours in order to evaporate any residual TBA, and then left for a few days in a container with a breathable cover to allow any remaining volatiles to evaporate before counting. For future reference it was noted that aggregates of a black material, which incorporated pollen at times, developed after treatment in the oven, generally from samples from the organic and humic, upper parts of the monolith. This will be discussed later.

Mounting of Samples for Pollen Analysis.

Each sample was mounted on a clean microscope slide. The slide was set in a jig which had a suitable position for the cover slip marked upon it. A drop of silicone oil (2000 cs) was firstly placed on the microscope slide and then a small drop of thoroughly mixed sample suspension was added to this and the two were mixed together and spread out into an asterisk shape. Any large particles were removed with a clean cocktail stick. The sample was covered with a 22mm x 22mm coverslip (thickness no. 0) and any air bubbles were carefully expelled. Each slide was labelled appropriately and the coverslips were secured with a drop of nail varnish at each corner. Ideally the slide thickness was 15-30 μm which enabled most grains to be rotated if required, and the aim was to have about 3-4 pollen grains in the field of view at the magnification used for counting (X400). The slides were then stored flat and up side down (so that small pollen grains would settle against the coverslip) until required.

Pollen Counting.

Pollen counts were carried out using a Leitz Laborlux K microscope at X400 magnification, by way of evenly spaced traverses of the complete coverslip. All the pollen grains that appeared in the field of view were recorded on a specially prepared pollen count record sheet. This had all the taxa likely to be observed listed on it, mainly at the level of the family or genus but also to be noted were any taxa not listed or those which could be identified to the species level; unknown pollen types; and indeterminable types. A total of approximately 300 grains was counted for each sample (excluding exotic, indeterminable and unknown pollen types), with additional slides being produced if there was an insufficient quantity of pollen represented on the initial slide.

2.5. Anthropogenic Indicators and their Interpretation.

The impact of humans has reputedly been the most important factor to affect and create vegetation change in Europe, since the onset of agriculture in Neolithic times. The role of humans changed from a passive to an active element which had direct and disturbing affects on the natural environment and the development of the landscape. Settlements, farming and changes in the economy all contributed to alteration of the landscape and creation of todays cultural landscape.

Pollen analysis, which has been used to reconstruct vegetation history is also employed to investigate the history of settlement and habitation, to determine the different agricultural economies in both pre-historic and historic times (Coggins, Fairless and Batey, 1983). Anthropogenic indicators or pollen from taxa which are highly correlated with human activities are represented in the pollen record.

Behre (1981) demonstrates the wide ecological range that many so-called anthropogenic indicators have, and also draws attention to the consequent importance of evaluating their presence or absence critically in pollen data. He outlines the principal anthropogenic indicators and their appearance in major farming practices for the part of Europe north of the Alps but stresses that in smaller regions, with more uniform soils and climate the evaluation of some of these indicators will be different.

Evidence of the pollen from cultivated crops is one of the best indicators of anthropogenic activity but it is also a very unreliable indicator. The absence of pollen is not significant and cereal cultivation cannot be excluded on the basis of this alone. Problems emerge because of the inability to distinguish between some taxa such as *Avena, Triticum* and *Hordeum* and many of the Leguminosae and Cruciferae taxa or to distinguish *Panicum* and *Setaria* from non cultivated grasses. These difficulties are compounded by the variation in pollen production and dispersal between the species (Behre, 1981).

There are other non agricultural anthropogenic indicators such as *Plantago lanceolata* which is an indicator of pasture land but will not grow in grazed forests or on dry treeless grazed heaths with sandy soils. Its presence may even indicate arable farming. Several species of *Rumex* are also regarded as important indicators of an open disturbed biotype such as occurs in cultivated areas, newly cleared woodlands and heaths. Chenopodiaceae, *Artemisia*, and *Urtica* are nitrophile species and occur around nitrogen rich areas associated with habitations and cultivated areas. However, within these groups are species with indistinguishable pollen, which occur commonly in natural communities, especially in coastal areas or on the nitrogenous banks of rivers and lakes (Behre, 1981).

Finally, pollen indeces have been used to determine the relationship of arable to pastoral economies, details of which are important when investigating economic development or the pattern of human settlement (Roberts *et al*, 1973).

In addition to pollen from particular taxa acting as anthropogenic indicators, evidence from pollen stratigraphy can be generated indicating woodland management by interpretation of the vegetation dynamics such as successional stages and the arrival of non-native species, as demonstrated by Huntley (1989). Detailed evidence of this nature can be derived from closed canopy sites, but will only illustrate the stand dynamics of the immediate 20-30m and therefore may not be applicable to the entire woodland. Bradshaw (1988) suggested that the most useful research design for studying the local pattern of vegetation has proved to be a series of closed canopy sites sites with one or more larger sites providing long term regional history. Furthermore, for studies of pollen data from historical times, a knowledge of contemporary woodland management or local historical data would be useful for interpretation (Behre, 1988; Rackham, 1980, 1990). Finally, knowledge of the ecology of the individual taxa is essential not just in terms of identifying anthropogenic activities or management, but as a guide in the interpretation of the pollen diagram.

2.6. Sediment Description.

Sediment descriptions were made using Troels Smith's system and abbreviations (Andy and Berglund, 1986) and Munsell colour charts. Macrofossil analysis was also under taken on the sieve residues of the pollen preparation samples using a Leica WILD MC3 dissection microscope, with a Volpi Intralux 4000 light source. Any macrofossils found should be stored under industrial meths to avoid deterioration.

Loss on ignition tests (LOI).

Each sediment was consecutively sampled at 1cm and these samples were used for the loss on ignition tests. In between each stage of the test the samples were kept in a dessicator, to avoid weight changes from atmospheric moisture. The weighing was carried out on a Mettler H5I five figure balance.

The labelled crucibles were first dried in an oven over night at 60 °C and then weighed. The samples were added to the crucibles which were then reweighed and returned to the 60 °C oven overnight. The crucibles and samples were weighed again before being put in a muffle furnace for 4 hrs at 550 °C, and reweighed upon cooling.

3. RESULTS.

3.1. Pollen Percentage Diagrams and Analysis: MOR # 1.

The pollen percentage diagram is illustrated in Figure 10. Samples were analysed every 1cm except between 16cm and 20cm depth where 17-19cm levels were omitted. Also the 3cm level was not sampled due to an insufficient quantity of samples for processing towards the end of the practical work. A x10 exaggeration was applied to taxa that were poorly represented for better resolution.

20-16cm; These levels are characterised by a high herb to tree sum ratio, but also by a high indeterminable sum and the largest quantity of *Lycopodium, Polypodium* and monolete and trilete spores and *Ericales.* Of tree and shrub pollen, *Quercus* and *Corylus* are relatively high, followed by *Alnus;* and *Calluna* is also significant. The herb pollen shows high Gramineae, with significant amounts of Cyperaceae, Compositae (Liguliflorae), Umbelliferae, and to a lesser extent *Aster* type, *Ranunculus* type and undifferentiated Rosaceae.

15-13cm: The herb to tree pollen ratio remains high although it is showing signs of decreasing. The indeterminable sum is still high, and there is a peak in trilete spores, with decreasing monolete spores and some *Polypodium. Betula* is now dominant in the tree and shrub pollen with increasing *Quercus* and some *Fagus,* a small peak in *Tilia* and a decrease in *Corylus. Calluna* peaks at these levels. There is a great variation in herb pollen, with peaks in Gramineae, *Anthemis* type, *Centaurea*, Chenopodiaceae, *Plantago* (undifferentiated, but mainly *P.maritima*) and *Ranunculus* type, with Cruciferae showing an increase. Compositae (Liguliflorae) is significant but showing a decrease, as are Umbelliferae and Rosaeceae. The most significant peak at these levels is that of the cereals, which were identified as *Triticum* type.

12-11cm: At this stage there is an approximately equal tree to herb pollen ratio, with some trilete spores and *Lycopodium*, and a variable indeterminable sum. There are significant amounts of *Betula* and *Quercus* pollen, and an increase in *Fagus*, with *Corylus* continuing to decease. *Calluna* begins to tail off also. Of herb pollen, Gramineae decreases although there is a slight peak in Cyperaceae. Cruciferae shows the most significant peak at this level and there is a small rise in *Geranium.* Caryophyllaceae begins to rise although there are decreases in *Plantago, Ranunculus,* Rosaceae and *Aster* type. There is no evidence of Compositae (Liguliflorae).

10-9cm: These levels signify the first time that the tree to herb pollen ratio becomes greater. There are few indeterminables and very little monolete and trilete spores. The rise in tree pollen is probably due to the increase in *Quercus*, accompanied by a peak in *Fagus*. *Corylus* increases very slightly and there is a decrease in *Betula*. Of the herb pollen, Gramineae and Cyperaceae remain significant fluctuating levels. There is a peak in Caryophyllaceae, with very small amounts of *Anthemis* type, *Aster* type, Cruciferae, *Plantago*, Primulaceae and *Ranunculus* type.

8-0cm: The high tree to herb pollen ratio remains constant throughout all these levels, there are few indeterminables and very little spores. *Quercus* clearly dominates the tree pollen with slightly increasing amounts of *Betula* and some *Corylus* There is a small rise in *Pinus* between 5-7cm. *Fagus* is no longer evident. There is a variety of herb taxa at very low levels, with significant amounts of Gramineae and to a lesser extent Cyperaceae.

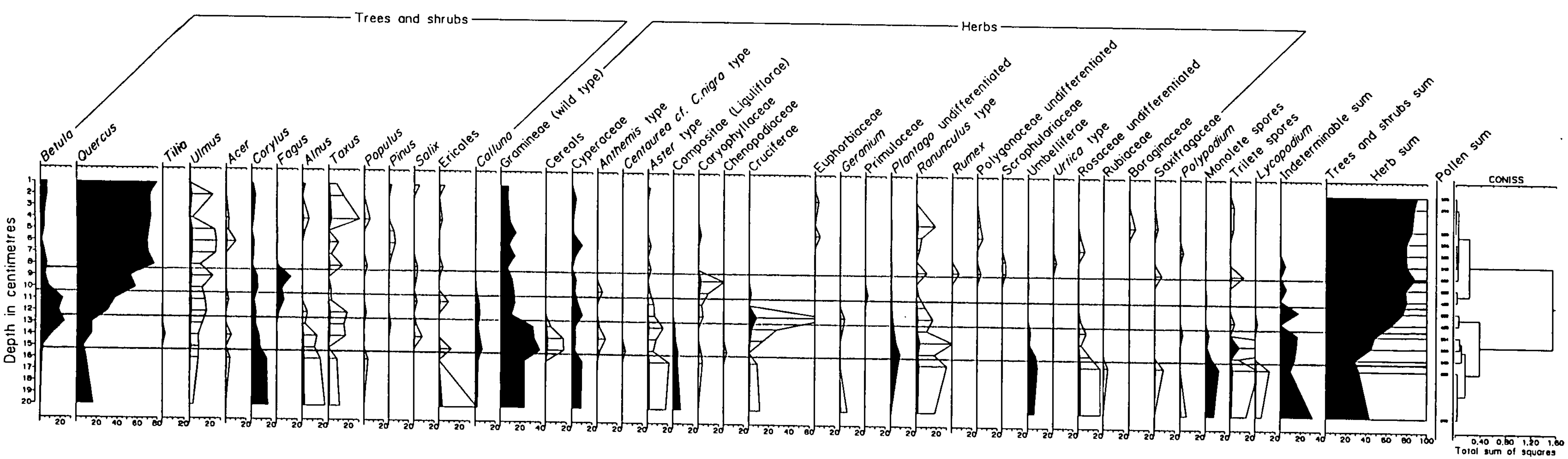
Throughout the diagram there has been a constant background level of *Ulmus* and *Taxus*, with variable *Acer* and *Alnus*, and some *Salix* and *Populus*.

A possible interpretation of the vegetation dynamics illustrated in this profile will be presented in the discussion. However it should be stressed at this point, that as there are evidently some sharp changes in the pollen record such as the peaks in cereals, *Fagus* and many of the herb taxa, there is no real indication of vertical mixing (Turner and Peglar, 1988). Also there are no indications of hiatuses or any other form of disturbance.

Therefore, as the pollen stratigraphy of this profile appears to be undisturbed, there is no reason why legitimate interpretations cannot be made from this diagram.

Care should be taken when interpreting the lowest layers of the profile, as here, the greatest quantity of indeterminable grains was recorded. Also, as cautioned by Havinga (1984), the presence of increased levels of *Lycopodium* and Compositae (Liguliflorae) was potentially a sign that differential preservation was taking place. The fact that there was pollen evident that was liable to deterioration such as *Taxus*, Cyperaceae, *Quercus* and *Polypodium* meant that it was possible for the more fragile grains to be preserved, but obviously a proportion has been lost. Direct interpretation would produce a biased result. For this reason after analysing the samples at 4cm intervals, it was decided that the integrity of the pollen record beyond 16cm was dubious and therefore the pollen record would only be interpreted from 16cm in depth. All relevent data are presented in Appendices 1 & 2.

Figure 10: Great Wood Upper Teesdale, Co. Durham.
Mor # 1, May 10th 1993.



J E Payne, August 1993.

3.2. Pollen Concentration Diagram and Analysis: MOR # 1.

A measure of the concentration of pollen grains per cc was estimated. This was calculated by the addition of a known quantity of exotic pollen to the samples before processing. These are recorded in the pollen count, but not included in the pollen sum and subsequent abundance determinations can be undertaken by expressing all fossil taxa in terms relative to the marker grain. Moore, Webb and Collinson (1991) suggested that one should aim for a final ratio of between 1:5 and 2:5 exotic to fossil grains.

It must be noted that after the count a minimum value for exotic pollen of 1 was substituted in samples that recorded entries of 0. These were at depths (cm) of 1, 6, 9, 10, 11, 13, and 14. Each unit width on the diagram represents a concentration of 100 000 grains. Also, only pollen grains were included on the pollen concentration diagram, no indeterminables or spores.

Figure 11 illustrates the pollen concentration diagram for mor # 1, with a x10 exaggeration for poorly represented taxa. The data are presented in Appendix 3. Several overall trends are considered.

- The total pollen concentration sum shows a non linear curve, reaching a maximum pollen concentration at 12cm and decreasing rapidly to 20cm.
- There are major fluctuations in the total pollen concentration sum before it peaks at 12cm. At 1cm, the concentration is particularly high, and at 8cm it decreases greatly.

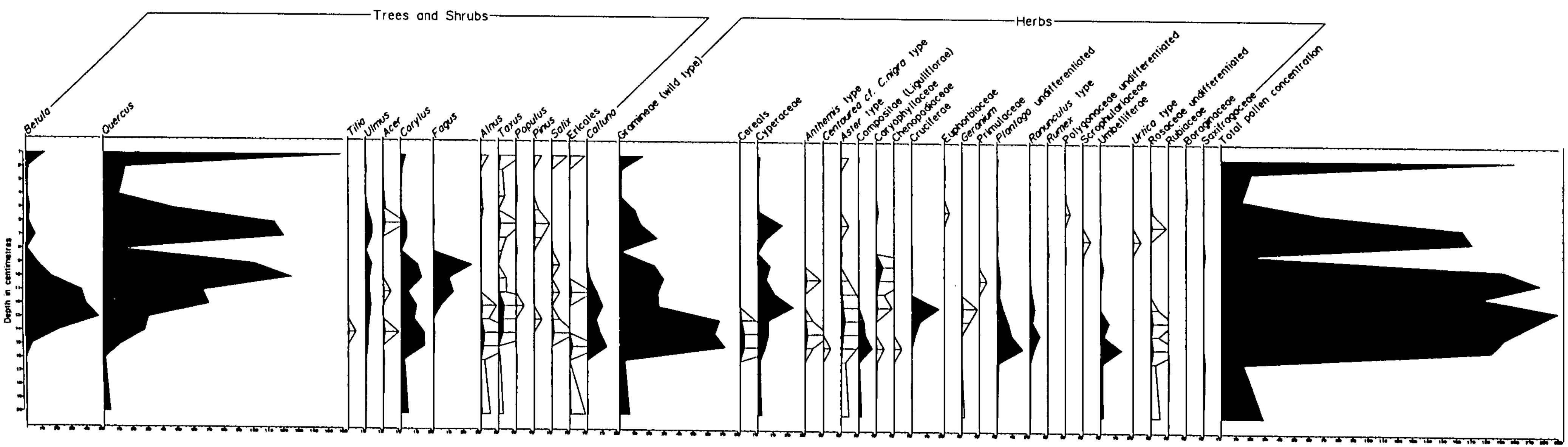
An overall interpretation of this diagram shows the greatest concentration of pollen grains towards the centre to the diagram. An increase in pollen of a particular taxon or as a whole, may be due to a number reasons all of which must be taken into account during interpretation.

1. The amount of pollen produced may have increased.
2. The mor humus may have grown more slowly.
3. Selective preservation of certain types of pollen may be taking place.
4. It might reflect an increase in humification.

An interpretative description to try to establish the factors governing the shape of this curve will be presented in a general over view when all potentially influencing evidence has been discussed.

However, it can be speculated that perhaps experimental error may be the causal factor producing such violent changes in concentration. Firstly there was a low count of exotic pollen, between 0 and 12 per sample with a total count of over 300 pollen grains, certainly now where near a ratio of 1:5 or 2:5. When calibrated with a heamocytometer there was a count of 53,600 per ml which should theoretically be adequate, as a count of 10^4/cc is suggested (Huntley and Allen, 1992). Therefore it may be likely that the estimated 1cc sample of sediment was inaccurate and that samples were over sized to varying extents, and therefore the exotic pollen solution will be differentially diluted, giving dubious results. Of course these results may also have been the product of physical loss during processing as cautioned by Green (1983). However, a general pattern of total pollen concentration can be seen.

Figure 11: Great wood, Upper Teesdale, Co. Durham.
Mor # 1 Pollen Concentrations, May 10th 1993.



3.3. Loss on Ignition Test Results: MOR # 1.

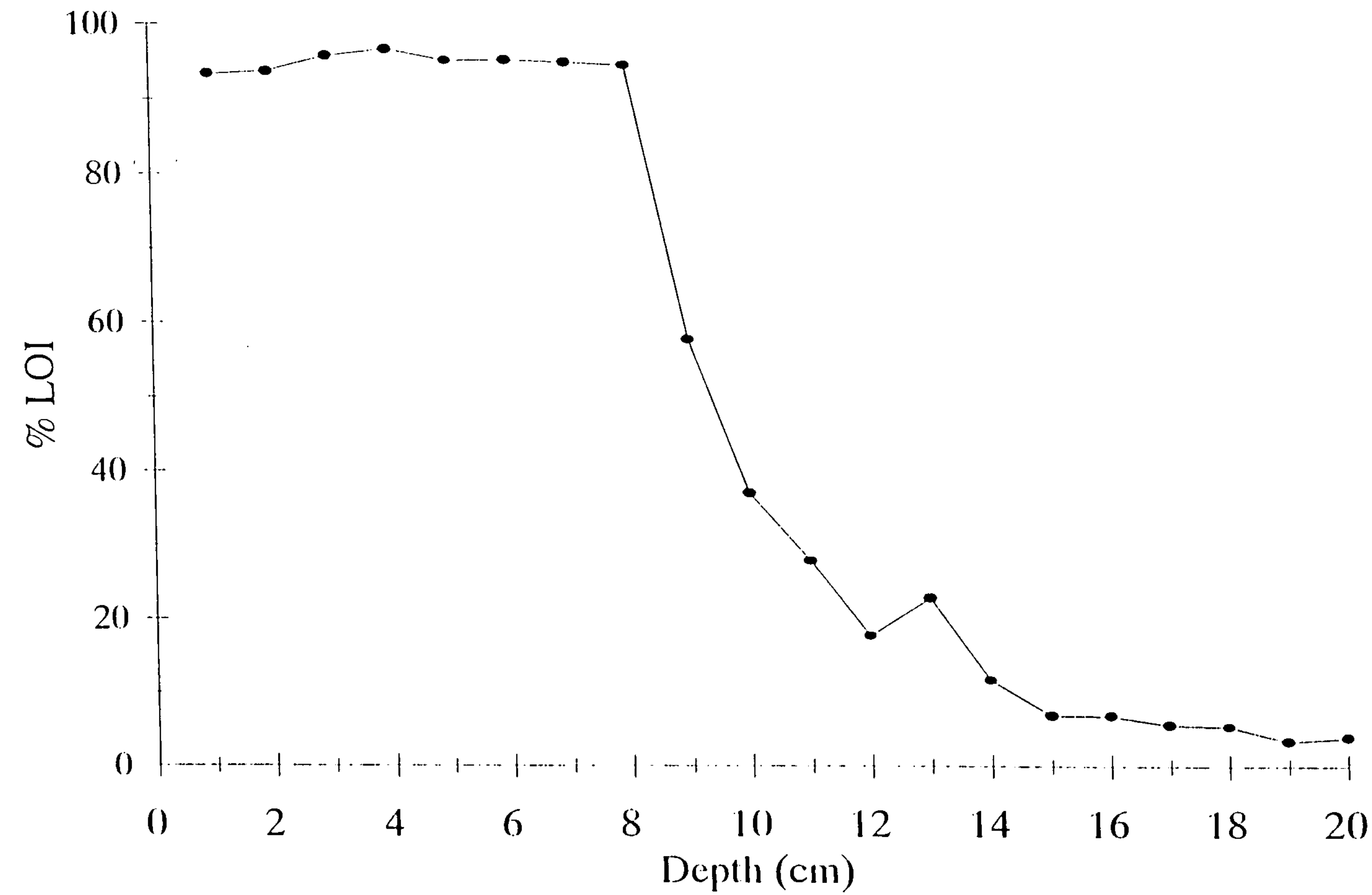
Loss on ignition tests (L. O. I.) are a means of describing the organic content of the soil profile. They are indication of accumulation rates and/or loss of organic material from the profile, and the degree of mineralisation.

Figure 12 shows the loss on ignition (L. O. I.) test results for mor # 1. The data for this figure are in Appendix 4.

This figure consists of three stages:
0-8cm. There is over 90 % L. O. I. at this stage indicating that the soil consisted largely of organic material.
9-14cm. Over this range there is a 80 % decrease in L.O.I. with a slight peak at 13cm. The curve seems to consist of two parts. An initial steep decline which turns gradually into a more shallow curve. Interpretation of this curve suggests that there is a sharp decline in the organic content of the soil which becomes less with depth.
15-20cm. At this stage there is a consistently low L. O. I. of 10 % suggesting that at this depth the soil had a low organic content.

To summarise, this graph illustrates that the major stratification within the organic layers of the soil profile is preserved. Therefore stratified pollen analytical changes can be interpreted meaningfully and in terms of a time sequence. O'Sullivan (1973) suggests that radical changes in pollen assemblage often coincide with soil stratigraphic changes. Evidence of this nature will be investigated in the discussion.

Figure 12: LOI results for Mor # 1



3.4. Sediment Description: MOR # 1.

Table 5: Sediment Lithology of Mor # 1 using Troels-Smith System and Abbreviations.

DEPTH	COLOUR (Munsell)	PHYSICAL PROPERTIES				HUMICITY	DEPOSITED ELEMENTS	REMARKS
		Nig	Strf	Sicc	Elas			
0-1cm	5 YR 3/3	2	0	4	4	+	T h 4	Mainly rootlets with dicotyledonous leaves and bark.
3-4cm	5 YR 2.5/2	3	0	3	4	1	T h 3/D h 3	Fragments of leaves, rootlets and humic material.
7-8cm	10 YR 2/2	3	0	3	3	2	Dg 3, As +, Ag +	Decaying strands of root and leaf matter. Pollen and amorphous organic material.
11-12cm	5 YR 2.5/1	4	0	1	1	-	L d 0, S h 3, A g 2, A s +	Amorphous organic material, fungal hyphae.
15-16cm	7.5 YR 3/4	2	0	2	0	-	L d +, A s 2, A g 2	mineral with some signs of organic matter.
19-20cm	10 YR 4/6	2	0	2	0	-	G min +, A s 3, A g 2	mineral, no signs of organic matter.

Table 5 is a summary of the sediment lithology as described by Troels-Smith (Andy and Berglund, 1986). The information that can be extracted from this description broadly indicates the following:

1. The brief description of the sample indicates that there is a steady degradation of plant matter with depth until 12 cm, where the decaying matter is reduced to amorphous organic material. Between 16 to 20cm the soil becomes increasingly mineralised. Fungal hyphae were recorded at 12cm.

2. Of the physical properties; Nigror, the degree of darkness gradually increases until 12cm in depth, after which the soil becomes more mineral and lighter in colour; Stratificatio, the degree of stratification, there is no stratification of the sediment other than in broad terms; Siccitas, the degree of dryness, the sediment becomes most moist at 12cm; Elasticitas, the degree of elasticity, gradually decreases with depth.

3. The deposited elements compound what the general remarks indicate.

There are consistent changes with depth, supporting results presented in 3.3. The profile appears to be a well stratified mor humus overlying a mineral soil.

Macrofossil Evidence.

Table 6: A Description of Macrofossils from the Sieve Residues of Mor # 1.

DEPTH (cm)	IDENTIFIED MACROFOSSILS
0-1	Seed of *Luzula*
5-6	*Salix* capsule (not definite)
6-7	Seed of *Luzula*; *Cenococcus geophyllum*
10-16	*Cenococcus geophyllum*

Luzula is to be found growing at the site of mor # 1 at present, therefore, it is no suprise to encounter seeds at 0-1cm depth. The presence of *Luzula* seeds at 7cm may mean the vegetation cover was similar to the present vegetation, although members of this genus do grow in open areas (Phillips 1980). The fungus *C.geophyllum* occurred at depths where there was humic material, as illustrated in Table 5. The relative quantities of fungi at each depth was unfortunately not estimated, however Kendrick (1959; cited by O'Sullivan, 1973), has indicated that fungal action is at a maximum just below the litter layer, and with depth soil meiofauna become more important. The least biological activity is supposedly at the amorphous humic layer. The above results would seem to indicate otherwise.

3.5. Multivariate Analysis: MOR # 1.

Non-agglomerative cluster analysis was carried out with CONISS, as part of the Tilia 1.10 and Tilia * Graph 1.7 software package. The results of the analysis provide a basis for the zonation in 3.1.. The major division lies between 10-11cm in depth where the tree and shrub pollen first dominates the herb pollen. The second major division is between 12-13cm and is characterised by an increase in herb species below 13cm and a change in the relative proportion of *Betula*, *Quercus* and *Corylus*. The decrease in herb species above this depth is reflected by the first major division. The third major division is between 8-9cm. Between 9 to 10cm in depth there are changes in the relative proportions of tree species, with a peak in *Fagus* and a sharp decline in *Betula*, accompanied by a low variety of herb species. Above this division a rather stable situation is seen and is confirmed by a very low dissimilarity coefficient. *Quercus* dominates the other tree taxa, all of which remain at a low unfluctuating level. There are a variety of herb taxa evident in low quantities. The last division is between 15-16cm. It is possible that this division reflects the initial stages of the decrease in the quantity of herb pollen either due to the canopy becoming more closed reducing the number of herb species or through differential deterioration of the pollen, leaving the more robust grains such as Compositae (Liguliflorae), *Lycopodium* and *Alnus* (Havinga, 1984).

3.6. Mor # 1: A General Interpretation.

In general the profile of mor # 1 was not thought to be disrupted in any way. The results of the L.O.I. tests showed consistent changes with depth, which were supported by the sediment lithology results. Cruickshank and Cruickshank (1981), noted that mor humus can be initiated to develop over acid brown earths after forest clearance or grazing is abandoned. This may be the case with this sediment as at 15cm there is a rise in humic content of the soil, which coincides with a rise in tree pollen. The preservation of pollen in mineral soils is notably unreliable, although it is feasible that the early stages may reflect a more open canopy and then a succession of forest regeneration, and in places the development of a mor humus such as this one, may have occurred.

The profile of the sediment also broadly explains the results of the pollen concentration diagram in 3.2.. There is a low concentration of pollen in the mineral part of the diagram below 16cm, reflecting the poor preservation qualities of the mineral soil. The generally low concentration of the pollen in the upper part of the diagram may reflect the less compacted nature of the organic material compared with the underlying humic material, which showed high concentrations. The spurious results at 1cm and 8cm are most likely due to inequalities in sample volume and other authors have had similar problems when estimating pollen concentrations with mor humus (Cruickshank and Cruickshank, 1981).

The divisions indicated by cluster analysis are used to illustrate the different zones in the diagram. As there is no indication of disturbance of the soil profile or differential deterioration of pollen (above 16cm in depth), a plausible interpretation can be extracted from this diagram.

3.1. Pollen Percentage Diagrams and Analysis: MOR # 2.

The pollen percentage diagram is illustrated in Figure 13, and poorly represented taxa have had a x10 exaggeration factor applied. Samples were analysed at consecutive 1cm intervals throughout the profile, and the data for this profile are in Appendices 5 & 6.

The entire diagram is characterised by a high tree and shrub to herb pollen sum ratio with *Quercus* dominating throughout, although there is slightly more herb pollen below 7cm. There is a continuous fluctuating level of indeterminable grains and it appears that cryptograms are more significant below 7cm.

<u>14-13cm:</u> At this stage *Quercus* is clearly dominating and showing signs of increasing. There are slight peaks in *Corylus* and *Pinus*, and also *Calluna;* with a low but significant level of *Ulmus*. Of the herb species, *Plantago* is the most significant next to Gramineae and Cyperaceae. There are also small peaks in *Anthemis* and *Geranium.*

<u>13-12cm:</u> *Quercus* continues to increase at this stage, there are small increases in *Salix*, *Acer* and also Ericales, and a decrease in *Corylus* and *Pinus*. Gramineae and Cyperaceae remain at a constant level and there is a peak in Cereal. There are also peaks in *Anthemis, Aster*, Compositae (Liguliflorae), *Plantago* and *Ranunculus.*

<u>12-11cm:</u> This stage is characterised by a continued rise in *Quercus* and a small peak in *Fagus. Pinus* reappears and there is a small rise in *Calluna*. There is a small decline in Gramineae and evidence of *Plantago, Ranunculus*, Rosaceae and Onagraceae.

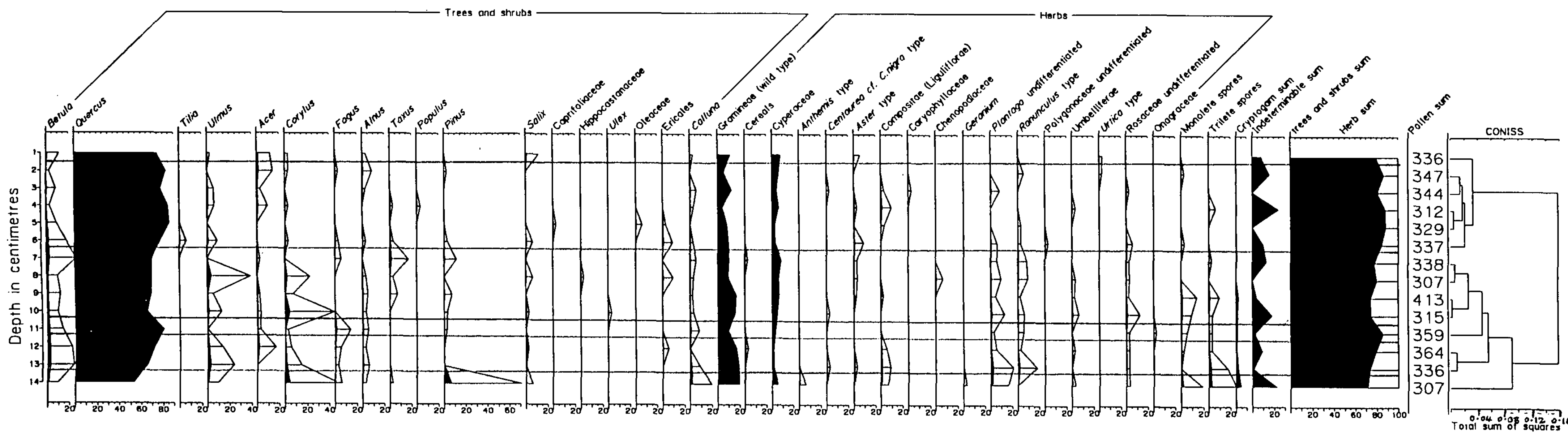
<u>10-7cm</u>: *Quercus* maintains a slightly reduced but constant level at this stage whereas *Fagus* disappears. There are corresponding increases in *Ulmus*, *Corylus*, *Pinus*, *Betula* and *Taxus*. The is some evidence of Hippocastanaceae, *Ulex* and Ericales. Gramineae fluctuates slightly and Cyperaceae gradually rises. The dominant herb species are *Plantago, Ranunculus*, Rosaceae and Umbelliferae with peaks in Chenopodiaceae, *Centaurea* and Compositae (Liguliflorae).

<u>6-2cm:</u> *Quercus* pollen is at its highest at this stage and other tree taxa of significance include *Acer*, *Ulmus*, and *Betula* and some *Fagus*. There are signs of *Tilia,* Caprifoliaceae, Oleaceae and *Populus*. *Plantago* and *Ranunculus* show signs of declining and there is a variety of other herb taxa including Polygonaceae, Compositae (Liguliflorae), *Centaurea* and Caryophyllaceae.

1-0cm: *Quercus* decreases slightly at this stage, with *Acer, Salix* and *Betula* and some *Calluna*. There is a low variety of herb taxa, with only *Urtica* and *Aster* of any significance.

The resolution of this diagram does not appear to be as clear as that of mor # 1. There are no real sharp changes in the pollen record, instead rather vague continuous basal levels of various taxa with *Quercus* dominating throughout, and several small peaks of other taxa. This may be a representation of the surrounding vegetation, but it could also be interpreted as evidence of disturbance of the profile. The indeterminable pollen throughout, and signs of resistant grains such as trilete spores including *Lycopodium, Pinus*, Compositae (Liguliflorae), Ericales and *Corylus* at lower depths, along with less resistant grains including *Polypodium, Taxus* and *Quercus* do cause some concern as this may indicate differential deterioration. Analysis of the sediment may give some insight into what is depicted in the diagram.

Figure 13: Great Wood, Upper Teesdale, Co. Durham.
Mor # 2, May 10th 1993.



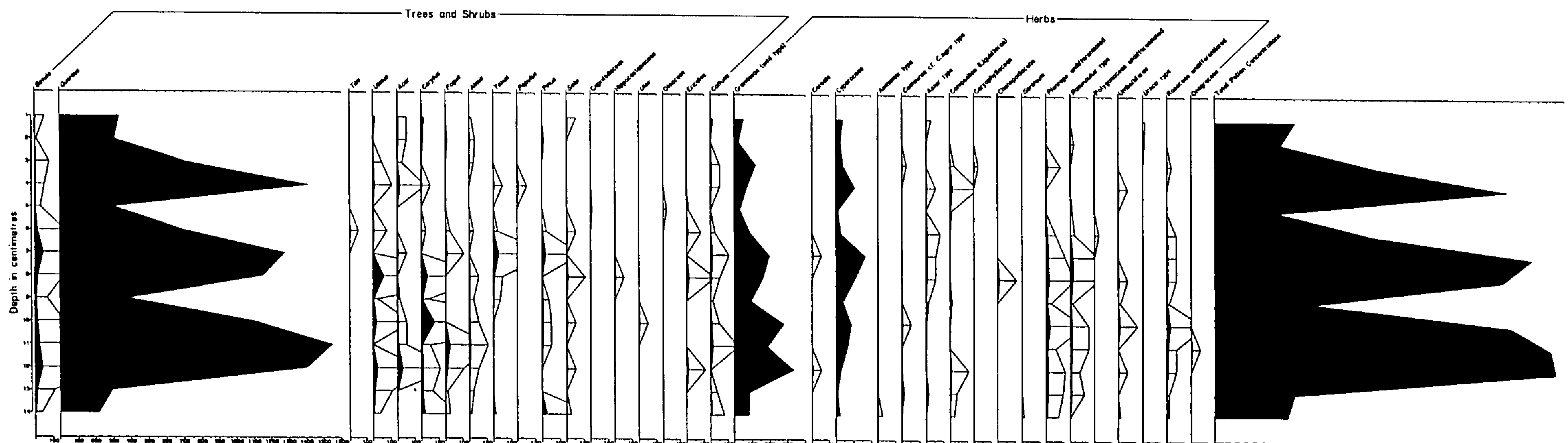
J E Payne, August 1993.

3.2. Pollen Concentration Diagram and Analysis: MOR # 2.

Figure 14 represents the pollen concentration diagram for mor # 2, with the data for this figure in Appendix 7. There is a x10 exaggeration on the less well represented taxa. The same principles apply as outlined in 3.2. (mor # 1). Several samples of mor # 2 were counted where there was no record of exotic pollen, these being 8, 11 and 12, therefore a minimum exotic pollen value of 1 was appointed to all of these. Each unit width on the pollen concentration diagram represents a value of 10 000.

There is no discernible pattern to the total pollen concentration sum, as it fluctuates greatly throughout the diagram. This may reflect very varying pollen concentration through out the soil profile for the variety of reasons outlined previously. Alternatively, it may be a product of experimental error as suggested for a similar problem encountered with mor # 1.

Figure14: Great Wood, Upper Teesdale, Co. Durham.
Mor # 2 pollen concentrations, May 10th 1993.



J E Payne, August 1993.

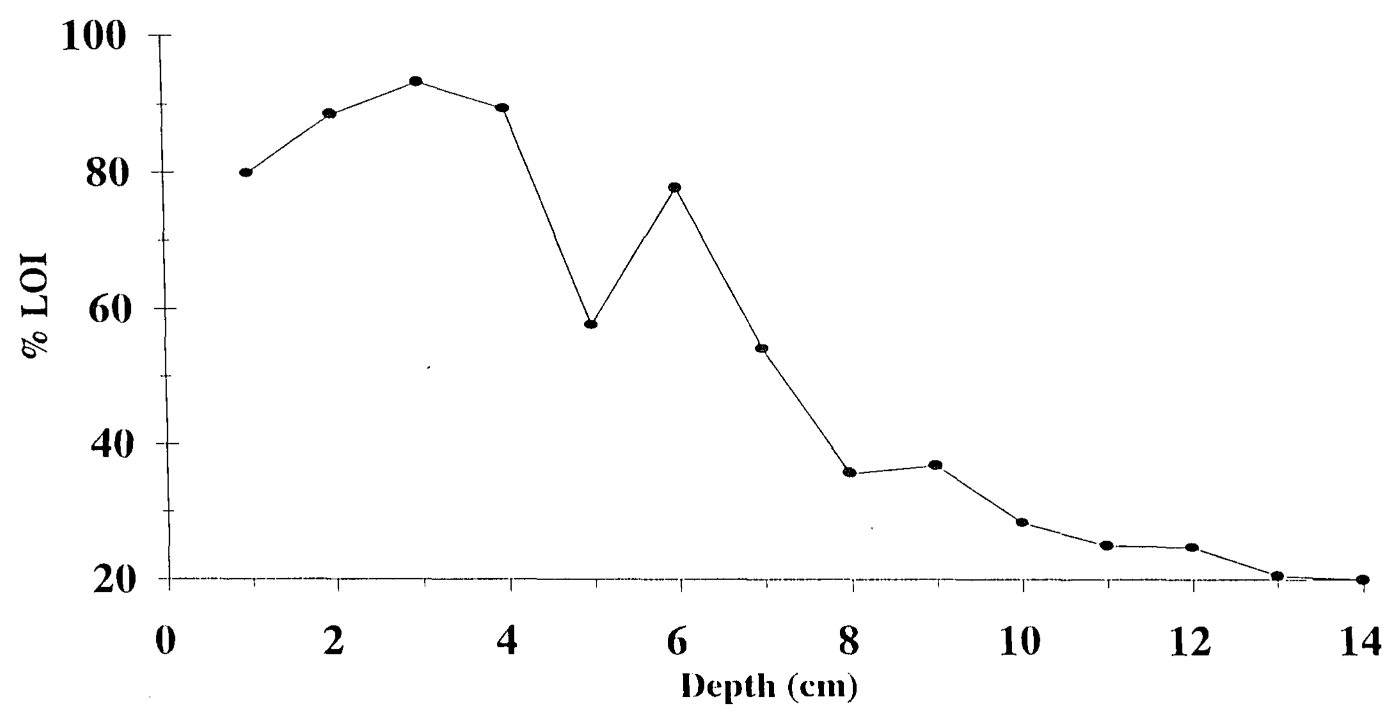
3.3. Loss on Ignition Test Results: MOR # 2.

Figure 15 illustrates the L.O.I. results for mor # 2. The data are in Appendix 8.

In broad terms there is a general decrease in organic material with depth. However, there is not a constant or regular transition but instead a rather wavering decline. Firstly, until 3cm depth there is a 10% increase in organic content. This then decreases rapidly so that at 5cm depth there is 57% organic content. This seemed possibly to be a spurious value, but was confirmed by a second test. After rising again to 78%, the organic content then declined gradually to 0% at 14cm depth.

These results suggest that there may be a lack of stratification of the soil and therefore the profile may have incurred possible disturbance or alternatively as O'Sullivan (1973) points out the lack of stratification may be due to the humus being formed relatively recently. The sharp decrease in organic content at 5cm corresponds with a low pollen concentration at this depth, however, there are no other correlations of the other fluctuations of pollen concentration with the L.O.I. results.

Figure 15: LOI results for Mor # 2



3.4. Sediment Description: MOR # 2.

Table 7: Sediment Lithology of Mor # 2 using the Troels-Smith Systems and Abbreviation.

DEPTH	COLOUR (Munsell)	PHYSICAL PROPERTIES				HUMICITY	DEPOSITED ELEMENTS	REMARKS
		Nig	Strf	Sicc	Elas			
0-1cm	10 R 2.5/1	2	0	3	2	3	T h 2, D h 2/ D g 2	Mainly fragments of leaves and some very decayed material-unidentifiable but not humified.
1-2cm	5 YR 2.5/1	2	0	3	2	3	T h 1, D g 3	Fragments of leaves, rootlets and decayed material.
3-4cm	5 YR 2.5/1	3	0	3	2	-	T h 1, D g 3/L d 3, S h +	Roots, very humified material and fungal hyphae.
5-6cm	10 YR 2/1	3	0	3	2	-	T h 1, D g 3, S h + A g	Increasingly humified material with some roots. Traces of mineral matter.

Table 7: continued.

7-8cm	10 YR 2/1	3	0	3	1	-	T h +, S h 2, A g 2, G min +	Mixture of humic and mineral material, live roots, fungal hyphae and pollen.
9-10cm	10 YR 3/2	3	0	2	0	-	T h +, S h 2, A g 2, A s +, G min +	Mixture of mineral and humic material, fungal hyphae and pollen.
11-12cm	10 YR 2/1	3	0	2	0	-	S h 2, A g 2, A s +, G min +	Mainly mineral with humic material.
13-14cm	10 YR 3/2	2	0	2	0	-	S h 1, A g 1, A s +, G min 1, G maj 1	Mainly mineral with some humic material.

Table 7 is a summary of the sediment lithology of mor # 2. The information presented can be summarised in the following points.

1. There do not appear to be any defined horizons in this profile but rather a gradual change from leaves and decayed material, to humic material, and finally to mainly mineral matter. Fungal hyphae were recorded between depths of 3-4cm until 9-10cm.

2. The physical properties demonstrate the following; Nigror, the sediment is reasonably dark to begin and increases gradually until 12cm, when it begins to lighten through the increase in the mineral proportion; Stratificatio, there is no fine stratification and no defined stratification in broad terms; Siccitas, the sediment becomes slightly dryer with depth; Elasticitas, the soil has a low elasticity to start with which decreases with depth.

3. The deposit elements correspond with the description provided by the physical properties and general remarks.

These results are compatible with the L.O.I. data, which also shows a gradual but wavering decrease in organic matter with depth, although the L.O.I. data does suggest that there might be no organic matter at 14cm. The first signs of mineral matter are at 5cm, which may be a causal factor for the sharp decline in organic matter at this depth on Figure 15.

Macrofossil Evidence

The only find in the macro fossil evidence was the very notable presence of charcoal in the sediment below 10 cm depth. Unfortunately, the amount of charcoal at each depth was not estimated, but its appearance is significant enough.

Some *Cenococcus geophyllum* was present at 12cm and fungal hyphae appear in the profile between 3-10cm as recorded in the sediment description. Although an estimation of the quantity of fungi with depth was not made, this is more representative of the distribution of fungi described by Kendrick (1959; cited by O'Sullivan, 1973), especially as there is no defined humic layer with low biological activity.

3.5. Multivariate Analysis: MOR # 2.

Cluster analysis, as described in 3.5.-mor # 1, was also used to indicate the zonation in the profile for 3.1.(mor # 2). The first noticeable feature is that the dissimilarity coefficient data are a factor of 10 lower than in mor # 1, which would confirm what is apparent in the diagram, that there is a more constant, unvarying pollen record. The divisions in this diagram are therefore very subtle.

The first major division occurs between 6-7cm, above which there is a slight decrease in herb pollen and in non-*Quercus* tree pollen. *Quercus*, which dominates the profile, is in greatest quantities from 6-2cm. Below 7cm, there are increased quantities of non-*Quercus* tree pollen, and herb pollen is at its greatest abundance. The second major division is at the lowest point of the profile (14-13cm) where there appears to be less *Quercus*, and peaks in other tree and shrub taxa, and some herbs. Above this there is an increase in *Quercus* pollen and a corresponding decline in other tree pollen and herbs. The third division lies between 12-11cm, above which is a temporary peak in tree pollen. The fourth division lies between 11-10cm and the final division is in the top 1cm of the profile where there is a decrease in *Quercus* and a slight increase in the other tree taxa, with very few herb taxa contributing to the increase of herb pollen.

The divisions outlined here are very subtle, mainly caused by slight fluctuations in the different proportions of the pollen. However, caution must be exercised when interpreting a diagram with one dominating species as the Fagerlind effect may the disguise the absolute changes in the abundance of the that taxon. Moore, Webb and Collinson (1991) point out that as a species approaches 100% a large absolute change in pollen input will cause little change in its representation.

Bearing the Fagerlind effect in mind, but still considering the subtlety of the changes, it is difficult to estimate how finely the cluster analysis dendrogram should be divided to produce zones. Moore, Webb and Collinson (1991), suggest that zones consisting of fewer than three samples should be avoided, however, when dealing with fine temporal and spatial resolution, such zones may be significant and in these cases, cluster analysis may accentuate important subtleties.

3.6. Mor # 2: A General Interpretation.

The profile of Mor # 2 poses some difficulties in interpretation. Firstly, although it appears broadly stratified, there is no clear definition between the layers. This of course could indicate disturbance of the sediment, and the signs of mineral matter at 5cm may be a product of this. When viewing the pollen diagram (3.1.) of mor # 2 as a whole, it is apparent that there are mainly gradual changes in the pollen quantities, and according to O'Sullivan, (1973), these seemingly gradual changes of vegetation depicted in the pollen diagram, may be a consequence of mixing of soil. Alternatively, there are a number of pieces of evidence that would point to the mor being formed relatively recently:

1. There is very little indication of a humic layer. O'Sullivan (1973) noted that in a soil profile without a humic layer most of the organic material would be of a recent origin.
2. The evidence of charcoal at the bottom of a profile indicates that earlier organic material has been burnt away (Bradshaw, 1988).

The implications of this evidence are crucial for the correct interpretation of the pollen diagram, for they imply that the mor humus represents a punctuated time period, which probably represents less of the pollen record in comparison to mor # 1. It also seems possible that the profile may have undergone mixing through disturbance.

Taking this evidence into consideration it can be inferred that the diagram depicts a reasonably closed canopy situation; that only part of the pollen record is depicted, as the earlier part was burnt away; and finally that the profile is possibly disturbed.

Another important point which must be considered when interpreting the diagram is the proximity of the sample site to the river. As previously mentioned, the pollen source area for a site within a closed canopy is 20-30 metres (Anderson, 1970) and therefore, a site on a forest edge is likely to be influenced by foreign pollen which according to Anderson (1970), would be deposited within a few tens of metres of the forest edge. So it is possible that the pollen source area may be somewhat more extensive than that of a site within the wood, such as mor # 1. In addition, vegetation which commonly grows on the river banks, such as *Urtica diocia* and Chenopodiaceae may cause complications when trying to interpret for anthropogenic indicators. This may also account for the continuous display of certain herbaceous species throughout most of the diagram such as *Ranunculus* and *Plantago.*

The pollen zonation was derived from the grouping displayed in the cluster analysis dendrogram. It was noted that the dissimilarity coefficient was very low compared to that of mor # 1 and that overall there was very little variation in the pollen proportions. With one species dominating the pollen record as does *Quercus*, complications can arise due to the Fagerlind effect.

4. DISCUSSION

4.1. Interpretation of Pollen and Sediment Data.

As previously mentioned, it is assumed that changes in the abundance of fossil pollen reflect changes in the plant populations represented, although there has been concern about the validity of this assumption with fine resolution pollen records (Green, 1983). There are many variables which have to be considered before an accurate and meaningful interpretation of the pollen record can be made. These have been discussed but need to be put in the context of these data although some variables have been considered in the results section.

Major variations can be produced through the sampling and processing procedures as illustrated by the possibly spurious results obtained for pollen concentrations. Green (1983) points out that perhaps the greatest source of random error in obtaining estimates of pollen concentrations is in physical loss during processing, a problem avoided by spiking the samples with calibrated suspensions of exotic pollen. In this study, uniform procedures were carried out to produce comparable samples and to reduce the overall variance, with the possible exception of sample extraction which may have been erroneous due to the nature of the sediment. This problem will be discussed later, and it is feasible that it will not interfere excessively with the interpretation of the pollen record.

Due to the predominance of *Quercus* in both mor # 1 and # 2, it may have been prudent to count a larger number of grains. Dimbleby (1957) suggested that if one species is highly predominant then the count should be increased to allow an adequate representation of subsidiary species. Birks and Birks (1980; cited by Moore, Webb and Collinson, 1991) show that commoner pollen types will in general be adequately represented in relatively small pollen counts of 600 or less. The lesser components of the pollen record require a larger total pollen sum to be counted if a reliable estimate of their proportional contribution to the assemblage is to be made. However bearing in mind the time available this was not possible; and as Green (1983) states where there is a small sampling interval it is more beneficial in biological, statistical and sedimentological terms to count more samples than more grains per sample.

Deterioration of pollen grains was also another potential source of error. For this reason the last four cm (20-17cm) of mor # 1 were disregarded. Here there were increased levels of grains considered resistant and increased counts of indeterminables and most significantly, grains liable to deterioration which suggested that there was a degree of differential deterioration. Obviously interpretations from this part of the sediment would be erroneous. In mor # 2 indeterminable grains are encountered throughout the pollen record. The increased counts of resistant types are towards the bottom of the sediment, and as in mor # 1 they are accompanied by significant amounts of less resistant grains. An interesting point to note is that the most of the indeterminable grains are unrecognisable due to mechanical damage and in some cases degradation (Appendices 1 & 5). Moore, Webb and Collinson (1991) suggest that if the "deterioration type" is noted, an idea of the conditions under which the sediments accumulated can be estimated. The cause of mechanical damage is generally due to the physical stress to which the grains have been exposed during their depositional history such as ingestion by soil invertebrates or through compaction, crushing and folding after deposition. Degradation, may be due to oxidation caused by drying of the sediment to some degree. Both of these deterioration types are liable to occur in mor humus (O'Sullivan, 1973) although the former was more important in these sediments.

Sediment analysis was crucially important in order to verify the findings of the pollen record. This concept was utilised by O'Sullivan (1973) who relied on pedological findings to clarify anomalies in various pollen diagrams. He considered a well stratified soil profile to represent in most cases, a lack of disturbance. Therefore other than slight vertical mixing between adjacent layers that would be picked up in the sediment by very fine resolution analysis, or obvious physical disturbance to the profile; accurate pollen records can be constructed from the pollen data and interpreted with respect to time. This criterion is being used, as stated to verify the pollen data. The L.O.I. results of mor # 1 indicate major stratification with no evidence of disturbance, and these findings are supported by the sediment lithology investigation. With no obvious signs of disturbance or mixing from the pollen diagram (Turner and Peglar, 1988), no reason can be envisaged why a feasible interpretation cannot be deduced from these data. Mor # 2 poses a different problem in that although the L. O. I. results show a broad stratification, it is not as defined as that of mor # 1. It also seems to have incurred a degree of mixing as mineral material is evident at 5cm depth, as indicated by the sediment analysis and is apparent in the L.O.I. results. The lack of stratification and the poorly developed humic layer are possibly signs that the sediment has a relatively recent origin. Another piece of evidence that might support this is the charcoal at the bottom of the sediment indicating that the earlier sediment had been burnt away at some time. Consequently, it can be tentatively assumed that mor # 2 is a more recent pollen record, only representing part of time scale represented by mor # 1. There was no comparable evidence in the latter sediment to indicate that it might equally be as recent a pollen record. A comparison of the pollen diagrams of mor # 1 and # 2 may indicate when this occurrence took place. Obviously radio carbon dating would be definitive in deciding this, as shown by other authors (Cruickshank and Cruickshank, 1981), but was not possible within the scope of this study.

The task of assigning a temporal scale is not simple as absolute dating was not undertaken, therefore features in the pollen diagrams are being compared with historical data to try to establish a tentative time scale. As, Bradshaw (1988) suggests, mor humus will only represent the last few hundred years, which is comparable with the time-scale of data compiled about the development of township Eggleston, where the wood is situated. The temporal resolution of these diagrams will be reasonably fine as the sediment is sampled in consecutive centimetres. The pollen concentration diagram should indicate that the more humic, lower sections of the profile are rich in pollen and spores as they are more resistant to decay than non pollen component of the humic matrix and accumulate as the compacted humic layer forms (Bradshaw, 1988), as mor # 1 shows very broadly. The longer period that the lower samples of the profile represent must be considered when assigning a time scale.

As the sediment was collected from a closed canopy site, it can be assumed that the majority of the pollen was from the surrounding 20-30m (Anderson, 1970). However, it cannot be presumed that this was always the case, and when there are signs of a more open canopy such as an increase in herb species, it should be noted that the pollen source area will have correspondingly increased, and therefore regional or extra-local sources must be taken into account.

The complications caused by the Fagerlind effect and the pollen percentages of different taxa not being totally independent of each other, have been partly considered in the results section. Firstly, the domination of *Quercus* in mor # 2, and to a lesser extent in mor # 1 causes difficulties, because large fluctuations in the absolute abundance of *Quercus* may not be adequately reflected by the proportional representation due to the Fagerlind effect. This would also cause increases in a less well represented taxa to have a greater effect on the proportional representation than would be reflected by the original vegetation. Secondly, as Green (1983) points out, with percentage data, any increase in the abundance of one taxon will cause the percentage pollen abundance for some other taxon to decrease. Therefore, spurious correlations between records for different taxa may arise. However, as there is a reasonable amount of diversity of pollen types and a great deal of precision is not required, there is no real need to correct for these factors (Prentice and Webb, 1986).

Surface sample pollen analyses to determine relative pollen productivity and representation were not carried out at this site as the scope of the study would not allow for it, never-the-less the correction factors suggested by Anderson (1970) or Bradshaw (1981) are broadly applicable to this data. However, these correction factors are merely being used as a guide to aid in the interpretation of the diagrams rather than being directly applied to the data, which is quite adequate for this study.

4.2. Comparison of the Pollen Record of Mor # 1 and Mor # 2.

The object of comparing the two pollen profiles is to illustrate if and where they represent one another in the pollen record. As they are more than 30 metres away from each other, in a closed canopy situation within a similar vegetation type in the wood, they may show similar vegetation dynamics or they may differ significantly due to particular dynamics of the immediately surrounding area. If a continuous closed canopy is not assumed or is not evident, a larger pollen source area will represented and may be comparable.

As already suggested from sediment lithology, mor # 1 appears to be reasonably well stratified and undisturbed, whereas mor # 2 is less well stratified, possibly disturbed and perhaps representing a more recent pollen record. But what evidence is there in the pollen record to support these claims?

Firstly, the most obvious difference in the two pollen records is the initially higher herb pollen sum in mor # 1 which is not evident in mor # 2 where tree pollen - almost exclusively *Quercus,* dominates throughout. This may be a fine example illustrating Anderson's findings (1970) that the pollen record is representing the stand dynamics of the vegetation in the surrounding 20-30m. If this is so, the area surrounding mor # 1 was perhaps a lot more open in the past compared to the vegetation in the area adjacent to mor # 2 which remained a closed canopy. It is obviously difficult to compare the two pollen records and there are no immediately apparent similarities, but this is a possible scenario and has to be considered. Another possible scenario is based on the sediment lithology evidence described above. It appears that the entire pollen record of mor # 2 resembles the top 8-9cm of mor # 1, with the possibility that the earlier part of the pollen record was lost through being burnt away. Other evidence to support this claim includes similar tree pollen sums, and similar proportions of the tree species, with *Quercus* dominating and residual levels of *Betula, Ulmus, Corylus,* and *Salix.* The vegetation represented by the herb pollen does differ although Gramineae and Cyperaceae have similar values in both pollen records. Specific evidence includes a similar sharp decline in *Fagus,* although it also appears in mor # 2 in more recent times. The main differences are in the occurrences of *Acer* and *Alnus,* and the sharp peak in Pinus evident in at the bottom of mor # 2. One other point to make is that whatever activities caused the mor humus to be burnt at the site of mor # 2 must have been relatively minor, as the tree pollen does not suggest major disturbance, and there is no significant increase in ruderals or other herb taxa.

The latter scenario is additionally supported by the values of the dissimilarity coefficient derived from cluster analysis. There is a factor of ten difference between the maximum dissimilarity coefficient values of the two pollen records - with mor # 1 at 1.6 and mor # 2 at 0.16. This is not suprising due to the fact that mor # 2 appears to change very little throughout the pollen record, and quite possibly did not incur and therefore will not represent the vegetation dynamics illustrated by mor # 1. However, the pollen record above the major division of mor # 1 between 10-11cm, which is considered to possibly represent the entire pollen record of mor # 2 has a dissimilarity coefficient of 0.2, which is in the same magnitude and furthermore almost exactly the same value as the figures derived for the entire pollen record of mor # 2.

Bearing this information in mind, for the purpose of this study mor # 2 will be considered to represent the portion of the pollen record of mor # 1 which lies above the first major division as defined by cluster analysis.

4.3. The Pollen Record in Relation to Documentary Evidence.

The reason for the historical review of Eggleston was to put the development of the township in perspective, in the time scale most likely represented by the mor humus profile. It could not be assumed that there would have always been a closed canopy, and therefore the data may represent a larger pollen source area. For this reason, detailed information has been provided on the development of the settlement; Eggleston hall and its owners; the agrarian history and the expansion of mining, all of which in one way or another may directly or indirectly have affected Great Wood.

Great Wood: A Historical Perspective.

Due to the nature of this project in terms of available time, it is impossible to consult primary sources. Therefore one must rely on what information is at hand. Consequently, the earliest information available is Richard Daines' map of 1614.(Figure 6)

This detailed map clearly shows how the East Field is the most advanced in the development of piece-meal enclosures and obviously quite well utilised. The position of Great Wood or any sign of woodland is absent. The area which Great Wood today occupies consisted, as mentioned previously, partly of demesne haughs, partly of the East Field and partly of "Barrenlawe" land or intakes. However, no distinction is made of any landuse, other than generally as haughs, meadows, "Barrenlawe" land or using the holding tenants name. Therefore it is difficult to predict if the wood existed but due to the inaccessible terrain over which most of the wood lies it is probable that it was not cultivated, other than for timber and wood needs and possibly for grazing, and that it was just seen as a part of the landscape within the set boundaries.

The 1790 map (Figure 7), thought to have been drafted after Enclosure clearly shows how the town fields have undergone the processes of amalgamation and consolidation. On this map, the entire stretch of valley side adjacent to the river is demesne land. This extended the manorial land to Raygill beck, the eastern boundary of Eggleston township. In "Hutchinson's history of Durham" (1786) written by a William Hutchinson of Eggleston, reference is made to "lofty sycamores around Eggleston hall and extended plantations hanging on the swift descents of the hills", suggesting that the sycamores of an advanced age surrounded the hall and that there had been a concerted effort to replant the wood near the Hall. There is no mention of an elaborate path winding along side the river, and no signs of foot paths on the map of 1790, or an artificial waterfall, as commented on by other authors. Brayley, (1808) states that there are "Several pleasant walks cut through rocks bordering on the Tees". These "walks" and in addition the artificial waterfall were indicated by Garland in (1834; cited by Alexander, 1972), "the pleasure grounds were most judiciously and tastefully disposed, containing an artificial waterfall of considerable height and, a subterranean walk which has been blasted into the rock at the river's side", and Fordyce (1857) who stated that there were botanical gardens and a chapel attached to Eggleston Hall; with an artificial waterfall and subterranean paths excavated by blasting the solid rock, winding alongside the Tees where it divides itself into several channels. Brayley (1808), Garland (1834; cited by Alexander 1972) and Fordyce (1857) all mentioned the path and the latter two the waterfall, and also botanical gardens, suggesting that perhaps the path was built some time between 1786 and 1808 (Photographs 13, 14, 15).

Much anecdotal evidence has been provided by Mr. Harry Beadle (pers comm) who had been Game Keeper at Eggleston for 43 years, his father for 48 years before him and his grand father, woodman for the Hutchinsons before that. He states that the path was wide enough for a pony and trap to use, and led down to the river where there were two bridges over the river leading to Doe Park, which was part of the estate lands and to Low Garth, a farm on the opposite bank of the Tees. These bridges eventually collapsed and only remnants of their existence are left. Close to the site of mor # 2, metal stays are embedded into the rock to which a footbridge was anchored, which led over to the farm. A small enclosure had been constructed near by in which the ponies you had ridden to the bridge could be left.

Additional evidence about the township is provided by a painting by C. Gibson of Eggleston Hall in 1783 (in Hutchinson, 1786). This clearly shows woodland extending on the eastern side of the Hall. There does not appear to be much evidence of piece-meal enclosure, which had largely declined by this time and the field boundaries of the town fields were still hedgerows.

Examination of the walls surrounding Great Wood today and in the surrounding fields show that they are constructed with the characteristic features of two rows of "through stones", as was required in the Enclosure Act (Photograph 18). Therefore Great Wood may have been enclosed thus almost certainly eliminating grazing animals by the end of the eighteenth century.

A map by C. and J. Greenwood from the first quarter of the nineteenth century shows a detailed image of the wood which clearly resembles the area of the wood as it is now, as shown by Alexander (1972) and as does a first edition O. S. map from circa 1850. In 1849 the Tithe Commutation Act recorded 550 acres of woodland in Eggleston, some of which represented Great Wood.

The information concerning the recent history of Great Wood was provided by Mr. Harry Beadle (pers comm). He states that in the time that he and his father have tended the wood (approximately 90 years), no management has been carried out at the southern part of the wood, from where both mor profiles were collected, and it has remained relatively undisturbed other than periodic grazing by intruding sheep and a few fir trees planted by the Gray family, which are noted on the SSSI vegetation survey as being approximately 40 years old. However at the northern part of the wood two *Acer* plantations have been planted in 1928 and 1944, and during the 1950's the plantation at Hall Close adjacent to the hall which consisted mainly of mature *Acer pseudoplatantus* and also *Fagus* was felled. However in his grand father's time the wood was extensively managed with the extraction of timber. Photographs 17 & 18 illustrate that the wood was more open in the past and that there are some older individual trees still remaining.

Photograph 13: The Path just below the Site of Mor # 1.

Photograph 14: The Path Running through an Excavated Passage in the Rock

Photograph 15: View of the Path which is Built up in Places (above).

Photograph 16: View of the Boundary Wall (right).

Photograph 17: Very MatureBranching *Quercus* Indicating Previously More Open Conditions (above).

Photograph 18: Very Mature Individual Trees Scattered Throughout (right).

The Intensification of Mining in Relation to Great Wood.

There are no available records to suggest that timber from Great Wood was used for any mining requirements although this cannot be discounted. As Mr. Beadle recalled (pers comm), the Hutchinsons managed the wood extracting the larger trees which may have been used for mine timbers and other requirements. Mining has been carried out in that area since the seventeenth century, but it did not intensify until later in the eighteenth century when the London Lead Company leased the mines and smelt mills at Eggleston in 1771. Intensive mining activities continued until the late nineteenth century.

As Great Wood was part of the demesne lands and may have been enclosed around the late eighteenth century, and due to its locality and inaccessibility, it is unlikely that extensive extraction of wood for mining purposes was undertaken, especially as coal was used for smelting (Alexander, 1972), although charcoal was the original source of fuel for smelting in the dales (Roberts *et al*, 1973). Alexander (1972) states that by 1850 the upper part of the dale was no longer a forest preserve as lead mining had brought increased accessibility for population and for cultivation.. The private preserves owned by the large landowners such as at Eggleston remained, and were confined to their landscaped and often exotic parklands.

Affects of Agricultural Intensification and Population Growth in Eggleston.

Some of the area now occupied by Great Wood was originally part of the town fields (Figure 6), so it is probable that before they were enclosed the woods were grazed and used for timber. It would be understandable why this area of land may have been left as woodland as it is very steep and in some places precipitous, so it would not be suitable for cultivation. Obviously, if the canopy was maintained in a reasonably open state, signs of agricultural activity may be picked up in the pollen record which may not be apparent with a closed canopy situation.

It appears that the main agricultural activity in this area over the past few hundred years has always been pastoral, with varying amounts of tillage depending on the climate and the demand. The most important crops cultivated where hay, oats, barley, rye and in good years wheat. The main expansion of agriculture occurred after 1750 due to rising populations in the dales and increasing economic activity, and possibly due partly to an improving climate. This was clearly evident from the amalgamation of the piece meal enclosures by late eighteenth century, and the culmination were the Enclosure Acts in 1785 and 1816. Previous to this before the effects of the agricultural revolution were felt, the unpredictable harvests and price fluctuations meant that arable farming was very much a subsidiary activity in the seventeenth century in Teesdale. There was a plough up campaign for land up to the 330m contour during the Napoleonic war (Roberts *et al*, 1973), which may have influenced cultivation in Eggleston because of an increase in cereal prices which were low before (1769-90), and after (1820) this period. By 1849, despite the increasing population in Eggleston which peaked at 788 in 1861, there was little land under tillage, only five acres in the middle field. After this time the area was predominantly pastoral with some tillage during the Second World War but not the First World War(Mr. Harry Beadle, pers comm).

Interpretation of the Pollen record.

Interpretation of the pollen record in relation to the documentary evidence will be undertaken firstly with mor # 1 as this is considered to represent a longer period of time. The bottom layers of mor # 1 (16-20cm) are being disregarded for reasons previously stated.

<u>Mor # 1</u>

15-13cm: The high herb pollen sum may indicate a more open canopy and as a result the catchment area of the pollen would be greater. This feature is adequately illustrated by the peak in cereal pollen at this point, which were identified as *Triticum*. Alternatively, this may reflect a reasonably diverse ground flora. There is an indication that there may have been some disturbance in the area shown by peaks in *Plantago*, *Centaurea*, Chenopodiaceae, *Rananculus* and Compositae (Liguliflorae) although these are also indicative of pastures and, due to the presence of *Calluna* - grazed forests (Behre, 1981), although this may have originated from the surrounding moorland. However a vegetational succession appears to be in progress. There is a decline in *Corylus*, which may either be a real indication of decline or merely a decrease in flowering in response to an increase in shading (Anderson, 1970) by the influx of *Betula*. The sharp rise in *Betula,* a fast growing opportunist species, intolerant to shade, gives two clues to the vegetation dynamics at that time. Firstly, there must have been an open canopy, and secondly whatever had previously suppressed the growth of the *Betula* seedlings had stopped. A corresponding increase in *Quercus* may also be due to the removal of what ever force was suppressing it. There is some evidence of *Fagus* at this stage in the pollen record, a species that would almost certainly have to have been planted at this site, and that is thus an indication of some type of management.

The type of response apparent above, would have been initiated in an open canopy situation through the forest being allowed to regenerate, possibly through the removal of grazing. With the growing importance of tillage after 1750, the grazing in the surrounding town fields may have been restricted, which would initiate regeneration. Also, as it is thought that the forest was enclosed around 1790, this will have contributed to the apparent regeneration due to the complete alleviation of grazing pressures. Furthermore Cruickshank and Cruickshank (1981), and O'Sullivan (1970) indicate that similar changes in management activities on a local scale such as abandonment of forest clearance and cultivation can cause the initiation of mor humus. The possibility that the wood was actively managed, is indicated through the appearance of *Fagus*, and the construction of the path some time between 1786 and 1808. This is in agreement with the record of landscape gardening that was apparently fashionable at the time. It is difficult to distinguish the source of the herb and shrub pollen but it is likely that it is a product of a combination of different factors. Firstly, the pollen source area of the open canopy, would show a more regional representation, demonstrated by the significant proportions of *Triticum* type pollen, arable weeds (including Compositae, Chenopodiceae, Cruciferae) and pastoral weeds such as undifferentiated *Plantago* (although *P.maritima* occurs naturally in these woods, and was reported to occur near Barnard Castle at this time (Hutchinson, 1786)) and Ranunculaceae (Roberts *et al*, 1973). The rise in cereal pollen may have been accentuated by the "plough up" during the Napoleonic War years and serves as a further indicator when assigning a time scale. *Calluna* may be indicative of a grazed forest but as mentioned, was possibly derived from the surrounding moor land. Secondly, the ruderal species may have arisen after grazing was abandoned in the wood and remained until there was a more complete canopy cover; or they were possibly the result of disturbance in the wood through path building and the continued use of the path.

With an estimate of woodland regeneration starting towards the mid eighteenth century, a timescale can be assigned to the pollen record. If sixteen consecutive samples have been extracted from a profile thought to originate soon after 1750, then each centimetre represents approximately 15 years, although the very organic material in the top 8cm of the profile will probably represent less than this, and the remainder more humic part of the profile progressively more. Therefore this period may represent the time between approximately 1750-1820.

12-11cm: The increasing tree pollen sum may be indicative of further canopy closure with *Corylus* reaching a low level. *Betula* begins to decline, which may be due to it being replaced by a climax tree, in this case *Quercus,* or through selective management. There are increasing amounts of *Fagus* which may also be replacing *Betula* and competing with *Quercus*. *Calluna* is also present which may indicate that canopy closure was still not complete and therefore the lack of cereal pollen at this depth may be a reflection of the agricultural trends. As for herb taxa, *Plantago* and Compositae (Liguliflorae) have decreased and there is a significant peak in Cruciferae which is difficult to explain as members of this family occur in a variety of habitats mainly disturbed or waste ground, associated with arable crops, in limestone areas and riverine habitats (Rose, 1981), any of which it may represent in this pollen record.. In addition there is an increase in *Geranium* and Caryophyllaceae. This sequence appears to represent the continuation of succession as suggested previously. If this is so, then canopy closure may not be complete, and the lack of cereal pollen may be a result of the move away from tillage in the recession that followed the Napoleonic war (Roberts *et al*, 1973), as is shown by only five acres of land in tillage in the Middle Field recorded in Ecclesiastical Tithe records in 1849 (Alexander, 1972).

10-9cm: This stage represents the greatest peak in *Fagus* with a corresponding, but slight decrease in *Quercus*. The sharp decline in *Betula* as mentioned previously may be due to dominance by another species or through removal by human management. The establishment of the mor humus may have influenced by the occurrence of *Fagus* near this site, as it is known to form mor soils (Rackham, 1980). By now *Calluna* is almost insignificant, again possibly due to canopy closure. This may also explain why there are so few herb species, as understorey beneath beech tends to be species poor, due to its formidable shading power and the intense root competition (Rowell, 1991). Caryophyllaceae peaks at this stage perhaps as a result of lack of competition from other herbaceous taxa.. These latter two zones (12-9cm) are thought to represent the time period of approximately 1820+-1900.

8-0cm: The very sharp decrease in *Fagus* is accompanied by a rise in *Quercus*. It is possible that the *Fagus* was felled or destroyed in some other way, as its demise is so rapid. Alternatively, the canopy may have remained open enough for *Fagus* pollen from a more distant tree to reach this site, the abrupt decline in pollen being due to the final closure of the canopy. Today there are a some mature Fagus a few hundred metres away. However, anecdotal evidence was provided by Mr. Beadle (pers comm), who stated that some mature *Fagus* trees and some *Quercus,* were removed from the southern part of the wood approximately 80 years ago before the Gray family first moved into Eggleston Hall. This event had been particularly memorable for grand father due to the struggle that incurred on trying to uproot and remove the large trees from that end of the wood. This coincides very well with the calculated time scale. There is a slight response by *Betula* to this but nothing significant. It appears that otherwise this part of the wood has been relatively undisturbed since this time, which is exactly as Mr. Beadle recalls (pers comm).

Overall, this diagram would appear to show a successional sequence from a more open woodland produced by grazing and management, through a period of gradual establishment of a closed canopy when management was abandoned, with several indications of human interference. The mature timber in the wood is estimated in the SSSI vegetation survey, to be 80-120 years old (in 1983), which supports the anecdotal evidence and the pollen record, that prior to the southern part of the wood being left undisturbed at the beginning of the century, management and thinning of trees may have been continually taking place maintaining a more open canopy and hence giving the age structure that is apparent now, with a few very mature individual trees scattered throughout.

<u>Mor # 2</u>

As mor # 2 is believed to represent a similar time scale to that covered by approximately 9-0cm in mor # 1, and therefore representing the pollen record from some time in the late nineteenth century, there appears little need to describe it in such detail, other than to point out significant features. The abrupt decline in *Fagus* may represent the removal of the timber from the southern part of the wood, and later signs of beech pollen may be derived from a larger source area than the immediate radius of the site, as previously implied from its close proximity to the river. Further indication of this occurring is the appearance of the pollen of Hippocastanaceae, *Ulex* and Oleaceae which would probably have been derived from outside this wood. The significance of the increase in *Acer* in more recent times is quite important as it may reflect the expansion of this taxon in the north and mid parts of the wood, as far as this site. The SSSI vegetation survey (Kirby, 1983) states that in addition to the mature trees, there is a second growth of trees of 40-50 years (in 1983) and a third growth of 10-15 years, which is may be what this increase in *Acer* represents. This expansion was possibly as a result of the *Acer* plantations close to the hall (felled in the 1950's) and in the northern parts of the wood (planted in 1928 and 1944), providing ample seeds for dispersal, coupled with the possible abandonment of any management regime at the turn of the century, and the opening of the woods through the death of *Ulmus* to the north of this site. *Acer* appears to be a more important species for regeneration in the mid and northern part of the wood which is more calcareous than the southern more acid part of the wood where *Betula* is more important. The two peaks in cereal are more difficult to interpret, although the one at 7cm may be indicative of the period of tillage during the Second World War (Mr. Harry Beadle, pers comm), and the other may be from a larger source area, although cereal pollen does not travel far once released. The presence of many of the herb species may be a factor of the riverside location of this site or through disturbance from the use of the adjacent path.

Lichenological Evidence at Great Wood.

Great Wood and its neighbour down stream, Shipely Wood are rated grade 3 for lichens in the B L S report, the highest grade given to any wood in north-east England (Kirby, 1983). Many of the species are nationally and regionally rare, and are characteristic of ancient woodland *Lobaria pulmonaria, L. laetevirens, Pachyphiale cornea, Catillaria sphaeroides, Bacidia epixanthoides* and *B. affinis* (Rose, Hawksworth and Coppins, 1970). The structure of the woodland and the biological diversity, such as the high numbers of vascular plants indicate that it is an ancient woodland and the pollen record indicates that there appears to be a continuity of woodland, with a more open possibly grazed or managed situation evident in the past. Rackham (1980) points out that lichens are often successful in wood pasture due to the continuity from wild wood as a result of the increased light and lack of competition from herbaceous plants, and with presence of pollards and ancient trees. Although, he notes that as grazing impoverishes ground vegetation wood pastures rarely have the rich variety of herbaceous plants that ancient woodlands have. In light of this evidence, and bearing in mind the inaccessibilty of this woodland and the history of the developement of the settlement, the relationship of the wood with the Hall, and the possiblilty of grazing and management, it is feasible that this is in essence an ancient woodland, and it has incurred much disturbance in the recent past but not so extensive to prevent it maintaining much of its varied herbaceous woodland vegetation and epiphytes. Without this disturbance, one wonders what the wood would resemble today?

4.4. An Evaluation of the Use of Mor Humus.

In the course of this study the mor humus has illustrated many favourable properties, and also problems which really need to be addressed. Of the favourable properties, are included the fine resolution available, both spatially-depending on the location of the site, and temporally. The fine spatial resolution has been demonstrated by immediate effect that the removal of *Fagus* timber from the surrounding woodland had on the pollen record about 90 years ago; and the ability to match up both regional and local events with the pollen record, depending on the perceived canopy cover at the time. The fine temporal resolution is evident through the degree of detail from which important information can be gathered, such as the short period of increased arable activity around the time of the Napoleonic War or the immediate effect that the abandonment of management showed in the pollen record. Finer sampling to give greater temporal resolution may be restricted due to bioturbation of the soil and possibly downwash of pollen, although as Bradshaw (1988) states these features are not really significant. Mor humus, if available at a woodland site, especially one which has not been replanted or severely managed, and therefore should theoretically have escaped disturbance, is a very valuable tool and can turn up some suprising results (Mitchell, 1988) and as Huntley argues (1989) may prove a useful aid in resolving conservation and management issues at particular sites.

However, a number of notable difficulties were encountered. Firstly, as demonstrated in this study, stratification and lack of disturbance of the humus profile is very important. The sediment lithology and L. O. I. tests were essential in order to determine this and to verify the validity of the data derived from the pollen record, especially in terms of a time scale. The integrity of the mor humus profile is perhaps the most crucial factor in this type of study, as problems caused by other variables can largely be avoided.

Sampling the sediment was an additional problem which has been encountered by other authors (Cruickshank and Cruickshank, 1981) as the very top layers of the sediment were tough and fibrous, and the organic and mineral layers tended to be very friable. It was very difficult to get accurate sample volumes of sediment, which although did not unduly affect the pollen record, meant that it was difficult to estimate pollen concentrations at the different layers of the sediment. This would have provided further evidence on the stratification of the humus. Several authors (Mitchell, 1988; Bradshaw, 1988; Bradshaw and Hannon, 1992) have suggested freezing the monoliths of sediment and sawing sections off, then measuring the precise volume of subsamples by water displacement. This should definitely be considered for similar studies in the future.

Finally, the last problem was encountered during the processing of the samples and requires a small alteration to be made in the preparation protocol. At the end of processing when the samples where heated in a 60 °C oven in order to drive off the remaining volatiles, some samples especially those from the more organic and humic parts of the profile tended to form solid aggregates of black material incorporating the pollen and making the sample difficult, and impossible in some cases to use. It is probable that this is the result of inadequate treatment of the samples (2-5 mins in boiling (10%) NaOH) to remove and disaggregate humic particles. Several suggestions have been made by other authors dealing with mor humus as to suitable treatments including preparation in a standard manner with an additional three days digestion in cold weak (2%) KOH (Bradshaw and Hannon, 1992) or two treatments with hot (10%) KOH, before and after sieving each sample (Mitchell, 1988).

If these problems are tackled sufficiently and great care is taken to eliminate all other sources of error, there is no reason why mor humus can not be used as a perfectly adequate medium for fine resolution pollen analysis.

4.5. Summary and Concluding Remarks.

To summarise what this study reveals, a number of aspects have to be considered. Firstly, mor humus is subjected to analysis to determine it's qualities and failings as a medium for fine resolution pollen analysis in a closed canopy situation. A number of points come to light.

1. Careful processing of the sediment must be carried out, with several alterations made to the preparation protocol to produce the most satisfactory results. A review of the volumetric sampling procedure is necessary as the sediment is quite difficult to work with.
2. The importance of a preserved soil stratigraphy cannot be emphasised enough and requires thorough examination of the sediment before an interpretation can be drawn from the pollen record. Macrofossil analysis of the samples are necessary and can produce vitally important information as illustrated in this study.
3. A complete knowledge of the properties and mechanisms behind the deposition of pollen in a closed canopy situation is fundamental for a correct interpretation of the pollen record. To avoid erroneous interpretations of the vegetational history a number of sediments will need to be sampled in a closed canopy situation to obtain a more complete picture, and also to circumvent problems encountered as outlined in point 2..

If processing is undertaken carefully and examination of the mor humus reveals satisfactory results, it is feasible that the data represented in the pollen record are chronologically correct. Therefore, the interpretation of the pollen diagram, when all the necessary factors taken into account, should illustrate the vegetational dynamics of the surrounding vegetation and possibly give clues to the regional vegetation depending the openness of the canopy, over the past few hundred years. The reason for the formation of the humus may be an important part in the woodland history as in this study.

In an appropriate woodland site, with access to adequate local and regional knowledge including first hand anecdotal information, a historical account of the wood can be developed within the estimated timescale. This can then be compared to the pollen record to equate any matching features, which as illustrated in this study can be can be refined enough to record the felling of a few trees.

Investigations of this kind have been undertaken previously (Huntley, 1989; Mitchell, 1988), and have revealed great insight into the stand dynamics of the particular woodland, including some suprising results contra to former ideas about vegetational history of the wood. The situation in Great Wood is that there are many indicators to suggest that the wood is an ancient woodland, none of which are being disputed and it is apparent that Great Wood has been largely affected by management with the selective planting and removal of particular tree species. It is interesting to speculate what the wood would resemble today had there been no mangement, and also to query what the future of the wood holds. To maintain it in it's present state or near to its previous state would require management to remove the invasive species of *Acer*, *Rhododendron* and possibly *Betula*, and replant *Ulmus*, *Fraxinus* and *Quercus*. However, is it feasible to interfere with the succession within this otherwise undisturbed wood when it is likely that latter three tree taxa were possibly selected for anyway, interms of their timber or aesthetic values. This is not a straightforward subject to approach and the value of utilising fine temporal and spatial resolution pollen records to approach conservation and management issues has already been outlined by Huntley (1989).

To conclude, there is much scope for this kind of study. That is, the comparison of the pollen record from mor humus profiles to illustrate the stand dynamics within a closed canopy, and possibly to provide regional information, and equating the resulting pollen data to historical documented information to determine a time scale and to ascertain such aspects as the history of management within the woodland.

5. References

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6. APPENDICIES

Appendix 1: Mor # 1 Pollen Counts

	1.0	**2.0**	**4.0**	**5.0**	**6.0**	**7.0**	**8.0**	**9.0**	**10.0**	**11.0**
Betula	24.0	19.0	12.0	15.0	3.0	12.0	18.0	15.0	32.0	70.0
Quercus	296.0	197.0	238.0	269.0	213.0	225.0	224.0	188.0	235.0	124.0
Tilia	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ulmus	0.0	6.0	1.0	9.0	8.0	8.0	3.0	8.0	5.0	5.0
Acer	0.0	0.0	1.0	1.0	3.0	0.0	0.0	0.0	0.0	1.0
Corylus	6.0	12.0	8.0	1.0	8.0	8.0	3.0	21.0	26.0	9.0
Fagus	1.0	0.0	0.0	1.0	1.0	0.0	3.0	49.0	20.0	25.0
Alnus	1.0	0.0	2.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0
Taxus	3.0	4.0	10.0	0.0	3.0	1.0	4.0	0.0	1.0	1.0
Populus	0.0	0.0	2.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0
Pinus	1.0	0.0	0.0	2.0	2.0	1.0	0.0	0.0	0.0	0.0
Salix	2.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0	0.0	1.0
Ericales	2.0	0.0	1.0	0.0	0.0	0.0	1.0	0.0	0.0	3.0
Calluna	0.0	0.0	2.0	1.0	1.0	0.0	0.0	0.0	4.0	13.0
Gramineae (wild type)	30.0	20.0	32.0	60.0	27.0	48.0	20.0	44.0	56.0	49.0
Cereals	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cyperaceae	3.0	12.0	4.0	5.0	31.0	11.0	0.0	16.0	11.0	21.0
Anthemis type	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0
Centaurea cf. *C.nigra* type	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Aster type	1.0	0.0	0.0	0.0	1.0	0.0	1.0	0.0	1.0	2.0
Compositae (Liguliflorae)	1.0	0.0	0.0	0.0	1.0	1.0	1.0	0.0	0.0	1.0
Caryophyllaceae	0.0	0.0	0.0	1.0	0.0	0.0	0.0	9.0	4.0	1.0
Chenopodiaceae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cruciferae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0
Euphorbiaceae	0.0	1.0	0.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0
Geranium	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Primulaceae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0
Plantago undifferentiated	2.0	1.0	2.0	3.0	0.0	2.0	3.0	3.0	5.0	3.0
Ranunculus type	0.0	0.0	6.0	2.0	1.0	0.0	3.0	0.0	1.0	3.0

Rumex	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	0.0	0.0
Polygonaceae undifferentiated	0.0	0.0	1.0	2.0	0.0	0.0	1.0	0.0	0.0	0.0
Scrophulariaceae	0.0	0.0	0.0	0.0	0.0	1.0	1.0	0.0	0.0	0.0
Umbelliferae	0.0	0.0	0.0	0.0	1.0	0.0	0.0	4.0	1.0	0.0
Urtica type	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0
Rosaceae undifferentiated	0.0	0.0	0.0	1.0	2.0	0.0	0.0	0.0	0.0	0.0
Rubiaceae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Boraginaceae	0.0	0.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Saxifragaceae	0.0	0.0	1.0	0.0	0.0	0.0	2.0	0.0	0.0	0.0
Polypodium	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0
Monolete spores	1.0	0.0	0.0	1.0	0.0	2.0	0.0	0.0	6.0	0.0
Trilete spores	0.0	1.0	1.0	0.0	0.0	0.0	4.0	0.0	0.0	0.0
Lycopodium	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Unknown	0.0	0.0	0.0	0.0	0.0	1.0	0.0	1.0	0.0	0.0
Indeterminable (broken)	0.0	0.0	0.0	0.0	0.0	1.0	0.0	3.0	0.0	7.0
Indeterminable (crumpled)	0.0	0.0	0.0	0.0	0.0	4.0	0.0	3.0	0.0	9.0
Indeterminable (degraded)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0
EUCALYPTUS COUNT	0.0	7.0	12.0	3.0	0.0	1.0	9.0	0.0	0.0	0.0
CRYPTOGAM SUM	1.0	1.0	1.0	1.0	1.0	2.0	4.0	0.0	6.0	0.0
INDETERMINABLE SUM	0.0	0.0	0.0	0.0	0.0	5.0	0.0	6.0	0.0	18.0
Trees, shrubs and vines sum	336.0	238.0	277.0	300.0	242.0	255.0	258.0	282.0	305.0	252.0
Herb sum	37.0	34.0	49.0	76.0	64.0	64.0	34.0	76.0	83.0	80.0
UNKNOWN	0.0	0.0	0.0	0.0	0.0	1.0	0.0	1.0	0.0	0.0
POLLEN SUM	373.0	272.0	326.0	376.0	306.0	319.0	292.0	358.0	388.0	332.0
Cryptogam sum + Pollen sum	374.0	273.0	327.0	377.0	307.0	321.0	296.0	358.0	394.0	332.0

Appendix 1: Mor # 1 Pollen Count (Continued).

	12.0	13.0	14.0	15.0	16.0	20.0
Betula	76.0	92.0	41.0	9.0	3.0	2.0
Quercus	131.0	58.0	53.0	23.0	22.0	45.0
Tilia	0.0	0.0	1.0	0.0	0.0	0.0
Ulmus	7.0	5.0	3.0	3.0	2.0	1.0
Acer	0.0	0.0	2.0	0.0	1.0	0.0
Corylus	20.0	17.0	29.0	30.0	35.0	45.0
Fagus	10.0	0.0	1.0	1.0	0.0	0.0
Alnus	2.0	1.0	5.0	4.0	4.0	6.0
Taxus	8.0	6.0	6.0	0.0	2.0	3.0
Populus	1.0	0.0	0.0	0.0	1.0	0.0
Pinus	0.0	1.0	0.0	0.0	0.0	0.0
Salix	0.0	1.0	3.0	0.0	0.0	0.0
Ericales	0.0	0.0	0.0	4.0	0.0	10.0
Calluna	20.0	12.0	17.0	25.0	7.0	7.0
Gramineae (wild type)	50.0	127.0	121.0	134.0	56.0	65.0
Cereals	0.0	2.0	6.0	6.0	0.0	0.0
Cyperaceae	45.0	14.0	14.0	10.0	24.0	26.0
Anthemis type	0.0	1.0	3.0	1.0	0.0	0.0
Centaurea cf. *C.nigra* type	0.0	0.0	0.0	1.0	0.0	0.0
Aster type	3.0	6.0	3.0	2.0	5.0	5.0
Compositae (Liguliflorae)	1.0	7.0	9.0	18.0	11.0	21.0
Caryophyllaceae	2.0	0.0	0.0	1.0	1.0	0.0
Chenopodiaceae	0.0	0.0	0.0	1.0	0.0	0.0
Cruciferae	35.0	11.0	5.0	0.0	2.0	3.0
Euphorbiaceae	0.0	0.0	0.0	0.0	0.0	0.0
Geranium	2.0	1.0	0.0	0.0	0.0	2.0
Primulaceae	0.0	0.0	0.0	0.0	0.0	0.0
Plantago undifferentiated	8.0	14.0	19.0	33.0	18.0	2.0
Ranunculus type	7.0	4.0	13.0	6.0	7.0	5.0
Rumex	0.0	0.0	0.0	0.0	0.0	0.0
Polygonaceae undifferentiated	0.0	0.0	0.0	0.0	0.0	0.0
Scrophulariaceae	0.0	0.0	0.0	0.0	0.0	0.0

Umbelliferae	0.0	11.0	5.0	27.0	23.0	18.0
Urtica type	0.0	0.0	0.0	0.0	0.0	0.0
Rosaceae undifferentiated	1.0	3.0	1.0	4.0	5.0	6.0
Rubiaceae	0.0	0.0	0.0	0.0	1.0	0.0
Boraginaceae	0.0	0.0	0.0	0.0	0.0	0.0
Saxifragaceae	0.0	0.0	0.0	0.0	2.0	0.0
Polypodium	0.0	1.0	0.0	0.0	0.0	2.0
Monolete spores	0.0	16.0	7.0	22.0	40.0	28.0
Trilete spores	2.0	0.0	38.0	3.0	8.0	5.0
Lycopodium	1.0	0.0	0.0	0.0	4.0	2.0
Unknown	0.0	1.0	0.0	0.0	0.0	0.0
Indeterminable (broken)	0.0	6.0	1.0	1.0	0.0	7.0
Indeterminable (crumpled)	0.0	10.0	13.0	7.0	7.0	20.0
Indeterminable (degraded)	0.0	1.0	2.0	6.0	3.0	5.0
EUCALYPTUS COUNT	1.0	0.0	0.0	1.0	8.0	5.0
CRYPTOGAM SUM	3.0	17.0	45.0	25.0	52.0	37.0
INDETERMINABLE SUM	0.0	17.0	16.0	14.0	10.0	32.0
Trees, shrubs and vines sum	275.0	193.0	161.0	99.0	77.0	119.0
Herb sum	154.0	201.0	199.0	244.0	155.0	153.0
UNKNOWN	0.0	1.0	0.0	0.0	0.0	0.0
POLLEN SUM	429.0	394.0	360.0	343.0	232.0	272.0
Cryptogam sum + Pollen sum	432.0	411.0	405.0	368.0	284.0	309.0

Appendix 2: Mor # 1 Pollen Percentage Data

	1.0	**2.0**	**4.0**	**5.0**	**6.0**	**7.0**	**8.0**	**9.0**	**10.0**	**11.0**	**12.0**
Betula	6.4	7.0	3.7	4.0	1.0	3.8	6.2	4.2	7.9	21.1	17.7
Quercus	79.4	72.4	73.2	71.5	69.6	70.5	76.7	52.5	57.9	37.3	30.5
Tilia	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ulmus	0.0	2.2	0.3	2.4	2.6	2.5	1.0	2.2	1.2	1.5	1.6
Acer	0.0	0.0	0.3	0.3	1.0	0.0	0.0	0.0	0.0	0.3	0.0
Corylus	1.6	4.4	2.5	0.3	2.6	2.5	1.0	5.9	6.4	2.7	4.7
Fagus	0.3	0.0	0.0	0.3	0.3	0.0	1.0	13.7	4.9	7.5	2.3
Alnus	0.3	0.0	0.6	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.5
Taxus	0.8	1.5	3.1	0.0	1.0	0.3	1.4	0.0	0.2	0.3	1.9
Populus	0.0	0.0	0.6	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.2
Pinus	0.3	0.0	0.0	0.5	0.7	0.3	0.0	0.0	0.0	0.0	0.0
Salix	0.5	0.0	0.0	0.0	0.0	0.0	0.3	0.3	0.0	0.3	0.0
Ericales	0.5	0.0	0.3	0.0	0.0	0.0	0.3	0.0	0.0	0.9	0.0
Calluna	0.0	0.0	0.6	0.3	0.3	0.0	0.0	0.0	1.0	3.9	4.7
Gramineae (wild type)	8.0	7.4	9.8	16.0	8.8	15.0	6.8	12.3	13.8	14.8	11.7
Cereals	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cyperaceae	0.8	4.4	1.2	1.3	10.1	3.4	0.0	4.5	2.7	6.3	10.5
Anthemis type	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0
Centaurea cf. *C.nigra* type	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Aster type	0.3	0.0	0.0	0.0	0.3	0.0	0.3	0.0	0.2	0.6	0.7
Compositae (Liguliflorae)	0.3	0.0	0.0	0.0	0.3	0.3	0.3	0.0	0.0	0.3	0.2
Caryophyllaceae	0.0	0.0	0.0	0.3	0.0	0.0	0.0	2.5	1.0	0.3	0.5
Chenopodiaceae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cruciferae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	8.2
Euphorbiaceae	0.0	0.4	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Geranium	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5
Primulaceae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0
Plantago undifferentiated	0.5	0.4	0.6	0.8	0.0	0.6	1.0	0.8	1.2	0.9	1.9
Ranunculus type	0.0	0.0	1.8	0.5	0.3	0.0	1.0	0.0	0.2	0.9	1.6
Rumex	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.0	0.0	0.0	0.0
Polygonaceae undifferentiated	0.0	0.0	0.3	0.5	0.0	0.0	0.3	0.0	0.0	0.0	0.0
Scrophulariaceae	0.0	0.0	0.0	0.0	0.0	0.3	0.3	0.0	0.0	0.0	0.0

Umbelliferae	0.0	0.0	0.0	0.0	0.3	0.0	0.0	1.1	0.2	0.0	0.0
Urtica type	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0
Rosaceae undifferentiated	0.0	0.0	0.0	0.3	0.7	0.0	0.0	0.0	0.0	0.0	0.2
Rubiaceae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Boraginaceae	0.0	0.0	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Saxifragaceae	0.0	0.0	0.3	0.0	0.0	0.0	0.7	0.0	0.0	0.0	0.0
Polypodium	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0
Monolete spores	0.3	0.0	0.0	0.3	0.0	0.6	0.0	0.0	1.5	0.0	0.0
Trilete spores	0.0	0.4	0.3	0.0	0.0	0.0	1.4	0.0	0.0	0.0	0.5
Lycopodium	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
Unknown	0.0	0.0	0.0	0.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0
Indeterminable (broken)	0.0	0.0	0.0	0.0	0.0	1.0	0.0	3.0	0.0	7.0	0.0
Indeterminable (crumpled)	0.0	0.0	0.0	0.0	0.0	4.0	0.0	3.0	0.0	9.0	0.0
Indeterminable (degraded)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0
EUCALYPTUS COUNT	0.0	7.0	12.0	3.0	0.0	1.0	9.0	0.0	0.0	0.0	1.0
CRYPTOGAM SUM	0.3	0.4	0.3	0.3	0.3	0.6	1.4	0.0	1.5	0.0	0.7
INDETERMINABLE SUM	0.0	0.0	0.0	0.0	0.0	5.0	0.0	6.0	0.0	18.0	0.0
Trees, shrubs and vines sum	90.1	87.5	85.2	79.8	79.1	79.9	88.4	78.8	79.6	75.9	64.1
Herb sum	9.9	12.5	14.8	20.2	20.9	20.1	11.6	21.2	20.4	24.1	35.9
UNKNOWN SUM	0.0	0.0	0.0	0.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0
POLLEN SUM	373.0	272.0	325.0	376.0	306.0	319.0	292.0	358.0	406.0	332.0	429.0
Cryptogam sum + Pollen sum	374.0	273.0	326.0	377.0	307.0	321.0	296.0	358.0	412.0	332.0	432.0

Appendix 2: Mor # 1 Pollen Percentage Data (continued).

	13.0	14.0	15.0	16.0	20.0
Betula	23.4	11.4	2.6	1.3	0.7
Quercus	14.7	14.7	6.7	9.5	16.5
Tilia	0.0	0.3	0.0	0.0	0.0
Ulmus	1.3	0.8	0.9	0.9	0.4
Acer	0.0	0.6	0.0	0.4	0.0
Corylus	4.3	8.1	8.7	15.1	16.5
Fagus	0.0	0.3	0.3	0.0	0.0
Alnus	0.3	1.4	1.2	1.7	2.2
Taxus	1.5	1.7	0.0	0.9	1.1
Populus	0.0	0.0	0.0	0.4	0.0
Pinus	0.3	0.0	0.0	0.0	0.0
Salix	0.3	0.8	0.0	0.0	0.0
Ericales	0.0	0.0	1.2	0.0	3.7
Calluna	3.0	4.7	7.3	3.0	2.6
Gramineae (wild type)	32.2	33.6	39.1	24.1	23.9
Cereals	0.5	1.7	1.7	0.0	0.0
Cyperaceae	3.6	3.9	2.9	10.3	9.6
Anthemis type	0.3	0.8	0.3	0.0	0.0
Centaurea cf. *C.nigra* type	0.0	0.0	0.3	0.0	0.0
Aster type	1.5	0.8	0.6	2.2	1.8
Compositae (Liguliflorae)	1.8	2.5	5.2	4.7	7.7
Caryophyllaceae	0.0	0.0	0.3	0.4	0.0
Chenopodiaceae	0.0	0.0	0.3	0.0	0.0
Cruciferae	2.8	1.4	0.0	0.9	1.1
Euphorbiaceae	0.0	0.0	0.0	0.0	0.0
Geranium	0.3	0.0	0.0	0.0	0.7
Primulaceae	0.0	0.0	0.0	0.0	0.0
Plantago undifferentiated	3.6	5.3	9.6	7.8	0.7
Ranunculus type	1.0	3.6	1.7	3.0	1.8
Rumex	0.0	0.0	0.0	0.0	0.0
Polygonaceae undifferentiated	0.0	0.0	0.0	0.0	0.0
Scrophulariaceae	0.0	0.0	0.0	0.0	0.0

Umbelliferae	2.8	1.4	7.9	9.9	6.6
Urtica type	0.0	0.0	0.0	0.0	0.0
Rosaceae undifferentiated	0.8	0.3	1.2	2.2	2.2
Rubiaceae	0.0	0.0	0.0	0.4	0.0
Boraginaceae	0.0	0.0	0.0	0.0	0.0
Saxifragaceae	0.0	0.0	0.0	0.9	0.0
Polypodium	0.2	0.0	0.0	0.0	0.6
Monolete spores	3.9	1.7	6.0	14.1	9.1
Trilete spores	0.0	9.4	0.8	2.8	1.6
Lycopodium	0.0	0.0	0.0	1.4	0.6
Unknown	1.0	0.0	0.0	0.0	0.0
Indeterminable (broken)	6.0	1.0	1.0	0.0	7.0
Indeterminable (crumpled)	10.0	13.0	7.0	7.0	20.0
Indeterminable (degraded)	1.0	2.0	6.0	3.0	5.0
EUCALYPTUS COUNT	0.0	0.0	1.0	8.0	5.0
CRYPTOGAM SUM	4.1	11.1	6.8	18.3	12.0
INDETERMINABLE SUM	17.0	16.0	14.0	10.0	32.0
Trees, shrubs and vines sum	49.0	44.7	28.9	33.2	43.8
Herb sum	51.0	55.3	71.1	66.8	56.2
UNKNOWN SUM	1.0	0.0	0.0	0.0	0.0
POLLEN SUM	394.0	360.0	343.0	232.0	272.0
Cryptogam sum + Pollen sum	411.0	405.0	368.0	284.0	309.0

Appendix 3: Mor#1 Pollen Concentrations.

	1.0	**2.0**	**4.0**	**5.0**	**6.0**	**7.0**	**8.0**
Betula	1286400.0	145485.7	53600.0	268000.0	160800.0	643200.0	107200.0
Quercus	15865600.0	1508457.1	1063066.6	4806133.0	11416800.0	12060000.0	1334044.5
Tilia	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ulmus	0.0	45942.9	4466.7	160800.0	428800.0	428800.0	17866.7
Acer	0.0	0.0	4466.7	17866.7	160800.0	0.0	0.0
Corylus	321600.0	91885.7	35733.3	17866.7	428800.0	428800.0	17866.7
Fagus	53600.0	0.0	0.0	17866.7	53600.0	0.0	17866.7
Alnus	53600.0	0.0	8933.3	17866.7	0.0	0.0	0.0
Taxus	160800.0	30628.6	44666.7	0.0	160800.0	53600.0	23822.2
Populus	0.0	0.0	8933.3	0.0	0.0	0.0	5955.6
Pinus	53600.0	0.0	0.0	35733.3	107200.0	53600.0	0.0
Salix	107200.0	0.0	0.0	0.0	0.0	0.0	5955.6
Ericales	107200.0	0.0	4466.7	0.0	0.0	0.0	5955.6
Calluna	0.0	0.0	8933.3	17866.7	53600.0	0.0	0.0
Gramineae (wild type)	1608000.0	153142.9	142933.3	1072000.0	1447200.0	2572800.0	119111.1
Cereals	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cyperaceae	160800.0	91885.7	17866.7	89333.3	1661600.0	589600.0	0.0
Anthemis type	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Centaurea cf. *C.nigra* type	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Aster type	53600.0	0.0	0.0	0.0	53600.0	0.0	5955.6

Compositae (Liguliflorae)	53600.0	0.0	0.0	0.0	53600.0	53600.0	5955.6
Caryophyllaceae	0.0	0.0	0.0	17866.7	0.0	0.0	0.0
Chenopodiaceae	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cruciferae	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Euphorbiaceae	0.0	7657.1	0.0	35733.3	0.0	0.0	0.0
Geranium	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Primulaceae	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Plantago undifferentiated	107200.0	7657.1	8933.3	53600.0	0.0	107200.0	17866.7
Ranunculus type	0.0	0.0	26800.0	35733.3	53600.0	0.0	17866.7
Rumex	0.0	0.0	0.0	0.0	0.0	0.0	11911.1
Polygonaceae undifferentiated	0.0	0.0	4466.7	35733.3	0.0	0.0	5955.6
Scrophulariaceae	0.0	0.0	0.0	0.0	0.0	53600.0	5955.6
Umbelliferae	0.0	0.0	0.0	0.0	53600.0	0.0	0.0
Urtica type	0.0	0.0	0.0	0.0	0.0	53600.0	0.0
Rosaceae undifferentiated	0.0	0.0	0.0	17866.7	107200.0	0.0	0.0
Rubiaceae	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Boraginaceae	0.0	0.0	8933.3	0.0	0.0	0.0	0.0
Saxifragaceae	0.0	0.0	4466.7	0.0	0.0	0.0	11911.1
Polypodium	0.0	0.0	0.0	0.0	1.0	0.0	0.0
Monolete spores	1.0	0.0	0.0	1.0	0.0	2.0	0.0
Trilete spores	0.0	1.0	1.0	0.0	0.0	0.0	4.0
Lycopodium	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Unknown	0.0	0.0	0.0	0.0	0.0	1.0	0.0
Indeterminable (broken)	0.0	0.0	0.0	0.0	0.0	1.0	0.0

Indeterminable (crumpled)	0.0	0.0	0.0	0.0	0.0	4.0	0.0
Indeterminable (degraded)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
EUCALYPTUS COUNT	1.0	7.0	12.0	3.0	1.0	1.0	9.0
CRYPTOGAM SUM	1.0	1.0	1.0	1.0	1.0	2.0	4.0
INDETERMINABLE SUM	0.0	0.0	0.0	0.0	0.0	5.0	0.0
Trees, shrubs and vines sum	336.0	238.0	277.0	300.0	242.0	255.0	258.0
Herb sum	37.0	34.0	49.0	76.0	64.0	64.0	34.0
UNKNOWN	0.0	0.0	0.0	0.0	0.0	1.0	0.0
POLLEN SUM	373.0	272.0	326.0	376.0	306.0	319.0	292.0
SAMPLE VOLUME	1.0	1.0	1.0	1.0	1.0	1.0	1.0
CONCENTRATION SPIKE (GRAINS/ml)	53600.0	53600.0	53600.0	53600.0	53600.0	53600.0	53600.0
VOLUME SPIKE ADDED (ml)	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Cryptogam sum + Pollen sum	374.0	273.0	327.0	377.0	307.0	321.0	296.0
Total pollen concentration	19992800.0	2082742.9	1451666.6	6717866.5	16401600.0	17098400.0	1739022.2

Appendix 3: Mor # 1 Pollen Concentrations (Continued).

	9.0	10.0	11.0	12.0	13.0	14.0	15.0
Betula	804000.0	1715200.0	3752000.0	4073600.0	4931200.0	2197600.0	482400.0
Quercus	10076800.0	12596000.0	6646400.0	7021600.0	3108800.0	2840800.0	1232800.0
Tilia	0.0	0.0	0.0	0.0	0.0	53600.0	0.0
Ulmus	428800.0	268000.0	268000.0	375200.0	268000.0	160800.0	160800.0
Acer	0.0	0.0	53600.0	0.0	0.0	107200.0	0.0
Corylus	1125600.0	1393600.0	482400.0	1072000.0	911200.0	1554400.0	1608000.0
Fagus	2626400.0	1072000.0	1340000.0	536000.0	0.0	53600.0	53600.0
Alnus	0.0	0.0	0.0	107200.0	53600.0	268000.0	214400.0
Taxus	0.0	53600.0	53600.0	428800.0	321600.0	321600.0	0.0
Populus	0.0	0.0	0.0	53600.0	0.0	0.0	0.0
Pinus	0.0	0.0	0.0	0.0	53600.0	0.0	0.0
Salix	53600.0	0.0	53600.0	0.0	53600.0	160800.0	0.0
Ericales	0.0	0.0	160800.0	0.0	0.0	0.0	214400.0
Calluna	0.0	214400.0	696800.0	1072000.0	643200.0	911200.0	1340000.0
Gramineae (wild type)	2358400.0	3001600.0	2626400.0	2680000.0	6807200.0	6485600.0	7182400.0
Cereals	0.0	0.0	0.0	0.0	107200.0	321600.0	321600.0
Cyperaceae	857600.0	589600.0	1125600.0	2412000.0	750400.0	750400.0	536000.0
Anthemis type	0.0	107200.0	0.0	0.0	53600.0	160800.0	53600.0
Centaurea cf. *C.nigra* type	0.0	0.0	0.0	0.0	0.0	0.0	53600.0
Aster type	0.0	53600.0	107200.0	160800.0	321600.0	160800.0	107200.0

Compositae (Liguliflorae)	0.0	0.0	53600.0	53600.0	375200.0	482400.0	964800.0
Caryophyllaceae	482400.0	214400.0	53600.0	107200.0	0.0	0.0	53600.0
Chenopodiaceae	0.0	0.0	0.0	0.0	0.0	0.0	53600.0
Cruciferae	0.0	53600.0	0.0	1876000.0	589600.0	268000.0	0.0
Euphorbiaceae	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Geranium	0.0	0.0	0.0	107200.0	53600.0	0.0	0.0
Primulaceae	0.0	53600.0	0.0	0.0	0.0	0.0	0.0
Plantago undifferentiated	160800.0	268000.0	160800.0	428800.0	750400.0	1018400.0	1768800.0
Ranunculus type	0.0	53600.0	160800.0	375200.0	214400.0	696800.0	321600.0
Rumex	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Polygonaceae undifferentiated	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Scrophulariaceae	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Umbelliferae	214400.0	53600.0	0.0	0.0	589600.0	268000.0	1447200.0
Urtica type	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rosaceae undifferentiated	0.0	0.0	0.0	53600.0	160800.0	53600.0	214400.0
Rubiaceae	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Boraginaceae	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Saxifragaceae	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Polypodium	0.0	0.0	0.0	0.0	1.0	0.0	0.0
Monolete spores	0.0	6.0	0.0	0.0	16.0	7.0	22.0
Trilete spores	0.0	0.0	0.0	2.0	0.0	38.0	3.0
Lycopodium	0.0	0.0	0.0	1.0	0.0	0.0	0.0
Unknown	1.0	0.0	0.0	0.0	1.0	0.0	0.0
Indeterminable (broken)	3.0	0.0	7.0	0.0	6.0	1.0	1.0

Indeterminable (crumpled)	3.0	0.0	9.0	0.0	10.0	13.0	7.0
Indeterminable (degraded)	0.0	0.0	2.0	0.0	1.0	2.0	6.0
EUCALYPTUS COUNT	1.0	1.0	1.0	1.0	1.0	1.0	1.0
CRYPTOGAM SUM	0.0	6.0	0.0	3.0	17.0	45.0	25.0
INDETERMINABLE SUM	6.0	0.0	18.0	0.0	17.0	16.0	14.0
Trees, shrubs and vines sum	282.0	305.0	252.0	275.0	193.0	161.0	99.0
Herb sum	76.0	83.0	80.0	154.0	201.0	199.0	244.0
UNKNOWN	1.0	0.0	0.0	0.0	1.0	0.0	0.0
POLLEN SUM	358.0	388.0	332.0	429.0	394.0	360.0	343.0
SAMPLE VOLUME	1.0	1.0	1.0	1.0	1.0	1.0	1.0
CONCENTRATION SPIKE (GRAINS/ml)	53600.0	53600.0	53600.0	53600.0	53600.0	53600.0	53600.0
VOLUME SPIKE ADDED (ml)	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Cryptogam sum + Pollen sum	358.0	394.0	332.0	432.0	411.0	405.0	368.0
Total pollen concentration	19188800.0	21761600.0	17795200.0	22994400.0	21118400.0	19296000.0	18384800.0

Appendix 3: Mor#1 Pollen Concentrations (Continued).

	16.0	**20.0**
Betula	20100.0	21440.0
Quercus	147400.0	482400.0
Tilia	0.0	0.0
Ulmus	13400.0	10720.0
Acer	6700.0	0.0
Corylus	234500.0	482400.0
Fagus	0.0	0.0
Alnus	26800.0	64320.0
Taxus	13400.0	32160.0
Populus	6700.0	0.0
Pinus	0.0	0.0
Salix	0.0	0.0
Ericales	0.0	107200.0
Calluna	46900.0	75040.0
Gramineae (wild type)	375200.0	696800.0
Cereals	0.0	0.0
Cyperaceae	160800.0	278720.0
Anthemis type	0.0	0.0
Centaurea cf. *C.nigra* type	0.0	0.0
Aster type	33500.0	53600.0

Compositae (Liguliflorae)	73700.0	225120.0
Caryophyllaceae	6700.0	0.0
Chenopodiaceae	0.0	0.0
Cruciferae	13400.0	32160.0
Euphorbiaceae	0.0	0.0
Geranium	0.0	21440.0
Primulaceae	0.0	0.0
Plantago undifferentiated	120600.0	21440.0
Ranunculus type	46900.0	53600.0
Rumex	0.0	0.0
Polygonaceae undifferentiated	0.0	0.0
Scrophulariaceae	0.0	0.0
Umbelliferae	154100.0	192960.0
Urtica type	0.0	0.0
Rosaceae undifferentiated	33500.0	64320.0
Rubiaceae	6700.0	0.0
Boraginaceae	0.0	0.0
Saxifragaceae	13400.0	0.0
Polypodium	0.0	2.0
Monolete spores	40.0	28.0
Trilete spores	8.0	5.0
Lycopodium	4.0	2.0
Unknown	0.0	0.0
Indeterminable (broken)	0.0	7.0

Indeterminable (crumpled)	7.0	20.0
Indeterminable (degraded)	3.0	5.0
EUCALYPTUS COUNT	8.0	5.0
CRYPTOGAM SUM	52.0	37.0
INDETERMINABLE SUM	10.0	32.0
Trees, shrubs and vines sum	77.0	119.0
Herb sum	155.0	153.0
UNKNOWN	0.0	0.0
POLLEN SUM	232.0	272.0
SAMPLE VOLUME	1.0	1.0
CONCENTRATION SPIKE (GRAINS/ml)	53600.0	53600.0
VOLUME SPIKE ADDED (ml)	1.0	1.0
Cryptogam sum + Pollen sum	284.0	309.0
Total pollen concentration	1554400.0	2915840.0

Appendix 4: Loss on Ignition (L.O.I.) Test Results for Mor # 1

Depth	Crucible Number	Crucible Weight	Crucible + Wet soil	Crucible + Oven dry	Crucible + Ignited	Wet Weight	Dry Weight	Ignited Weight	% LOI
1	1	13.96992	14.54076	14.20926	13.98582	0.57084	0.23934	0.01590	93.36
2	2	14.09875	14.67187	14.30924	14.11207	0.57312	0.21049	0.01332	93.67
3	3	13.81366	14.38766	14.02565	13.82266	0.574	0.21199	0.00900	95.75
4	4	13.82695	14.47325	14.0524	13.83446	0.6463	0.22545	0.00751	96.67
5	5	13.8332	14.74115	14.12366	13.8473	0.90795	0.29046	0.01410	95.15
6	6	13.98612	15.05639	14.29629	14.00091	1.07027	0.31017	0.01479	95.23
7	7	13.27689	14.01867	13.50296	13.28838	0.74178	0.22607	0.01149	94.92
8	8	14.72825	15.7772	15.03563	14.74494	1.04895	0.30738	0.01669	94.57
9	9	13.71508	15.00681	14.24461	13.93881	1.29173	0.52953	0.22373	57.75
10	10	13.20938	14.79772	14.02869	13.72399	1.58834	0.81931	0.51461	37.19
11	11	13.77213	16.3225	15.21828	14.81334	2.55037	1.44615	1.04121	28.00
12	12	13.69256	16.21984	15.34487	15.04961	2.52728	1.65231	1.35705	17.87
13	13	13.88962	17.48871	16.08626	15.58176	3.59909	2.19664	1.69214	22.97
14	14	13.4125	16.09042	15.36666	15.13573	2.67792	1.95416	1.72323	11.82
15	15	14.27437	18.49552	17.59488	17.36173	4.22115	3.32051	3.08736	7.02
16	16	13.66676	15.8483	15.39394	15.27372	2.18154	1.72718	1.60696	6.96
17	17	13.93568	16.97885	16.39128	16.25016	3.04317	2.4556	2.31448	5.75
18	18	13.10422	15.71787	15.21958	15.10328	2.61365	2.11536	1.99906	5.50
19	19	13.67314	17.55636	16.85935	16.74754	3.88322	3.18621	3.07440	3.51
20	20	16.37535	19.91228	19.23148	19.11789	3.53693	2.85613	2.74254	3.98

Appendix 5: Mor # 2 Pollen Counts

	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0	11.0
Betula	4.0	1.0	3.0	1.0	3.0	6.0	9.0	3.0	5.0	3.0	5.0
Quercus	250.0	289.0	268.0	264.0	283.0	262.0	238.0	215.0	287.0	207.0	289.0
Tilia	0.0	0.0	0.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0	0.0
Ulmus	1.0	0.0	2.0	2.0	0.0	3.0	0.0	12.0	2.0	4.0	0.0
Acer	4.0	5.0	1.0	3.0	0.0	0.0	1.0	0.0	1.0	1.0	1.0
Corylus	1.0	1.0	0.0	1.0	0.0	1.0	0.0	7.0	3.0	14.0	1.0
Fagus	0.0	1.0	0.0	0.0	0.0	1.0	2.0	0.0	0.0	0.0	5.0
Alnus	1.0	3.0	1.0	0.0	0.0	1.0	0.0	1.0	2.0	1.0	2.0
Taxus	0.0	0.0	0.0	1.0	0.0	1.0	6.0	1.0	3.0	0.0	0.0
Populus	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pinus	0.0	1.0	0.0	0.0	0.0	1.0	4.0	0.0	3.0	1.0	1.0
Salix	4.0	0.0	0.0	0.0	0.0	2.0	0.0	2.0	0.0	1.0	0.0
Caprifoliaceae	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0
Hippocastanaceae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0
Ulex	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0
Oleaceae	0.0	0.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0
Ericales	0.0	0.0	0.0	0.0	1.0	3.0	0.0	3.0	0.0	0.0	0.0
Calluna	1.0	0.0	2.0	1.0	0.0	1.0	2.0	1.0	1.0	1.0	3.0
Gramineae (wild type)	39.0	20.0	45.0	13.0	28.0	34.0	37.0	30.0	71.0	52.0	35.0
Cereals	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0
Cyperaceae	28.0	23.0	15.0	20.0	9.0	10.0	31.0	20.0	28.0	16.0	12.0
Anthemis type	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Centaurea cf. *C.nigra* type	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0
Aster type	2.0	0.0	0.0	1.0	0.0	3.0	1.0	1.0	1.0	0.0	0.0
Compositae (Liguliflorae)	0.0	0.0	1.0	3.0	1.0	0.0	0.0	0.0	1.0	0.0	0.0
Caryophyllaceae	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Chenopodiaceae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	0.0	0.0
Cruciferae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Euphorbiaceae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Geranium	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Primulaceae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Plantago undifferentiated	0.0	0.0	3.0	0.0	0.0	2.0	2.0	3.0	2.0	4.0	1.0
Ranunculus type	0.0	2.0	0.0	0.0	1.0	1.0	3.0	3.0	1.0	2.0	2.0
Rumex	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Polygonaceae undifferentiated	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0
Scrophulariaceae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Umbelliferae	0.0	0.0	0.0	1.0	0.0	0.0	0.0	1.0	1.0	2.0	0.0
Urtica type	1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rosaceae undifferentiated	0.0	0.0	1.0	0.0	0.0	2.0	1.0	1.0	1.0	4.0	1.0
Rubiaceae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Boraginaceae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Onagraceae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0
Saxifragaceae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Polypodium	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Monolete spores	0.0	1.0	0.0	0.0	0.0	1.0	0.0	0.0	6.0	3.0	2.0
Trilete spores	0.0	0.0	0.0	2.0	0.0	0.0	1.0	0.0	4.0	1.0	1.0
Lycopodium	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Unknown	0.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Indeterminable (broken)	4.0	10.0	0.0	11.0	0.0	6.0	6.0	0.0	2.0	9.0	2.0
Indeterminable (crumpled)	4.0	5.0	0.0	13.0	0.0	4.0	7.0	0.0	1.0	7.0	0.0
Indeterminable (degraded)	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	2.0	0.0
EUCALYPTUS COUNT	4.0	5.0	2.0	1.0	5.0	2.0	1.0	0.0	4.0	1.0	0.0
CRYPTOGAM SUM	0.0	1.0	0.0	2.0	0.0	1.0	1.0	0.0	10.0	4.0	3.0
INDETERMINABLE SUM	8.0	16.0	0.0	24.0	0.0	10.0	13.0	0.0	4.0	18.0	2.0
trees, shrubs and vines sum	266.0	301.0	277.0	274.0	290.0	284.0	262.0	246.0	307.0	234.0	307.0
Herb sum	70.0	46.0	67.0	38.0	39.0	53.0	76.0	61.0	106.0	81.0	52.0
UNKNOWN	0.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
POLLEN SUM	336.0	347.0	344.0	312.0	329.0	337.0	338.0	307.0	413.0	315.0	359.0
Cryptogam sum + Pollen sum	336.0	348.0	344.0	314.0	329.0	338.0	339.0	307.0	423.0	319.0	362.0

Appendix 5: Mor # 2 Pollen Counts (Continued).

	12.0	**13.0**	**14.0**
Betula	8.0	8.0	3.0
Quercus	262.0	220.0	163.0
Tilia	0.0	0.0	0.0
Ulmus	5.0	8.0	3.0
Acer	6.0	0.0	0.0
Corylus	2.0	5.0	15.0
Fagus	2.0	1.0	2.0
Alnus	1.0	2.0	1.0
Taxus	0.0	0.0	1.0
Populus	0.0	0.0	0.0
Pinus	0.0	0.0	22.0
Salix	1.0	0.0	2.0
Caprifoliaceae	0.0	0.0	0.0
Hippocastanaceae	0.0	0.0	0.0
Ulex	0.0	0.0	0.0
Oleaceae	0.0	0.0	0.0
Ericales	2.0	0.0	0.0
Calluna	0.0	3.0	6.0
Gramineae (wild type)	62.0	65.0	60.0
Cereals	1.0	0.0	0.0
Cyperaceae	5.0	5.0	17.0
Anthemis type	0.0	0.0	2.0
Centaurea cf. *C.nigra* type	0.0	1.0	0.0
Aster type	0.0	1.0	0.0
Compositae (Liguliflorae)	2.0	3.0	2.0
Caryophyllaceae	0.0	0.0	0.0
Chenopodiaceae	0.0	0.0	0.0
Cruciferae	0.0	0.0	0.0
Euphorbiaceae	0.0	0.0	0.0
Geranium	0.0	0.0	1.0
Primulaceae	0.0	0.0	0.0
Plantago undifferentiated	2.0	7.0	5.0

Ranunculus type	1.0	6.0	0.0
Rumex	0.0	0.0	0.0
Polygonaceae undifferentiated	0.0	0.0	0.0
Scrophulariaceae	0.0	0.0	0.0
Umbelliferae	1.0	0.0	1.0
Urtica type	0.0	0.0	0.0
Rosaceae undifferentiated	1.0	1.0	1.0
Rubiaceae	0.0	0.0	0.0
Boraginaceae	0.0	0.0	0.0
Onagraceae	0.0	0.0	0.0
Saxifragaceae	0.0	0.0	0.0
Polypodium	0.0	0.0	0.0
Monolete spores	1.0	0.0	6.0
Trilete spores	1.0	6.0	8.0
Lycopodium	0.0	0.0	0.0
Unknown	0.0	0.0	0.0
Indeterminable (broken)	3.0	0.0	6.0
Indeterminable (crumpled)	5.0	0.0	10.0
Indeterminable (degraded)	1.0	1.0	6.0
EUCALYPTUS COUNT	0.0	4.0	4.0
CRYPTOGAM SUM	2.0	6.0	14.0
INDETERMINABLE SUM	9.0	1.0	22.0
trees, shrubs and vines sum	289.0	247.0	218.0
Herb sum	75.0	89.0	89.0
UNKNOWN	0.0	0.0	0.0
POLLEN SUM	364.0	336.0	307.0
Cryptogam sum + Pollen sum	366.0	342.0	321.0

Appendix 6: Mor # 2 Pollen Percentages.

	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0	11.0
Betula	1.2	0.3	0.9	0.3	0.9	1.8	2.7	1.0	1.2	1.0	1.4
Quercus	74.4	83.3	77.9	84.6	86.0	77.7	70.4	70.0	69.5	65.7	80.5
Tilia	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.0	0.0	0.0	0.0
Ulmus	0.3	0.0	0.6	0.6	0.0	0.9	0.0	3.9	0.5	1.3	0.0
Acer	1.2	1.4	0.3	1.0	0.0	0.0	0.3	0.0	0.2	0.3	0.3
Corylus	0.3	0.3	0.0	0.3	0.0	0.3	0.0	2.3	0.7	4.4	0.3
Fagus	0.0	0.3	0.0	0.0	0.0	0.3	0.6	0.0	0.0	0.0	1.4
Alnus	0.3	0.9	0.3	0.0	0.0	0.3	0.0	0.3	0.5	0.3	0.6
Taxus	0.0	0.0	0.0	0.3	0.0	0.3	1.8	0.3	0.7	0.0	0.0
Populus	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pinus	0.0	0.3	0.0	0.0	0.0	0.3	1.2	0.0	0.7	0.3	0.3
Salix	1.2	0.0	0.0	0.0	0.0	0.6	0.0	0.7	0.0	0.3	0.0
Caprifoliaceae	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0
Hippocastanaceae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0
Ulex	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0
Oleaceae	0.0	0.0	0.0	0.0	0.6	0.0	0.0	0.0	0.0	0.0	0.0
Ericales	0.0	0.0	0.0	0.0	0.3	0.9	0.0	1.0	0.0	0.0	0.0
Calluna	0.3	0.0	0.6	0.3	0.0	0.3	0.6	0.3	0.2	0.3	0.8
Gramineae (wild type)	11.6	5.8	13.1	4.2	8.5	10.1	10.9	9.8	17.2	16.5	9.7
Cereals	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0
Cyperaceae	8.3	6.6	4.4	6.4	2.7	3.0	9.2	6.5	6.8	5.1	3.3
Anthemis type	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Centaurea cf. *C.nigra* type	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0
Aster type	0.6	0.0	0.0	0.3	0.0	0.9	0.3	0.3	0.2	0.0	0.0
Compositae (Liguliflorae)	0.0	0.0	0.3	1.0	0.3	0.0	0.0	0.0	0.2	0.0	0.0
Caryophyllaceae	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Chenopodiaceae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.0	0.0	0.0
Cruciferae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Euphorbiaceae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Geranium	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Primulaceae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Plantago undifferentiated	0.0	0.0	0.9	0.0	0.0	0.6	0.6	1.0	0.5	1.3	0.3

Ranunculus type	0.0	0.6	0.0	0.0	0.3	0.3	0.9	1.0	0.2	0.6	0.6
Rumex	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Polygonaceae undifferentiated	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0
Scrophulariaceae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Umbelliferae	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.3	0.2	0.6	0.0
Urtica type	0.3	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rosaceae undifferentiated	0.0	0.0	0.3	0.0	0.0	0.6	0.3	0.3	0.2	1.3	0.3
Rubiaceae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Boraginaceae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Onagraceae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3
Saxifragaceae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Polypodium	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Monolete spores	0.0	0.3	0.0	0.0	0.0	0.3	0.0	0.0	1.4	0.9	0.6
Trilete spores	0.0	0.0	0.0	0.6	0.0	0.0	0.3	0.0	0.9	0.3	0.3
Lycopodium	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Unknown	0.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Indeterminable (broken)	4.0	10.0	0.0	11.0	0.0	6.0	6.0	0.0	2.0	9.0	2.0
Indeterminable (crumpled)	4.0	5.0	0.0	13.0	0.0	4.0	7.0	0.0	1.0	7.0	0.0
Indeterminable (degraded)	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	2.0	0.0
EUCALYPTUS COUNT	4.0	5.0	2.0	1.0	5.0	2.0	1.0	0.0	4.0	1.0	0.0
CRYPTOGAM SUM	0.0	0.3	0.0	0.6	0.0	0.3	0.3	0.0	2.4	1.3	0.8
INDETERMINABLE SUM	8.0	16.0	0.0	24.0	0.0	10.0	13.0	0.0	4.0	18.0	2.0
trees, shrubs and vines sum	79.2	86.7	80.5	87.8	88.1	84.3	77.5	80.1	74.3	74.3	85.5
Herb sum	20.8	13.3	19.5	12.2	11.9	15.7	22.5	19.9	25.7	25.7	14.5
UNKNOWN	0.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
POLLEN SUM	336.0	347.0	344.0	312.0	329.0	337.0	338.0	307.0	413.0	315.0	359.0
Cryptogam sum + Pollen sum	336.0	348.0	344.0	314.0	329.0	338.0	339.0	307.0	423.0	319.0	362.0

Appendix 6: Mor # 2 Pollen Percentages (Continued).

	12.0	13.0	14.0
Betula	2.2	2.4	1.0
Quercus	72.0	65.5	53.1
Tilia	0.0	0.0	0.0
Ulmus	1.4	2.4	1.0
Acer	1.6	0.0	0.0
Corylus	0.5	1.5	4.9
Fagus	0.5	0.3	0.7
Alnus	0.3	0.6	0.3
Taxus	0.0	0.0	0.3
Populus	0.0	0.0	0.0
Pinus	0.0	0.0	7.2
Salix	0.3	0.0	0.7
Caprifoliaceae	0.0	0.0	0.0
Hippocastanaceae	0.0	0.0	0.0
Ulex	0.0	0.0	0.0
Oleaceae	0.0	0.0	0.0
Ericales	0.5	0.0	0.0
Calluna	0.0	0.9	2.0
Gramineae (wild type)	17.0	19.3	19.5
Cereals	0.3	0.0	0.0
Cyperaceae	1.4	1.5	5.5
Anthemis type	0.0	0.0	0.7
Centaurea cf. *C.nigra* type	0.0	0.3	0.0
Aster type	0.0	0.3	0.0
Compositae (Liguliflorae)	0.5	0.9	0.7
Caryophyllaceae	0.0	0.0	0.0
Chenopodiaceae	0.0	0.0	0.0
Cruciferae	0.0	0.0	0.0
Euphorbiaceae	0.0	0.0	0.0
Geranium	0.0	0.0	0.3
Primulaceae	0.0	0.0	0.0
Plantago undifferentiated	0.5	2.1	1.6

Ranunculus type	0.3	1.8	0.0
Rumex	0.0	0.0	0.0
Polygonaceae undifferentiated	0.0	0.0	0.0
Scrophulariaceae	0.0	0.0	0.0
Umbelliferae	0.3	0.0	0.3
Urtica type	0.0	0.0	0.0
Rosaceae undifferentiated	0.3	0.3	0.3
Rubiaceae	0.0	0.0	0.0
Boraginaceae	0.0	0.0	0.0
Onagraceae	0.0	0.0	0.0
Saxifragaceae	0.0	0.0	0.0
Polypodium	0.0	0.0	0.0
Monolete spores	0.3	0.0	1.9
Trilete spores	0.3	1.8	2.5
Lycopodium	0.0	0.0	0.0
Unknown	0.0	0.0	0.0
Indeterminable (broken)	3.0	0.0	6.0
Indeterminable (crumpled)	5.0	0.0	10.0
Indeterminable (degraded)	1.0	1.0	6.0
EUCALYPTUS COUNT	0.0	4.0	4.0
CRYPTOGAM SUM	0.5	1.8	4.4
INDETERMINABLE SUM	9.0	1.0	22.0
trees, shrubs and vines sum	79.4	73.5	71.0
Herb sum	20.6	26.5	29.0
UNKNOWN	0.0	0.0	0.0
POLLEN SUM	364.0	336.0	307.0
Cryptogam sum + Pollen sum	366.0	342.0	321.0

Appendix 7: Mor # 2 Pollen Concentrations.

	1.0	2.0	3.0	4.0	5.0	6.0	7.0
Betula	53600.0	10720.0	80400.0	53600.0	32160.0	160800.0	482400.0
Quercus	3350000.0	3098080.0	7182400.0	14150400.0	3033760.0	7021600.0	12756800.0
Tilia	0.0	0.0	0.0	0.0	0.0	53600.0	0.0
Ulmus	13400.0	0.0	53600.0	107200.0	0.0	80400.0	0.0
Acer	53600.0	53600.0	26800.0	160800.0	0.0	0.0	53600.0
Corylus	13400.0	10720.0	0.0	53600.0	0.0	26800.0	0.0
Fagus	0.0	10720.0	0.0	0.0	0.0	26800.0	107200.0
Alnus	13400.0	32160.0	26800.0	0.0	0.0	26800.0	0.0
Taxus	0.0	0.0	0.0	53600.0	0.0	26800.0	321600.0
Populus	0.0	0.0	0.0	53600.0	0.0	0.0	0.0
Pinus	0.0	10720.0	0.0	0.0	0.0	26800.0	214400.0
Salix	53600.0	0.0	0.0	0.0	0.0	53600.0	0.0
Caprifoliaceae	0.0	0.0	0.0	0.0	10720.0	0.0	0.0
Hippocastanaceae	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ulex	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Oleaceae	0.0	0.0	0.0	0.0	21440.0	0.0	0.0
Ericales	0.0	0.0	0.0	0.0	10720.0	80400.0	0.0
Calluna	13400.0	0.0	53600.0	53600.0	0.0	26800.0	107200.0
Gramineae (wild type)	522600.0	214400.0	1206000.0	696800.0	300160.0	911200.0	1983200.0
Cereals	0.0	0.0	0.0	0.0	0.0	0.0	53600.0

Cyperaceae	375200.0	246560.0	402000.0	1072000.0	96480.0	268000.0	1661600.0
Anthemis type	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Centaurea cf. C.nigra type	0.0	0.0	26800.0	0.0	0.0	0.0	0.0
Aster type	26800.0	0.0	0.0	53600.0	0.0	80400.0	53600.0
Compositae (Liguliflorae)	0.0	0.0	26800.0	160800.0	10720.0	0.0	0.0
Caryophyllaceae	0.0	0.0	26800.0	0.0	0.0	0.0	0.0
Chenopodiaceae	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cruciferae	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Euphorbiaceae	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Geranium	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Primulaceae	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Plantago undifferentiated	0.0	0.0	80400.0	0.0	0.0	53600.0	107200.0
Ranunculus type	0.0	21440.0	0.0	0.0	10720.0	26800.0	160800.0
Rumex	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Polygonaceae undifferentiated	0.0	0.0	0.0	0.0	0.0	26800.0	0.0
Scrophulariaceae	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Umbelliferae	0.0	0.0	0.0	53600.0	0.0	0.0	0.0
Urtica type	13400.0	10720.0	0.0	0.0	0.0	0.0	0.0
Rosaceae undifferentiated	0.0	0.0	26800.0	0.0	0.0	53600.0	53600.0
Rubiaceae	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Boraginaceae	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Onagraceae	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Saxifragaceae	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Polypodium	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Monolete spores	0.0	1.0	0.0	0.0	0.0	1.0	0.0
Trilete spores	0.0	0.0	0.0	2.0	0.0	0.0	1.0
Lycopodium	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Unknown	0.0	0.0	0.0	2.0	0.0	0.0	0.0
Indeterminable (broken)	4.0	10.0	0.0	11.0	0.0	6.0	6.0
Indeterminable (crumpled)	4.0	5.0	0.0	13.0	0.0	4.0	7.0
Indeterminable (degraded)	0.0	1.0	0.0	0.0	0.0	0.0	0.0
EUCALYPTUS COUNT	4.0	5.0	2.0	1.0	5.0	2.0	1.0
CRYPTOGAM SUM	0.0	1.0	0.0	2.0	0.0	1.0	1.0
INDETERMINABLE SUM	8.0	16.0	0.0	24.0	0.0	10.0	13.0
trees, shrubs and vines sum	266.0	301.0	277.0	274.0	290.0	284.0	262.0
Herb sum	70.0	46.0	67.0	38.0	39.0	53.0	76.0
UNKNOWN	0.0	0.0	0.0	2.0	0.0	0.0	0.0
POLLEN SUM	336.0	347.0	344.0	312.0	329.0	337.0	338.0
SAMPLE VOLUME	1.0	1.0	1.0	1.0	1.0	1.0	1.0
CONCENTRATION SPIKE (GRAINS/ml)	53600.0	53600.0	53600.0	53600.0	53600.0	53600.0	53600.0
VOLUME SPIKE ADDED (ml)	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Cryptogam sum + Pollen sum	336.0	348.0	344.0	314.0	329.0	338.0	339.0
Total Pollen Concentrations	4502400.0	3719840.0	9219200.0	16723200.0	3526880.0	9031600.0	18116800.0

Appendix 7: Mor # 2 Pollen Concentrations (Continued).

	8.0	9.0	10.0	11.0	12.0	13.0	14.0
Betula	160800.0	67000.0	160800.0	268000.0	428800.0	107200.0	40200.0
Quercus	11524000.0	3845800.0	11095200.0	15490400.0	14043200.0	2948000.0	2184200.0
Tilia	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ulmus	643200.0	26800.0	214400.0	0.0	268000.0	107200.0	40200.0
Acer	0.0	13400.0	53600.0	53600.0	321600.0	0.0	0.0
Corylus	375200.0	40200.0	750400.0	53600.0	107200.0	67000.0	201000.0
Fagus	0.0	0.0	0.0	268000.0	107200.0	13400.0	26800.0
Alnus	53600.0	26800.0	53600.0	107200.0	53600.0	26800.0	13400.0
Taxus	53600.0	40200.0	0.0	0.0	0.0	0.0	13400.0
Populus	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pinus	0.0	40200.0	53600.0	53600.0	0.0	0.0	294800.0
Salix	107200.0	0.0	53600.0	0.0	53600.0	0.0	26800.0
Caprifoliaceae	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Hippocastanaceae	53600.0	0.0	0.0	0.0	0.0	0.0	0.0
Ulex	0.0	0.0	53600.0	0.0	0.0	0.0	0.0
Oleaceae	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ericales	160800.0	0.0	0.0	0.0	107200.0	0.0	0.0
Calluna	53600.0	13400.0	53600.0	160800.0	0.0	40200.0	80400.0
Gramineae (wild type)	1608000.0	951400.0	2787200.0	1876000.0	3323200.0	871000.0	804000.0
Cereals	0.0	0.0	0.0	0.0	53600.0	0.0	0.0

Cyperaceae	1072000.0	375200.0	857600.0	643200.0	268000.0	67000.0	227800.0
Anthemis type	0.0	0.0	0.0	0.0	0.0	0.0	26800.0
Centaurea cf. C.nigra type	0.0	0.0	53600.0	0.0	0.0	13400.0	0.0
Aster type	53600.0	13400.0	0.0	0.0	0.0	13400.0	0.0
Compositae (Liguliflorae)	0.0	13400.0	0.0	0.0	107200.0	40200.0	26800.0
Caryophyllaceae	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Chenopodiaceae	107200.0	0.0	0.0	0.0	0.0	0.0	0.0
Cruciferae	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Euphorbiaceae	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Geranium	0.0	0.0	0.0	0.0	0.0	0.0	13400.0
Primulaceae	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Plantago undifferentiated	160800.0	26800.0	214400.0	53600.0	107200.0	93800.0	67000.0
Ranunculus type	160800.0	13400.0	107200.0	107200.0	53600.0	80400.0	0.0
Rumex	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Polygonaceae undifferentiated	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Scrophulariaceae	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Umbelliferae	53600.0	13400.0	107200.0	0.0	53600.0	0.0	13400.0
Urtica type	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rosaceae undifferentiated	53600.0	13400.0	214400.0	53600.0	53600.0	13400.0	13400.0
Rubiaceae	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Boraginaceae	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Onagraceae	0.0	0.0	0.0	53600.0	0.0	0.0	0.0
Saxifragaceae	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Polypodium	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Monolete spores	0.0	6.0	3.0	2.0	1.0	0.0	6.0
Trilete spores	0.0	4.0	1.0	1.0	1.0	6.0	8.0
Lycopodium	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Unknown	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Indeterminable (broken)	0.0	2.0	9.0	2.0	3.0	0.0	6.0
Indeterminable (*crumpled*)	0.0	1.0	7.0	0.0	5.0	0.0	10.0
Indeterminable (degraded)	0.0	1.0	2.0	0.0	1.0	1.0	6.0
EUCALYPTUS COUNT	1.0	4.0	1.0	1.0	1.0	4.0	4.0
CRYPTOGAM SUM	0.0	10.0	4.0	3.0	2.0	6.0	14.0
INDETERMINABLE SUM	0.0	4.0	18.0	2.0	9.0	1.0	22.0
trees, shrubs and vines sum	246.0	307.0	234.0	307.0	289.0	247.0	218.0
Herb sum	61.0	106.0	81.0	52.0	75.0	89.0	89.0
UNKNOWN	0.0	0.0	0.0	0.0	0.0	0.0	0.0
POLLEN SUM	307.0	413.0	315.0	359.0	364.0	336.0	307.0
SAMPLE VOLUME	1.0	1.0	1.0	1.0	1.0	1.0	1.0
CONCENTRATION SPIKE (GRAINS/ml)	53600.0	53600.0	53600.0	53600.0	53600.0	53600.0	53600.0
VOLUME SPIKE ADDED (ml)	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Cryptogam sum + Pollen sum	307.0	423.0	319.0	362.0	366.0	342.0	321.0
Total Pollen Concentrations	16455200.0	5534200.0	16884000.0	19242400.0	19510400.0	4502400.0	4113800.0

Appendix 8 :Loss on Ignition (L.O.I.) Test Results for Mor # 2.

Depth	Crucible number	Crucible Weight	Crucible + Wet soil	Crucible + Oven dry	Crucible + ignited	Wet Weight	Dry Weight	Ignited Weight	% loi
1	1	13.96988	15.27188	14.33154	14.04268	1.302	0.36166	0.0728	79.87
2	2	14.09868	15.3996	14.43169	14.13715	1.30092	0.33301	0.03847	88.45
3	3	13.81371	14.90121	14.09144	13.83254	1.0875	0.27773	0.01883	93.22
4	4	13.82689	15.05277	14.18913	13.86537	1.22588	0.36224	0.03848	89.38
5	5	13.83307	15.26183	14.38625	14.06747	1.42876	0.55318	0.2344	57.63
6	6	13.98618	15.17518	14.3722	14.07178	1.189	0.38602	0.0856	77.82
7	7	13.27673	14.4289	13.7374	13.48789	1.15217	0.46067	0.21116	54.16
8	8	14.72824	17.40068	16.02555	15.5615	2.67244	1.29731	0.83326	35.77
9	9	13.71494	15.02125	14.35926	14.12168	1.30631	0.64432	0.40674	36.87
10	10	13.20973	14.71783	14.06344	13.82036	1.5081	0.85371	0.61063	28.47
11	11	13.77322	15.50109	14.8031	14.54546	1.72787	1.02988	0.77224	25.02
12	12	13.6924	15.622	14.96339	14.64756	1.9296	1.27099	0.95516	24.85
13	13	13.8894	15.47242	14.9264	14.7125	1.58302	1.037	0.8231	20.63
14	14	13.4125	15.3523	14.62067	14.37879	1.9398	1.20817	0.96629	20.02
5*	5	13.60735	14.66723	14.02499	13.7875	1.05988	0.41764	0.18015	56.86

* : Repetition of test on sample 5 to investigate if original result was spurious.