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LATE HOLOCENE PALAEOECOLOGY AND HUMAN IMPACT ON THE ENVIRONMENT OF NORTHERN BRITAIN.

LISA DUMAYNE

A thesis submitted for the degree of

DOCTOR OF PHILOSOPHY

FACULTY OF SCIENCE

Department of Geography

August 1992

UNIVERSITY OF SOUTHAMPTON

ABSTRACT

FACULTY OF SCIENCE

DEPARTMENT OF GEOGRAPHY

Doctor of Philosophy

LATE HOLOCENE PALAEOECOLOGY AND HUMAN IMPACT ON THE ENVIRONMENT OF NORTHERN BRITAIN.

by Lisa Dumayne

Pollen diagrams from nine mire sites in northern Britain have been constructed to assess the record of human impact on vegetation over the last 3,000 years. Of particular interest is the effect of the Roman invasion and occupation of northern Britain on vegetation, especially that related to the construction of the Hadrianic and Antonine Walls, forts and roads. Pollen analysis was undertaken to investigate whether the impact was widespread across the frontier zone or was related to the proximity to Roman Walls and forts.

During the Roman occupation of northern Britain between A.D. 71 and A.D. 411, large amounts of timber and turf were needed for the construction of forts and other structures and it is estimated that a fort 4 acres in size would have needed 22, 000 cubic feet of timber for its construction (Keppie, 1986). Woodland was also cleared to create a military clear zone, for the production of lime, for cooking and to create open land for agriculture. The effect of these activities on the environment of the frontier zone has not been intensively studied and few pollen diagrams concerned with the anthropogenic impact on the vegetation have previously been produced from the area (Barber, 1981; Turner, 1979; Davies and Turner, 1979). Therefore, a regional reconstruction of vegetation history has been undertaken and was long overdue.

The results of high-resolution pollen analysis of the nine sites, supported by 25 radiocarbon dates, have demonstrated that the first major and permanent clearance of vegetation at certain sites occurred during the Iron Age, and this is followed by a second clearance relating to the Roman occupation. At Fozy Moss, Northumbria, no Iron Age clearance occurs and the first major clearance occurs at the time of the Roman occupation. The dramatic response of the grass pollen curves and the relatively low level of arable indicators, is in accord with the archaeological evidence for the Roman impact being one of woodland clearance for military purposes rather than for settled agriculture. Results indicate that the degree of clearance is related to distance from Roman structures. Sites close to Hadrian's and the Antonine Wall record the highest levels of grass pollen - 80% at Fozy Moss; 55% at Letham Moss: 40% at Walton Moss and Fannyside Muir. Dogden Moss, situated in the inter-wall area, also displays high grass levels - 50% - attributable to the moss being situated in an area amenable for agriculture. For sites at greater distances from the major archaeological structures, Gramineae percentages are lower. At Carsegowan Moss, Wigtonshire, Glasson Moss, Cumbria and Cranley Moss, Lanarkshire, the Gramineae curves barely reach 30%.This indicates that the Roman occupation was not as intense as at the other sites. Ellergower Moss, Dumfriesshire, is in an area outside the influence of the Roman occupation and here Gramineae levels do not begin to rise until much later.

Thus the hypothesis - that the proximity of an area to the Roman structures will be reflected in a greater degree of forest clearance - is upheld by the above results, but this appears not to have been the first major human impact on the landscape of the region. The record of vegetation change is described up to the present day and evidence for prehistoric agriculture discussed. The concepts of pollen source areas, inter-site variability, agricultural indicators and agricultural indicies are explored in relation to the palynological results.

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ACKNOWLEDGEMENTS.

I am indebted to Dr. Keith Barber for his invaluable supervision, advice and encouragement throughout the tenure of my studentship.

I would like to thank Dr. Jim Milne for his assistance with computing and for writing the pollen programme used to calculate and plot the diagrams presented in this thesis; Mr. David Andersen for assistance in the laboratory and Rob Stoneman for his help during field work. I am also grateful to Dr. Alayne Perrott and Mr. Alan Perrott for allowing me access to their computer programme for calculating magnetic susceptibilty values.

Thanks are also owed to the landowners for allowing access to the sites used in this study and to English Nature and Scottish Natural Heritage for providing unpublished information that was of great help in site selection.

I am also grateful to S.E.R.C. (S.B.A.C.) for providing me with the studentship and to Dr. D. D. Harkness at the N.E.R.C. Radiocarbon Laboratory at East Kilbride for analysis of the samples sent for radiocarbon dating.

Thanks are also due to those who allowed access to unpublished literature and for stimulating discussions - Dr. P. Wiltshire, Dr. R. Tipping, Dr. R. Jones. Dr. J. Dickson, Mrs C. Dickson and Dr. R. Scaife. I would also like to express my thanks to friends who have helped in various ways and to my parents who have been an endless source of encouragement and support throughout my education.

CHAPTER 1.

INTRODUCTION.

1.1 Aims.

During the late Holocene humans became a large and growing component of the biotic environment, began to effect the natural ecosystem, and determine the evolution of the modern landscape. There are many methods available that can be used to obtain data relevant to the reconstruction of environments associated with human groups (Tooley, 1981) and palaeoecological methods can be employed to reconstruct humanly induced changes. One element of the ecosystem on which human activity has a great impact is the natural vegetation and such changes can be reconstructed using pollen analysis. Palynology provides one method for the detection of human impact on prehistoric and historic environments (Edwards, 1991) and can be used as a tool to reconstruct the evolution of the modern landscape.

However it is essential that the results of pollen analysis do not serve alone as the basis for reconstruction, and the support of radiocarbon dates and a knowledge of the archaeological record are vital. The archaeological and palynological records have to be interpreted in relation to each other and the environment must be seen as a dynamic factor in the study of archaeology. The aim of the environmental archaeologist should therefore be to define the characteristics of the physical environment that provide a matrix for, and interact with, socio-economic systems (Butzer, 1982, 4). This is attempted in the present project.

The abundance of archaeological remains and literature pertaining to the Roman occupation of northern Britain provides a rich source of archaeological evidence which can be combined with palynological data to assess the impact of the Roman invasion and occupation on regional vegetation in northern Britain. The affect of the Roman occupation on the vegetation of the frontier zone has not been intensively studied and few pollen diagrams concerned with anthropogenic impact have been have been produced from this area of northern Britain. Those which are available (Turner, 1979; Davies and Turner, 1979; Barber, 1981) record an almost complete lack of clearance activity during the Neolithic, Bronze Age and Iron Age. This all changes dramatically with the Roman invasion and occupation of the area and the pollen evidence suggests that the first major human impact on vegetation in northern Britain was related to the Roman invasion and occupation of the area. However, most diagrams are not radiocarbon-dated or directly related to anthropogenic impact. Consequently knowledge of vegetation change is limited.

Based on a number of hypotheses it is the contention of this project that the first large-scale and permanent vegetation clearance in northern Britain is related to the Roman invasion and occupation of northern Britain and that such clearance is related to distance from Roman military structures such as Hadrian's Wall, the Antonine Wall, forts and milecastles. The main issues under consideration are therefore: how far had woodland clearance proceeded by the time of the Roman occupation of northern Britain; to what extent were the Romans actually responsible for accelerating it and to what extent did the Roman occupation affect vegetation across the frontier zone as a whole.

The aim of this study is to examine the regional palynological record from a series of large mires in northern Britain in light of human impact and the archaeological record. Vegetation change is analysed with particular

reference to the effect of the Roman occupation of northern Britain. Numerous mires suitable for such a study are to found in the area providing ample opportunity for such study. Single cores were taken from the centre of nine sites and a regional vegetation record constructed using pollen analysis and inter-site comparisons made (Jacobson and Bradshaw, 1981; Berglund, 1986; Bradshaw, 1991). Analysis of prehistoric agriculture is undertaken, the concepts of pollen source area discussed and the integration of the palynological and archaeological record evaluated.

1.2 Thesis Structure.

To provide a framework for this project, a review of relevant literature is presented in Chapter 2. The first part briefly outlines the literature relating to pollen analysis, more specifically pollen representativity and the elucidation of human impact in pollen diagrams. The second part of Chapter 2 describes the archaeological setting for the project and the archaeological evidence to which the palynological results will be related. The Roman invasion and occupation of northern Britain is discussed and archaeological evidence for the Roman occupation presented.

Chapter 3 describes the methodology employed in this study, both in the field and the laboratory, and Chapter 4 is a long but necessary chapter in which the pollen diagrams and the pollen assemblage zones are described. Chapter 5 examines the relationship between the palynological results and the archaeological record and contains detailed discussion on the nature of human impact and agriculture throughout the time period under study. The application and significance of the results within environmental archaeology and a general palaeoecolgical framework are discussed in Chapter 6 and the concluding chapter, Chapter 7, discusses the wider implications of the work undertaken. Botanical nomenclature follows that of Clapham *et al.* (1989) and pollen nomenclature follows that of Moore *et al.* (1991). For the purposes of this study the term northern Britain refers to the area of the Hadrianic-Antonine frontier zone.

CHAPTER 2.

LITERATURE REVIEW.

2.1 Pollen Representation.

Palynological analysis of the palaeoenvironmental record from suitable sedimentary sequences can provide a detailed description of past vegetation in an area, including the impact of humans upon it. Pollen analysis is a useful tool for reconstructing past vegetation as pollen grains are produced in large numbers, are mixed well by atmospheric turbulence and dispersed uniformly over a wide area. They are resilient, can be preserved in a variety of deposits, retrieved in great quantities and are easily identifiable, allowing pollen assemblages to be compared in space and time (Birks and Birks, 1980, 156). Each of the above aspects will be considered in the light of the research undertaken in this project.

2.1.1 Pollen Representativity - General Literature.

All flowering plants produce pollen, the quantity varying between different species, within species, with the age of the plant, the density of the vegetation stand, climate, exposure and other ecological parameters. These factors effect the composition of pollen deposited at a site. This is directly relevant to any palynologist as it affects the chances of a particular taxon being represented in the pollen assemblage (Andersen, 1970; Krzywinski, 1977; Moore *et al.*, 1991, 181).

Differential pollen production between species is an important factor to consider when interpreting any pollen data. Plants pollinated by animals, birds or insects (zoophilous) produce a small number of grains which, because of the nature of pollination are rarely dispersed into the atmosphere. Consequently, the pollen of such species is rarely found in deposits sampled for regional pollen analysis and usually only occur in pollen diagrams as indicator species (Behre, 1981). Wind pollinated (anemophilous) plants produce large quantities of pollen that are liberated into the air, dispersed over a wider area, eventually falling out as pollen rain and represented in a regional pollen diagram (Faegri *et al.*, 1989, 11). However, there are variations in pollen production between wind pollinated taxa (Faegri, 1966). For example, *Pinus* is a high pollen producer and is often over-represented in diagrams, whilst *Fagus* is a low producer and its presence in a diagram alone is significant (McAndrews and Wright, 1969; Bennett, 1984).

Besides pollen productivity, pollen dispersal efficiency, or the ease with which pollen is dispersed from a plant, is also an important factor influencing the final pollen assemblage. Dispersal efficiency depends on the micro-climate of the site into which the pollen is released, the aerodynamic properties of the pollen grain and wind speed (Maguire, 1983; Moore *et al.*, 1991, 183). In general, anemophilous species have better dispersal efficiencies than zoophilous species. Various studies have been undertaken in an attempt to understand differences in both pollen production and dispersal and to derive correction factors which can be applied to increase the accuracy with which pollen assemblages can be interpreted. Andersen (1967, 1970) obtained indicies of pollen production by undertaking studies on pollen productivity and dispersal efficiency of trees using surface pollen samples from mixed deciduous forests (Table 2.1). These results can be compared with a study by Erdtman (1969, 118), who based an index of relative production and dispersal efficiency of pollen types on their weight, volume and settling velocity. However, Andersen's figures appear more realistic as they combine pollen productivity with pollen fallout and short range dispersal efficiency. Work on relative pollen production in forested areas in southern England has also shown that the

general rank order of tree pollen production is comparable to Andersen's data (Bradshaw, 1981 a).

Table 2.1 Pollen Production Rates (Related To *Fagus* = 1.0).

Andersen (1967, 1970)		Erdtman (1969)	
TAXA	PRODUCTION RATE	TAXA	PRODUCTION RATE
Pinus	4.2	*Alnus*	17.7
Betula	4.2	*Pinus*	15.8
Quercus	4.1	*Tilia*	13.7
Alnus	3.0	*Corylus*	13.7
Picea	1.5	*Betula*	13.6
Carpinus	1.1	*Picea*	13.4
Fagus	1.0	*Carpinus*	7.7
Tilia	0.7	*Quercus*	1.6
Fraxinus	0.6	*Fagus*	1.0

Andersen (1967, 1970, 1973) also derived a correction factor from the production rates ($P\text{-}_{rel}$) to correct for differential production and dispersal bias. $P\text{-}_{rel}$ is the ratio of absolute pollen production of a species to that of another species and the following correction factors should be applied:

Quercus, Betula, Alnus, Pinus and *Corylus* 1 + 4
Carpinus 1 + 3
Ulmus, Picea 1 + 2
Fagus, Abies, Populus 1 + 1
Tilia, Fraxinus, Acer 1 + 2

The above studies are of little practical use when considering pollen dispersal as they do not take into account complicating factors such as differential pollen production within species, deposition above ground and movements of air masses. A number of other correction factors have been used to overcome the problem of production and dispersal bias, the earliest being Iversen (1947) who proposed a correction factor to be applied to pollen data, based on the division of pollen taxa into 3 groups - A, B, and C. Group A consists of the species that produce great quantities of pollen (e.g. *Pinus*, *Corylus*, *Betula*); B of those producing moderate amounts of pollen (*Quercus*, *Fraxinus*, *Fagus*); and C of pollen types that are scarce, producing or releasing little pollen, but which may be of indicator value where the presence in a diagram is important (*Ilex*, *Vitis*). A sub-group, B_2, consists of those species which are small producers or dispersers, but are important in the diagram. If a more realistic representation is required, the fraction of each group can be altered by simple calculations, but this seems to be a too simplistic approach to correct for the complexities of pollen production and dispersal.

The problems of the relationship between pollen production/dispersal and actual vegetation were also addressed by Fagerlind (1952), who suggested a representativity factor to account for bias. Fagerlind (1952) showed that the assumption of linearity between absolute pollen density and vegetation gives rise to a relationship among percentages which is neither linear nor simple. In a system with more than three taxa, the pollen percentage of any one taxon theoretically depends on its own abundance and the abundance of others. This non-linearity is the Fagerlind effect (Faegri *et al.*, 1989), but is a theoretical phenomenon which is not important in practice. Fagerlind himself (1952) showed that a rough correction of pollen percentages reduced non-linearity, and the Fagerlind effect has since been disproved. Webb *et al.* (1978, 1981) showed that pollen percentages are approximate linear functions of relative tree abundances in a data set from the U.S.A. and Prentice and Webb (1986) also discussed how the Fagerlind effect can be eliminated through correcting pollen percentages by appropriate factors to give a more linear and precise pollen - vegetation relationship. The statistical examination of data sets from the United States, demonstrated that pollen percentages can be read directly as if they were linear functions of tree abundances, that pollen and tree percentages of anemophilous taxa are more closely related than previously thought and that the

Fagerlind effect is low in forests with high diversity. Therefore, changes in pollen percentages can be interpreted as a comparable change in relative abundances of taxa in the vegetation.

Fagerlind's (1952) work was extended by Davis (1963) who proposed a ratio (R) to express the relationship between the representation of a species in the pollen count and in the actual vegetation. This can be calculated using the following formula:

$$R_A = \frac{\text{\% pollen of species A}}{\text{\% representation of A in the vegetation}}$$

There are four assumptions underlying the use of the R-value: that the vegetation consists of taxa which all contribute pollen to a site; individual plants of each taxon are uniformly distributed throughout an infinitely sized area; the number of pollen grains of a given type is directly proportional to the number of plants producing pollen of that type, but that the proportionality constant differs among pollen types; that pollen percentages are measured without error and therefore are an accurate record of pollen delivered to any point in the infinite sized area (Davis, 1963). The R-value takes into account differences between species in terms of their dispersal efficiency and pollen production and therefore, the true proportional representation of a species in the vegetation can be determined if the pollen percentage is corrected by using R-values. However, this model does not account for all sources of variation and conditions are too complex for general R-values to be imposed. It is not accurate to use pollen production when relating the composition of pollen rain to the composition of the vegetation and the effectiveness of pollen transport is also important (Faegri, 1966). The R-value of a species will be affected by the local environment, the distance between the pollen source and the deposition site, forest composition and structure, pollen transport efficiency, the size of the site in which the pollen is deposited, regional vegetation and the spatial extent of the pollen producing vegetation (Andersen, 1970; Moore *et al.*, 1991, 184).

To correct for the relative pollen representation of a species, Andersen (1970, 1973) introduces the concept of the R_{rel}-value. This depends on factors such as the abundance of the species; of the composition of the vegetation and can be used to correct the pollen spectra, allowing the percentage area of a species to be calculated.

A study of pollen dispersal beneath a forest canopy undertaken by Bradshaw (1981 a and b, 1988), demonstrated that the relation between pollen frequency and plant numbers in a given area has to be analysed if pollen diagrams are to be used as records of past tree populations. This relationship was studied by comparing pollen content of moss polsters in the forest, from which a rank order of the number of grains deposited per unit of tree basal area was derived - *Betula*, being greater than *Pinus*, *Taxus*, *Alnus*, *Quercus*, *Fraxinus*, *Fagus*, *Salix*. With the exception of *Quercus*, a consistent order of pollen representation can be recognised. Fossil pollen was converted to an estimation of tree basal area using a regression coefficient. The corrections applied in this study are only applicable to sites with similar sampling properties to moss polsters and are therefore not applicable to regional pollen diagrams.

Applications of statistical techniques have shown a rough consistency between the relative pollen representation of the same tree taxa in comparable sampling sites located in different areas. Calibrations between pollen production and forest composition can then be used to estimate past forest composition from pollen spectra (Prentice 1986 a). Webb *et al.* (1981), Birks and Gordon (1985), Parsons and Prentice (1981, 1986), Parsons *et al.* (1983), Prentice (1986 a, b), Prentice *et al.* (1987) and Schwartz (1989) discuss the use of the R-value method and attempt to standardise the values by applying various statistical techniques to correct for the statistical errors inherent in the pollen data.

Further problems inherent in understanding the exact nature of pollen dispersal include an unknown amount of pollen being trapped in and filtered by the forest canopy (Tauber, 1965); deposition rates varying with the size and weight of different pollen types; the aggregation and clumping of pollen grains; and the nature of air flow. Sutton's formula (1947; Faegri *et al.*, 1989, 24) is a model which is often used as a basis for the calculation of pollen transport. The model shows that dispersal is based on atmospheric turbulence and wind speed, but it is a poor approximation of what actually takes place. It cannot correct for the diffuse nature of the pollen source, the scavenging of pollen by different surfaces or conditions, and only considers the local component of the pollen rain.

All the statistical correction techniques outlined above are complex and fossil pollen has been shown to have a reasonably direct relationship with vegetation. Prentice and Webb (1986) state:

> "Our results support the continued results of pollen percentages for at least two reasons. Firstly the traditional interpretation model, which assumes a linear relationship between pollen and tree percentages, is upheld as a reasonable first approximation. Secondly, our results show that pollen and tree percentages are even more closely related than is apparent from scatter diagrams of pollen and tree percentages. "

Therefore, in terms of the research undertaken in this project the application of the statistical techniques discussed above is unnecessary.

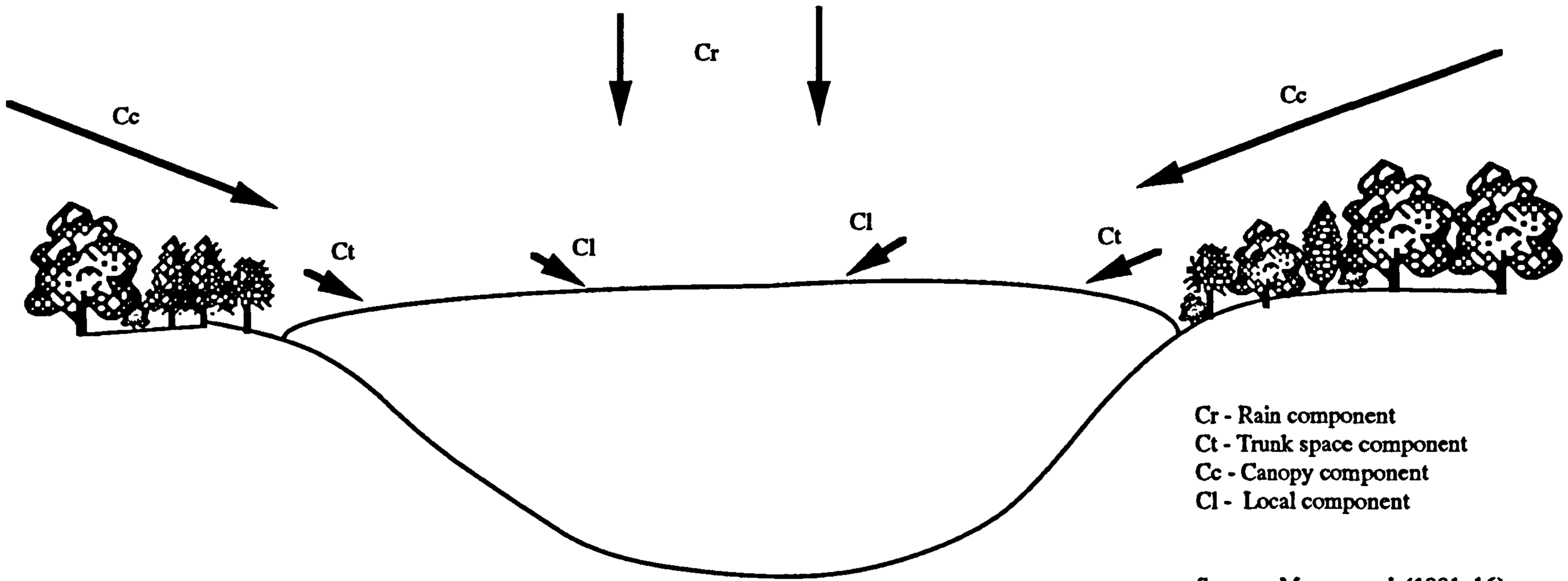
2.1.2 Pollen Representativity - Large Mires.

The principles behind pollen rain and transport need to be considered if pollen representation in large mires is to be assessed. In any given site, it is important to consider the sources of the pollen and the means by which it arrived at the site. Only in this way can the pollen assemblage be interpreted in terms of the past vegetation (Moore *et al.*, 1991, 12). A detailed interpretation of regional pollen diagrams presupposes a detailed knowledge of pollen transfer and a number of models have been constructed in an attempt to understand this.

Tauber (1965 1967 a, b, 1977) constructed a model showing that pollen deposited on a site consists of three components - a trunk space component (C_t), a canopy component (C_c) and a rain component (C_r). Pollen transfer is composite in nature and the different components will reflect the vegetation within different sized areas. Most of the pollen transport was assumed to take place in the trunk space and to come from within a few 100 m. of the sampling point (Tauber, 1965), but measurements of pollen in the trunk space of a forest in Denmark were lower than expected if this was the main process of pollen grain transport (Tauber, 1967 a, b). Pollen carried above the canopy will reflect vegetation within several kilometres, though with a rapidly decreasing efficiency at increasing distances. The rainout component will be even more regional in nature. Where a forest is interrupted by a mire, the air currents which pass through the trunk space will deposit some of the pollen on to its surface, the share of the three components varying with the size of the basin, the density of the vegetation surrounding the basin and with meteorological conditions. In small mires, the trunk-space component is likely to dominate, but in a large mire the regional component of several tens of kilometres may be reflected (Figure 2.1).

Tauber's model forms the basis for interpreting data from any site located in a forested environment, but each site needs special consideration and it is necessary to modify the model for specific site needs. Tinsley and Smith (1974) have tested the validity of Tauber's model by examining the decline of pollen deposition

FIGURE 2.1 THE INPUT OF POLLEN INTO A RAISED MIRE.



Cr - Rain component
Ct - Trunk space component
Cc - Canopy component
Cl - Local component

Source - Moore *et al.* (1991, 16)

in moss polsters with increasing distance from a woodland edge in the North Yorkshire Moors. The pollen spectra were shown to reflect the adjacent plant communities and there was a rapid decline in arboreal pollen within 100 m. of the edge (compared to Tauber's distance of 400 m.), followed by a further gradual decline in tree pollen deposition. This could be due to the fact that the site under study was situated in a valley. Similar results have been obtained in the study of the pollen content of surface moss samples in the North Yorkshire Moors (Cundill, 1979). In the light of Tauber's model (1965), the high pollen values obtained from the first 100 m. can be seen to represent deposition of the trunk space component; beyond this distance the pollen deposited is mainly derived from the canopy and rain-out components. Such observations have implications for diagrams which have been interpreted as containing evidence for anthropogenically induced vegetation clearance. Arboreal pollen values less than 50% indicate woodland within 100 m. of the site, values of 25 - 50% may be interpreted as either from a site within 100 m. of the woodland edge or a site surrounded by dispersed trees. Those greater than 50% suggest that the canopy was closed (Tinsley and Smith, 1974).

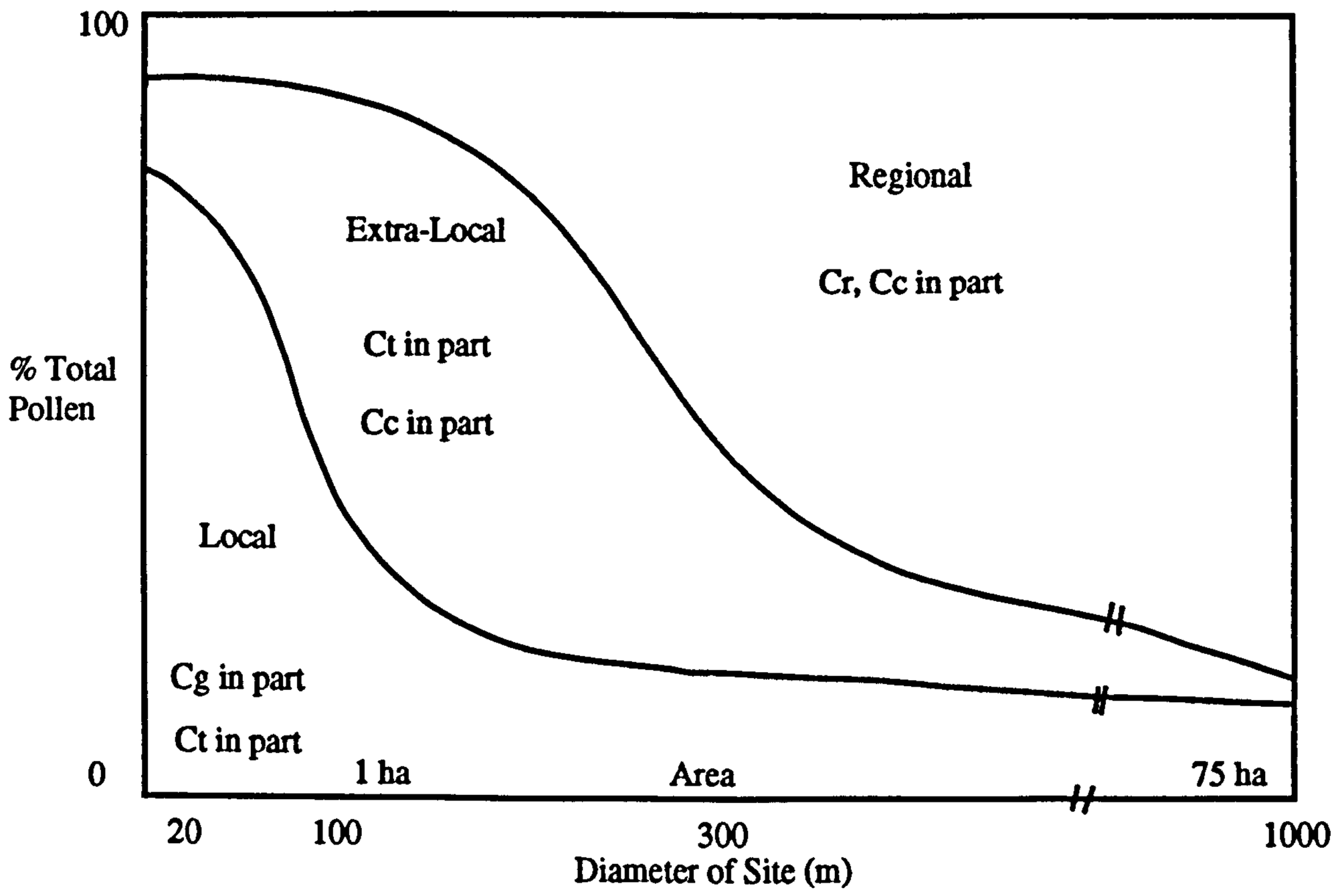
Oldfield (1970) extended Tauber's model (1965) by considering the relationship between theoretical dispersal and deposition and accounting for differences in the percentage strength of a pollen source and distance from the sampling site. The same contribution to the pollen rain at a sampling site can be made by many contributing pollen source strengths and distances. If a correction factor translating the frequency of pollen type to abundance of tree taxa is to be applied, the distance from the collecting point to the vegetation forming a pollen source needs to be known.

Janssen (1966, 1973) has also investigated the nature of pollen source areas and his division of pollen rain into a local component, extra-local component and regional component is directly relevant to the research undertaken in this project. Local pollen is derived from plants that grow close to the sampling point and on a mire would include species such as Ericaceae, Cyperaceae and *Sphagnum* spp.. Extra-local pollen is derived from trees surrounding the site. Regional pollen comprises the airborne component of the pollen rain which has been transported over considerable distances so that only large-scale vegetation types are recognisable. Janssen's (1966, 1973) model therefore describes the relationship between the magnitude of the pollen deposited at a site and the areas from which individual pollen grains originated.

Since the original studies of Tauber and Janssen a number of studies of pollen source area and pollen rain have been undertaken. On a local scale, Andersen (1970, 1974, 1978) presented a model which proposed that the pollen deposited on the floor of a Danish forest was derived from trees within 20-30 metres of the sampling site. A linear equation and correlation coefficient indicate that, assuming production was constant, pollen deposition was proportional to the tree crown and basal areas. As the canopy opens above the sampling site, the basin size is effectively increased, and the representation of extra-local and regional pollen increase. This is important in diagrams which show human induced woodland clearance because, as woodland is removed, the area from which the pollen rain is derived increases.

Therefore, size is an important consideration in site selection. Jacobson and Bradshaw (1981), combining and extending the ideas of Tauber (1965, 1967 a, b, 1977), Andersen (1970, 1974, 1978) and Janssen (1966, 1973), present a model that describes the relationship between basin size and pollen source area and which predicts the proportions of local, extra-local and regional pollen in basins of different sizes (Figure 2.2). The model relates basin size to the areas from which the pollen originates and the component in which the pollen travelled to the basin. For the purposes of the model, local pollen is defined as that which is derived from plants growing within 20 metres of the edge of the site. Extra-local pollen is derived from between 20 metres to several 100 metres and regional pollen from greater distances. As the forest canopy opens above sites of increasing basin size the model predicts increased representation of extra-local and regional pollen. Although the model was constructed for lakes with no inflowing streams, the mode of

Figure 2.2 Relationship Between The Size of a Site And The Relative Proportion Of Pollen Originating From Different Areas Around The Site.



Source: Jacobson and Bradshaw (1981)

pollen transport for mires should be similar. However, since all pollen transport to ombrotrophic mires is aerial, and since there is minimal vertical or horizontal mixing of pollen after deposition (Bradshaw, 1991), pollen diagrams from mires are more accurate than those from lake basins. Oldfield (1970) states:

> "Fewer assumptions or uncertainties about dispersal in particular occur if ombrogenous bog sites are used rather than lake sites, for in the latter case, dispersal by stream flow or soil wash is added to aerial dispersal which is by far the most important factor responsible for pollen deposition on bog surfaces."

Bradshaw (1991) discusses how an open site 1 km. in diameter will sample the surrounding vegetation in a biased manner. Most pollen arriving at the site will have originated from within the surrounding 30 km. (Bradshaw and Webb, 1985), but species closer to the sampling site are over-represented. Nevertheless, pollen data at this spatial scale are those best suited to reconstruct former regional vegetation patterns.

2.1.3 Other Factors Influencing Pollen Source Area And Representativity.

Other than site size, the pollen source area also varies with the type of pollen grain. Lighter grains are easily transported and therefore have larger source areas (Tauber, 1965). Bradshaw and Webb (1985) and Prentice (1985), discuss the relative size of the pollen source area for arboreal pollen types. They detect a descending scale of pollen source area for *Pinus*, *Quercus*, *Betula*, *Tsuga*, *Ulmus*, *Fagus* and *Acer*.

Prentice (1985, 1986 a, b) solves the problem of differential production and dispersal bias in relation to pollen source areas by the use of a simple model. Pollen source area and pollen representation depend on basin size according to functions that describe the amount of pollen remaining airborne at increasing distances from the source. In Prentice's model each pollen spectrum is modelled using the sum of pollen components and the background pollen component common to all sites in the region, which allows the pollen originating from the extra-regional area to be estimated. The model therefore explains the known effect of basin size and the observed character of pollen spectra in terms of production, dispersal and depositional processes, allowing the prediction of pollen source area for a basin of any size.

Jackson (1990) showed in a study of lakes in the United States, how pollen source area is also dependent on the spatial distributions of tree populations around the site. The technique of surface isopoll mapping has been used by Webb (1973) to reconstruct pollen source area and Prentice (1983) has also predicted the pollen source areas of moderate sized lakes in Southern Sweden using this technique. The maps are based on principal components analysis and cluster analysis of the pollen data and summarise the major gradients and patterns of regional vegetation as they are sensed by the modern pollen spectra. These reflect the quantitative features of variation in forest composition, as well as the degree of human impact in the form of agriculture and regeneration after abandonment.

Pollen representation depends on the extent to which a species is under or over-represented in the relative abundance of taxa. Over-representation of local pollen in a regional diagram is a common problem and is of particular significance when pollen producing vegetation forms part of the sediment matrix, as is the case with peat. In this case, the problem is overcome by excluding the local pollen producers from the pollen sum, thus removing their effect on the final diagram. The problem of under-representation of species is also of central importance to the interpretation of regional vegetation affected by humans. Herb species are important indicators of human impact, but such species are not subject to long distance transport and their occurrence is more local in character (Vuorela, 1977; Behre, 1986). Differential representation is shown in a study on the Isle of Caenn Ear, Outer Hebrides, (Randall *et al.*, 1986), where the vegetation communities were not represented accurately by the pollen spectra and some species were important in the community

but absent or low in the pollen record. In this study pollen representation was grouped into three categories: as well represented and widely distributed; pollen taxa recorded in their parent communities but not well represented; and pollen taxa recorded in low frequency. The study indicated that, in spite of this loose relationship, the pollen spectrum from each community was distinct from the rest, demonstrating the local nature of the pollen rain.

The effect of extra-regional pollen on the percentage diagram is considered to be negligible (Jacobson and Bradshaw, 1981). Very few pollen grains travel long distances and thus, overall do not effect the diagram. It is often the case that the pollen of extra-regional species can be detected in a diagram by the very fact that they do not always occur in the area under study.

2.1.4 Pollen Deposition And Preservation.

All pollen dispersed and transported by wind will be deposited and from the time of deposition becomes incorporated into the medium which surrounds it. Pollen can be deposited in a variety of environments - mires, soils and lakes - and incorporated into their sediments. The research reported here is concerned with the analysis of pollen from mires and as mires develop, pollen landing on the surface vegetation will be incorporated into the peat deposit. Rowley and Rowley (1956) showed that larger grains such as *Pinus* are trapped on the bog surface, whilst smaller grains can percolate through the interstices of the living *Sphagnum*. However, the high rate of *Sphagnum* growth means that the downward mixing of the pollen is not important on the time-scale involved in pollen analytical studies. In a laboratory based study, Clymo and Mackay (1987) showed that the velocity of upward water movement in peat is more than sufficient to overcome the rate of sinking of pollen in the unsaturated zone.

Lack of knowledge about the susceptibility of individual pollen grains to decay, may also lead to misinterpretation of pollen diagrams. Certain conditions for the preservation of pollen deposited have to be met. Despite pollen being composed of sporopollenim and being extremely resistant, degradation as a result of the activity of micro-organisms will occur in aerobic conditions with a high p^H. To be preserved, pollen has to be deposited under conditions of low microbiological activity, found in waterlogged, acidic environments. Such conditions are present in peat deposits where most grains can be retrieved in an almost uncorroded and unaltered state. Even under such conditions waterlogged pollen is sometimes subject to decay if the p^H is high. In a study of pollen from a mire near High Force, Teesdale, differential rates of pollen preservation were found to occur within the mire. The pollen evidence points to poor pollen preservation in the damp hollows and better preservation in the drier hummocks (Wilkinson and Huntley, 1987). A similar study of a mire in Canada came to the same conclusion (Irwin, 1989).

Decay, deterioration and differential preservation of grains are important as they may lead to biased pollen counts (Hall 1981). An experimental study by Havinga (1967, 1984), indicated strong degradation in clays, but very little in *Sphagnum* peat. A twenty-year experiment of pollen degradation showed that in peat with low biological activity, attack was confined to exine thinning and degrading. In a similar study, Cushing (1967) outlines five categories of pollen preservation: well preserved, corroded, degraded, broken and crumpled. Peats were found to contain mainly corroded grains and when such corrosion occurs it acts selectively. Havinga (1964, 1984) and Sangster and Dale (1961) show that under oxidising conditions certain grains are corroded more rapidly than others. This is summarised in Table 2.2.

Such corrosion is a complicated concept as it comprises the effects of external factors (microbial attack, oxidation, mechanical processes) and factors inherent in the composition of the pollen grains themselves. Chemical or biochemical attack always begins with oxidation and the more readily the pollen is oxidised, the more rapidly it is destroyed by subsequent attack. Differential recognition is also a problem (Hall,

Table 2.2 Sequence of Increasing Pollen Oxidation Susceptibility (Havinga, 1964, 1984).

SPECIES LISTED IN ORDER OF INCREASING OXIDATION SUSCEPTIBILITY
Lycopodium
Polypodium
Pinus
Tilia
Alnus
Myrica
Corylus
Betula
Carpinus
Populus
Quercus
Ulmus
Fagus
Fraxinus
Acer
Salix

1981). Some grains are easier to recognise in a degraded state than others, For example, *Chenopodium* is easier to recognise than Gramineae. The effect may also give less reliable results in older samples, which have been degraded over a longer period of time. Fire may also inflict various degrees of damage on pollen and considerably reduces its frequency. This is important in peat which is subject to periodic burning (Havinga, 1964). Although the differences in the preservation ability of various pollen types can lead to a biased representation of taxa in the final pollen diagram, fossil pollen spectra from mires give a more complete and quantitatively accurate picture of the original pollen rain than, for example, a lake or pond (Sangster and Dale, 1961).

Thus, if the problems of pollen production, dispersal and degradation are taken into account, pollen found in a deposit is a measure of the frequency of any flowering, wind pollinated species in a region.

2.1.5 Anthropogenic Impact Recorded In Pollen Diagrams And Its Interpretation.

Environmental archaeology uses the methods of the natural sciences to elucidate a variety of archaeological problems (Butzer, 1982, 5). An off-site application of pollen analysis to archaeological problems (i.e. from mires or lakes at a distance from archaeological sites), of the nature undertaken in this project, brings data on human interference with vegetation into a wider context and allows a greater continuity and higher resolution of analysis than does on-site pollen studies (Butzer, 1982, 5; Edwards, 1991). However, the examination of clearance activity in pollen diagrams is not simple. The nature of clearance activity, its inference from pollen spectra, the spatial distribution of mire sites and the proximity of such sites to prehistoric activity needs to be questioned.

Humans influence vegetation in two ways - directly through plant cultivation and indirectly through animal husbandry (Faegri *et al.*, 1989, 179). The following account of the literature will concentrate on these influences.

The most common representation of the human impact in pollen diagrams is a change in the frequency of tree pollen over time with the corresponding increase in pollen of light demanding plants and pioneering tree species (Edwards, 1979). The use of indicator species is also important in the assessment of human impact. A species is a positive indicator where its presence implies human impact and a negative indicator when it is intolerant of human presence because it declines or becomes absent from a diagram. This is the case of the *Ulmus* decline found in many pollen diagrams, dated to around 3,000 B.C. (Pennington, 1969;

Smith, 1981, 125). The narrower and more defined the ecological tolerance of a taxon, the more indicative it is of human activity (Faegri *et al.*, 1989, 182), but exclusive indicators are rare and most of them overlap several communities (Behre, 1981).

The appearance and increase of pollen from cultivated species obviously points to agricultural activity, but in addition to cereals, taxa such as *Artemisia*, Umbelliferae, Chenopodiaceae and Cruciferae have been accepted as indicators of arable land use (Edwards, 1988). Weed communities depend on the cultivation methods employed. In a mixed agricultural economy with long term rotation, perennial weeds are favoured. Under continuous short term cultivation, annual species are better suited as the extensive root systems of perennials are sensitive to yearly cultivation activity (Behre, 1981; Faegri *et al.*, 1989, 180). The weed species of fallow ground are the most difficult to determine. In the first year of fallow, weed species of the preceding cultivation phase will be represented, with perennial species having a competitive advantage. As the ground will not have been disturbed, species from the last crop to be cultivated will also survive and flower. Succession will then occur with the weed community being displaced. Therefore detection of fallow in pollen diagrams is a problem because fallow can be floristically diverse and can support weeds of field crops, ruderals and other weeds (Behre, 1981).

Flora including Gramineae, *Plantago* and *Pteridium* have been taken to indicate forest clearance for grazing and the maintenance of open space by continued grazing pressure (Edwards, 1988; Hicks, 1971). Examination of recent and historical evidence for animal husbandry has shown that episodes of pastoral activity may be of many centuries duration and post occupational grazing may explain long term pastoral episodes in pollen profiles (Buckland and Edwards, 1984).

However, cultural landscapes are usually a mixture of land uses and agriculture and it is often difficult to identify the single components. A number of attempts have been made at determining the ratios of pastoral and arable land. Steckhan (1961) and Lange (1975) devised indices based on the ratios of cereal and *Plantago* pollen and Kramm (1978) cereal to Gramineae pollen. Turner (1964) has attempted to separate such components in pollen diagrams by the use of a pastoral/arable index. Arable indicators include *Artemisia*, *Polygonum*, Cereals, and Compositae and pastoral indicators are *Plantago* species, Gramineae and Ranunculaceae. The pastoral/arable index can be determined from the following formula:

$$\text{Arable/pastoral Index} = 100 \times \frac{\textit{Plantago}}{\textit{Plantago}+\text{Compositae}+\text{Cruciferae}+\textit{Artemisia}+\text{Chenopodiaceae}+\text{Cereals}}$$

Riezebos and Slotboom (1978) present an alternative arable/pastoral ratio. Arable land use is suggested by the presence of Cereals, *Fagopyrum*, *Linum*, *Rumex*, *Artemisia* and *Centaurea* and pastoral by Gramineae, Papilionaceae and *Plantago lanceolota*. The problem with using such indexes is that the groups do not have a distinct ecological niche and where different regions and crops are involved an arable/pastoral index is inappropriate. The local conditions, composition of cultivated species and their dispersal capacity need to be known.

There are a number of shortcomings with the indicator approach. It is difficult to identify some herbs to species level and the indicative value of a species which appears in a diagram for the first time is greater than those which grew in the area in small quantities before human influence began (Caseldine, 1981). In regional diagrams the effects of human activities cannot be separated or localised (Andersen, 1978). The sediment accumulation rate and resolution of the pollen diagram is also important in distinguishing human influence and indicator species (Maguire, 1983; MacDonald and Edwards, 1991; Edwards and MacDonald, 1991).

Many herbs are poorly represented in the pollen count because they are poor pollen dispersers or are insect

pollenated. *Triticum*, *Hordeum* and *Avena* produce much pollen which remains in the hulls and is therefore poorly dispersed and infrequently found in profiles (Behre, 1981). Vuorela (1973), undertook a study to describe the distribution and proportion of arboreal pollen and cultural indicators around agricultural fields in Finland. Non-arboreal pollen was seen to decline sharply away from field areas, especially at the entrance to an adjacent forest due to the filtering effect of the forest vegetation. The factors which affect the presence of anthropogenic indicators include the reduced force of air currents along the ground; low pollen production and dispersal; local over-representation caused by insects and over-representation of nearby trees. There is often no present day analogue to past cultivation methods (Caseldine *et al.*, 1978).

There are further difficulties in interpreting the presence of cereals in the pollen data (Willerding, 1986, 135; Edwards, 1989). The significance of pollen from allogamous species (e.g. *Secale cereale*) originating from areas of agricultural production is not comparable to the pollen of autogamous species (e.g. *Triticum*), which is usually released by human manipulation. It is therefore difficult to make any precise statement of the share of each species in tillage. Dispersal of cereal pollen by human activity is important. Vuorela (1973), notes that *Cerealia* grains at the edge of an arable field consisted of agglomerations of several grains which could not have been wind dispersed. In a study of modern pollen rain produced by cereal crops, Hall (1988) concluded that harvesting processes, in which cereals are hulled on site, contribute greatly to pollen dispersal and concentration. Moreover, the absence of cereal from a diagram is not in itself significant and the possibility of cereal cultivation can not be excluded on the basis of that alone (Edwards, 1979). For example, in an area of unenclosed round houses dated to the first millennium B.C. in Northumbria, Gates (1983) interprets the field patterns and stone clearances as indicating arable land use, but arable episodes are not represented in the pollen diagrams, which instead point to recurrent episodes of small-scale woodland clearance for pasture. Arable phases may not have been recorded because of poor cereal dispersal abilities, the small size of clearance and the thin dispersal of settlements. Thus, the pollen curves of cultivated species are a definite but an unreliable indicator of anthropogenic activity.

The ecological setting of other species is difficult to determine. Pastoral indicators may represent the growth of field-edge weeds or grassland lying fallow between cultivation (Buckland and Edwards, 1984; Edwards, 1979). *Plantago lanceolota* was for long regarded as signifying undisturbed grassland or pasture, but it is also present in rotational farming and the recolonisation of abandoned cultivated land following a period of fallow. It may also be associated directly with a settlement area (Behre, 1981) and Groenman-van Waateringe (1986) found that it was not clear whether *Plantago lanceolota* represented pasture and meadow conditions or arable agriculture as it was found in association with charred cereal remains in Iron Age barrows in the Netherlands. *Rumex acetosa* can not only indicate mineral-rich wet meadows and pastures, but also ruderal communities, whilst *Rumex acetosella* is indicative of winter crops on acidic sandy soils and also fallow soils, peaty acidic soils, poor meadows and ruderal communities. Chenopodiaceae, *Urtica* and *Artemisia* are also associated with both cultivated areas and natural communities. The unqualified inference of pastoralism from the presence of indicator species is dangerous as species indicative of pastoralism are produced in abundance and may travel further than cereal pollen. Instead of relying on the use of indicator species pastoral agriculture is more accurately displayed by high values of Gramineae and *Plantago*, the absence of cereals and reduced values of woodland taxa (Edwards, 1979).

There is a distinct inverse correlation between distance from a site and the presence of anthropogenic indicators (Behre, 1981). Thus, if clearance is taking place at a distance from the site, it might not be recognised or be under-represented in a regional diagram, especially if it is small-scale (Caseldine, 1981; Hicks, 1988). Behre and Kuˇcan (1986, 95) studied the development of the north-west German landscape from the Neolithic with the aim of recording the individual phases of occupation to determine respective settlement areas and to reconstruct the economy of the area for each period. A network of ten pollen diagrams was analysed from a single raised mire but the occupation phases were poorly defined because of

the large pollen source area. In general, studies have shown that the record of anthropogenic indicators is low outside the occupation areas. Human activities are better reflected in the pollen record when the sampling site is close to the area where the vegetation change took place (Janssen, 1986). Edwards (1982) has outlined the problems of detecting anthropogenic influence on the woodland edge. During prehistory, woodland manipulation would have been strongest at the periphery of the forest as this was more accessible and if palynological evidence for this can be shown, areas of early occupation can be predicted. However, unless the sampling site is close to the forest edge, local impact is unlikely to be detected. For small sites and clearances close to, but separated from the bog by a wood, clearance may not be detected in a diagram from the bog centre because filtration of air-borne pollen makes high resolution detection of the impact difficult to determine. Mires would have been unattractive for settlement and therefore such areas are likely to remain tree fringed, causing filtration and delaying local registration of vegetation disturbance. Given the greater distance of the central profile from the area of disturbance, a diagram from the centre of a mire may give an erroneous picture of small-scale clearance. The impact on the woodland edge is not detected unless the site sampled is less than 30 metres from the nearest disturbed woodland, but such sites would not show regional and distant clearances. Such inter-site variability has been demonstrated in Shropshire where at Birchgrove Pool and Berth Pool, only 400 m. apart, significant differences in the pollen record are recorded (Barber and Twigger, 1987; Twigger, 1988).

As a result of the above limitations on the interpretation of agricultural indicators, Edwards (1988) concludes that little more than a broad set of categories of agricultural land use can be derived from pollen diagrams. These include mixed farming with the presence of cereals, Gramineae and other herbs; possible cereal cultivation as part of a mixed farming system where weed taxa is common but cereals are not present; and non-specific disturbances where weeds indicate pasture, husbandry, wind throw of trees and settlement clearances. A more comprehensive picture of land use change can usually be derived from a consideration of the whole plant community which produced the vegetation reflected in the pollen diagram, rather than through the use of indicator species.

Therefore, the nature, magnitude and duration of clearance observed in the pollen diagram depends on an infinitely variable number of conditions, which include clearance size, frequency of pollen production, dispersal and deposition and the unknown proximity of areas to the sampling site. If the problems of pollen production, dispersal and deposition are taken into account the registration of human impact in pollen diagrams understood, pollen analysis of large mires will enable an assessment of human impact on vegetation to be made. If archaeological evidence is also available, then the use of pollen data in conjunction with archaeological information will enable a rigorous assessment of vegetation change associated with that particular archaeological period, particularly if it is a well defined event. One such event for which a wealth of archaeological evidence is available is the Roman invasion and occupation of northern Britain.

2.2 The Romans In Northern Britain: Invasion, Frontier Building And Occupation.

Assessment of human impact on vegetation is based upon the interpretation of pollen diagrams, which contain the weaknesses and problems outlined in section 2.1. To interpret the pollen data and to understand fully the impact which the Roman occupation of northern Britain had on vegetation, it is necessary to consider Roman history and archaeology of the area. The following review of the archaeological literature is based on secondary sources and published interpretations of archaeological data, including artefactual, literary, epigraphic and numistic evidence.

2.2.1 The Roman Invasion.

Before Caesar's invasion of southern England, Britain was virtually unknown to the Roman Empire. Caesar led two expeditions to Britain in 55 B.C. but these did little to alter the relationship between Britain and Rome (Richmond, 1963; Todd, 1981; Breeze, 1982; Keppie, 1986, 7) and it was not until almost a century later, in A.D.43, that Roman troops led by Claudius brought the tribes of southern Britain under Roman control (Breeze and Dobson, 1987, 10). By A.D.47 these had either been subdued or had passively submitted to Roman rule (Johnson, 1989).

The Claudian invasion of A.D. 43 had little direct impact on the people of the north and the decision to incorporate Brigantia into the the Roman province was only taken after the rupture between the queen, Cartimandua, and her consort, Venutius (Hartley, 1966; Breeze and Dobson, 1985). Venutius took the throne in the same year as Cerialis was appointed as governor and in A.D. 71, the troops were ordered to campaign in northern Britain and conquer the Brigantes (Keppie, 1986,8; Higham, 1986, 149). The troops advanced along Dere Street to Newstead and beyond the Tyne-Solway gap to Annandale and Clydesdale. A temporary line of forts was constructed along each route (Breeze, 1982) and roads were built with a cleared strip of land on either side to provide visibility and to protect travellers from surprise attack (Keppie, 1986). However, campaigning rather than fort building was Cerialis' main concern and there is little archaeological evidence of his campaigns (Higham, 1986, 151), except possibly for a line of forts and camps between the Forth and Clyde (Hanson and Maxwell, 1980). The extension of military activity triggered off the northwards displacement of some aristocrats and their followers (Megaw and Simpson, 1979, 491) and the narrative of Tacitus leaves us with little doubt that the north was in a state of widespread open rebellion, led by the Brigantes and backed up by the more northern tribes. Between A.D. 71-74, Cerialis led a three year campaign and

> "after a series of battles, some not un-costly, Cerialis had operated, if not triumphed over the major part of the Brigantian territory" (Tacitus, *Agricola*, xvii in Cunliffe, 1991, 207).

Agricola succeeded Cerialis as governor in A.D. 74 and concentrated on the conquest of the north. A.D. 78 and 79 were spent consolidating Brigantia as far as the Tyne - Solway line, taking control of the entire region through a series of raids and bribery. The XXth *Valeria Victrix* legion moved through the area occupied by the Carvetti, but it was not until A.D. 78 that permanent structures were built in the territory (Higham and Jones, 1985, 15). In A.D. 80, Agricola marched north of the River Tay and concentrated military activity in Selgovian territory. The narrative of Tacitus records that the tribes were too terrified to resist (Higham, 1986, 156). The Votadini were less harshly treated, probably already being clients of Rome. The Novantae in south-west Scotland were subject to a separate campaign of A.D. 82 (Young, 1959; Robertson, 1976) and in A.D. 83, troops marched beyond the Firth of Forth and the Tay to Speyside, where the highland tribes were conquered at the battle of Mons Graupius (Wilson 1967; Higham, 1986;156; Maxwell, 1981, 1991; Daniels, 1989), leaving the Romans in control of all of lowland Scotland. By the end of the A.D. 80s, the tribal resistances had collapsed and after the enemy was defeated and disarmed, forts (e.g. Birrens, Carlisle, Gatehouse of Fleet) and roads were built and their territory controlled by the army's presence (Hanson, 1981; Breeze, 1982, 22; Cunliffe, 1991, 207). Not all tribes were incorporated into the province as some were made by treaty into client kingdoms, relieving pressure on the Roman army (Bewley, 1984) and for most of the time the tribes were left to run their own affairs. As the client kings died, the treaties between them and Rome lapsed or were re-negotiated with the successor, or the territory was incorporated into the province (Breeze, 1982, 23; Keppie, 1986, 67).

In the A.D. 80s, the majority of Roman troops were withdrawn from Scotland because of the hostility of the tribes and the need for Roman troops to assist with troubles in Dacia (Johnson, 1989). At this time the

series of forts and watch towers which formed a frontier running along the road north of Strageath were abandoned, but sufficient troops were available to hold southern Scotland (Breeze, 1982, 61). A new frontier became established along the Stanegate - a road and line of forts which had been constructed in A.D. 83 from Kirkbride on the Solway, to Corbridge on the Tyne (Breeze and Dobson, 1987; Jones, 1991). Two main north-south roads, connecting all forts, were also built and were intersected by two east-west routes which suggests that sea bases were positioned on the coast at Irvine and Stranraer (Richmond, 1958, 50).

2.2.2 Hadrian's Wall.

Hadrian became emperor in A.D. 117 and chose to improve and supplement the existing Stanegate frontier, which implies that it had not met with success (Breeze, 1982, 73; Frere, 1987, 110). Hadrian's main objective was defence rather than attack and to that end, he commissioned that a wall was to be built as a permanent and obvious frontier. This was constructed between A.D. 122 and A.D. 130 and stretched from Bowness, on the Solway Firth (Austen, 1991) to Wallsend in Newcastle Upon Tyne (Mann, 1988) (Figure 2.3). Hadrian's Wall was constructed following the most direct route, where the Tyne-Solway gap interrupts the Pennine chain, and although the wall crossed a number of terrains - the undulating slopes of the Tyne valley, the Whin Sill and the sandstone ridges of the flatter Solway coast - it maintained a close relationship with the Stanegate road whilst taking advantage of strategic ground.

Constructional differences in the masonry suggest that the wall was built by detachments from three legions, supplemented by labour from the local tribes. The total number of soldiers assigned to construction duties is unknown. Specific centuries or cohorts were assigned to this work, with 45 yards being allotted to each century in turn and with construction beginning in the east (Wilson, 1967; Crow, 1991 b; Johnson, 1989).

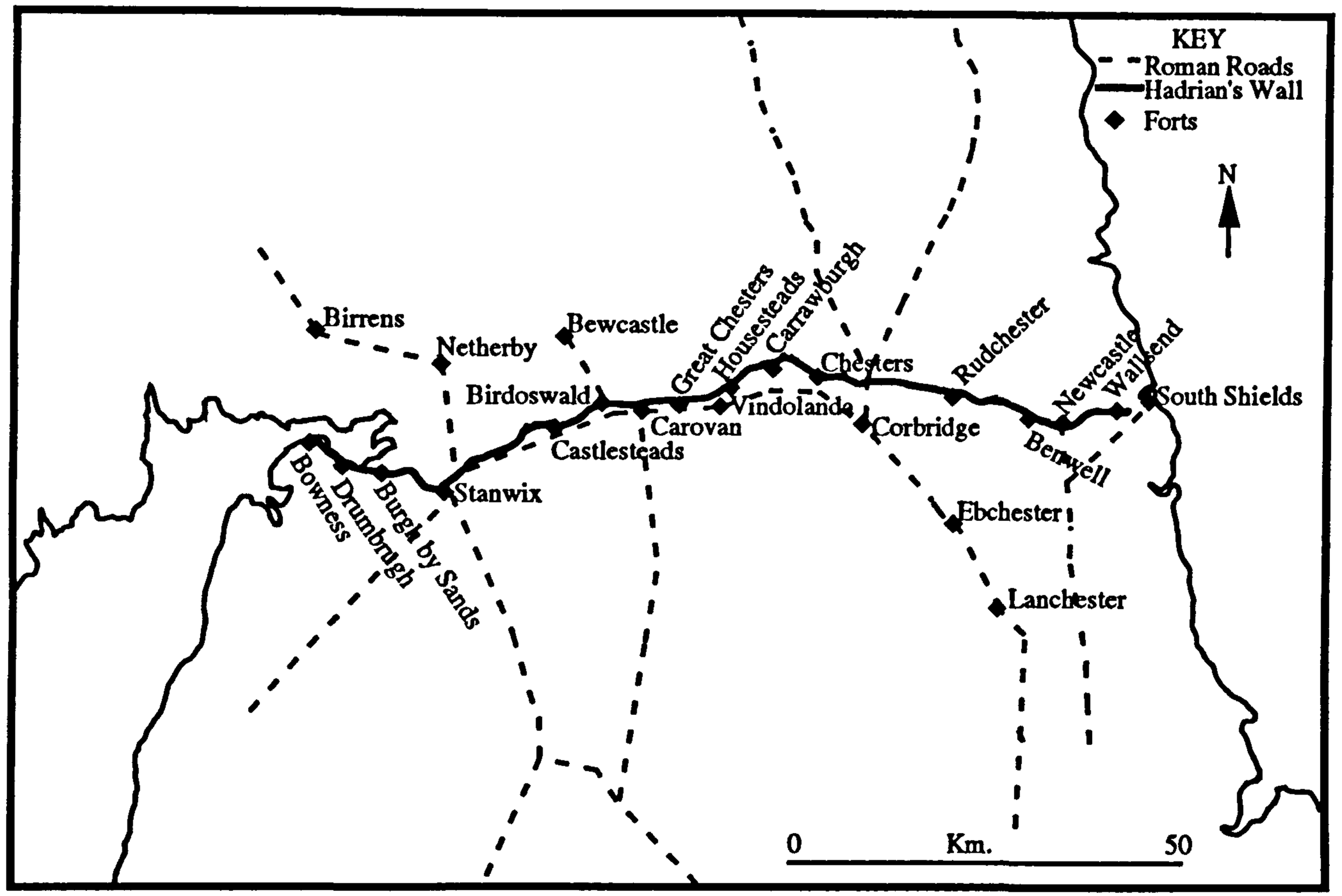
The wall is 76 Roman miles long (1 Roman mile = 0.93 miles) (Johnson, 1989) and is composed of rubble bound with clay or mortar, the outer faces being of carefully cut rectangular sandstone blocks, finished with a layer of plaster (Crow, 1991 a, b; Hill, 1991). It was 15 feet high, with an additional parapet 6 feet high, and 10 feet wide, which in places was later reduced to 8 feet. The western end of the wall between Irthing and Solway, was 20 Roman feet wide and initially built of turf because of a local stone shortage. This implies that a speedy completion was required. This was replaced with stone in A.D. 163 (Breeze, 1982; Breeze and Dobson, 1987; Johnson, 1989).

To the north of the wall a flat bottomed ditch or fosse, 27 to 40 Roman feet wide and 9 feet deep, was cut, except where the terrain rendered it superfluous (e.g. on the Whin Sill). The material dug out of the ditch was thrown to the north to heighten its outer scarp and a berm, 20 Roman feet wide on the stone wall and 6 feet wide on the turf wall, was built between the wall and the ditch (Birley, 1963; Dobson and Breeze, 1970).

Before the wall was constructed, milecastles were built at one mile intervals, with a turret between each milecastle. The milecastles were constructed of stone on the stone wall and turf on the turf wall (Breeze, 1982, 87) and differ in design according to the different legions which built them, though all contained barrack blocks for approximately 40 men (Johnson, 1989). Gates in the milecastles provided a way through the wall, indicating that the wall was not a closed frontier. The turrets provided shelter and observation posts with accommodation for 12 men and there could therefore have been no more than 60 men to each wall mile, though reinforcements were added in times of trouble (Johnson, 1989).

A distinction was originally made between the patrolling garrison on the wall and a fighting garrison on the Stanegate, but the hostility of the natives led to the movement of the units from the Stanegate to the wall

Figure 2.3 Map of Hadrian's Wall Showing Forts.



Source - Johnson (1989)

(Higham, 1986, 163). Sixteen forts were built along the length of the wall in a certain sequence. At first, twelve forts spaced 7.5 Roman miles apart were built and by the end of Hadrian's reign the last four had been added (Frere, 1987, 115; Johnson, 1989). The forts vary in size and position, but where topography allowed were built astride the wall and wherever possible were situated in areas of good quality agricultural land (Breeze and Dobson, 1985). In places the ditch was infilled and stone turrets (e.g. turret 36b for Housesteads) and milecastles (e.g. milecastle 43 for Greatchesters) were dismantled to allow the forts to be built (Johnson, 1989; Hill, 1991). The forts were typically built in a playing-card shape and with ramparts of stone backed with earth and surrounded by a ditch. Outpost were situated at Birrens, Netherby Bewcastle and Stanwix. The internal buildings of the fort were initially built of wood (Birley, 1963).

A flat bottomed ditch, or *vallum*, 20 Roman feet wide and 10 feet deep with an earth rampart either side (20 feet wide and 5 feet high), was later added to the south of the wall (Birley, 1963; Hind, 1989). The *vallum* follows the course of the wall for most of its length, deviating to avoid the forts. It reduced the ease with which the area could be crossed (Richmond, 1958, 62; Breeze, 1982). Its subsidiary purpose was to link the forts with a method of lateral communication other than the Stanegate and a metalled road was built for this purpose (Johnson, 1989). Civilian settlements appear to have been forbidden in the area and at Housesteads, the only Hadrianic civilian settlement, or *vicus*, was built beyond the *vallum*, twenty metres south of the fort (Breeze, 1982). Other modifications included the narrowing of the wall to 8 feet to speed its completion and the extension of the wall without a *vallum* from Newcastle to Wallsend (Breeze and Dobson, 1987).

A series of four forts (Beckfoot, Maryport, Burrow Walls and Moresby), milecastles and towers, but no wall, extended along the Cumbrian coastline for 26 miles, terminating at St. Bees. Mileforts and towers were placed at 1 mile and $^1/_3$ mile intervals respectively and these presumably fulfilled the function of spotting and intercepting raiders and controlling coastal shipping (Breeze, 1982; Johnson, 1989). The coastal defences may also have been designed to segregate Cumbria from potential allies in south-west Scotland.

2.2.3 The Concept Of A Frontier.

The major purpose of the wall was military. It was an attempt to defend and control a territory which had no obvious military coherence and marked the limit of Roman control on Brigantian territory (Johnson, 1989). It therefore divided the Romans from the Barbarians in the north (Rowland, 1988) and tribes incorporated in the Roman province to the south were treated more favourably. It also protected the Roman province from raiding and attack by the northern tribes (Wilson, 1967).

Hadrian's Wall has no provision for artillery fire and is too narrow to have been used as a fighting platform (Breeze and Dobson, 1987). The wall was also a political and administrative boundary. It barred north-south routes, except at milecastles, which presumably functioned as customs barriers where trade and the movement of people was regulated rather than prevented. The wall must have inconvenienced those practising transhumance (Johnson, 1989), but it also aided the peaceful economic exploitation of the province to the south. (Breeze, 1982, 85).

2.2.4 The Roman Army On Hadrian's Wall.

Under the early Empire, the Roman army consisted of legions, each with 5,000 Roman citizens. The main fighting body was organised into *Centuriae* (centuries) of 80 men. Six centuries formed a *cohort* (500 men) and 10 cohorts a legion with a Roman senator (*legate*) in command. Under him were 6 officers (*tribunes*) (Johnson, 1989). Three legions occupied Hadrian's Wall, the IInd *Augusta*, VIth *Victrix* and XXth *Valeria Victrix* and each legion contained its own engineering corps, maintenance staff, medical service and artillery

corps (Breeze, 1982). From the beginning of occupation, auxiliary troops were raised from the frontier tribes, in return for Roman citizenship, and organised into *cohorts* (Birley, 1963; Wilson, 1988). The total number of troops in Britain during the second century A.D. is estimated to have been 52,000 (Hanson and Maxwell, 1983 a, 3) and of these it is suggested that the auxiliary force on Hadrian's Wall amounted to 12,000 men (Robertson, 1970, 26). However, this is disputed by Breeze and Dobson (1987), who consider that 7986 men were stationed in the primary forts on the wall, excluding those on the Cumbrian coast and a total of 9090 were stationed in all the forts on the wall, excluding those on the Cumbrian coast.

2.2.5 The Antonine Wall.

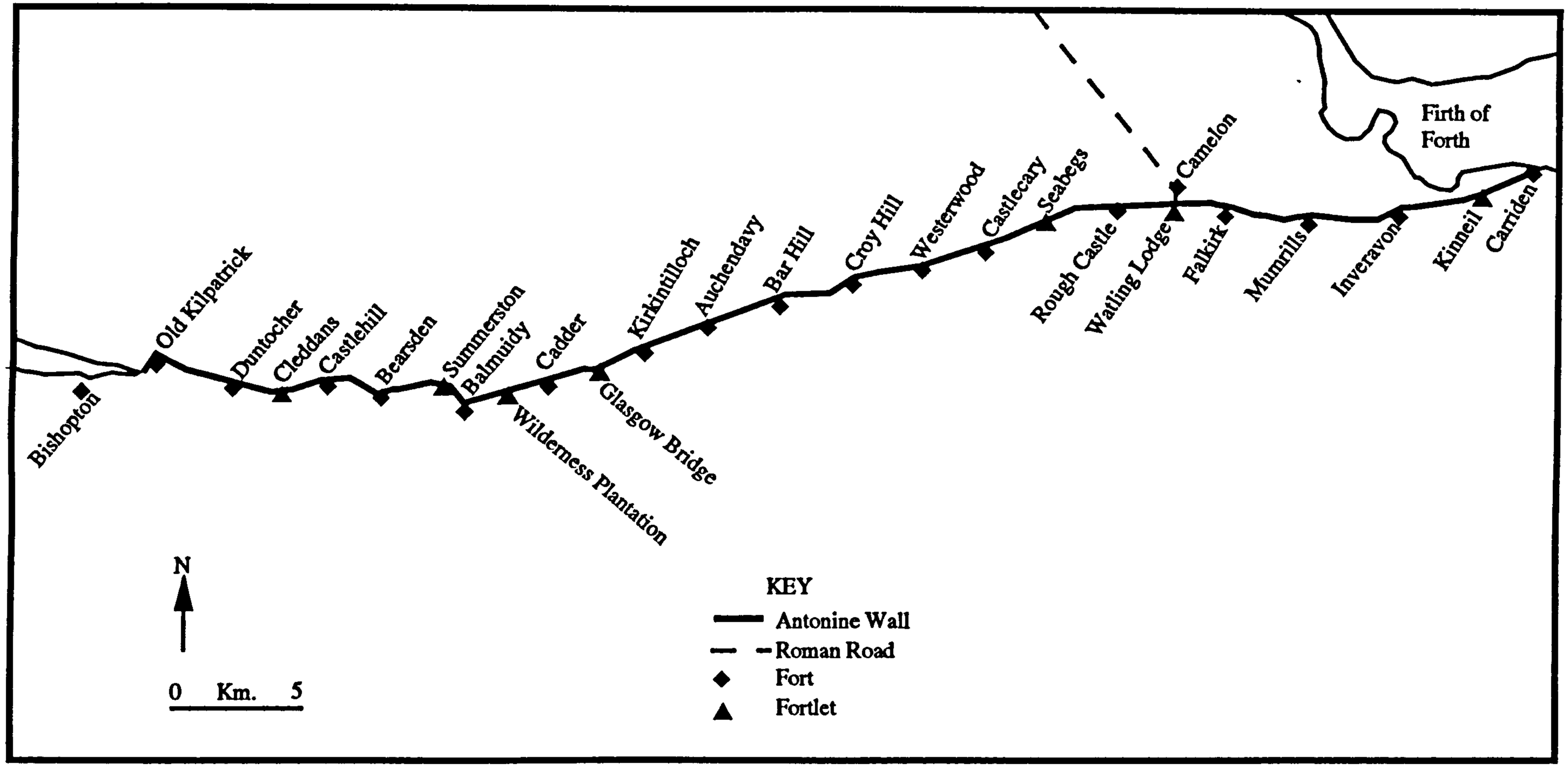
In A.D. 138 Antonius Pius succeeded Hadrian and a year later mounted a full-scale invasion of lowland Scotland (Keppie, 1986, 13; Frere, 1987, 126). The enemy was pushed across the Forth-Clyde isthmus, leaving Hadrian's Wall drained of troops. War ended in A.D. 142 and a new frontier, the Antonine Wall, was established (Breeze, 1976; Maxwell, 1983; Higham, 1986, 169) (Figure 2.4). The earlier Agricolan occupation had already set out a fort and road infrastructure and the advance north took place along this route (Robertson, 1970, 7) with Antonine structures being built in a position based on their Agricolan predecessors (Breeze, 1982, 100). The move north could have been a result of trouble from the tribes which led to a reappraisal of the Roman position; a political move by the Governor to strengthen his position; or due to the fact that Hadrian's Wall was too far south to be in contact with the main centre of opposition (Williams, 1981; Breeze, 1982, 99). Strategically Hadrian's Wall had been a failure as the potential enemies to the north were beyond its reach, but tactically the wall had been a success and it was perhaps for that reason that a similar wall was built to the north. Small legionary detachments on Hadrian's Wall replaced the original garrisons which were removed to the new line or the forts between. Hadrian's Wall was not fully abandoned until the Antonine Wall was complete, when the *vallum* was made smaller and the gates were removed to allow free passage through the Wall (Breeze and Dobson, 1987).

The Antonine Wall is 40 Roman miles long and stretches from Carriden on the Firth of Forth (Bailey and Devereux, 1987) to Old Kilpatrick on the Firth of Clyde (Johnson, 1989). For most of its length it clings to the southern slopes of the valley of the Forth-Clyde isthmus. It was constructed by the three legions which had built Hadrian's Wall. A series of marching camps were also built along the Forth-Clyde line, fifteen to the south of the wall and three to the north. These may have been labour camps for the men engaged in wall construction.

The Antonine Wall was built mainly of turf, though clay was used in the east for the first ten miles. It stood on a stone foundation to alleviate drainage problems. The wall was 14 feet wide and 10 feet high, (Breeze and Dobson, 1987) with the top covered by a wooden palisade (Robertson, 1970). A northward ditch, 40 feet wide and 12 feet deep and separated from the rampart by a 20 feet wide berm, ran along the length of the wall, except at Croy Hill where solid rock made excavation impossible (Robertson, 1970, 12). A military way, built before the wall, ran along its length allowing communication and the transport of materials.

Six forts, eight miles apart, were planned, but during construction the number of forts was increased to twenty (Gillam, 1976; Johnson, 1989). The forts were placed at two mile intervals and were similar to those on Hadrian's Wall, though the arrangements were not uniform. The temporal relationship of the forts to the wall varies: some forts were built prior to the rampart, two after the rampart, but most were contemporary. The forts all face north and vary in size from 0.2 ha. at Duntocher to 2.6 ha. at Mumrills (Breeze, 1982). Each fort also had an associated annexe in which buildings such as shops and houses which could not be provided in the fort were built.

Figure 2.4 Plan of The Antonine Wall Showing Forts and Fortlets.



Source - Breeze and Dobson (1987).

Fortlets were built before or at the same time as the rampart between the forts at Watling Lodge, Glasgow Bridge and Wilderness Plantation. A series of signalling posts was also constructed and enclosures and structures known as expansions were added later. These expansions consisted of six turf platforms built on a stone base against the rear of the wall. They acted as warning beacons but were too badly placed to have formed a signalling system. Three enclosures, consisting of a single ditch surrounded by a slight turf rampart enclosing an area 18 feet square, were attached to the rear of the wall, but their function is not clear (Keppie and Walker, 1981; Breeze and Dobson, 1987). The wall did not exist in isolation and a series of outpost forts was built to the north, linked to the wall by a road. These would have served to protect and control the tribes in the Fofe region. There were also two east-west roads, one extending from Lockerbie reaching the Dee at Glenlochar, the other beginning at Newstead and leading to Castledykes and then Loudon Hill on the Ayrshire border.

The Antonine Wall differed from Hadrian's Wall in that no *vallum* was provided and there were fewer installations to protect the wall from attack. Few *vici*, except for those located at Carriden and Croy Hill, have been discovered on the Antonine Wall (Breeze, 1989).

The Antonine Wall was therefore built and designed in the light of the Hadrianic frontier and was modified to suit building problems. Its aim was presumably to control the movement of people in and out of the province at a convenient point and to serve as a base providing a reservoir of troops to draw upon in emergency (Breeze and Dobson, 1987).

2.2.6 Troops On The Antonine Wall.

Frere (1987, 144) argues that of the 30,350 troops in northern Britain during the A.D. 140s, 23,500 of them were in Scotland and by the second Antonine period this had been reduced to 20,000. Approximately 20,000 men were needed to garrison the forts in Scotland and probably 7,000 of these were located on the Antonine Wall itself. Five of the six primary wall forts were capable of holding a full cohort of 500 men and Mumrills, Kilpatrick, Carriden and Balmuidy were capable of holding 1,000 men. Thus, the garrison of the primary forts probably amounted to around 4,000 men each and the fortlets 1,000 men. The secondary forts of Castlecary, Barhill and Cadder held bodies of troops 500 strong, whilst Westerwood, Croy Hill, Rough Castle and Duntocher held smaller garrisons. The fact that there is evidence for the forts being manned by more than one auxiliary troop, seems to indicate that garrisons were changed at least once during the Antonine occupation (Robertson, 1970, 125; Hanson and Maxwell, 1983 a, 158).

In the original plan of the wall, the troops were relatively evenly distributed along its length but, in its final form, a greater concentration at its western end is apparent. Six of the forts in the west are of sufficient size to hold full auxiliary units as opposed to only three in the east. This could be because the tribes in the western area (Campsie and Kilsyth hills) were more hostile (Hanson and Maxwell, 1983 a, 169).

2.2.7 The Fluctuating Frontier

The period following the construction of the Antonine Wall was one characterised by tribal uprisings. A revolt led by the Brigantes in A.D. 150s led to the destruction of the forts at Brough, Newstead and Birrens and other structures. The forts were either burnt by the attacking tribes or by the troops themselves on withdrawal (Johnson, 1982) and the first period of occupation of the Antonine Wall came to an end.

The uprising was suppressed by the new governor, Verus. Scotland was abandoned and between A.D. 158 and A.D. 184, Hadrian's Wall reoccupied (Daniels, 1970; Mann, 1988). The Hadrianic forts were repaired

and reoccupied by smaller units (Higham, 1986; 169; Mann, 1988), the *vallum* was cleaned out and a road (the Military Way) built.

Within two years (i.e. by A.D. 160), the Antonine structures were rebuilt and reoccupied, but by A.D. 168 - 169 and the accession of a new emperor, Marcus Aurelius, most forts in Scotland had once again been abandoned (Hanson and Breeze, 1991; Daniels, 1991). This was prompted by a central political decision. Along with trouble from the tribes of northern Britain, the empire was faced with a series of more serious frontier crises and troops were redeployed from Britain to the Danube. Calpurinus Agricola was appointed as general in Britain, with instructions to redeploy troops on Hadrian's Wall. Supervision of the Cumbrian coasts did not recommence and there was a shift of military emphasis from the coast of south west Scotland to the Tweed basin (Higham, 1986, 169/170; Keppie, 1986, 16).

In the 180s, the frontier positions broke down under pressure from the north and Cassius Dio recorded an attack in which tribes crossed Hadrian's Wall. The Roman government responded to the challenge and the situation was resolved by Ulpius Marcellus, as the Romans retaliated and cleared the enemy from the province (Higham, 1986, 172). By A.D.192 (Breeze and Dobson, 1987) or A.D. 195 (Mann, 1988) the frontier was pushed back to the position of the Antonine Wall for the last time.

Breeze (1988) suggests that the Romans did not conquer all of Britain because the highlanders were too warlike to be conquered and that the physical relief of the highlands was too daunting a prospect. It was also perhaps not economically worthwhile for the Romans to bring Scotland into the empire and the native infrastructure was insufficiently urban to provide food supplies for the army. The political nature of the empire and geographical isolation of Britain, combined with events elsewhere may also have prevented total conquest.

2.2.8 The Reoccupation Of Hadrian's Wall.

In A.D. 192, Albinus, the governor of Britain, transferred part of the force from northern Britain to the continent in an attempt to gain power from Severus. Albinus was defeated and the new emperor, Severus, dispatched reinforcements to Britain under governor Lupus to protect Hadrian's Wall, which had been invaded by the Brigantes in A.D. 208. Lupus ordered that forts be reconstructed and the Romans readvanced into Scotland from bases at Corbridge and South Shields in A.D. 208 (Higham, 1986, 172). The outpost forts were strengthened, thus reducing the importance of the wall itself (Breeze, 1982, 136). In some cases the layout of the fort was preserved and structures were rebuilt in stone. The granaries were reconstructed demonstrating that fort provisioning continued to be a matter for central authority.

Peace was established and maintained for most of the Third Century and Roman security was not challenged. When Caracalla became emperor upon the death of his father, Severus, he ordered the abandonment of Scotland, except for the forts of Bewcastle, Netherby, High Rochester and Risingham. All Roman troops were withdrawn from Scotland and Hadrian's Wall once again became a fixed frontier (Higham, 1986, 172). Throughout the Third Century the Votadini and their neighbours enjoyed a high degree of security overseen by Roman forces. During this period of stability there is some evidence of troop withdrawal from the area, perhaps being ordered abroad in support of Roman troops in Gaul in the 260s and 270s, or to garrison the newly constructed Saxon shore defences on the south and east coasts (Higham, 1986, 21). Archaeological evidence for abandonment is difficult to establish. There does seem to have been a decline in the upkeep of buildings not serving as accommodation (Higham and Jones, 1985, 126), but it is thought that forts were commonly abandoned across the length of the wall (Higham, 1986, 213).

The villages, or *vici*, outside the forts expanded in size (e.g. Housesteads, Vindolanda), accommodating

civilians - wives, families, veterans, traders and travellers, who were eventually made citizens of the Roman Empire (Branigan, 1980; Salway, 1980; Graham, 1982). The construction of the Roman roads aided the growth of settlements with trade, agriculture and crafts being carried out to supply the Roman army. Traders built shops and small industrial activity grew up. The *vallum* kept the *vici* from encroaching on the wall (Birley, 1973 a, b, c and d, 1989).

North of the Wall, Constantius Chlorus carried out a brief campaign in A.D. 306, but upon his withdrawal there is no evidence that any more forts beyond the wall were garrisoned. Constantine visited Britain as emperor in A.D. 312 and may have been responsible for the withdrawal of troops from Piercebridge, Newcastle and Ebchester, but there can be little doubt that the frontier forces maintained control over southern Scotland. The coasts were under increasing surveillance and civilians in the fort at South Shields were joined by military personnel (Higham, 1986, 215).

At the beginning of the Fourth Century, part of the wall garrison was withdrawn to support one of the contenders for the *imperium*. The Picts took this opportunity to plunder the wall, but by A.D. 305, the wall garrison under Theodosius had reoccupied and rebuilt the wall and its outposts. The Fourth Century was a time of instability and the reduced frontier army was faced with increasing pressure from tribal forces. The military authorities responded by *ad hoc* means and protected the province from attacks by the Picts, Scots, Saxons, Franks and Attacotti. Fort sites were refurbished and improved, whilst the *vici* grew. At Housesteads the *vicus* had grown to cover 10 acres and the archaeological evidence suggests that it undertook commerce with the garrison and over a wider area. At Carlisle the vici was 74 acres and Corbridge 40 acres. The *vici* now came to occupy the area between the *vallum* and the forts and the one strict division between Roman citizens and native declined (Salway, 1980).

Evidence for site destruction is uncommon, though some sites do seem to have suffered significant disasters from the A.D. 340s onwards. Written accounts indicate that in the early A.D. 360s the Picts and Scots, who had been laying waste to land around the forts, made treaties with Rome. Renewed incursions occurred in A.D. 365 and the climax of the raids was reached in A.D. 367 when the tribes conspired to overwhelm the British province. The campaigns of Theodosius in A.D. 367 - 368 imply that most of the raiders were encountered south of the Pennines. The campaign successfully expelled the raiders from the provinces (Higham and Jones, 1985, 126; Higham, 1986, 236; Frere, 1987, 339). The wall was made more secure by widespread rebuilding and all forts were to some degree reoccupied. From the A.D. 360s there was a marked decline in the use of *vici* and economic decline seems to have begun (Higham, 1986, 239).

The barbarian problem continued to plague the northern frontier. In the 380s Maximus led the Roman troops into Galloway, which became a client-kingdom. Maximus was responsible for significant troop withdrawals to the continent so that from the A.D. 380s the frontier was significantly under-garrisoned. The successors to Maximus did little for the north and in the last years of Britain's formal attachment to Rome, campaigns by the Picts and the Scots meant there was no peace. Troops were gradually withdrawn to defend parts of the Empire on the continent and Imperial policies elsewhere, leaving Britain to its own devices. In A.D. 398, an expeditionary force under Stilcho cleared raiders from the province and took naval action against the Picts, Irish and Saxons, but South Scotland and Northumberland were not wrested from the barbarians. After Stilcho's retreat, more troops were withdrawn from the frontier (Higham, 1986, 240).

By the end of the century the Roman forces on the wall had been evacuated to a dangerous level. Constantine left Britain for Gaul and in his absence the Saxons raided Britain in A.D. 408. In A.D. 409, the rural proletariat of southern Britain revolted against the aristocracy and Rome. Constantine perished in A.D. 411 and from then on Britain was ruled by usurpers. There is no evidence that the north joined with this southern rebellion, but the collapse of organized government in the south was disastrous for the north,

as disruption of pay occurred. Those garrisons which remained were abandoned by the support structure of the Empire and most units must have found their position untenable. The units were forced back upon the local supply base and in many areas the army could not have responded quickly enough by cultivating land next to forts. By A.D. 420, no recognisable units of the army occupied the wall. Without support, the remaining military units probably disbanded themselves by desertion and society had to readjust to a reduced resource base, dependent on local supplies (Higham, 1986, 241; Breeze and Dobson, 1987).

2.3 Romans And Vegetation - The Approach.

The Roman occupation of northern Britain could potentially have had a profound effect on vegetation in the frontier. The events and themes outlined in the literature, especially the size of the Roman garrison, the building of military installations, growth of the *vici*, agriculture and the long period of occupation (*c.* 350 years) are activities which would have an affect on vegetation. If the average peat accumulation rate for raised mires in northern Britain is taken as *c.* 14 years/cm. (Barber *et al.*, 1992), then the occupation period would be represented by a considerable depth of peat (*c.*25-30 cm.) thus allowing a high resolution palynological record to be obtained.

The abundance of archaeological remains and literature pertaining to the Roman occupation of northern Britain, provides a rich source of archaeological evidence. This evidence can be combined with palynological data from a series of large mire sites to assess the impact of the occupation on regional vegetation in the Hadrianic-Antonine Frontier zone. Few radiocarbon dated pollen diagrams relating to anthropogenic impact have been produced from this area and consequently knowledge of vegetation history is limited. Two hypotheses were used in this study:

1. The first large-scale and permanent vegetation clearance in northern Britain is attributable to the Roman invasion and occupation of the area. This hypothesis is based on the results obtained by Turner (1979) and Barber (1981), where a series of pollen diagrams from across the Hadrianic-Antonine frontier zone show minimal amounts of vegetation clearance during the Neolithic, Bronze and Iron Ages when the landscape was predominantly forested. This changes dramatically with the Roman invasion and occupation of the area and this suggests that the first major human impact on vegetation in this region of northern Britain was related to this event. The sparsity of Bronze Age and Iron Age archaeological remains in the area seems to support these palynological results. The paucity of settlement suggests that the north was not intensely settled and that population concentration was low. In contrast, the abundance of archaeological remains relating to the Roman occupation provides a rich source evidence which suggests that the area was intensely occupied and that society was highly organised and vegetation clearance could perhaps be related to the expansion of population in the north.

2. The proximity of an area to Roman archaeological structures, such as frontier walls and forts, will be reflected in a greater degree of forest clearance. Pollen analysis can be used to investigate whether the impact of the Roman occupation on vegetation was widespread across the frontier zone. During the Roman occupation large amounts of timber must have been needed for the construction of the defences and other subsidiary uses such as cooking. To avoid the cost of transporting timber, woodland clearance probably occurred around Roman structures. In contrast, those areas where the Roman occupation was less intense and around native settlements outside the immediate frontier zone, clearance would be expected to be lower.

CHAPTER 3.

METHODOLOGY.

3.1 Site Selection.

There are a large number of mires widely distributed across the Hadrianic-Antonine frontier zone and these provide numerous sites which could have been used for vegetation reconstruction. For the purposes of this project and the objectives outlined in Section 2.3 site selection was based upon a number of criteria. The main factor influencing site choice was the size of the site and for a regional pollen record to be obtained, a large mire, preferably at least 1 km.^{2}, was required (Jacobson and Bradshaw, 1981). The location of sites in relation to the Roman archaeological structures was also important to assess the validity of the second hypothesis - that the degree of clearance is related to distance from Roman archaeological structures. Therefore, sites at various distances from archaeological remains were required.

Due to the limited number of published regional pollen diagrams, a wide distribution of sites was sought to enable an assessment of variability across the region to be made. In order to assess inter-site variability in the pollen record within a small geographical area, one mire was chosen for its proximity to a site where a previously published pollen diagram was available. Site choice was constrained by the condition of the mire and as far as possible, sites which had been influenced by peat cutting, burning and drainage were avoided. The high levels of urbanisation and industrialisation in the Central Valley of Scotland severely limited the number of suitable sites along the Antonine Wall.

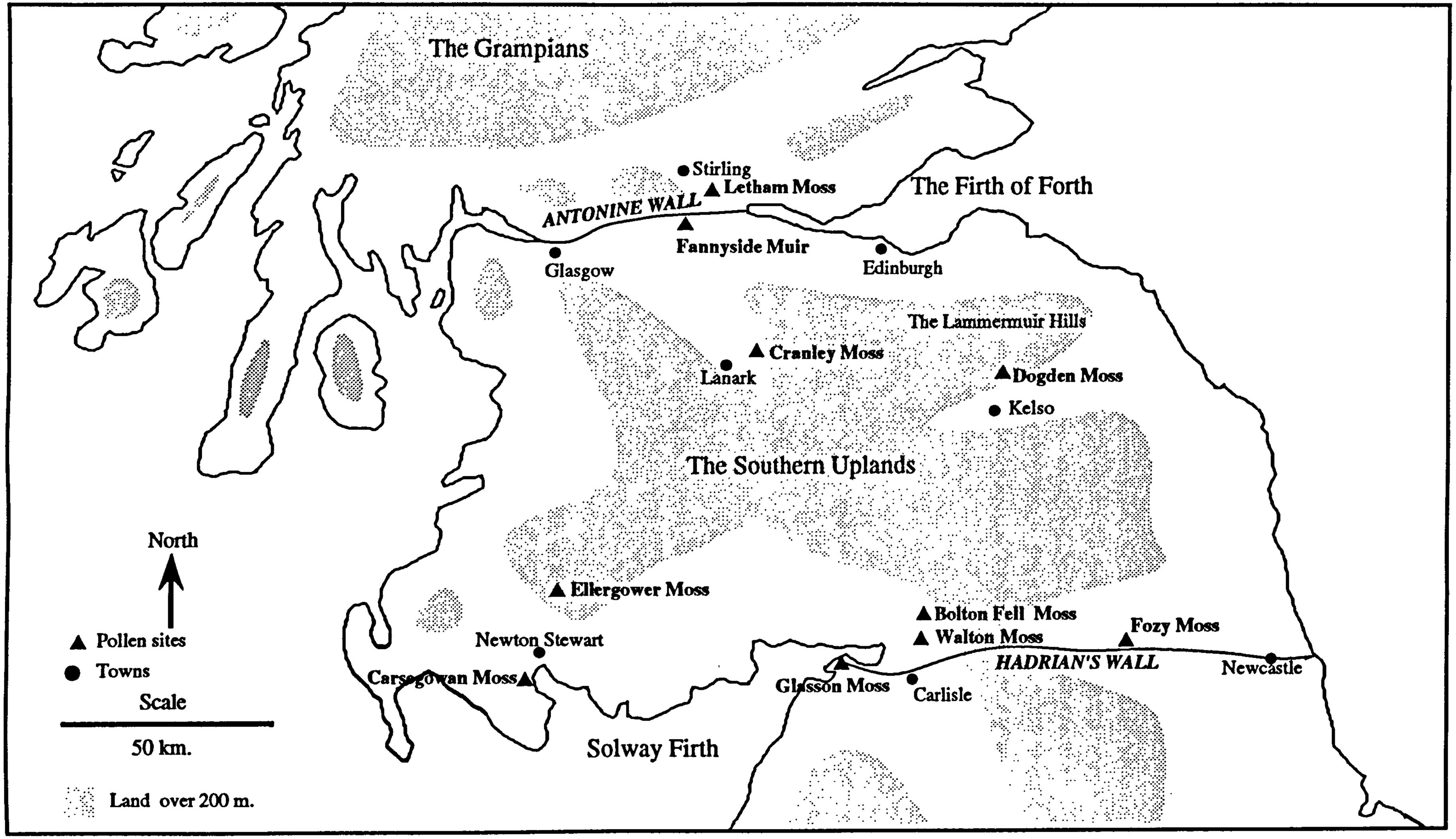
With these factors in mind, the following nine mires were selected for study (Table 3.1). Their distribution is shown in Figure 3.1.

Table 3.1 Sites Selected For Study.

Site.	National Grid Reference of Mire Centre.	Acronyms Used In This Study
1. Walton Moss, Cumbria.	NY 504667	WLM
2. Glasson Moss, Cumbria.	NY 238603	GLM
3. Fozy Moss, Northumbria.	NY 830714	FZM
4. Carsegowan Moss, Wigtonshire	NX 454555	CGM
5. Letham Moss, Stirlingshire.	NS 880865	LTM
6. Fannyside Muir, Strathclyde.	NS 800746	FSM
7. Cranley Moss, Lanarkshire.	NS 935475	CYM
8. Dogden Moss, Berwickshire.	NT 705500	DGM
9. Ellergower Moss, Dumfriesshire.	NX 482796	EGM

Six of the study sites are lowland raised mires; Fannyside Muir is an area of blanket bog; Ellergower Moss is an upland raised mire and Fozy Moss is a 'valley mire'. Site maps and their location in relation to archaeological structures can be found in the Map Appendix.

Figure 3.1 Map Showing Location of Study Sites.



3.2 Site Descriptions.

3.2.1 Walton Moss, Cumbria.

Walton Moss, lying 13 km. north-east of Carlisle, was chosen for analysis as it is situated only 3.5 km. north of Hadrian's Wall and the same distance from Stanwix, Castlesteads and Netherby Roman forts, and a Roman road to the west. It lies only 1 km. south of Bolton Fell Moss (Barber, 1981), facilitating a comparison of pollen diagrams from two adjacent sites. Walton Moss, 155 ha. in extent and 95 m. above sea level (O.D.), is part of a raised mire system, which also includes Broomhill, Breaks and Glebe Mosses. The mire vegetation is dominated by *Sphagnum* species, *Calluna vulgaris*, *Erica tetralix* and *Eriophorum vaginatum*. *Sphagnum* spp. cover varies between 70% and 100% over most of the moss. Limited areas of the mire have been modified by past peat cutting, burning and drainage and in these parts some *Molinia caerulea* occurs. The core analysed was obtained from the unmodified area. Small areas of *Betula* dominated scrub occur around the periphery of the moss. The mire is a Site of Special Scientific Interest and no palaeoecological work has previously been undertaken on this site.

3.2.2 Glasson Moss, Cumbria.

Glasson Moss lies 16 km. west of Carlisle and 1 km. west of the village of Glasson. It was chosen for analysis because it is situated 0.5 km. south of Hadrian's Wall. A series of Roman milecastles, but no forts, are present. The site is 210 ha. in extent and is one of four extensive lowland raised mires on the seaward side of the Solway plain - the others being Drumbrugh Moss, Bowness Common and Whitrigg Common. Glasson Moss has developed over estuarine alluvium, and is separated from Bowness Common to the west by a ridge of glacial till. The vegetation of the mire is mainly composed of *Sphagnum* spp., *Drosera rotundifolia*, *Vaccinium oxycoccos*, *Calluna vulgaris*, *Erica tetralix* and *Eriophorum vaginatum*. Although modified in the past by drainage, peat cutting and fires (in 1956, 1965, 1971, 1976), a third of the moss retains an intact mire surface dominated by *Sphagnum* spp. (Greig, 1975; Lindsay, 1977; Moresby, unpub.), from which the core was taken. Glasson Moss is a Site of Special Scientific Interest and a National Nature Reserve. The early Holocene palaeoecology of the site has been studied by Walker (1966), but no radiocarbon dates were published.

3.2.3 Fozy Moss, Northumbria.

Fozy Moss, a virtually flat oligotrophic mire, though probably not ombrotrophic, lies 7 km. north of Haydon Bridge and adjacent to the B6318 road. The mire was chosen for analysis as it lies only 200 m. north of Hadrian's Wall and Sewing Shields milecastle. The fort of Carrawburgh is 3 km. to the east and Housesteads 3.5 km. to the west. The vegetation is dominated by *Sphagnum* species, especially *Sphagnum papillosum*, but *Vaccinium oxycoccus*, *Erica tetralix* and *Eriophorum* spp. are also present. The site has been influenced by a number of widely spaced drainage ditches, but is otherwise intact. No previous work has been undertaken on this site.

3.2.4 Letham Moss, Stirlingshire.

Letham Moss, a lowland raised mire 123 ha. in extent, is situated on the coastal plain of the Firth of Forth, 3 km. north of Stenhousemuir and 15 m. above sea level (O.D.) on estuarine silts and clays. The Antonine

Wall and forts at Camelon and Mumrills lie 7 km. to the south and a Roman road runs 5 km. to the west. The moss is being cut commercially so little of the original surface remains except under the tram lines which were laid on the moss prior to cutting. A monolith of peat was removed from a cut face adjacent to such a tram line obtaining a sample which probably included the original mire surface. The surface vegetation of the sampling area consisted of *Calluna vulgaris*, *Rumex* species, *Eriophorum* spp. and Gramineae, but no *Sphagnum*. A rand vegetation of *Betula* scrub is present. No previous palaeoecological work has been carried out on this site.

3.2.5 Fannyside Muir, Strathclyde.

Fannyside Muir is an extensive area of blanket mire situated 6 km. west of Cumbernauld and 5 km. south of the Antonine Wall and the associated forts of Castlecary and Seabegs. It lies 168 m. above sea level (O.D.). The mire has been affected by anthropogenic activity in a number of ways. It is divided into two by a road and almost the entire site has been affected by drainage. Around 30% of the site has been afforested with *Pinus sylvestris* and part of the western side of the mire has been commercially cut. The core was obtained from the eastern section of the bog, in an area which has been relatively untouched. The surface vegetation of this area consists of *Eriophorum vaginatum* and *Sphagnum* species. No palaeoecological work has previously been undertaken on this site.

3.2.6 Dogden Moss, Berwickshire.

This site is situated 5 km. north west of Greenlaw, 80 km. south east of the Antonine Wall, 80 km. north of Hadrian's Wall and 18 km. north-east of Newstead Roman fort. Impedance of drainage by a system of fluvio-glacial kames has resulted in the development of a confined raised mire, 1155 ha. in extent. The mire vegetation consists mainly of *Sphagnum* species and *Eriophorum* spp., although a number of rare plants, such as *Blysmus compressus*, occur in some areas. No previous palaeoecological work has been undertaken on this site.

3.2.7 Cranley Moss, Lanarkshire.

Cranley Moss is situated 2 km. north of Carstairs, 40 km. south of the Antonine Wall and adjacent to Castledykes fort and a Roman road. It is one of the few remaining areas of intact raised mire in this region and is consequently a Site of Special Scientific Interest. The mire is 100 ha. in extent and the vegetation is dominated by *Sphagnum* species, including *Sphagnum imbricatum* which is known at only two other sites in Strathclyde. There is a broad marginal area of associated scrub, marsh and wet moorland communities. No previous palaeoecological work has been undertaken on this site.

3.2.8 Carsegowan Moss, Wigtonshire.

This site was chosen as it lies at least 35 km. from the nearest Roman structure, thus allowing assessment of vegetation change outside the area of direct Roman influence. This lowland site is situated 3 km. north of Wigtown and is one of a number of raised mire sites on the Dumfries and Galloway coastal plain. It is situated at an altitude of 9 m. O.D. on estuarine clay and is surrounded by an area of gley soil and silts. It is 50 ha. in extent. The surface vegetation of the mire includes *Sphagnum* species, *Eriophorum* spp., *Calluna vulgaris*, *Erica tetralix*, some *Myrica gale* and a central stand of *Pinus sylvestris*. Carsegowan Moss has some drainage ditches and peat has been cut around the edges of the moss. No previous palaeoecological work has been performed on the site.

3.2.9 Ellergower Moss, Dumfriesshire.

Ellergower Moss is an upland raised mire lying adjacent to the Silver Flow complex and Loch Dee (Boatman 1983). Ellergower Moss has formed on the relatively flat mineral ground, is 22 ha. in extent and lies at an altitude of 230 m. O.D.. The surrounding hills are now extensively forested with Forestry Commission plantations but the moss remains in a pristine condition and is part of the Silver Flowe National Nature Reserve. The vegetation is dominated by *Sphagnum* spp., including *Sphagnum imbricatum*, *Eriophorum angustifolium*, *Calluna vulgaris* and *Erica tetralix*.. Some palynological work has been undertaken by Clymo *et al.* (1990) and adjacent sites have been studied by Birks (1972) and Edwards *et al.* (1991a).

3.3 Field Methods.

3.3.1 Coring Strategy.

One core was obtained from the centre of each mire. Salmi (1976), suggests that a single core would give an erroneous picture of pollen representativity but more recent work has shown that relative pollen frequencies from a single core are representative of a basin as a whole (Webb *et al.*, 1978; Turner *et al.*, 1989). A central location was chosen to ensure that a truly regional vegetational record was obtained (Turner, 1965). The cores were taken using a 30x9 cm. Russian-pattern corer (Barber, 1984), but at Letham Moss, samples were obtained from a cut face using 50x10x10 cm. aluminium monolith tins. All cores were taken to a depth of 3 m. except where monolith tins were used on a drained (the peat therefore experiencing shrinkage) and cut site where 2 metres of peat were extracted. Assuming an average accumulation rate of *c.*14 years/cm. for ombrotrophic mires in Northern England (Barber *et al.*, 1992), 3 metres of peat would ensure that samples covering the Roman period were collected. Each individual section of core was transferred to a split plastic drain-pipe, wrapped in aluminium foil and stored in a refrigerator at 4°C.

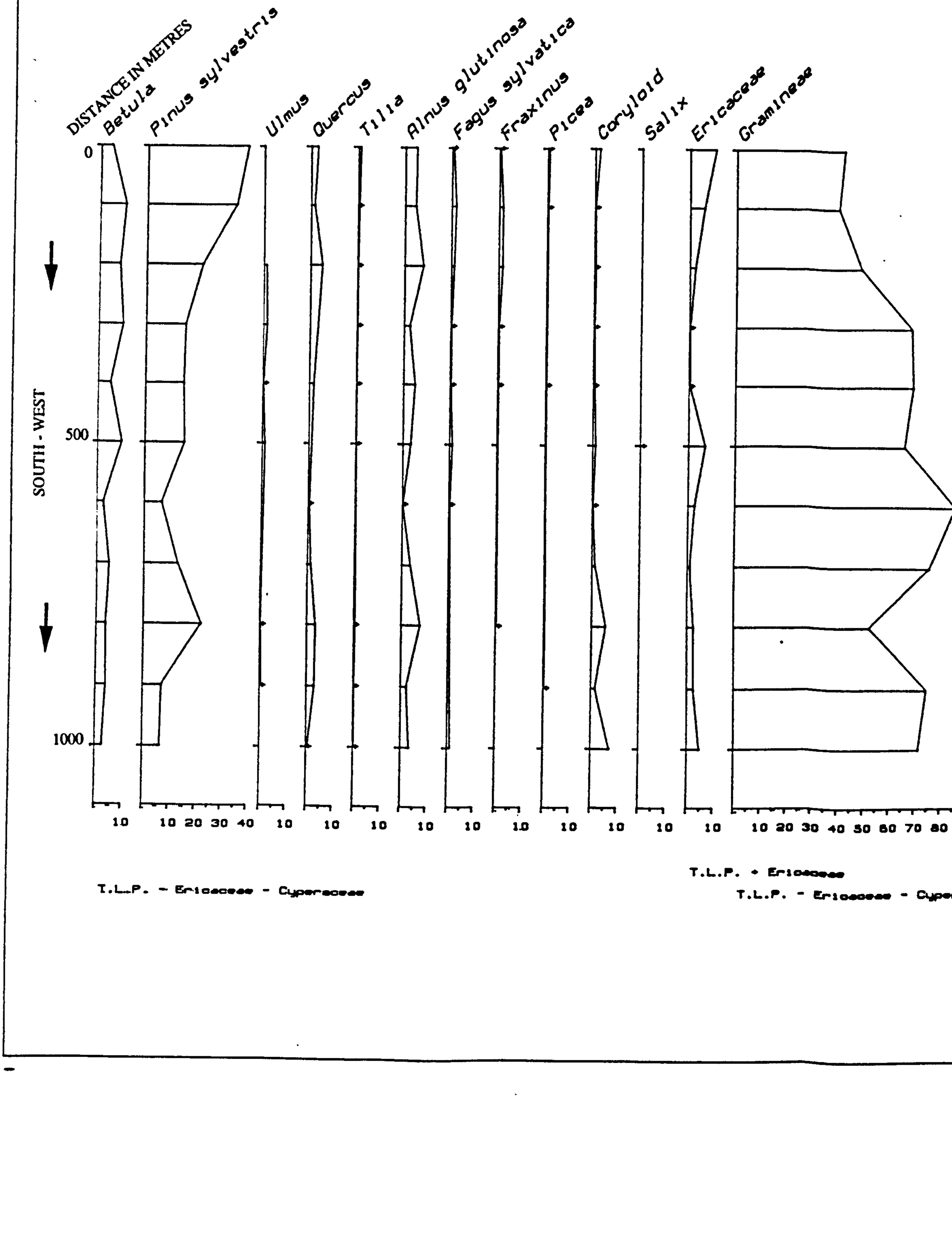
At Walton Moss, a series of surface moss samples were obtained at 100 m. intervals in a transect which ran for 1,000 m. from the centre of the mire towards its south-western margin (see Map Appendix). These surface samples were analysed for pollen in order to assess the differences in the representation of species between the centre and edge of the site (Wright, 1967; Caseldine, 1981). The results show (Figure 3.2) that there is not much variation in the pollen content of the samples, except for *Pinus* which varies between 10% and 40%, probably due to the influence of local plantations.

3.3.2 Sediment Stratigraphy.

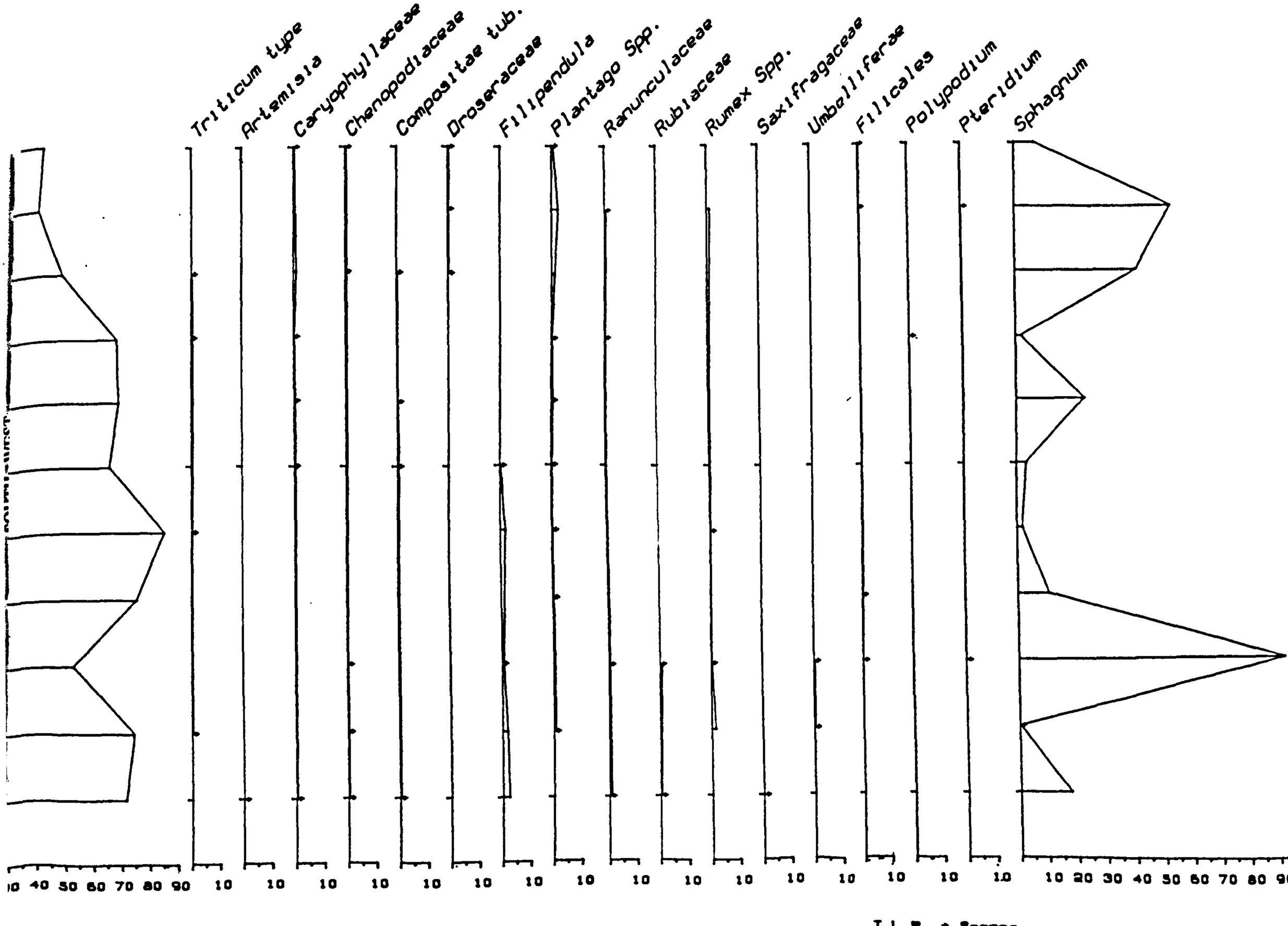
The study of the matrix from which the pollen grains are to be recovered is important for the evaluation of the pollen diagram (Faegri *et al.*, 1989, 39). The Troels-Smith sediment description system (Troels-Smith, 1955) supplemented with additional observations was used to record stratigraphy in the field, with further observations being made in the laboratory. Troels-Smith is an appropriate method which enables a systematic description of the deposit and the physical status of the components (colour, elasticity, dryness, humicity and stratification) to be made without any inference as to its mode of origin. Assessment of the characteristics is made on a scale of 0 to 4 which can then be diagramatically represented using a series of symbols (Troels-Smith, 1955; Birks and Birks, 1980; Aaby and Berglund, 1986). Due to the difficulties of generating Troels-Smith symbols on a computer, an alternative key has been devised. The results are shown in Figures 3.3 to 3.12.

CONTAINS PULLOUTS

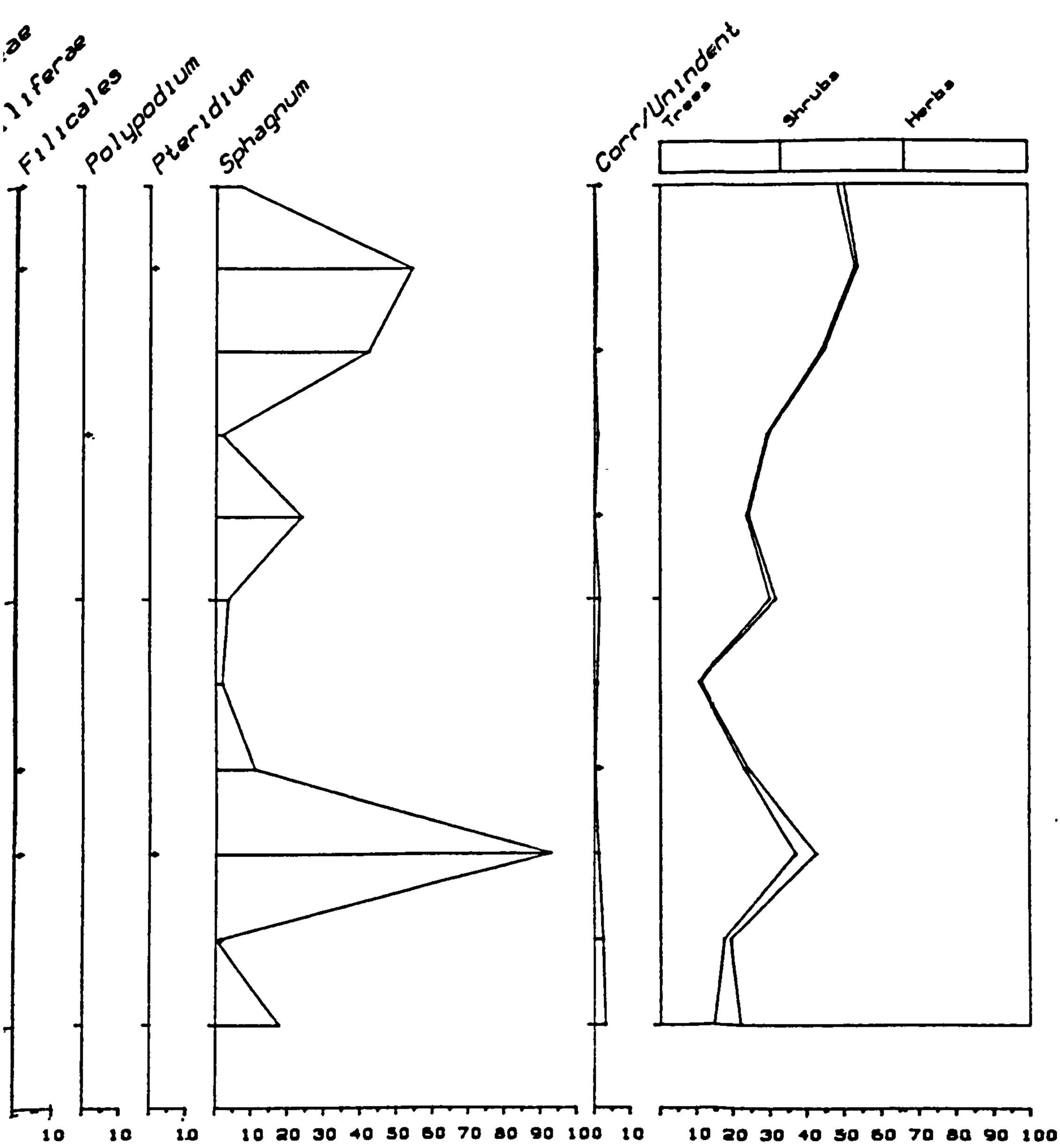
FIGURE 3.2 WA


DISTANCE IN METRES
Betula
Pinus sylvestris
Ulmus
Quercus
Tilia
Alnus glutinosa
Fagus sylvatica
Fraxinus
Picea
Coryloid
Salix
Ericaceae
Gramineae
0
500
1000
SOUTH - WEST
10
10 20 30 40
10 20 30 40 50 60 70 80
T.L.P. - Ericaceae - Cyperaceae
T.L.P. - Ericaceae

GURE 3.2 WALTON MOSS, CUMBRIA SURFACE SAMPLES



Analysis: Lisa



T.L.P. • Spores

T.L.P. • Corr/Unid

Analysis: Lisa Dumayne. 1992

FIGURE 3.3 KEY FOR STRATIGRAPHIC SYMBOLS.

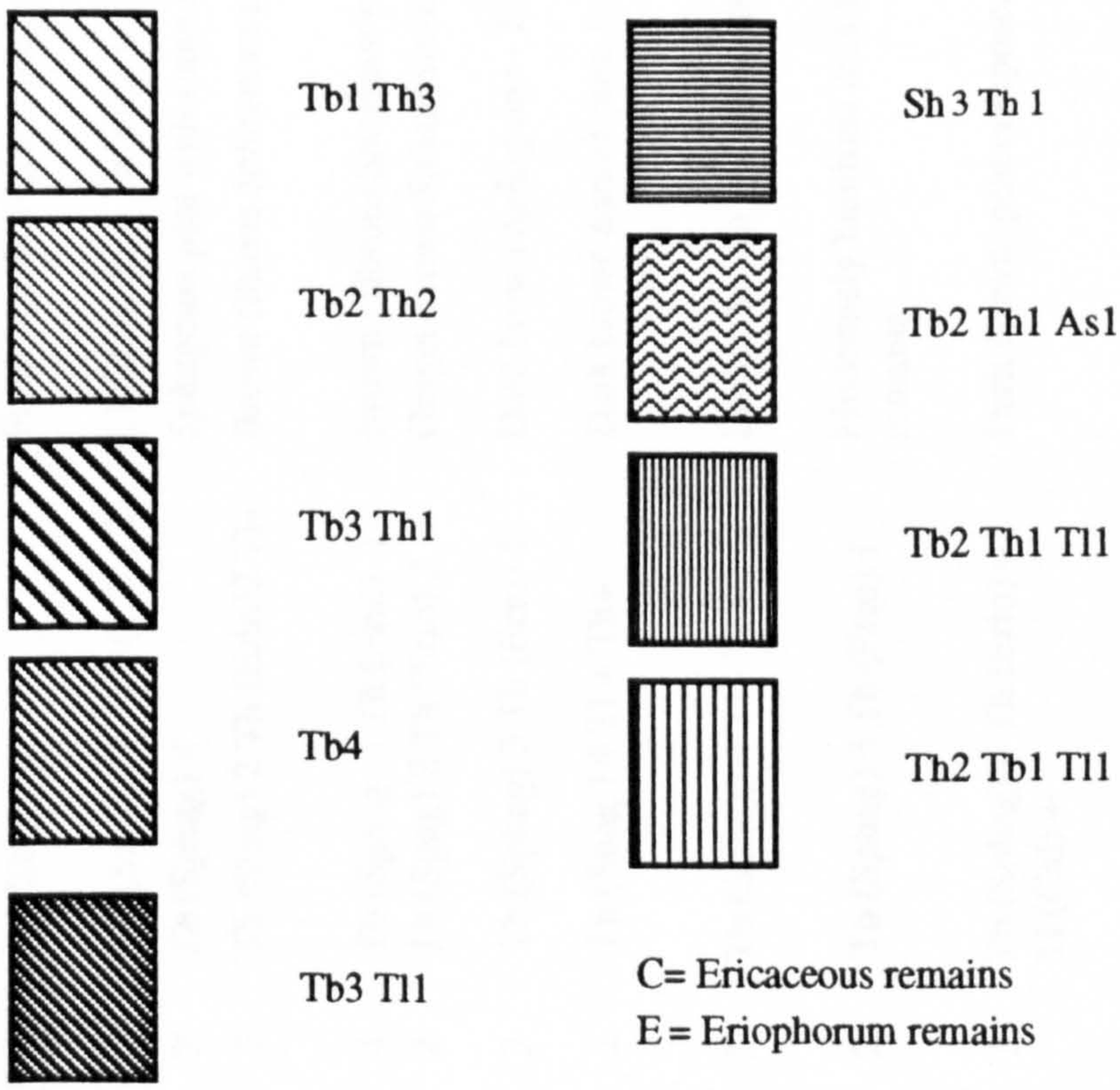
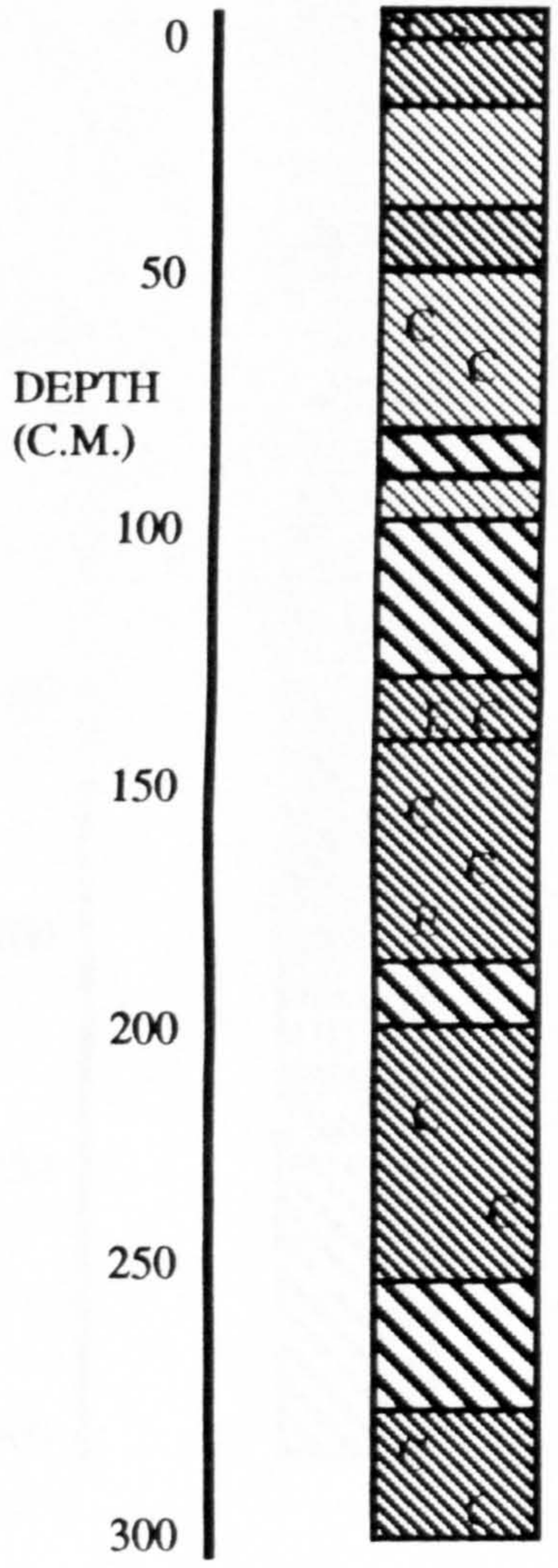
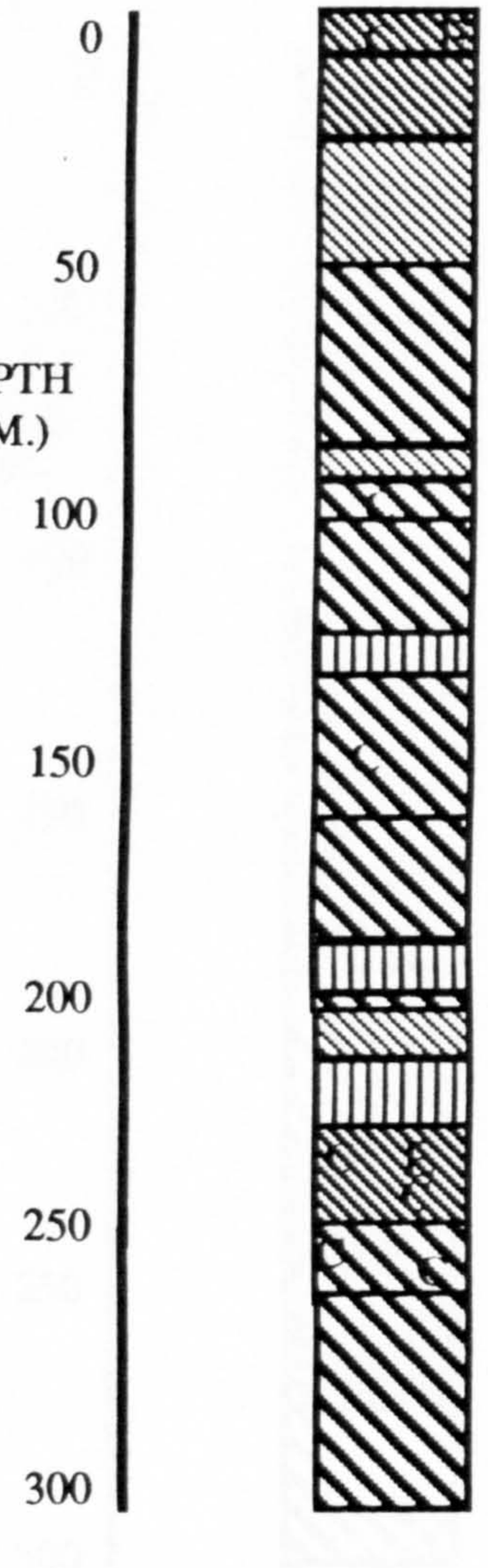


FIGURE 3.4 STRATIGRAPHY - WALTON MOSS



NIG.	ELAS.	HUM.	COMPONENTS	DESCRIPTION
2	4	0	Tb (Sphag) 4 Tl +	Very fresh peat dominated by *Sphagnum magellanicum*. Some *Erica tetralix*.
2	4	1	Tb (Shag,) 4	Fresh yellow-green peat, with some Ericaceous and *Eriophorum* remains
3	4	3	Tb (Sphag) 2 Th (Erio) 2	Light medium brown peat.
3	3	2	Tb (Sphag) 4	*Sphagnum* peat with some *Eriophorum*. Light brown in colour
2	4	2	Tb (Shag) 2 Th (Erio)2 Tl+	Brown fibrous *Sphagnum* peat rich in *Eriophorum* remains
3	4	4	Tb (Sphag 3 Th (Erio) 1	Brown fibrous *Spagnum* peat
3	3	2	Tb (Spag) 2 Th (Erio) 2	Ginger-brown *Sphagnum-Eriophorum* peat. Quite fibrous.
3	3	3	Tb (Sphag) 3 Th (Erio) 1	Dark brown *Sphagnum - Eriophorum* peat with some Ericaceous reamins
3	3	2	Tb (Spag) 4 Tl + Th+	Dark brown almost pure *Sphagnum* peat
3	3	3	Tb (Sphag) 4 Tl+ Th+	Darker brown *Sphagnum* peat.
3	3	2	Tb (Sphag) 3 Th (Erio) 1	Moderately humified dark brown peat with distinct *Eriophorum* remains
3	3	3	Tb (Sphag) 4 Th (Erio) + Tl (Cal) +	Dark brown peat composed almost purely of *Sphagnum*
3	3	3	Tb (Sphag) 3 Th (Erio) 1	*Spahgnum* peat with some *Eriophorum*. Very dark brown in colour
3	3	3	Tb (spag) 4 Th (Erio) + Sic = 1 Tl (Cal) + Strat =0	Very dark brown peat.

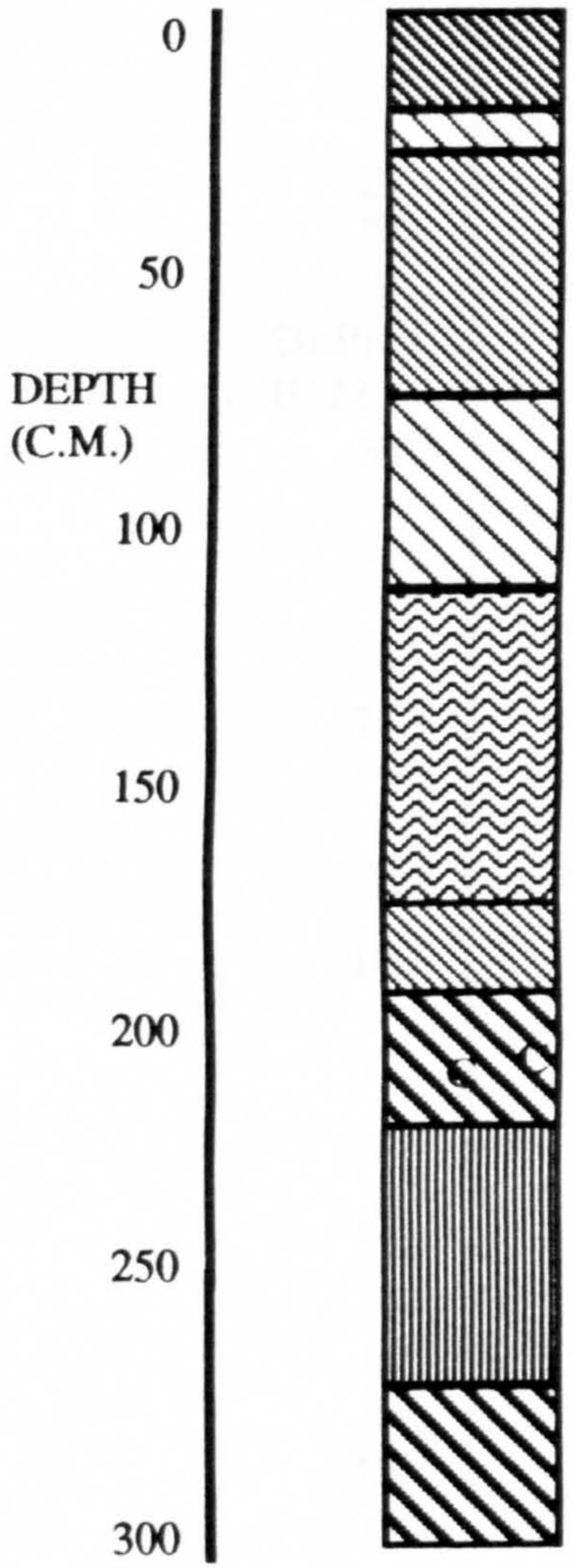
FIGURE 3.5 STRATIGRAPHY - GLASSON MOSS



DEPTH (C.M.)	NIG.	ELAS.	HUMO	COMPONENTS	DESCRIPTION
0	2	4	1	Tb (Spag) 4 Th (Erio)+ Tl (Cal) +	Very fresh *Sphagnum* dominated peat, mainly *Sphagnum magellanicum.*
	4	3	2	Tb (Sphag) 4	
	4	2	4	Tb (Sphag) 2 Th (Erio) 2	Dark brown peat, quite well humified
50					
	3	3	4	Tb (Sphag) 3 Th (Erio) 1	Dark red-orange peat.
	3	3	3	Tb (Sphag) 2 Th (Erio) 2	Dark brown *Sphagnum-Eriophorum* peat
100	3	3	4	Tb (Sphag) 3 Th (Erio) 1 Tl (Cal) +	
	3	3	3	Tb (Sphag) 3 Th (Erio) 1	Bright red relatively cheesey peat
	3	3	4	Tb (Sphag) 2 Th (Erio) 1 Tl (Cal) 1	Dull red peat containing layer of charcoal
150	4	2	4	Tb (Sphag) 3 Th (Erio) 1 Tl (Cal) +	Bright red relatively humified peat
	3	3	4	Tb (Sphag) 3 Th (Erio) 1 Tl (Cal) +	Dull red *Sphagnum-Eriophorum* peat
	3	2	4	Tb (Sphag) 2 Th (Erio) 1 Tl (Cal) 1	
200	3	3	4	Tb (Sphag) 3 Th (Erio) 1	Well humified *Sphagnum-Eriophorum* peat
	3	3	3	Tb (Sphag) 2 Th (Erio) 2	Yellowish - red peat
	3	3	3	Tb (Sphag) 2 Th (Erio) 1 Tl (Cal) 1	Brown peat, with *Eriophorum* and *Calluna*
	3	3	2	Tb (Sphag) 4 Th + Tl +	Reddish coloured *Sphagnum* peat
250	3	3	4	Tb (Sphag) 3 Th (Erio) 1 Tl (Cal) +	Dark red - brown *Sphagnum* rich peat
	3	3	2	Tb (Sphag) 3 Th (Erio) 1	Relatively fresh dull red peat
300					

Sic = 1
Strat = 0

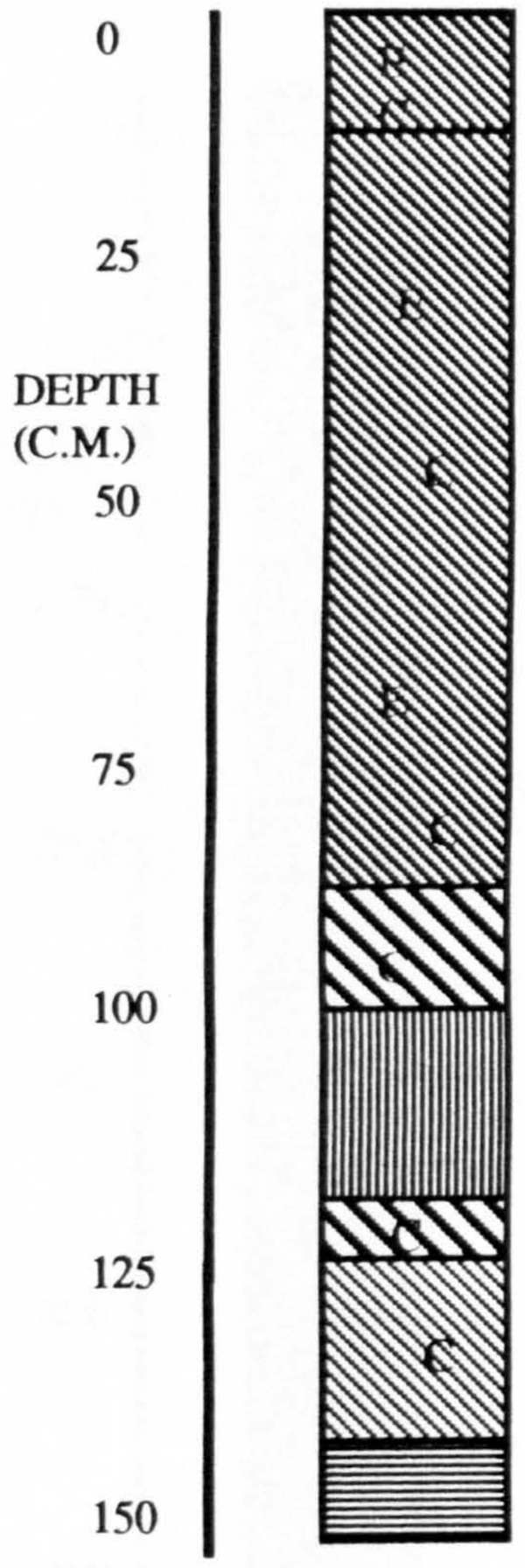
FIGURE 3.6 STRATIGRAPHY - FOZY MOSS



NIG	ELAS	HUMO	COMPONENTS	DESCRIPTION
1	4	1	Tb (Sphag) 4 Th (Vac) +	Fresh green *Sphagnum* peat, with *Vaccinium* remains
3	2	3	Tb (Sphag) 1 Th (Erio) 3	Peat dominated by *Eriophorum* root bases and stems
3	2	3	Tb(Sphag) 2 Th (Erio) 2	Light brown peat, slightly drier
2	2	3	Tb (Sphag) 1 Th (Erio) 3	Very fibrous light brown peat
3	3	4	Tb (Sphag) 2 Th (Erio) 1 As1	Dark yellow-brown peat with clay inwash
3	3	4	Tb (Sphag) 2 Th (Erio) 2	Dark chocolate brown peat Quite cheesey
3	2	3	Tb (Sphag) 3 Th (Erio) 1 Tl(Cal) +	Dark chocolate brown peat
3	2	3	Tb (Sphag) 2 Th (Erio) 1 Tl (Cal) 1	Dark brown chocolate peat with large *Calluna* stems
3	3	4	Tb (Sphag) 3 Th (Erio) 1	Milk chocolate brown peat

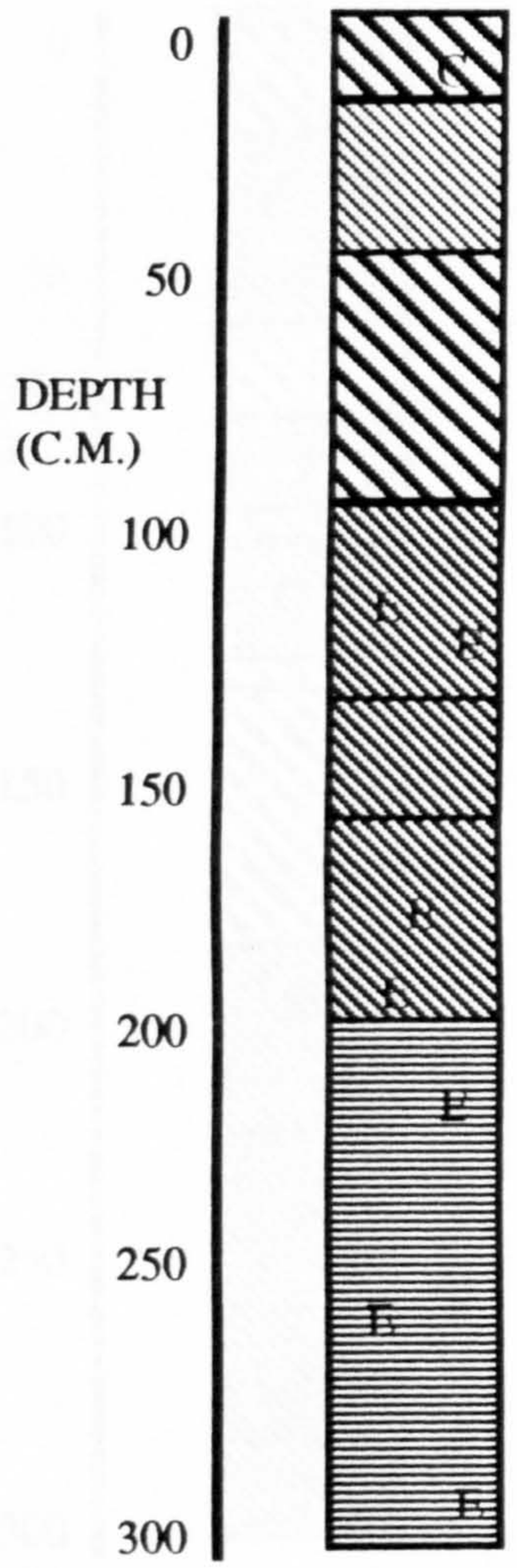
Sic = 1
Strat =0

FIGURE 3.7 STRATIGRAPHY - LETHAM MOSS



NIG	ELAS	HUMO	COMPONENTS	DESCRIPTION
4	0	4	Tb(Sphag) 4 Th (Erio)+ Tl (Cal) +	Dark brown to black peat with layers of charcoal
2	3	1	Tb (Sphag) 4 Th (Erio)+ Tl (Cal)+	Yellow-brown *Sphagnum* peat
3	3	4	Tb (Sphag) 3 Th (Erio) 1 Tl (Cal) +	Very dark brown cheesey peat
3	3	4	Tb (Sphag) 2 Th (Erio) 1 Tl (cal) 1	Dark brown peat
3	2	3	Tb (Sphag) 3 Th (Erio) 1 Tl (Cal) +	Very dark brown peat less humified
3	2	3	Tb (Sphag) 2 Th (Erio) 2 Tl (Cal) +	
4	Sic = 1 1 Strat = 0	4	Sh 3 Th (Erio) 1	Black humified peat

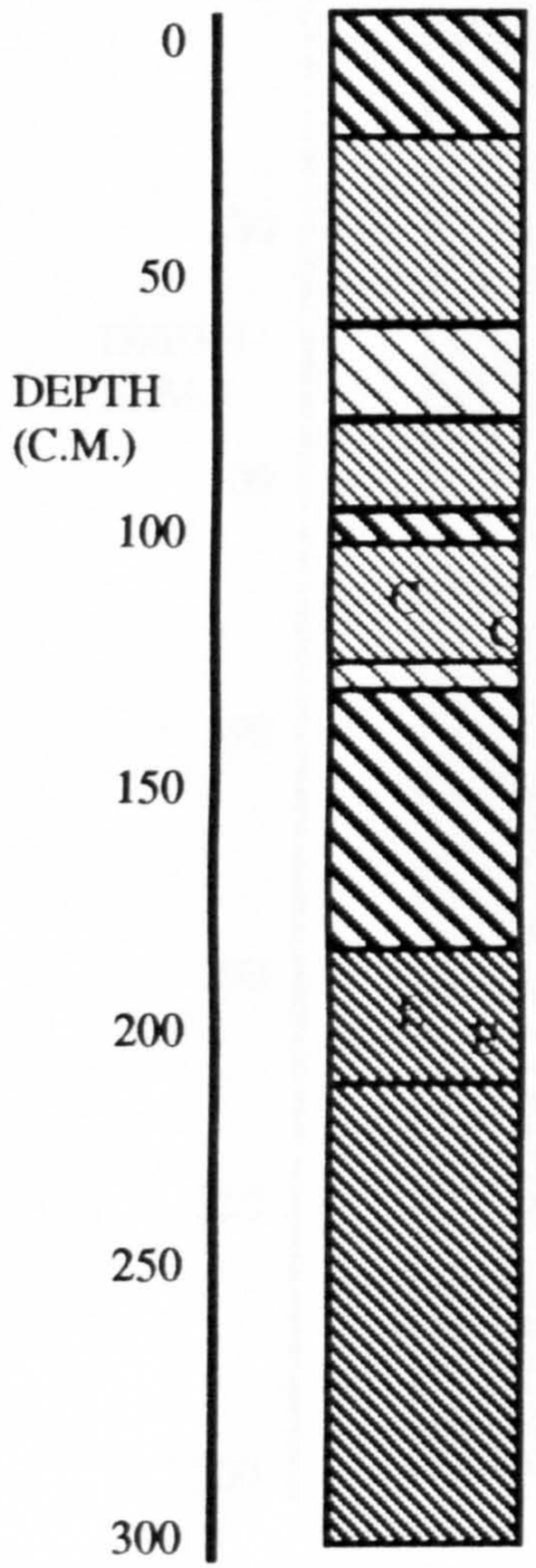
FIGURE 3.8 STRATIGRAPHY - FANNYSIDE MUIR



	NIG	ELAS	HUMO	COMPONENTS	DESCRIPTION
A	2	4	0	Tb (Sphag) 3 Th (Erio) 1 Tl (Cal) +	Very fresh light green peat
B	3	3	2	Tb (Sphag) 2 Th (Erio) 2	
C	3	3	3	Tb (Sphag) 3 Th (Erio) 1	Very dark cheesey peat
D	3	3	3	Tb (Sphag) 4 Th (Erio) +	Dark brown peat, almost pure *Sphagnum*
E	3	3	3	Tb (Sphag) 4	
F1	4	3	4	Tb (Sphag) 4 Th (Erio) +	
F2	4	2	3	Sh 3 Th (Erio) +	Very humified peat, almost black

Sic = 1
Strat = 0

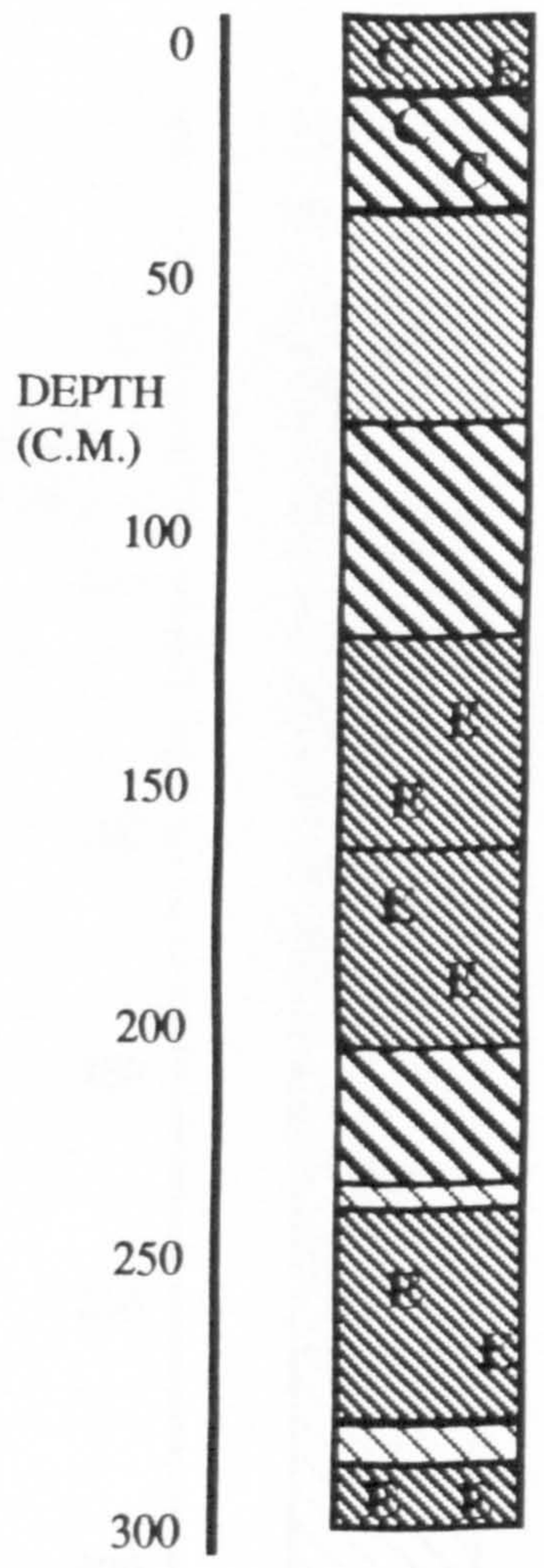
FIGURE 3.9 STRATIGRAPHY - DOGDEN MOSS



	NIG	ELAS	HUMO	COMPONENTS	DESCRIPTION
	2	4	0	Tb (Sphag) 3 Th (Erio) 3	Fresh green-yellow peatd dominated by *Sphagnum cuspidatum*
	3	3	2	Tb (Sphag) 2 Th (Erio) 2	
	3	3	2	Tb (Sphag) 1 Th (Erio) 3	Dark brown *Sphagnum-Eriophorum* peat
	3	3	2	Tb(Sphag) 2Th (Erio) 2	Light - chocolate brown peat
	3	2	2	Tb (Sphag) 3 Th (Erio) 1	
	3	3	2	Tb (Sphag) 2 Th (Erio) 2 Tl (Cal) +	Dark brown relatively fresh peat
	3	3	2	Tb (Sphag) 1 Th (Erio) 3	Peat dominated by stems and roots of *Eriophorum*
	4	3	3	Tb (Sphag)3 Th (Erio) 1	
	3	2	3	Tb (Sphag) 4 Th (Erio) +	Very dark chocolate brown
	4	2	4	Tb (Sphag) 4	Very dark brown cheesey peat

Sic =1
Strat =0

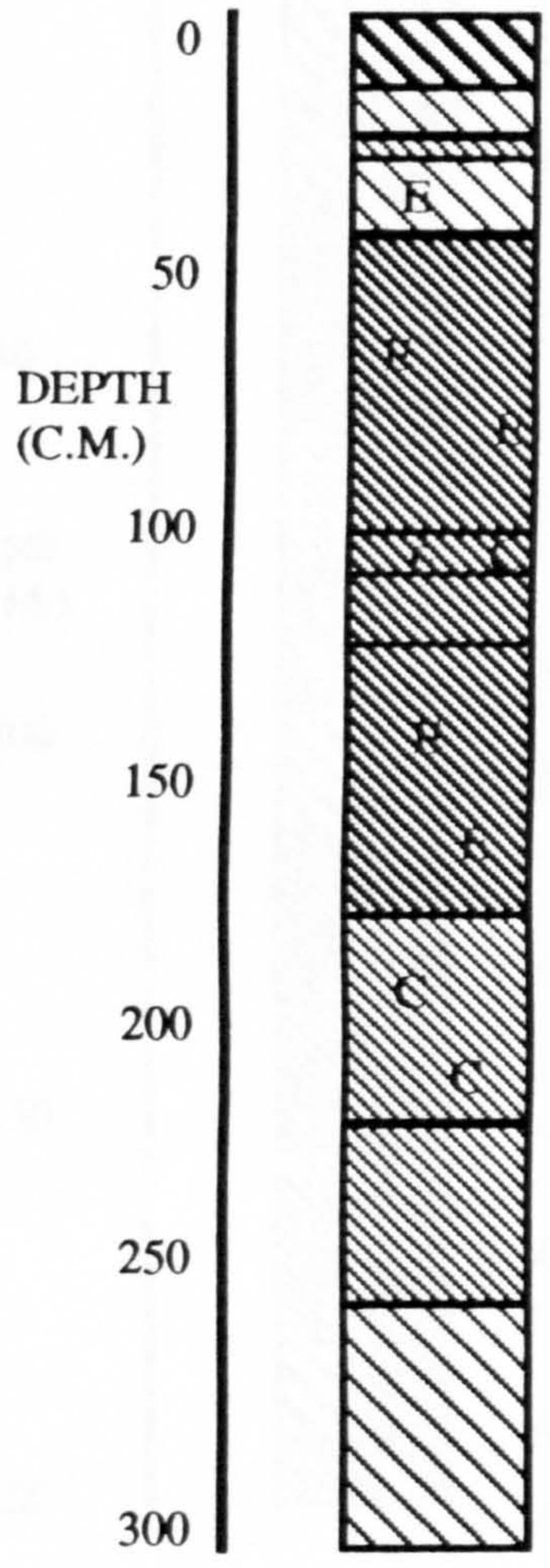
FIGURE 3.10 STRATIGRAPHY - CRANLEY MOSS



	NIG	ELAS	HUMO	COMPONENTS	DESCRIPTION
	2	4	1	Tb (Sphag) 4 Tl (Cal) + Th (Erio) +	Very fresh *Sphagnum magellanicum* peat
	3	3	1	Tb (Sphag)3 Th (Erio) 1 Tl (Cal) +	
	3	3	1	Tb (Sphag) 2 Th (Erio) 2	
	3	3	2	Tb (Sphag) 3 Th (Erio) 1	Medium brown *Sphagnum* peat
	3	3	3	Tb (Sphag) 4 Th (Erio) +	
	4	2	4	Tb (Sphag) 4 Th (Erio) +	Well humified dark chocolate brown peat
	3	2	4	Tb (Sphag) 3 Th (Erio) 1	
	4	2	4	Tb (Sphag) 1 Th (Erio) 3	Peat dominated by large *Eriophorum* root base
	4	2	4	Tb (Sphag) 1 Th (Erio) 3	
	4	2	4	Tb (Sphag) 4 Th (Erio) +	Very humified black cheesey peat

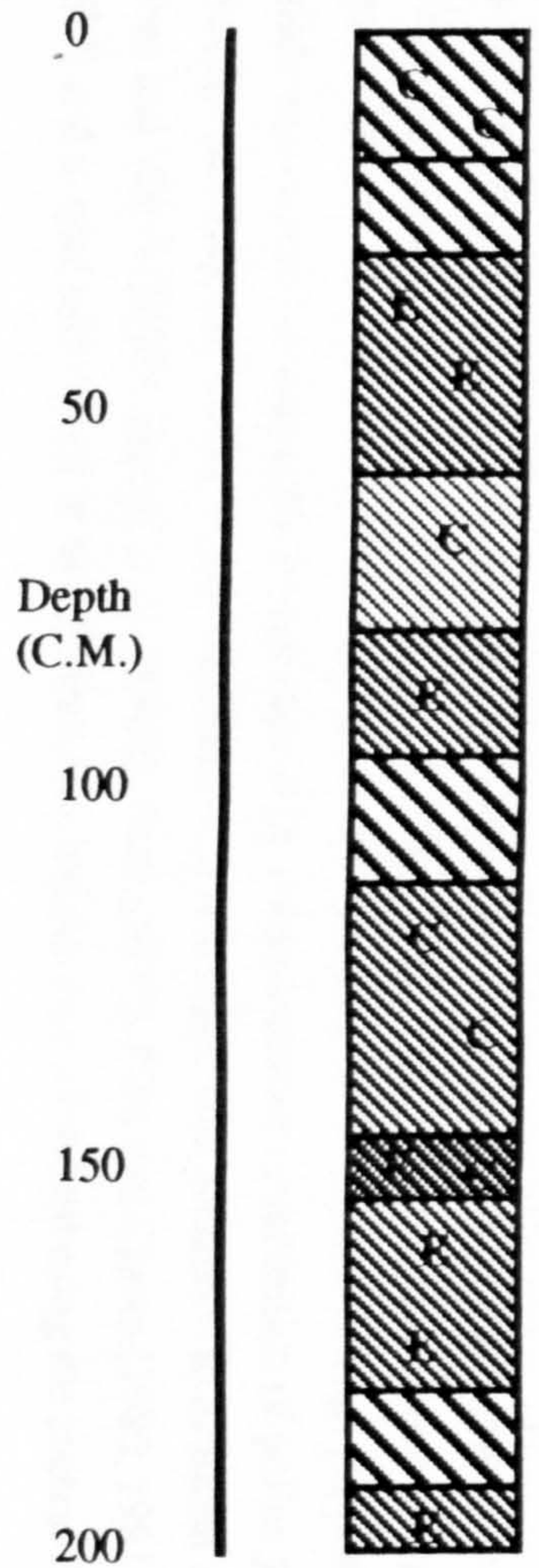
Sic= 1
Strat = 0

FIGURE 3.11 STRATIGRAPHY - CARSEGOWAN MOSS



	NIG	ELAS	HUMO	COMPONENTS	DESCRIPTION
E	3	4	1	Tb (Sphag) 3 Th (Erio) 1	Fresh peat, dominated by *Sphagnum*
	3	2	3	Tb (Sphag) 1 Th (Erio) 3	Dense *Eriophorum* root bases and stems
	3	3	4	Tb (Sphag)2 Th (Erio) 2	
	2	2	2	Tb (Sphag) 1 Th (Erio) 1	Light yellow *Eriophorum* stems and roots
D	3	3	4	Tb (Sphag) 4 Th (Erio) +	*Sphagnum* dominated peat
A	3	2	3	Tb (Spag) 4 Tl (Cal) + Th (Erio) +	
B	3	2	3	Tb (Sphag) 4	Brown *Sphagnum* peat
	2	2	3	Tb (Sphag) 4 Th (Erio) +	Yellow brown peat
C	3	2	3	Tb (Sphag) 2 Th (Erio) 2 Tl (Cal) +	Chocolate brown peat
	3	2	3	Tb (Sphag) 2 Th (Erio) 2	
	4	2	4	Tb (Sphag) 1 Th (Erio) 3	Very dark brown *Eriophorum* dominated peat
			Sic =1 Strat = 0		

FIGURE 3.12 STRATIGRAPHY - ELLERGOWER MOSS



	NIG	ELAS	HUMO	COMPONENTS	DESCRIPTION
C	2	4	1	Tb (Sphag) 3 Th (Erio) 1 Tl 9Cal) +	Fresh green-yellow *Sphagnum* peat
C	3	3	3	Tb (Sphag) 3 Th (Erio) 1	Chocolate brown peat
F	3	3	3	Tb (Sphag) 4 Th (Erio) +	Dark brown peat
C	3	3	3	Tb (Sphag) 2 Th (Erio) 2 Tl (Cal) +	
F	4	3	3	Tb (Sphag) 4 Th (Erio) +	Cheesey, humified peat with some *Eriophorum*
F	3	2	3	Tb (Sphag) 3 Th (Erio) 1	Dark humified peat
C	4	2	3	Tb (Sphag) 4 Th (Erio) + Tl (Cal) +	
C	4	2	3	Tb (Sphag) 3 Tl (Cal) 1 Th (Erio) +	Dark chocolate brown peat
F	4	2	3	Tb (Sphag) 4 Th (Erio) +	
F	4	2	3	Tb (Sphag) 3 Th (Erio) 1	
F	4	2	3	Tb (Sphag) 4 Th (Erio) +	Humified peat, almost black

Sic = 1 Strat = 0

3.4 Laboratory Methods.

3.4.1 Sampling Procedure.

Peat samples 1-2cm.^{3}, were taken from the cores using a clean spatula and scalpel. The surface of each core section was cleaned in the laboratory prior to the sampling to prevent contamination and any modern material dragged down with the corer was also removed. The cores were than sampled for pollen analysis at 4 cm. intervals between 300 cm. and 100 cm. and at 8 cm. or 16 cm. intervals from 100 cm. to the top of the core. After this initial analysis, the cores were then sampled at 1 cm. intervals over the horizon where the first major change in Gramineae pollen percentages (demonstrating clearance) occurred.

3.4.2 Pollen Preparation.

The samples for pollen analysis were prepared using the technique outlined in Barber (1976). All samples were subject to two potassium hydroxide treatments and acetolysis was undertaken only for three minutes to prevent the destruction of *Sphagnum* spp. spores (Charman, 1990). Samples from Fozy Moss (151 cm.-134 cm.) were treated with hydrofluoric acid. The pollen slides were mounted in silicone fluid rather than glycerol jelly because pollen grains remain more spheroidal in a fluid media of low viscosity than a highly viscous or solid media (Praglowski, 1970). Silicone fluid also allows the grains to be rotated, permitting an assessment of all of their characteristics to be made (Andersen, 1965), and does not alter the size of the pollen grain with storage. Silicone mounts are also more permanent (Reitsma, 1969; Faegri *et al.*, 1989,75).

3.4.3 The Pollen Sum.

In this study, all samples were counted using a pollen sum of at least 250 non-mire pollen - the sum being based on a total of 250 land pollen, excluding Ericaceae and Cyperaceae. Experimental studies which assess the variation in pollen frequency with respect to the total pollen count, have shown that frequencies do not vary significantly once a sum of 200 to 250 grains has been reached (Crabtree, 1968; Rull, 1987). The exclusion of Ericaceae and Cyperaceae from the sum is a departure from the recommendations of Wright and Patten (1963) who state that species should not be excluded from the sum as this would lead to the misrepresentation of vegetation types. The purpose of this project is to undertake a study of regional pollen rain and because Ericaceae and Cyperaceae grow on the mire surface, they are defined as local pollen and would thus distort the regional picture (Moore *et al.*, 1991, 172). A sum of 250 non-mire pollen would also allow direct comparison of the results with those from Bolton Fell Moss.

3.4.4 Pollen Counting And Identification.

The pollen grains were counted and identified at x400 magnification on a Nikon Optiphot microscope. To aid interpretation of certain pollen types a x60 apochromatic lens and a x100 apochromatic oil immersion lens were used. Counting was carried out by systematically traversing the prepared slides and recording all pollen grains and spores that were seen (Moore *et al.*, 1991, 167). The slide was moved one and a half fields of view perpendicular to the first traverse to avoid repeated counting of the grains. A large proportion, if not all of each slide was counted to eliminate errors caused by the non-random distribution of pollen grains on the slide (Brookes and Thomas, 1963). Pollen identification was made with reference to Erdtman *et al.* (1961), Moore and Webb (1978), Faegri *et al.* (1989), Punt (1976), Punt and Clarke (1980, 1981, 1984), Andrew (1984) and to type slides held in the laboratory. Cereals were identified using the criteria of Andersen

(1979), Dickson (1988) and Edwards (1989) and Rosaceae by using Reitsma (1961) and Eide (1981). In general, the preservation of the pollen grains was very good and few unidentified or corroded grains were recorded.

Pollen concentration values were calculated for Walton Moss. Three *Lycopodium* tablets were dissolved in 10% hydrochloric acid to prevent clumping of pollen grains and then added to each sediment sample (Stockmarr, 1971; Francis and Hall, 1985; Tipping, 1987). Pollen concentrations were calculated using the following formula:

$$\text{Fossil Pollen Concentration} = \text{Number of exotics added} \times \frac{\text{Fossil Pollen Counted}}{\text{Exotic Pollen Counted}}$$

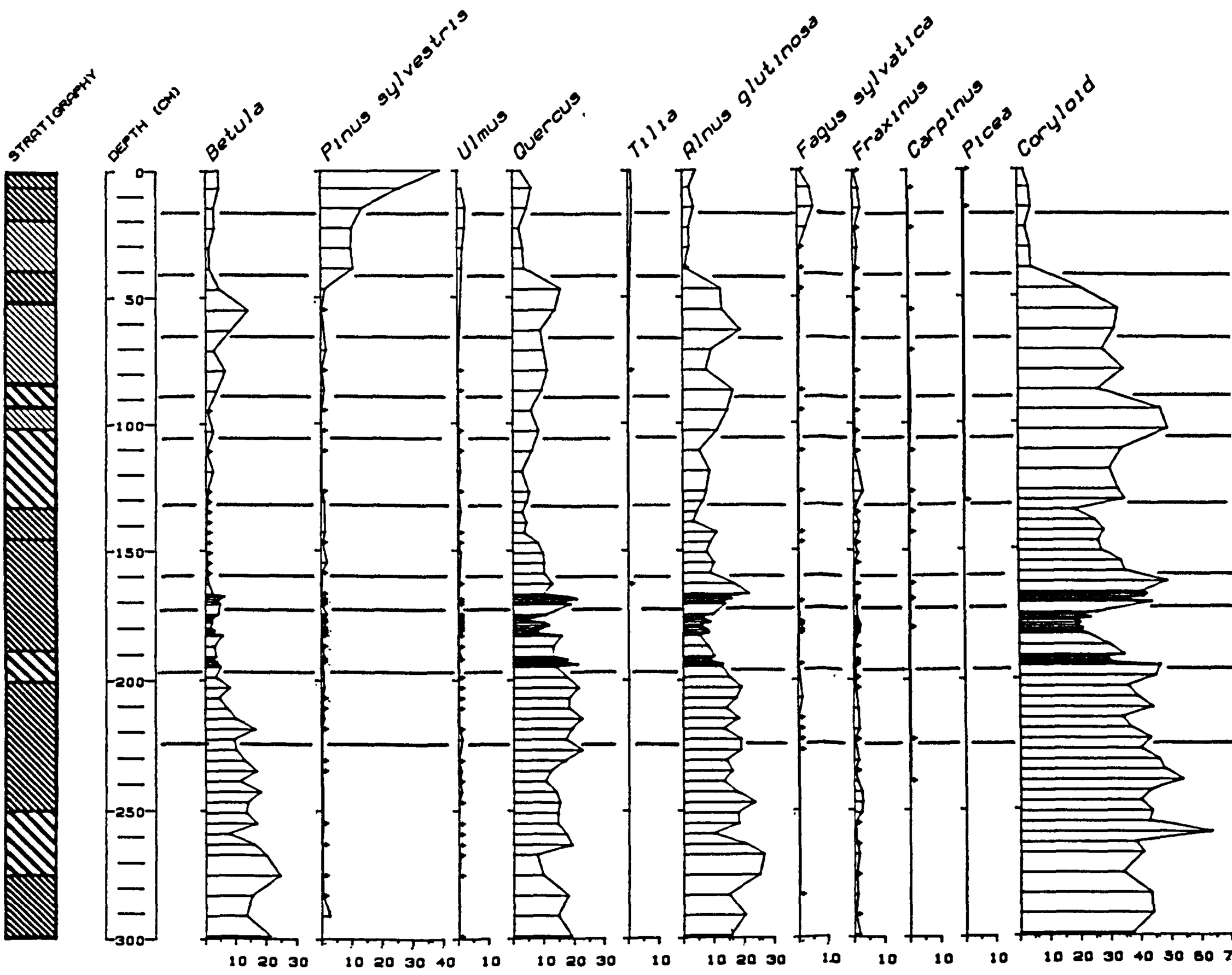
However, the values for Walton Moss were highly variable and this was probably a result of inaccuracies and difficulties in obtaining exactly 1 c.c. of peat using a calibrated brass sampler. The displacement method is not suitable for friable *Sphagnum*-rich peat (Jacobson and Bradshaw, 1981). This procedure was therefore not adopted for the other cores.

3.4.5 Diagram Production.

Relative percentage pollen diagrams (Figures 3.13 to 3.21) were calculated and drawn using a programme written for use on the Acorn Archimedes computer by Dr. J. Milne in the Southampton University Geography Department. The main problem with percentage calculations is that in respect of a single taxon, real variation in the pollen rain must always affect the percentage values for all others. This is known as the Fagerlind effect (Fagerlind, 1952) and must be considered when interpreting changes in such diagrams, but Prentice and Webb (1986) demonstrate that such effects are minimal if the following conditions are met: there is a linear relationship between vegetation and pollen; there are no large fluctuations in pollen input; and if there is no sediment or pollen focusing.

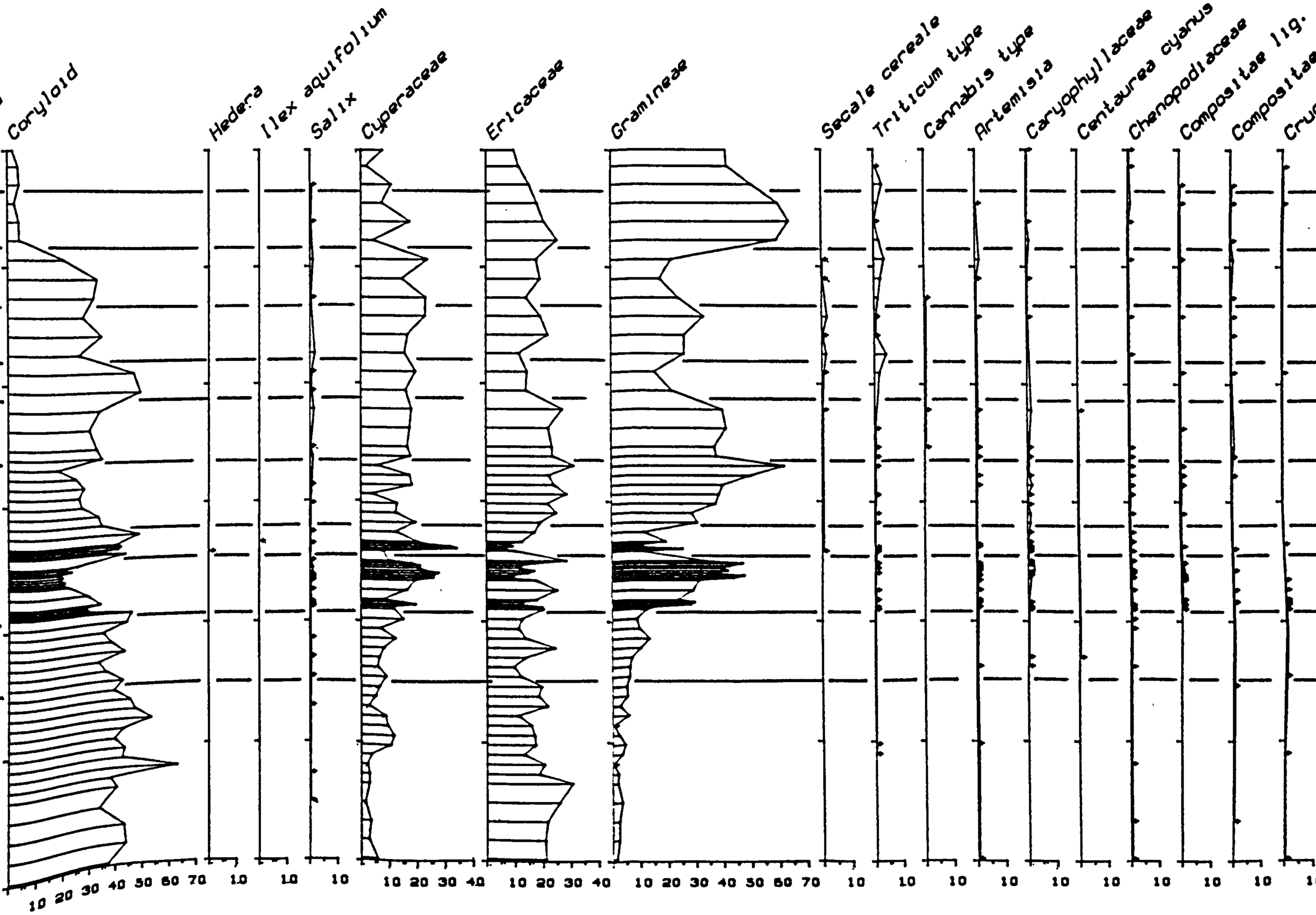
3.4.6 Diagram Organisation.

Plant nomenclature follows that of Clapham *et al.* (1989). In the pollen diagrams, trees and shrubs are shown as a percentage of non-mire pollen. *Corylus* and *Myrica gale* were not differentiated due to the difficulty of distinguishing between the two pollen types and they are therefore represented as Coryloid (Edwards, 1981; Sunberg, 1985). There is no *Myrica gale* present on the sites today (except at Carsegowan Moss), and it is unlikely that the species grew on the sites in the past (Perring and Walters, 1976) and consequently the Coryloid curve is likely to be composed predominantly of *Corylus*. Ericaceae is shown as a percentage of non-mire pollen plus Ericaceae, and Cyperaceae is shown as a percentage of non-mire pollen plus Cyperaceae. Other herbs are shown as a percentage of non-mire pollen. *Cannabis* type is undifferentiated due to the difficulties in identification outlined in Whittington and Gordon (1987). Rosaceae, *Plantago* and *Rumex* species are undifferentiated to improve their representation in the diagram, but were identified to species or type level. The data are tabulated on pollen count sheets held at the University of Southampton Palaeoecology Laboratory. Spores are shown as a percentage of total pollen plus spores. Unidentifiable grains, which despite reference to keys and type slides could not be assigned to any taxa, and those which were too degraded to be recognised are expressed as a percentage of total pollen plus unidentifiable.



T.L.P. – Ericaceae – Cyperaceae

FIGURE 3.13 WALTON MOSS. CUMBRIA

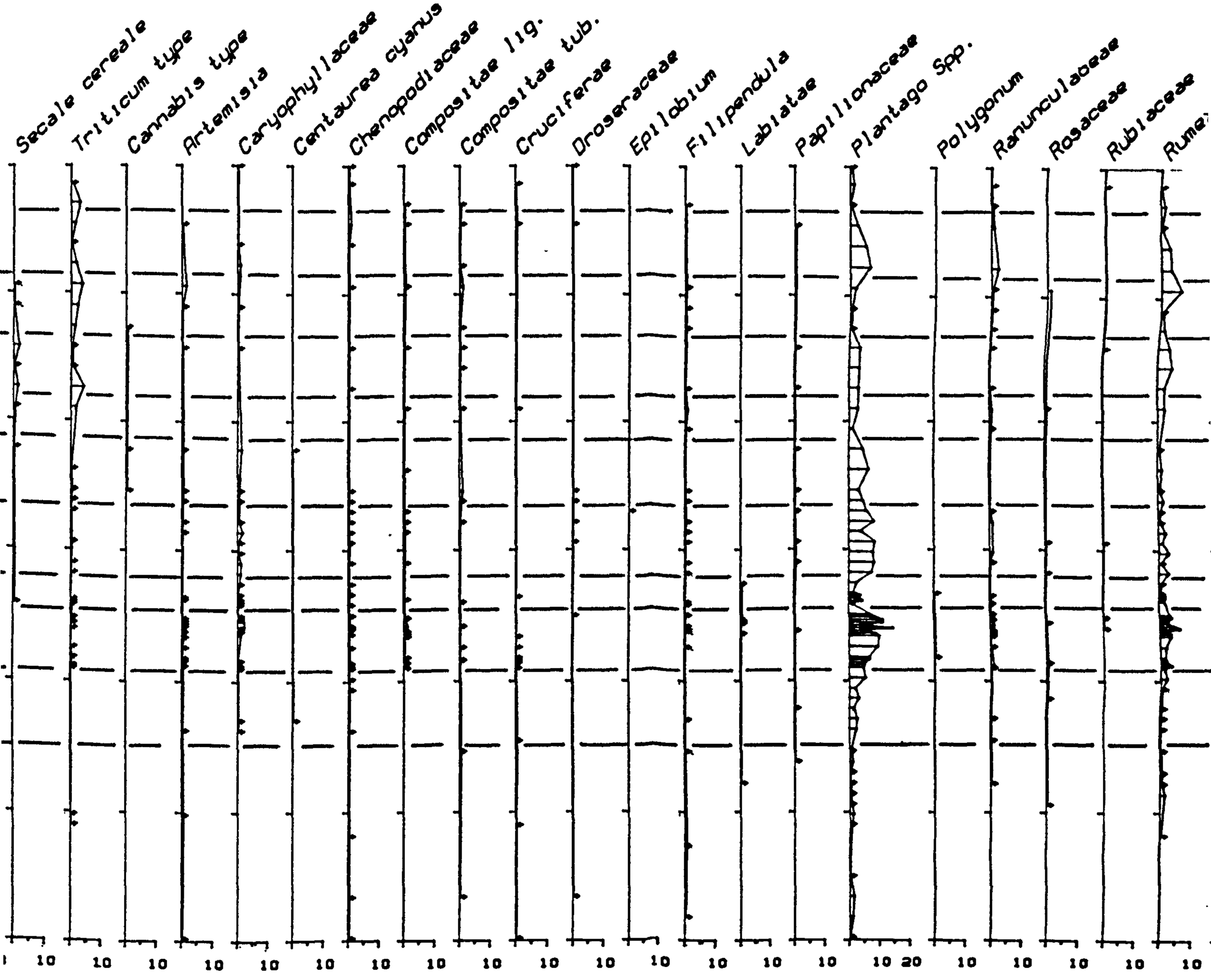


T.L.P. + Cyperaceae

T.L.P. - Ericaceae - Cyperaceae

T.L.P. + Ericaceae

FIGURE 3.13 WALTON MOSS. CUMBRIA



gonum
Ranunculaceae
Rosaceae
Rubiaceae
Rumex Spp.
Saxifragaceae
Succisa
Thalictrum
Umbelliferae
Urtica
Valeriana
Filicales
Polypodium
Pteridium
Sphagnum

10 10 10 10 10 10 10 10 10 10 10 10 10

10 20 30 40 50 60 70 80 90

T.L.P. + Spores

Corr/Uninident
Trees
Shrubs
Herbs

10

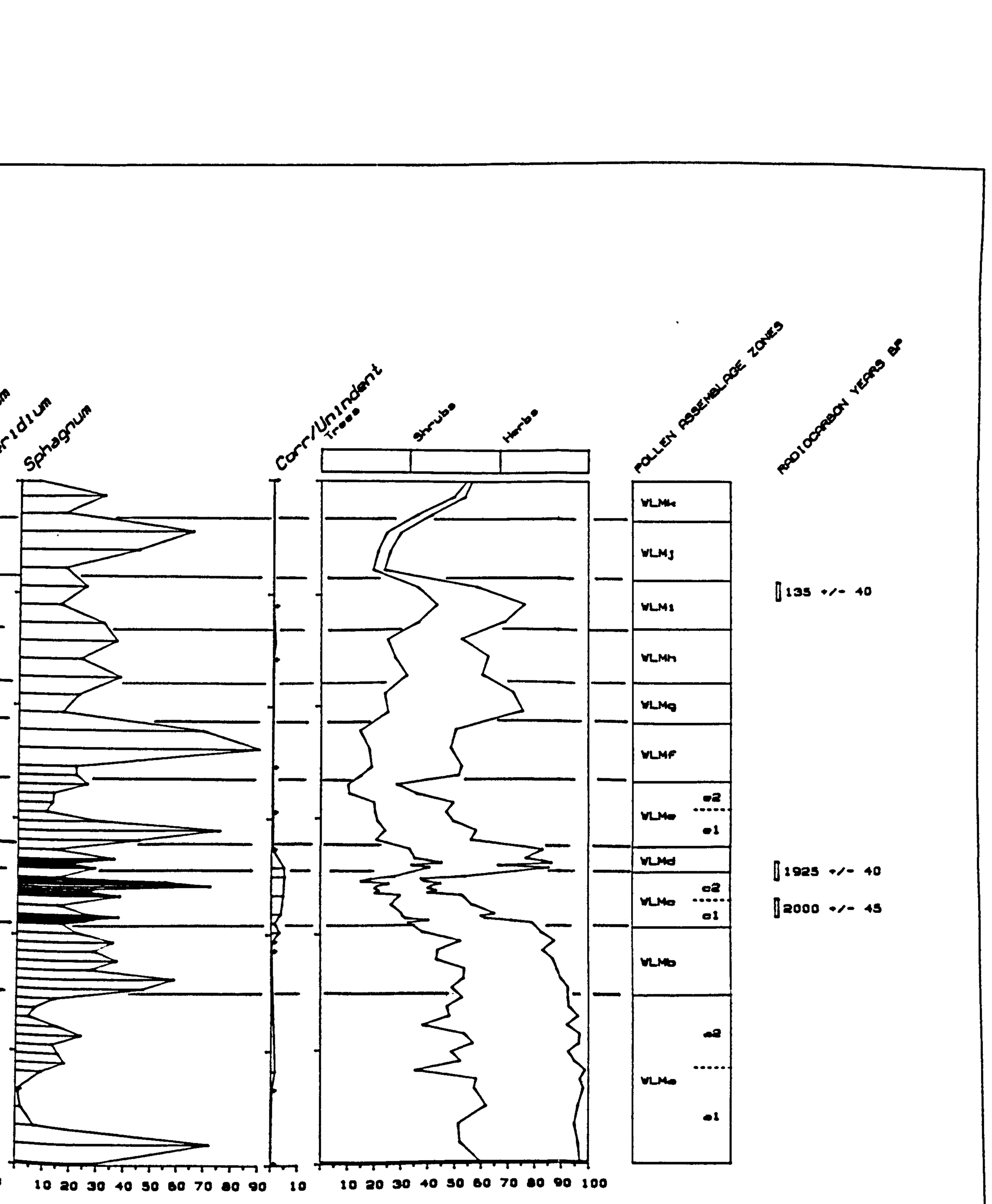
10 20 30 40 50 60 70 80 90 100

T.L.P. + Corr/Unid

POLLEN ASS

VLMk
VLMj
VLMi
VLMh
VLMg
VLMf
VLMe
VLMd
VLMc
VLMb
VLMa

Analysis: Lisa Dum



Analysis: Lisa Dumayne, 1992

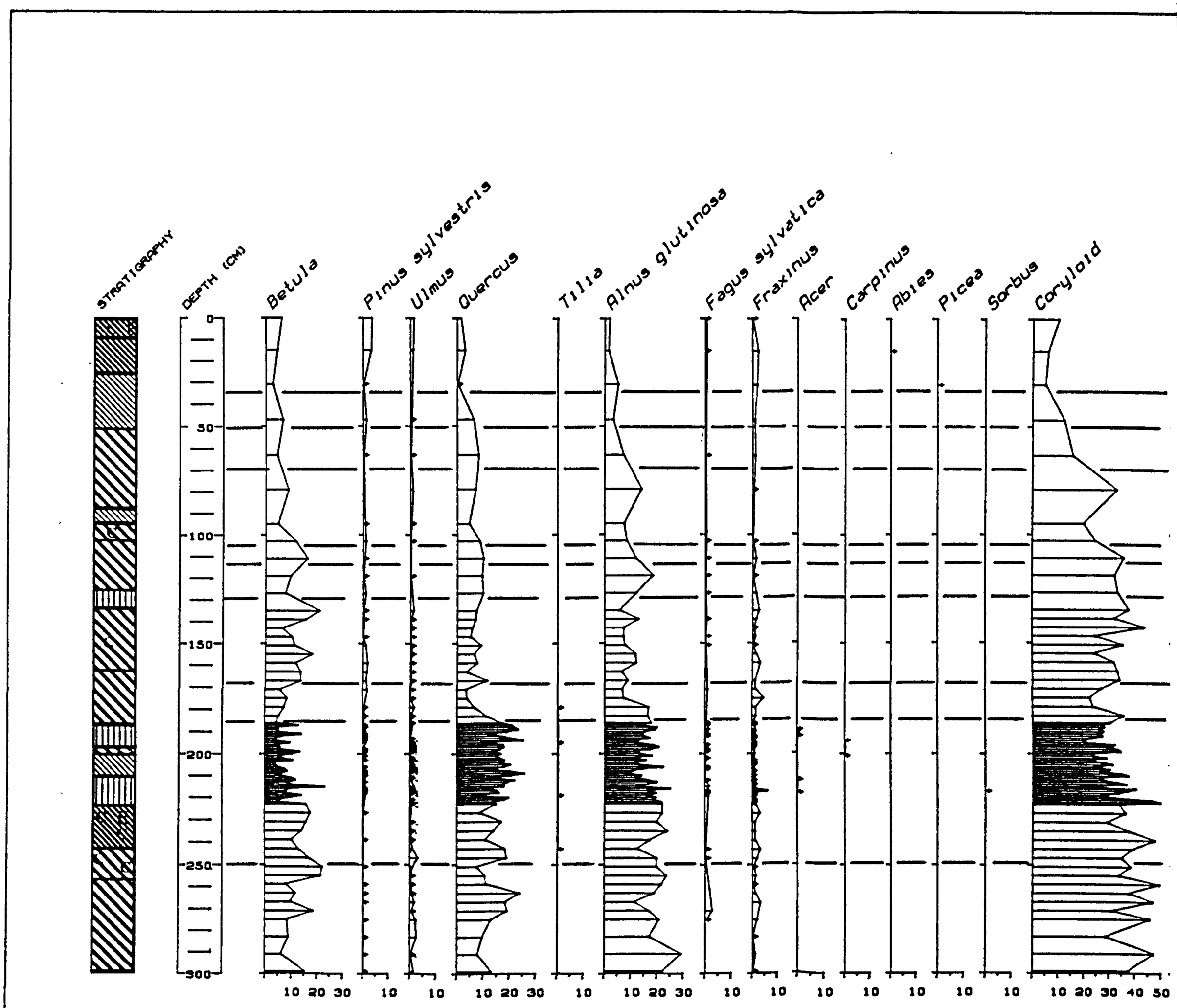
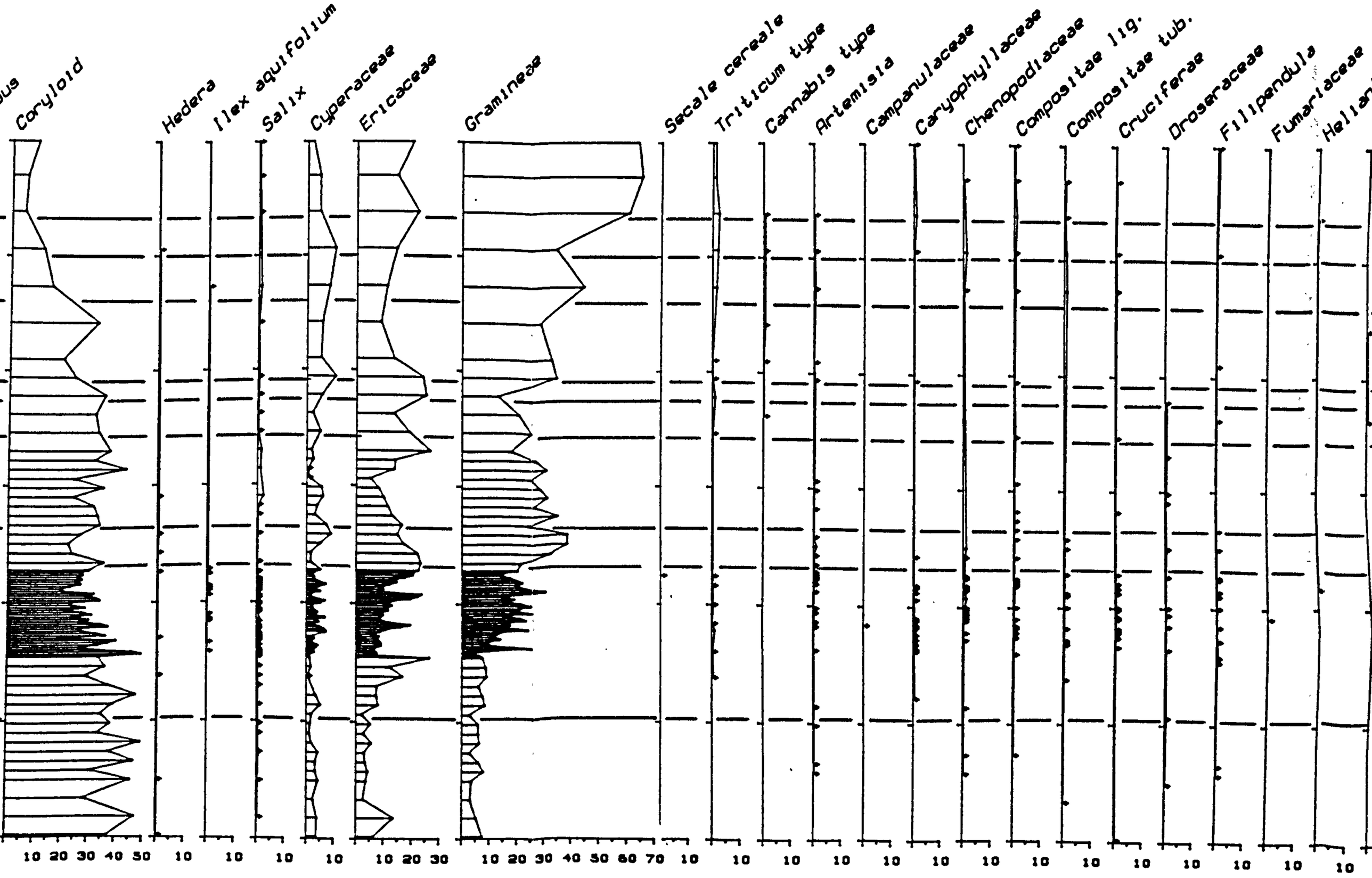

STRATIGRAPHY
DEPTH (CM)
Betula
Pinus sylvestris
Ulmus
Quercus
Tilia
Alnus glutinosa
Fagus sylvatica
Fraxinus
Acer
Carpinus
Abies
Picea
Sorbus
Coryloid
0
50
100
150
200
250
300
10 20 30
10
10
10 20 30
10
10 20 30
10
10
10
10
10
10
10
10 20 30 40 50
T.L.P. - Ericaceae - Cyperaceae

FIGURE 3.14 GLASSON MOSS. CUMBRIA



T.L.P. + Cyperaceae/L.P. - Ericaceae - Cyperaceae

T.L.P. + Ericaceae

FIGURE 3.14 GLASSON MOSS, CUMBRIA

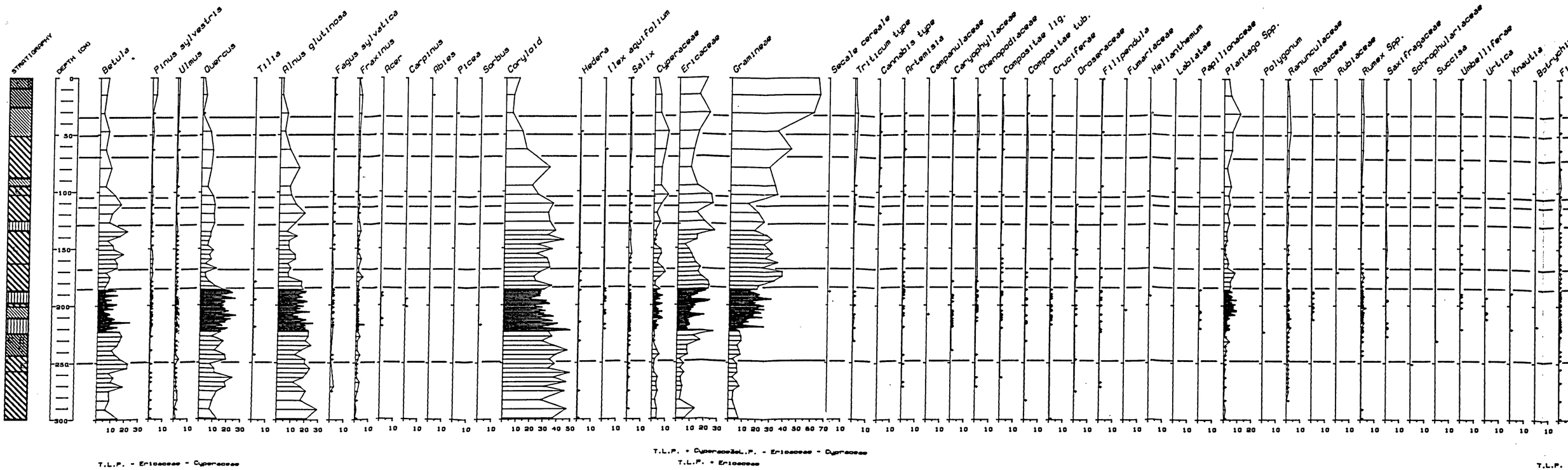
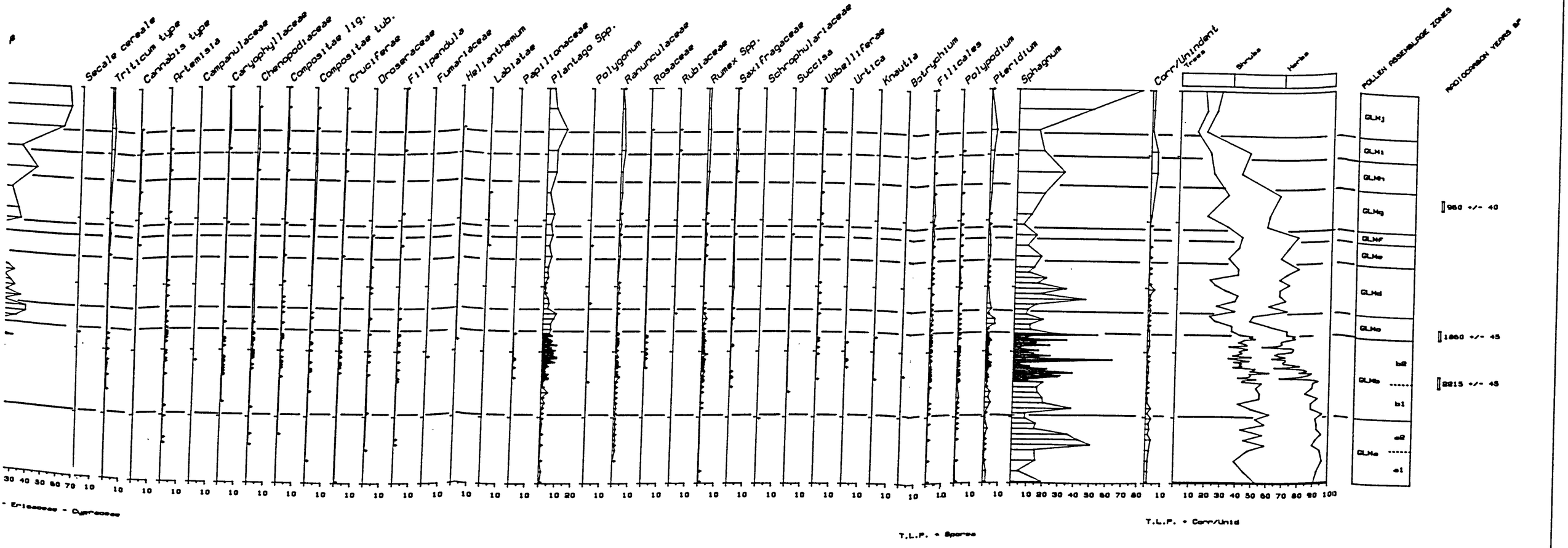


FIGURE 3.14 GLASSON MOSS, CUMBRIA



Analysis: Lisa Dumayne, 1992

FIGURE 3.15 FOZY MOSS. NORTHUMBRIA.

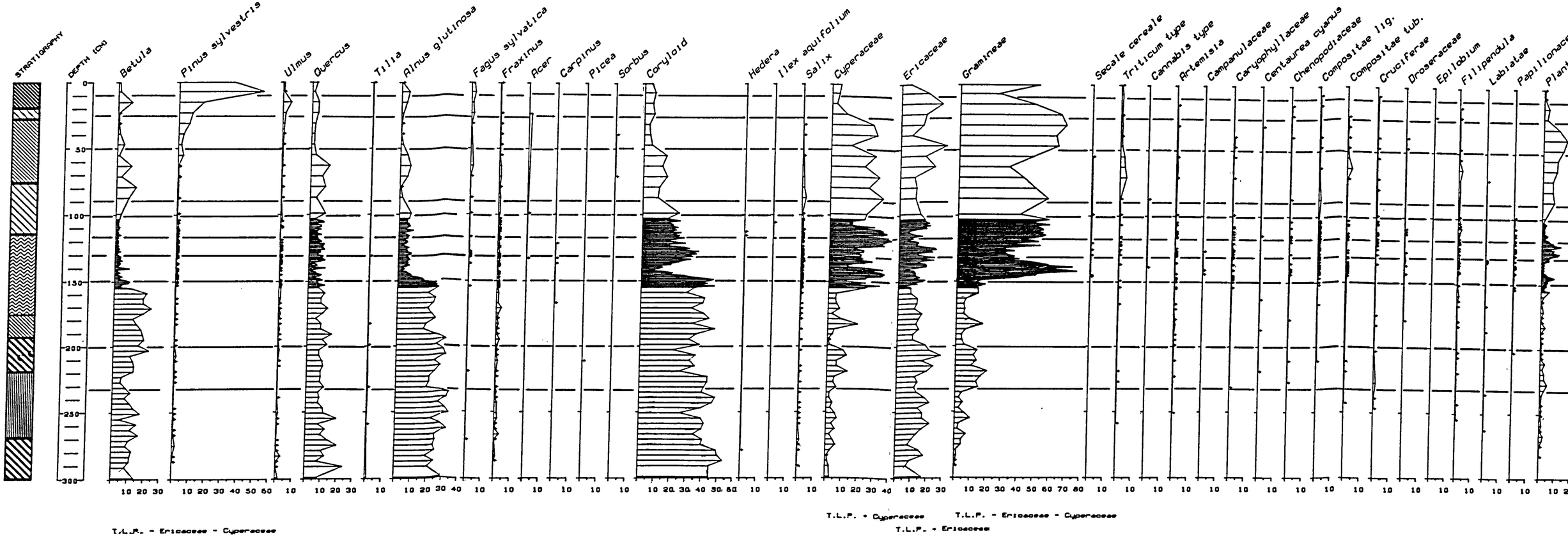
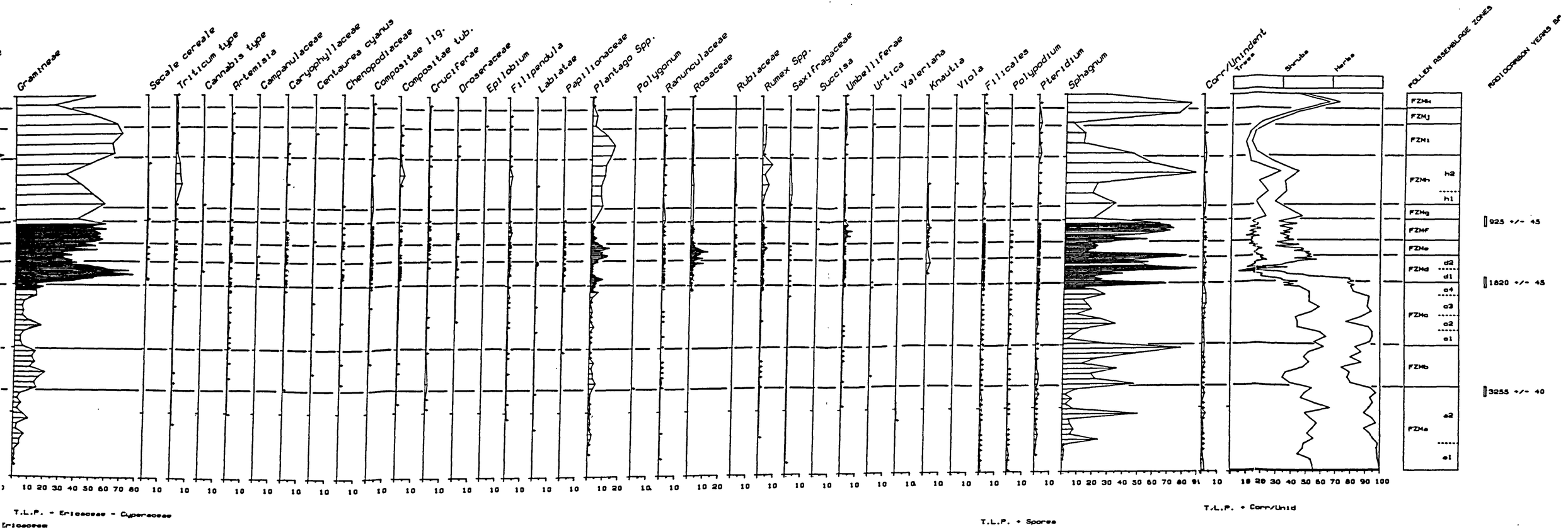


FIGURE 3.15 FOZY MOSS. NORTHUMBRIA.



Analysis: Lisa Dumayne, 1992

FIGURE 3.16 LETHAM MOSS, STIRLINGSHIRE

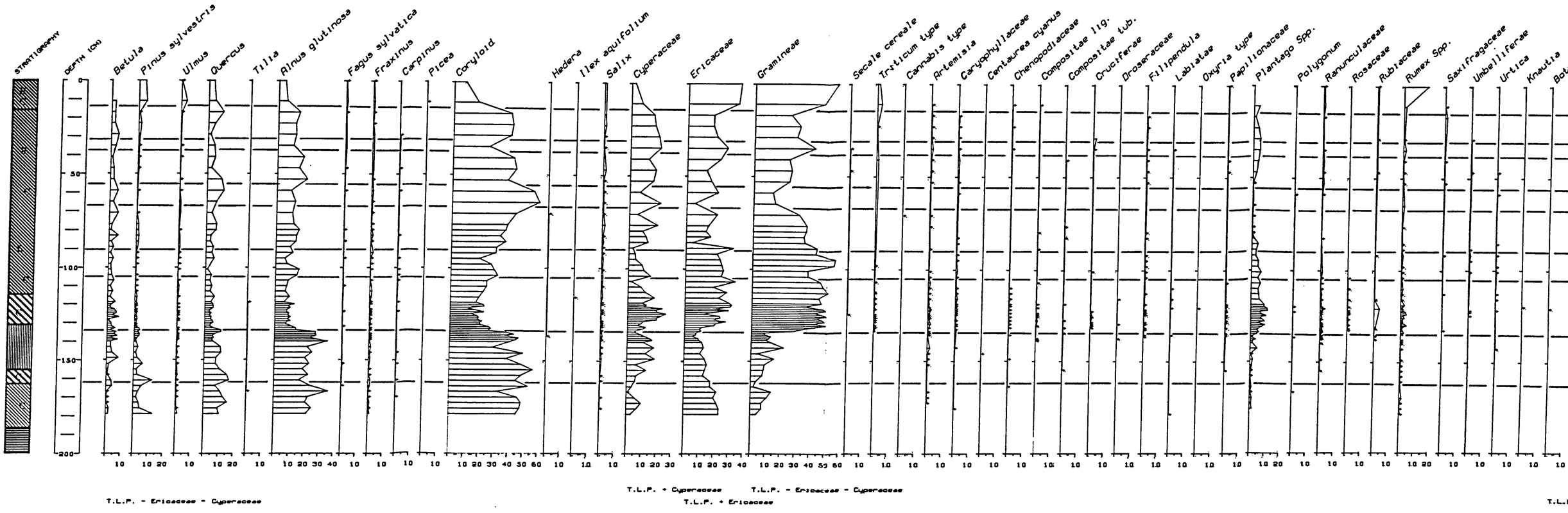
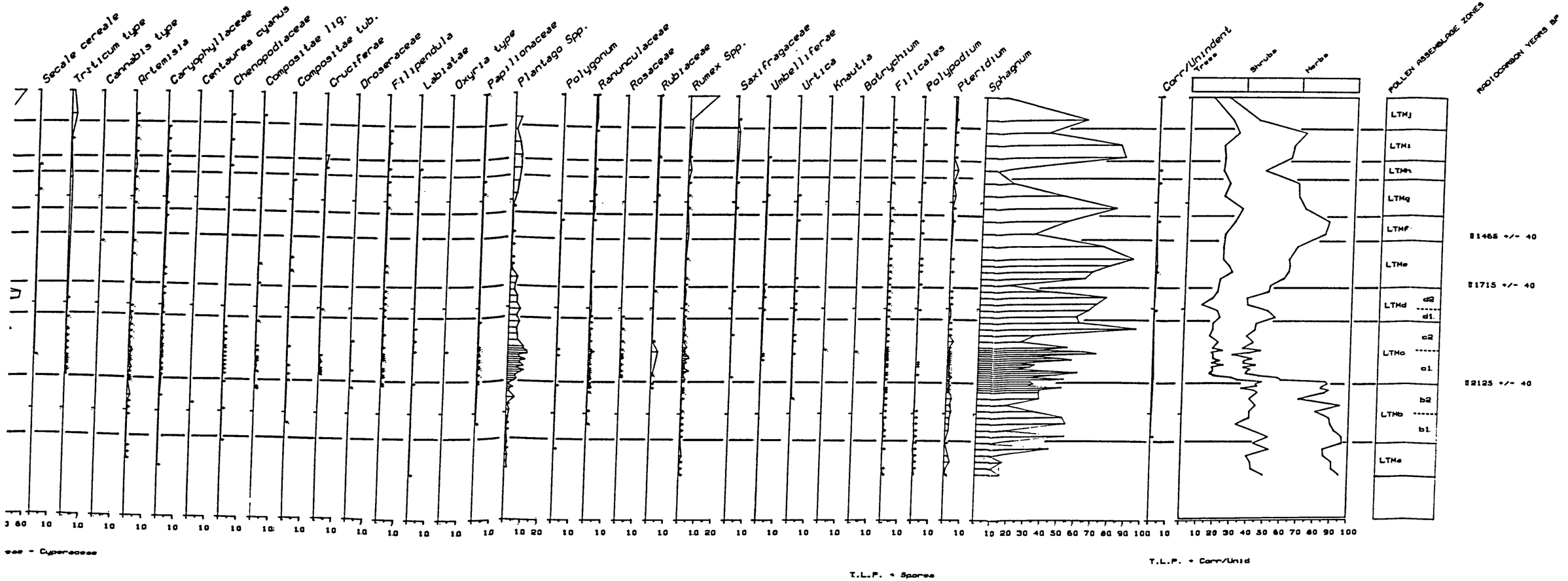


FIGURE 3.16 LETHAM MOSS, STIRLINGSHIRE



Analysis: Lisa Dumayne, 1992

FIGURE 3.17 FANNYSIDE MUIR. STRATHCLYDE.

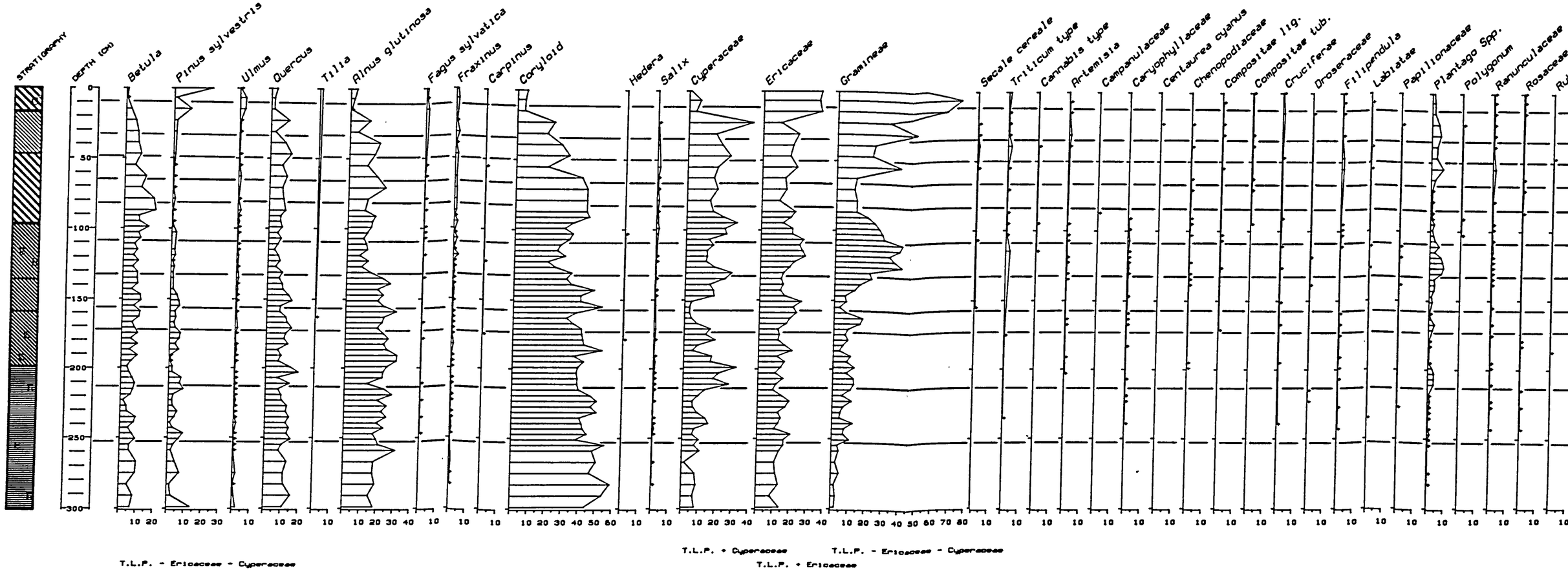


FIGURE 3.17 FANNYSIDE MUIR. STRATHCLYDE.

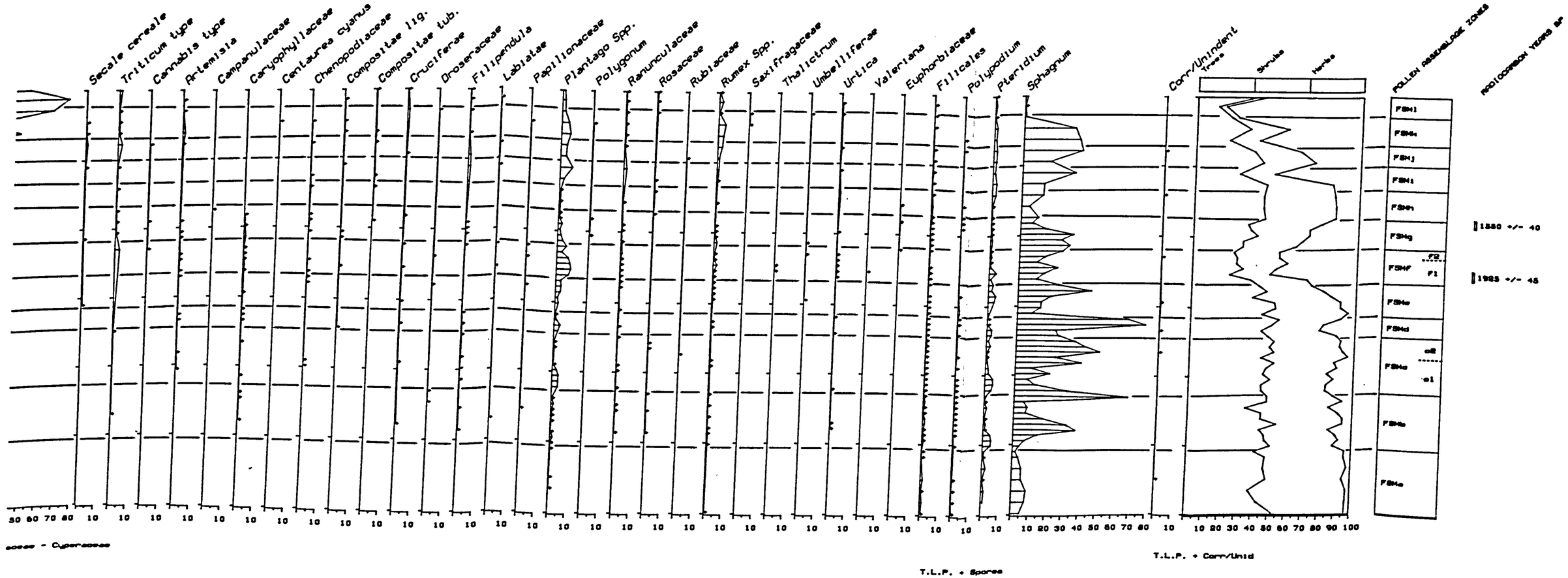

Secale cereale
Triticum type
Cannabis type
Artemisia
Campanulaceae
Caryophyllaceae
Centaurea cyanus
Chenopodiaceae
Compositae lig.
Compositae tub.
Cruciferae
Droseraceae
Filipendula
Labiatae
Papilionaceae
Plantago Spp.
Polygonum
Ranunculaceae
Rosaceae
Rubiaceae
Rumex Spp.
Saxifragaceae
Thalictrum
Umbelliferae
Urtica
Valeriana
Euphorbiaceae
Filicales
Polypodium
Pteridium
Sphagnum
Corr/Unindent
Trees
Shrubs
Herbs
POLLEN ASSEMBLAGE ZONES
RADIOCARBON YEARS BP
FSH1
FSH4
FSH3
FSH2
FSHh
FSHg
FSHF
f2
f1
FSHe
FSHd
FSHc
c2
c1
FSHb
FSHa
1550 +/- 40
1925 +/- 45
50 60 70 80
10 10 10

FIGURE 3.18 DOGDEN MOSS, BERWICKSHIRE.

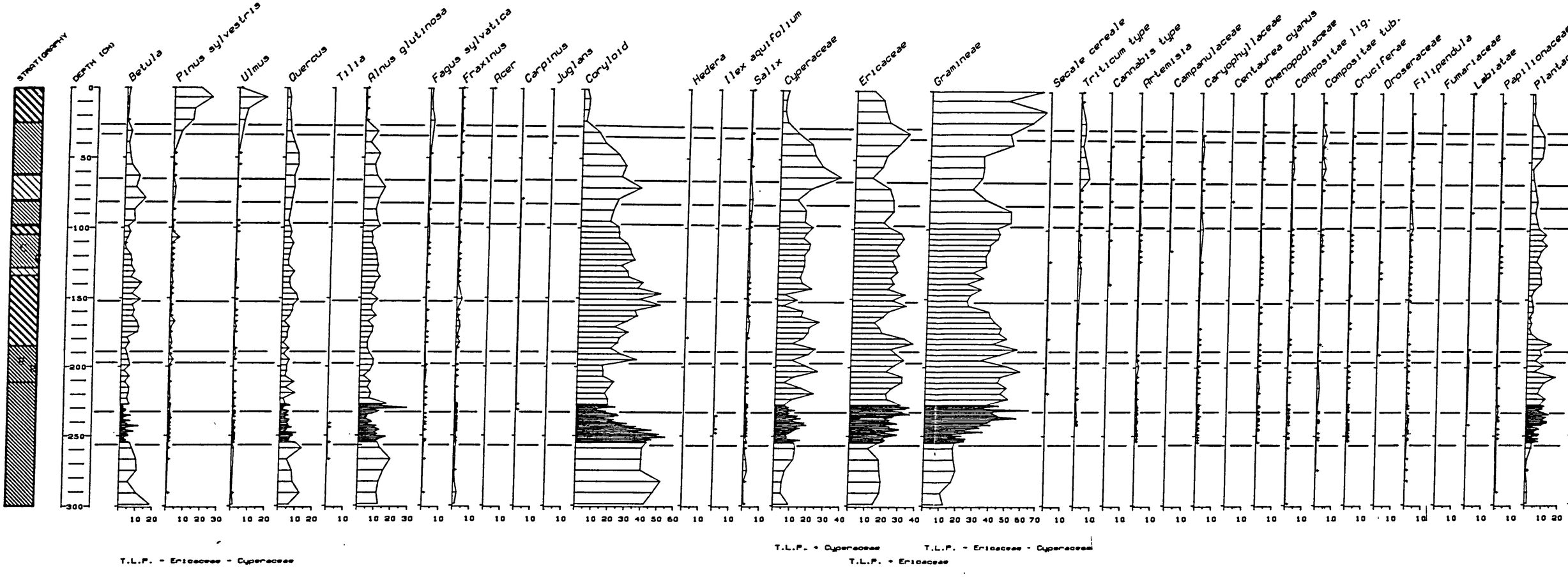
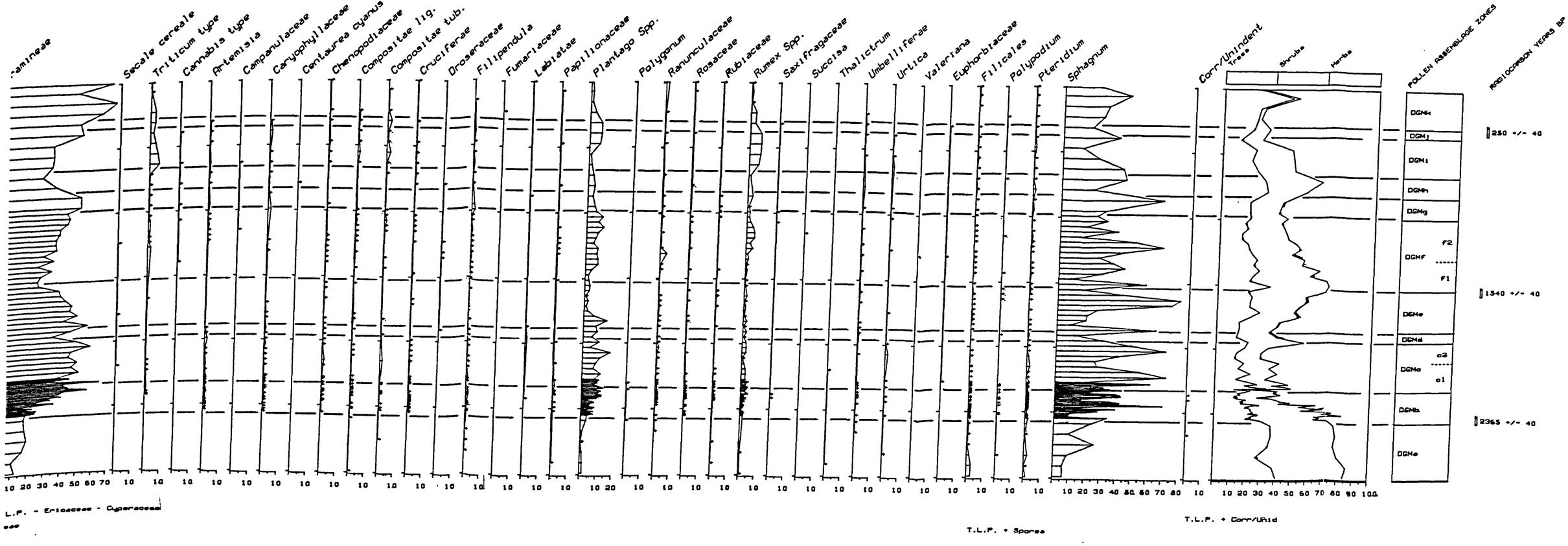


FIGURE 3.18 DOGDEN MOSS, BERWICKSHIRE.



Analysis: Lisa Dumayne, 1992

FIGURE 3.19 CRANLEY MOSS, LANARKSHIRE.

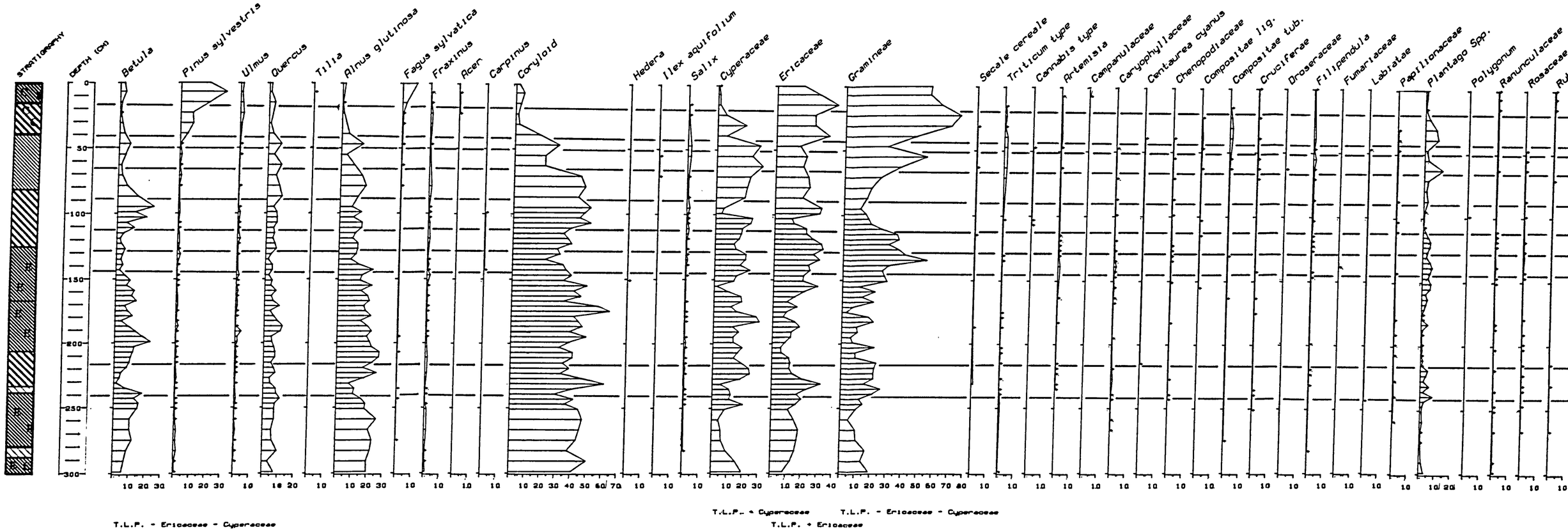
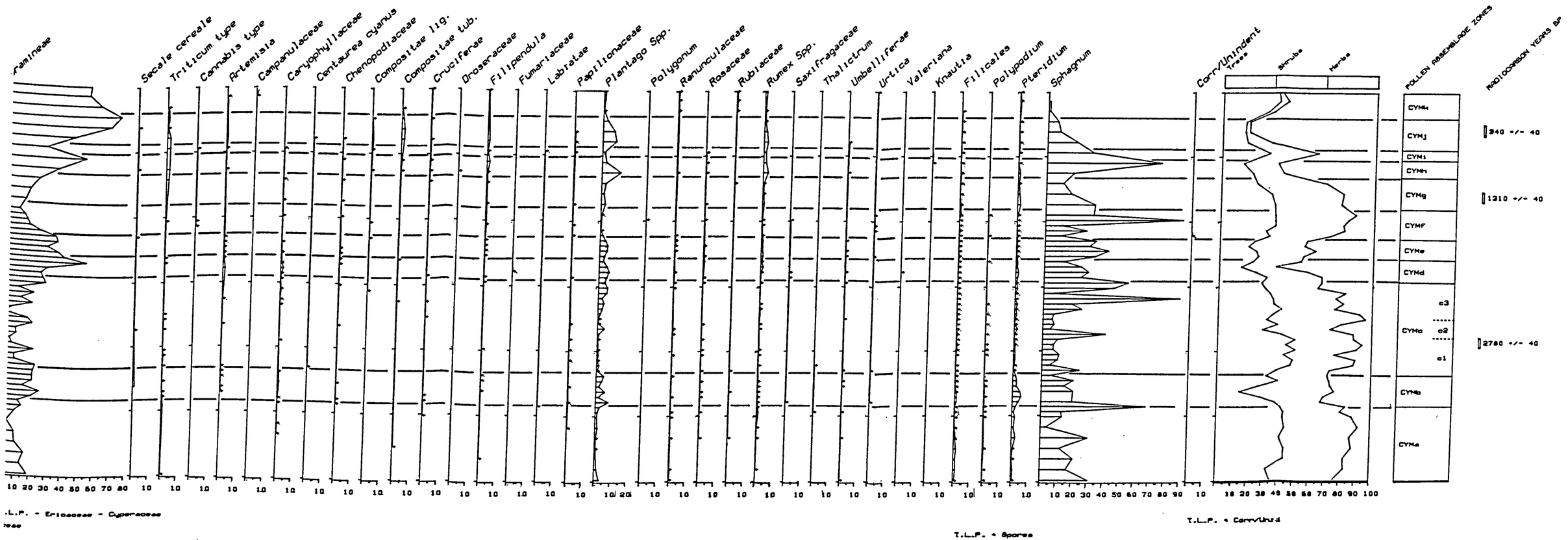


FIGURE 3.19 CRANLEY MOSS, LANARKSHIRE.



Analysis: Lisa Dumayne, 1992

FIGURE 3.20 CARSEGOWAN MOSS, WIGTONSHIRE

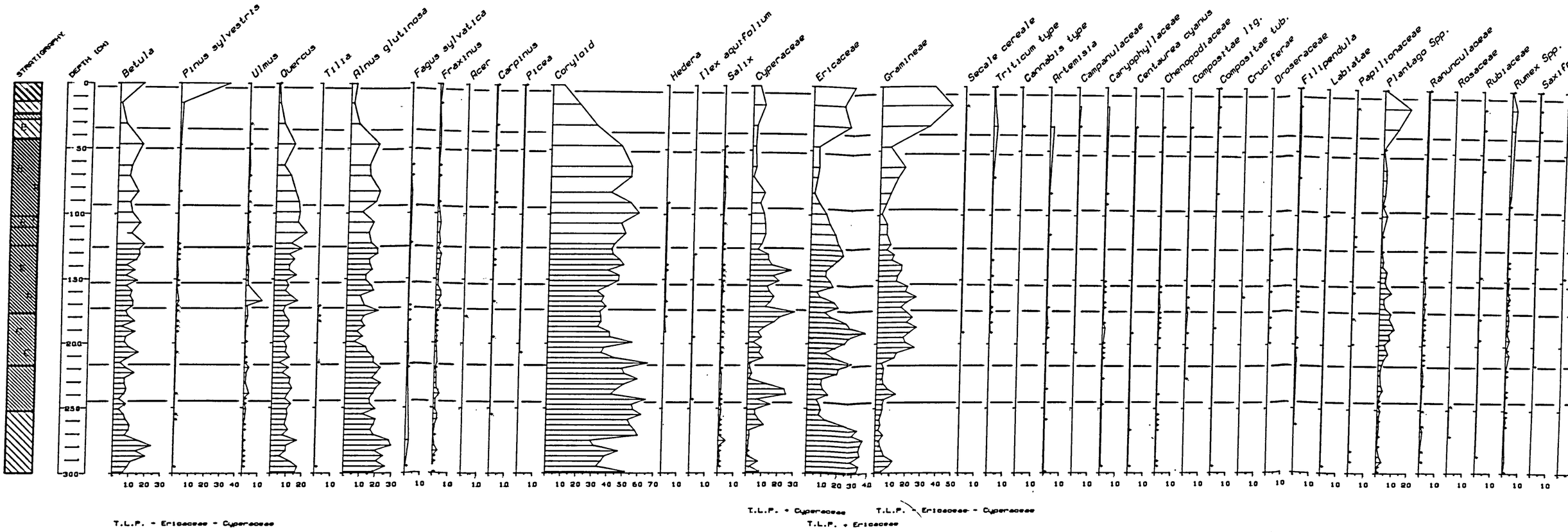
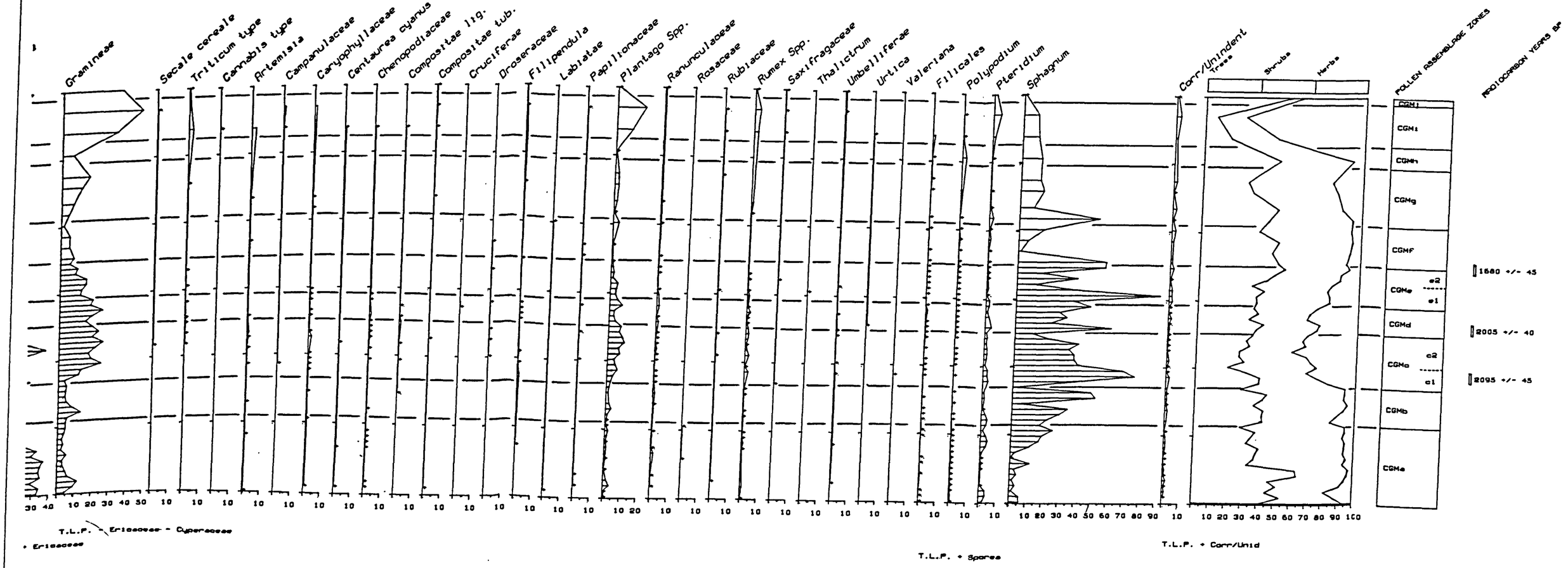


FIGURE 3.20 CARSEGOWAN MOSS, WIGTONSHIRE



Analysis: Lisa Dumayne, 1992

FIGURE 3.21 ELLERGOWER MOSS. DUMFRIESSHIRE

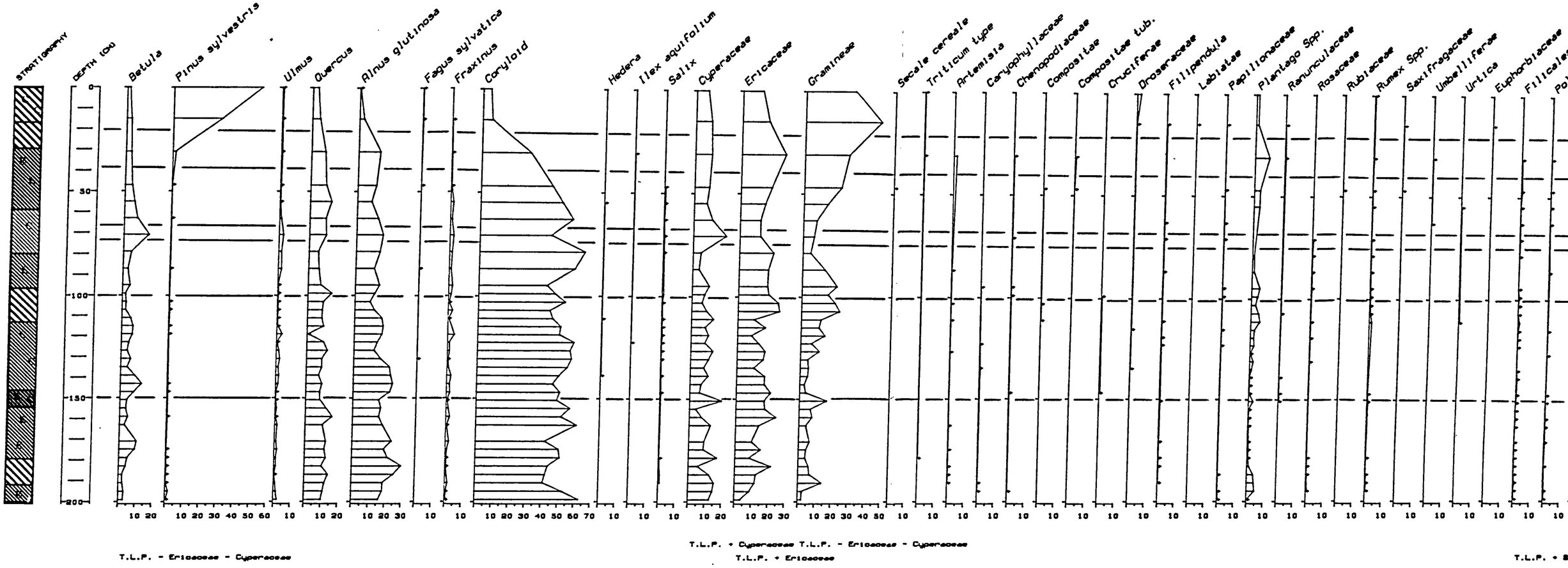
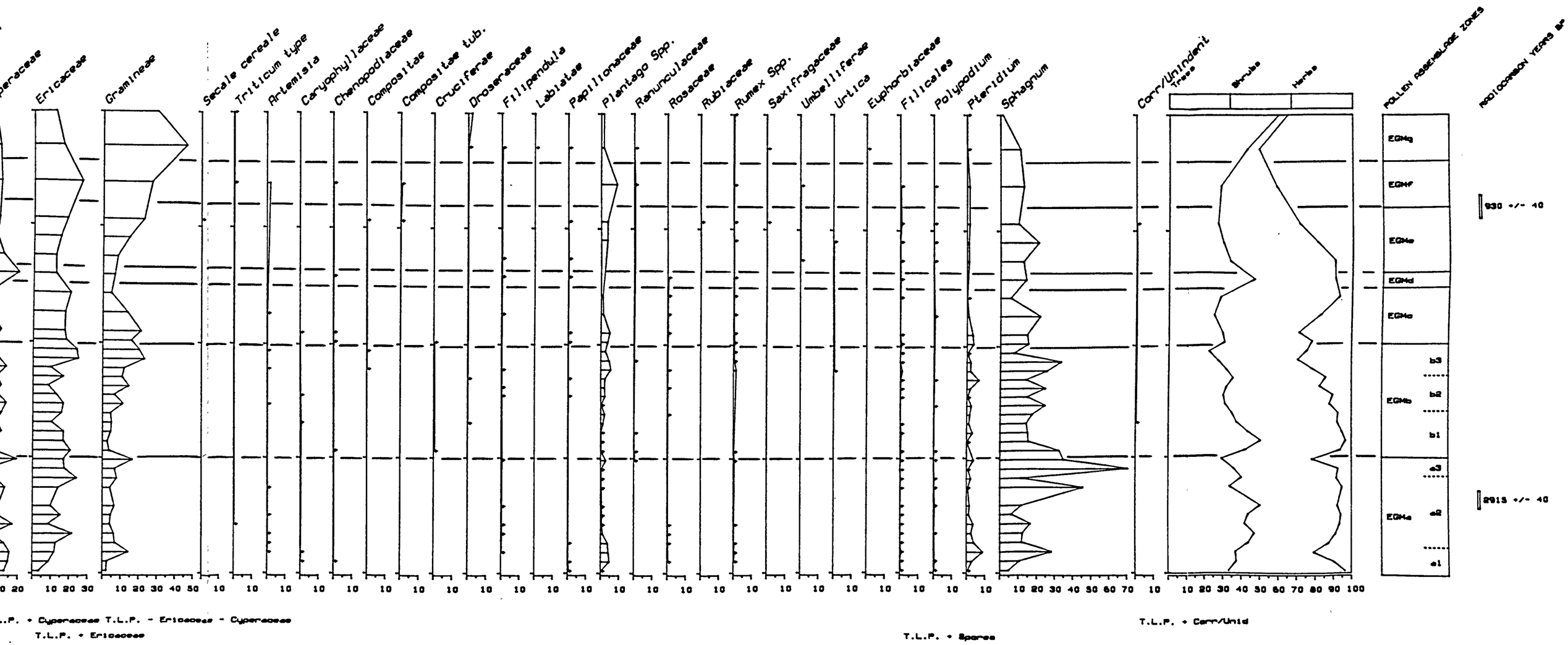
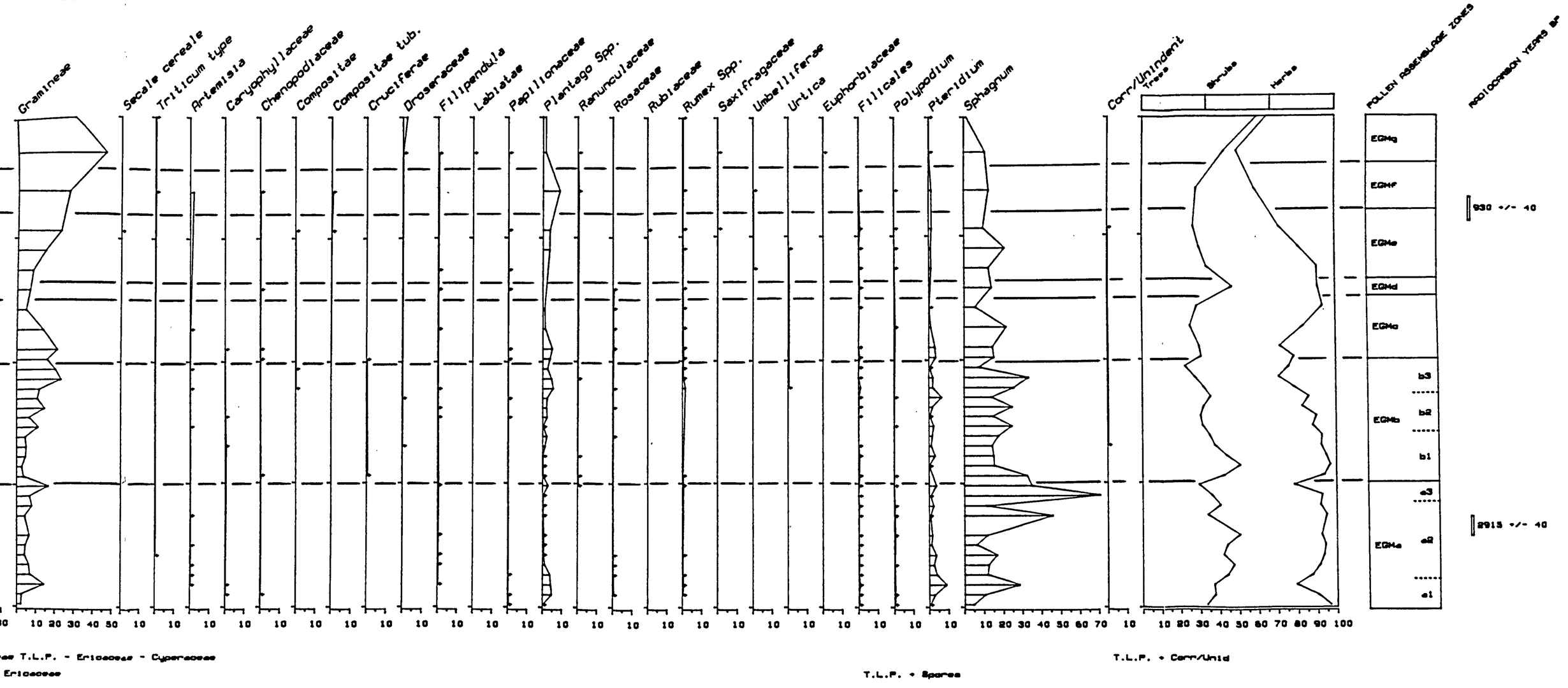


FIGURE 3.21 ELLERGOWER MOSS. DUMFRIESSHIRE



Analysis: Lisa Dumayne. 1992

FIGURE 3.21 ELLERGOWER MOSS. DUMFRIESSHIRE



Analysis: Lisa Dumayne, 1992

3.4.7 Diagram Zonation.

The use of pollen assemblage zones has been discussed by Faegri *et al.* (1989,104), Moore *et al.* (1991, 178) and Birks and Birks (1980, 168). A pollen zone has been variously defined. Strictly speaking a zone represents a biostratigraphic unit - a sequence within the diagram characterised by its flora. Pollen may be uniform throughout the zone or may undergo definite changes (Birks and Birks, 1980, 168 Faegri *et al.*, 1989, 104). A zone has also been defined as a body of sediment with a consistent and homogeneous fossil pollen content that is distinguished from adjacent sediment by differences in the kind and frequencies of its contained fossil pollen (Birks and Birks, 1980, 168). Moore *et al.* (1991, 178) state that a zone must be relatively uniform and that the zone boundary must pass through the portion of the curves where change is most marked. Pollen diagrams zoned on the basis of inferred human impact have been separated into episodes (Oldfield, 1963), sections (Turner, 1964), zonules (Edwards, 1979) and phases (Hirons and Edwards, 1986; Chambers *et al.*, 1988). The pollen diagrams in this study (Figures 3.13 to 3.21) have been divided into phases on the basis of major changes in taxa.

Various approaches to the statistical zoning of pollen diagrams have been outlined in the literature (Gordon and Birks, 1972, 1974; Walker and Wilson, 1978; Walker and Pittelkaw, 1981; Birks and Gordon, 1985, 89). Gordon and Birks (1972) conclude that:

> "inspection of pollen diagrams, the original zonations and the results of numerical analysis shows that similar stratigraphical divisions are obtained by all numerical methods and that the zonations derived at by statistical procedures correspond to those arrived at by visual inspection".

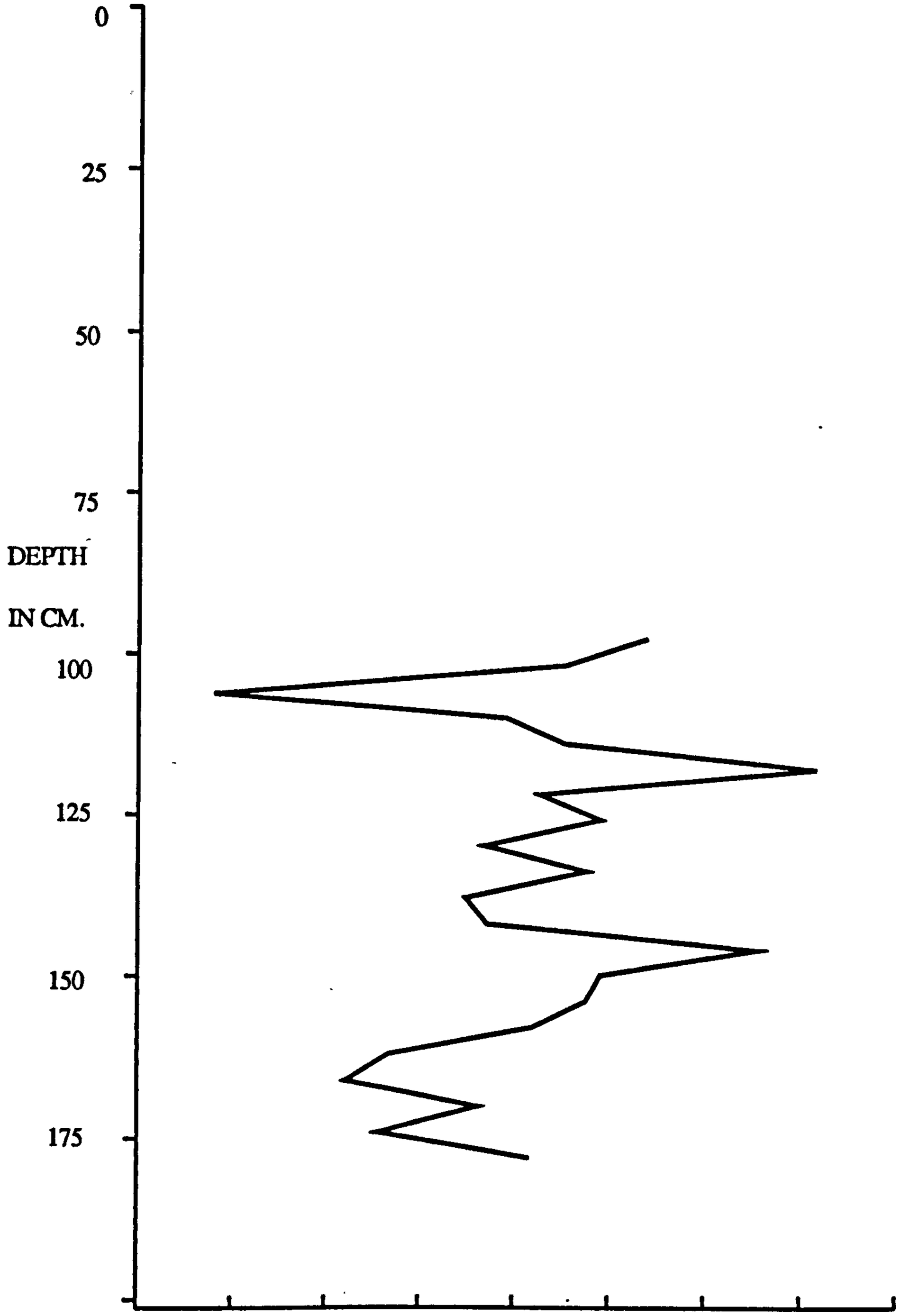
Therefore, the pollen diagrams have been zoned by eye.

3.4.8 Analysis Of Magnetic Minerals.

The magnetic properties of minerals can provide significant clues for sediment source identification (Yu and Oldfield, 1989). Magnetic susceptibility (c) is a measure of the response of a sample to the presence of a magnetic field and is the ease with which a sample can be magnetised. It provides a guide to the concentration of magnetic minerals in a sample and therefore environmental information, such as soil erosion (Thompson and Oldfield, 1986, 25). If c is measured at both low and high frequencies, frequency dependent susceptibilty (c_{fd}) can be calculated. The difference between the low and high frequency measurement is a function of the contribution to total low frequency susceptibility made by fine 'viscous' ferrimagnetic grains close to the superparamagnetic/stable single domain border. The frequency dependent susceptibility of a sample gives specific information on the proportion of the magnetic mineral content derived from the direct weathering of rock or of soil (Oldfield *et al.*, 1983; Oldfield, 1986, 55; Oldfield, 1991).

As shown by the stratigraphy (Figure 3.6), a layer of minerogenic sediment was evident between 151 cm. - 134 cm. in the core from Fozy Moss. Samples of wet sediment were taken at 1 cm. intervals between 180 cm. - 150 cm. and dried for 48 hours at 40°C. in a Gallenkamp Hotbox oven. Each dried sample was then placed in a weighed magnetics tube and tested for magnetic susceptibility and frequency dependent susceptibility using a Bartington M.S.1 susceptibility meter and a M.S.1B sensor. The values (S.I. units) were calculated on a Research Machines 4802 computer in the School of Geography, University of Oxford. The results are displayed in Figure 3.22 and show that a very low concentration of magnetic minerals was

FIGURE 3.22 LOW FREQUENCY MAGNETIC SUSCEPTIBILITY RESULTS FOR FOZY MOSS.



present. The readings were too low to give any frequency dependent results.

3.4.9 Statistical Analysis.

Multivariate statistical analysis can be used to reduce the multi-dimensional nature of complex data to a low dimensional data set, which is more easily presented and perceived (Prentice, 1986 b; Digby and Kempton, 1984). Two methods are often used on pollen data - principal components analysis (P.C.A.) or correspondence analysis (C.A.). Principal components analysis is a linear model which gives equal weight to each taxa and models the responses of each taxa in relation to the principal components axes. The axes can be thought of as theoretical environmental gradients and therefore, taxa which occur in a similar environment are represented as points situated close together. The first axis is the line of best fit through the points and the second is at right angles to the first. The eigenvalue of each point is the variance of the scores on a given principal components axis (Johnston, 1980; Gordon, 1982; Digby and Kempton, 1984). Correspondence analysis is a unimodal model and is a powerful technique for detecting patterns in complex data which include rare and abundant pollen types (Ter Braak, 1988; Birks *et al.*, 1988b).

To determine whether any distinct groupings of taxa could be identified and related to an environmental gradient the pollen data was subject to multivariate statistical analysis using the CANOCO computer programme (Ter Braak, 1988) . Turner (1986) used principal components analysis to identify groups of taxa which were likely to represent different farming communities and analysis of the data set in this study was undertaken with this objective in mind. The data from all sites was analysed using principal components analysis and correspondence analysis. The data from Walton Moss was also analysed using detrended correspondence analysis (used for data which show the arch effect using correspondence analysis (Hill, 1979; Ter Braak, 1988)). Principal components analysis was undertaken on all land pollen species, then on non-arboreal species and finally on non-arboreal pollen excluding Gramineae. Birks *et al.* (1988) discuss how principal components analysis is not suitable for identifying human impact from percentage data because numerically rare, but important, taxa are considered equal with taxa which occur in abundance. Principal components analysis was used as it is a linear model and clearance was assumed to progress in a linear manner (as clearance increases, then the abundance of herbs would increase; or as pastoral agriculture increased the abundance of pastoral indicator pollen would increase).

3.5 Radiocarbon Dating.

At least two samples from each core (total of 27) were submitted to the N.E.R.C. Radiocarbon Laboratory in East Kilbride for radiocarbon dating. ^{14}C is produced in the upper atmosphere by the action of cosmic rays and enters the earth's carbon cycle as carbon dioxide through assimilation by living organisms such as plants (Libby, 1955). When a plant dies the intake of carbon dioxide stops and the ^{14}C which it contains begins to decay at a rate of 5570 ± 30 years (i.e. the half life). The measurement of the amount of radiocarbon will allow the time which has elapsed since death to be determined (Olsson, 1968).

All samples submitted were composed of at least 85% *Sphagnum* spp., with samples containing *Eriophorum* spp. being avoided to minimise contamination caused by rootlet penetration. The problem of different carbon isotope fractionation by plants was minimised by using samples composed predominantly of *Sphagnum* spp., which exhibit similar fractionation of carbon isotopes (Pilcher, 1991 a). Other sources of error inherent in radiocarbon dating were not considered to be important for peat. Terrestrial sediments are not influenced by the hardwater effect, where submerged plants (e.g. in lakes) can extract carbon from waters contaminated with carbon from older sources such as limestone, thus giving an erroneous date. Peats,

especially in ombrotrophic deposits, are not influenced by mixing of different aged materials, by ground water percolation or any large-scale root penetration (Bowen, 1985, 117; Bradley, 1986, 55). Contamination of sample by modern carbon was avoided by extreme care whilst handling samples in the field and laboratory.

The dates quoted by the laboratory were not calendar ages and are based on the assumption that the ^{14}C content of the atmosphere has remained constant over time (Damon *et al.*, 1978; Pilcher, 1991 a). As the radiocarbon content of the atmosphere has not remained constant over time, the dates were calibrated using a computer programme (Stuiver and Reimer, 1986) based on the high precision dendrochronology calibration curves (Pearson and Stuiver, 1986; Stuiver and Becker, 1986). Such calibration sets have proved useful in solving archaeological and environmental dating problems from around the Bronze Age/Iron Age boundary, where the calibration curve is almost horizontal from 400-800 B.C. (Pearson *et al.*, 1986).

Therefore, all quoted radiocarbon dates are the calibrated dates and unless otherwise stated, are the mid-point of the date range with the highest probability at the 1d (68%) confidence level. Despite the fact that the date of a particular sample can lie anywhere within the range, the mid-point was taken in each case to provide a measure of standardisation. The 2σ(98%) confidence limit was not used in the interpretation, as the ranges on these dates are too wide, presenting a problem when relatively short archaeological events need to be dated. This problem cannot be avoided and therefore caution must surround the interpretations. Also the dates at some levels were obtained by correlations using the pollen record and documented events (e.g. Pine rise) and therefore, the 98% confidence limit dates can to some extent be considered to be less useful. Appendix 1 contains a list of dates, their calibrations and the probabilities. The age-depth curves for each site have been calculated using the mid points of the range with the highest probability at the 68% confidence level and are displayed in Figures 3.23 to 3.31 as they form the basis of the following interpretations and discussion. The error bars have not been plotted, but the estimated errors can be found in Appendix 1. The age of the peat in between each pair of radiocarbon dates has been extrapolated using the accumulation rate curves. However, it is important to recognise that interpolation between the radiocarbon dated samples assumes that the growth rate was constant between the dated levels and inaccuracies in extrapolation increase as a sample becomes further away from the radiocarbon date. Many radiocarbon dates for diagrams published in the literature were not calibrated prior to publication and therefore they have been calibrated using the method outlined above to increase the accuracy of the dates and to allow comparison with known archaeological events and with the dates in this study (Appendix 1).

FIGURE 3.23 AGE-DEPTH CURVE FOR WALTON MOSS.

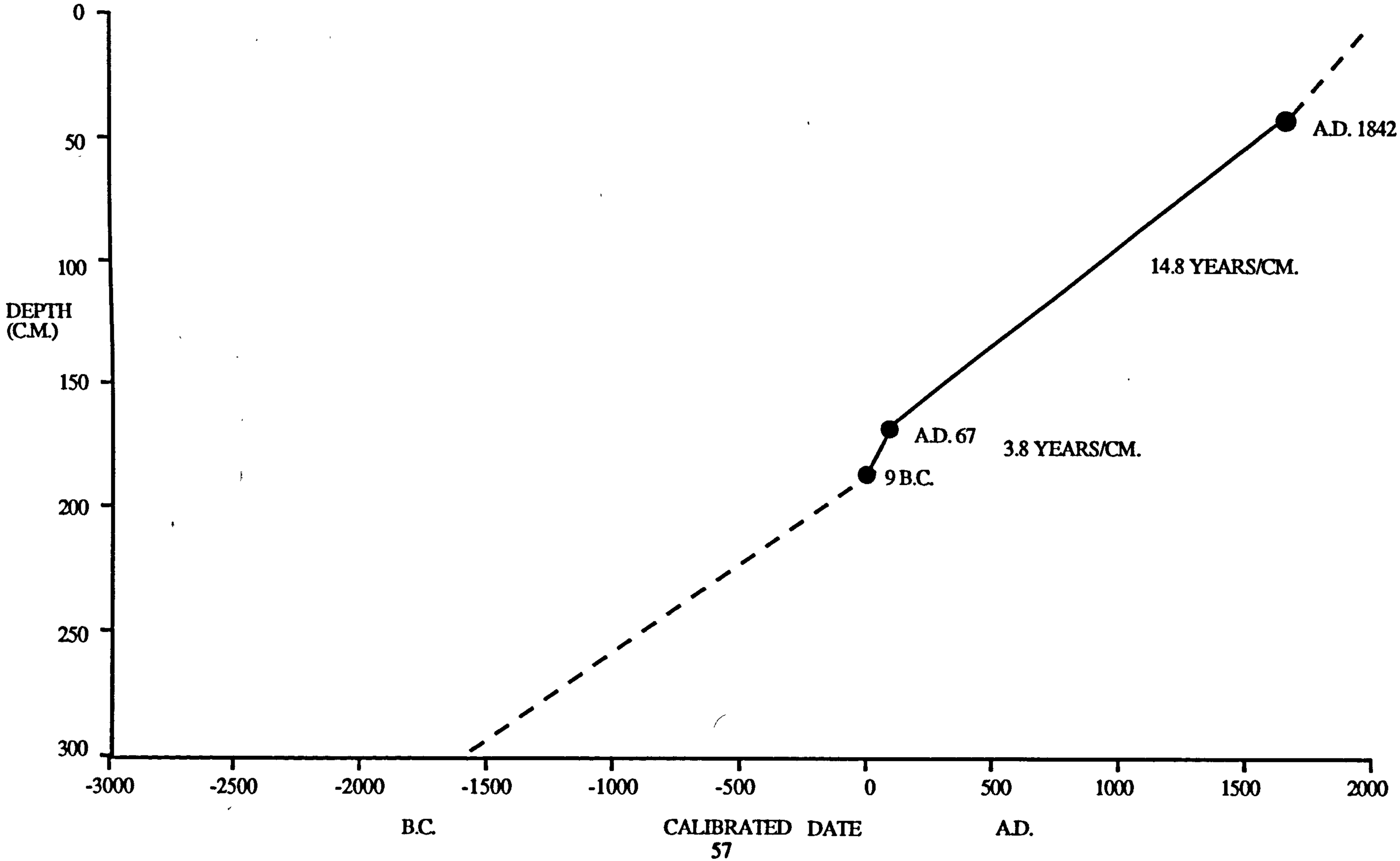


FIGURE 3.24 AGE-DEPTH CURVE FOR GLASSON MOSS.

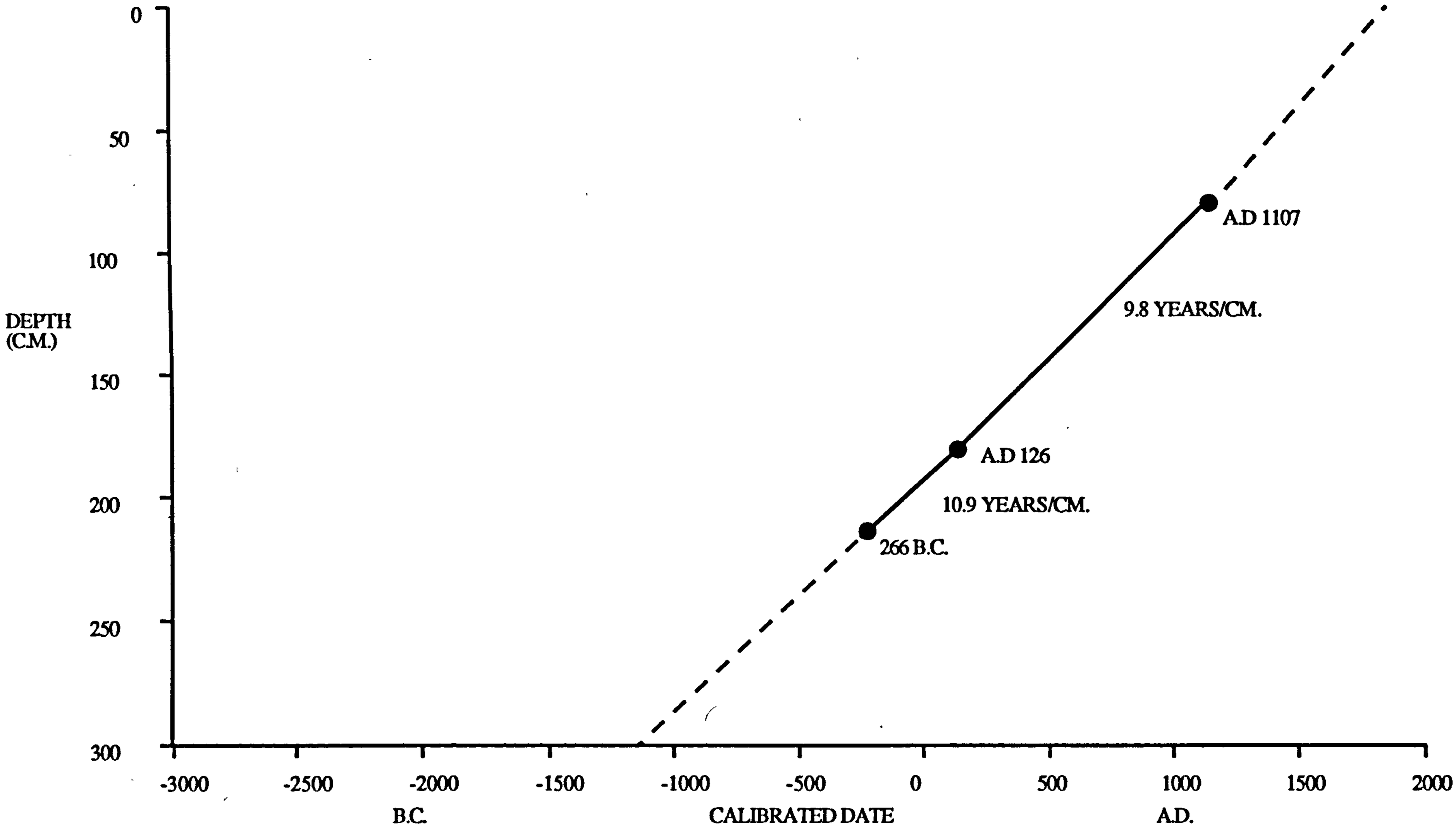


FIGURE 3.25 AGE-DEPTH CURVE FOR FOZY MOSS.

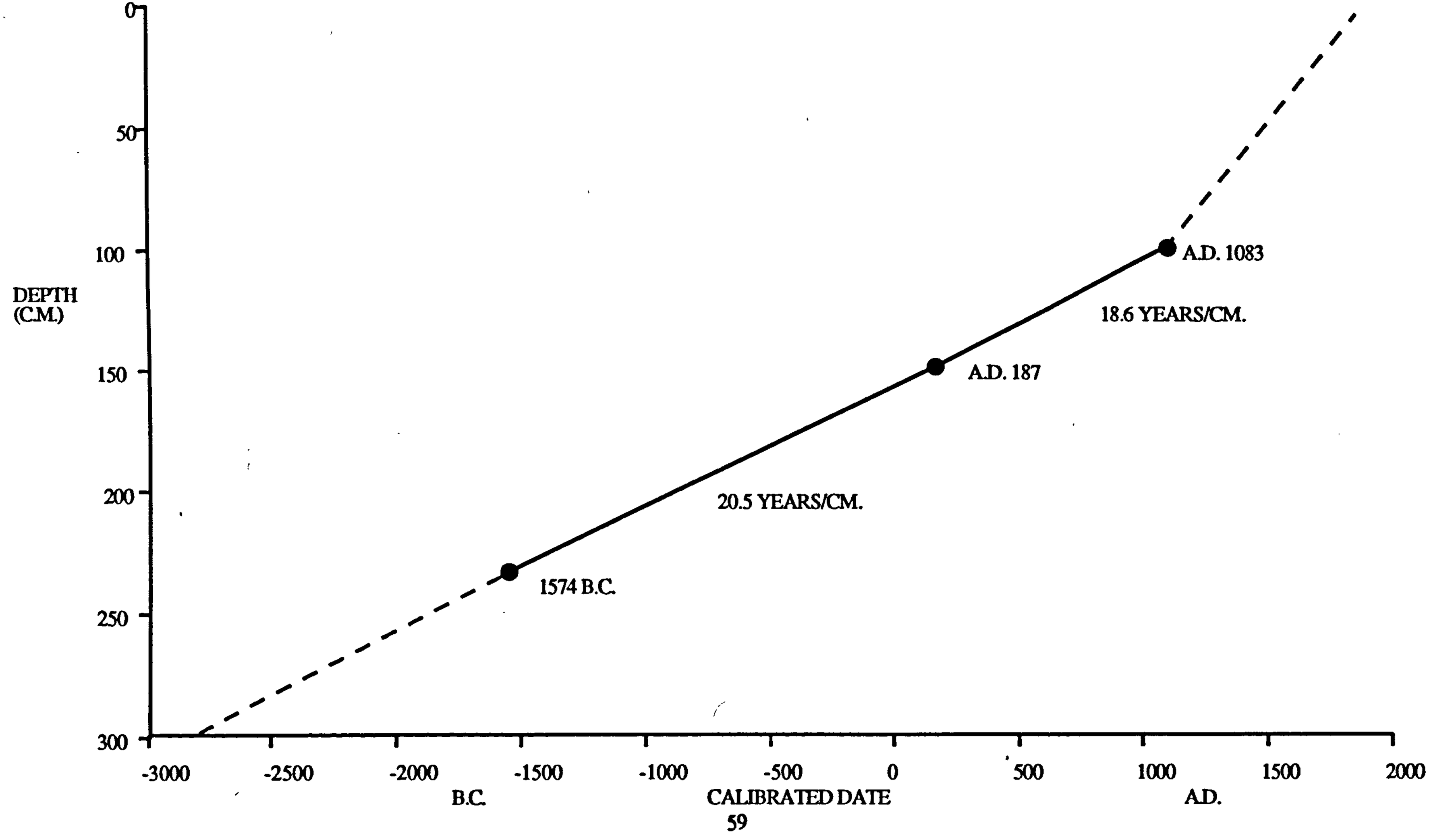


FIGURE 3.26 AGE-DEPTH CURVE FOR LETHAM MOSS.

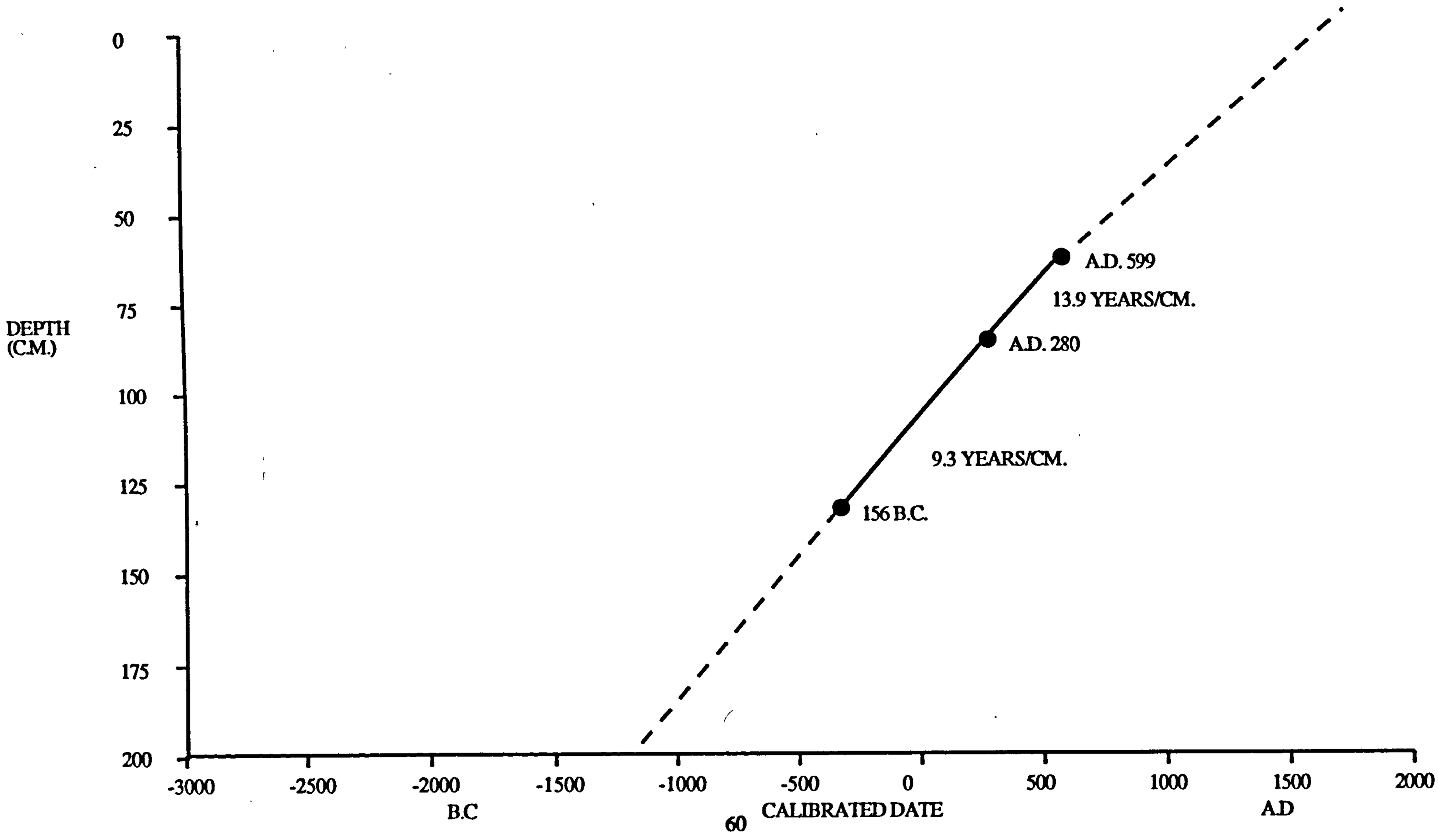


FIGURE 3.27 AGE-DEPTH CURVE FOR FANNYSIDE MUIR.

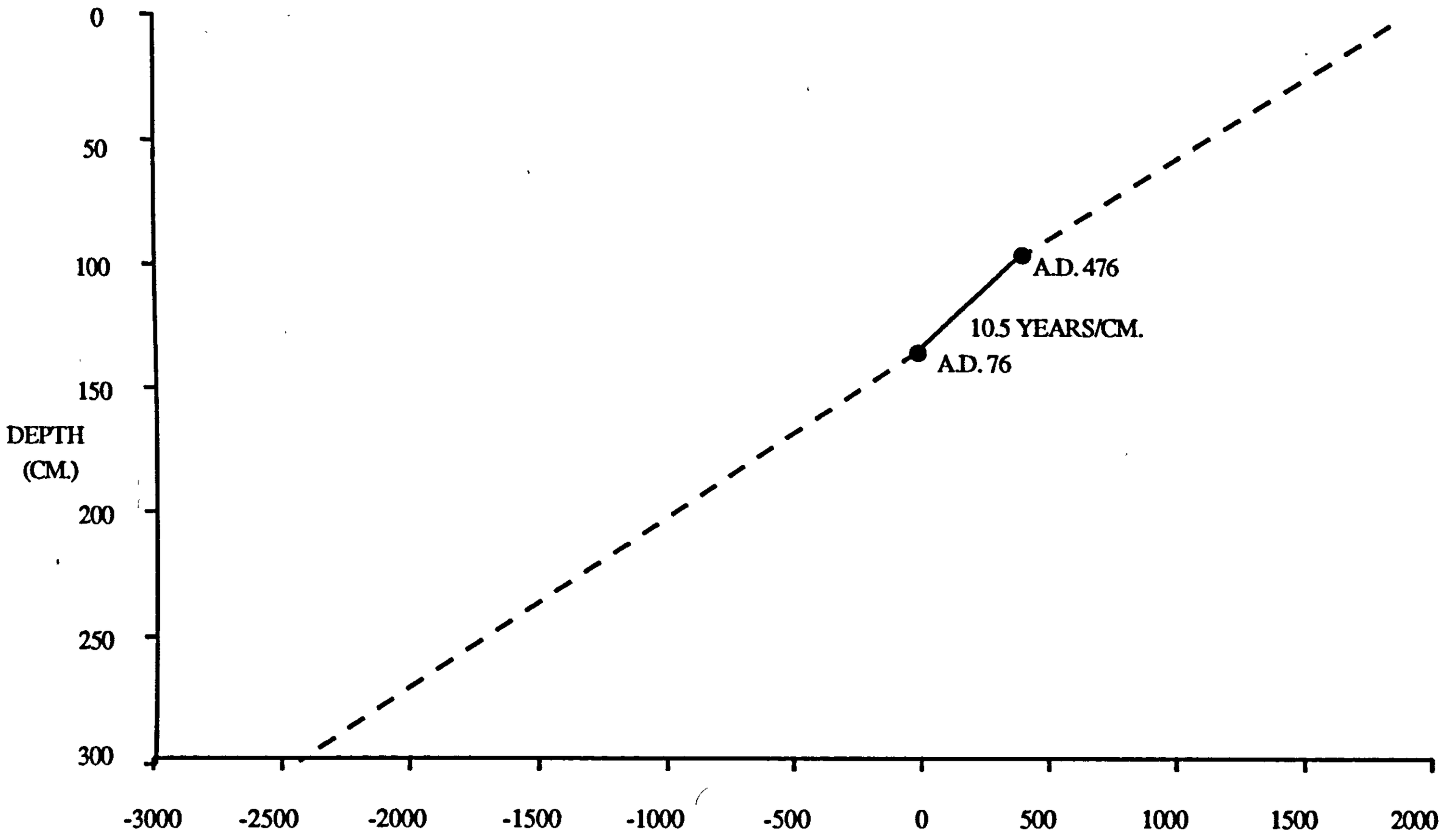


FIGURE 3.28 AGE-DEPTH CURVE FOR DOGDEN MOSS.

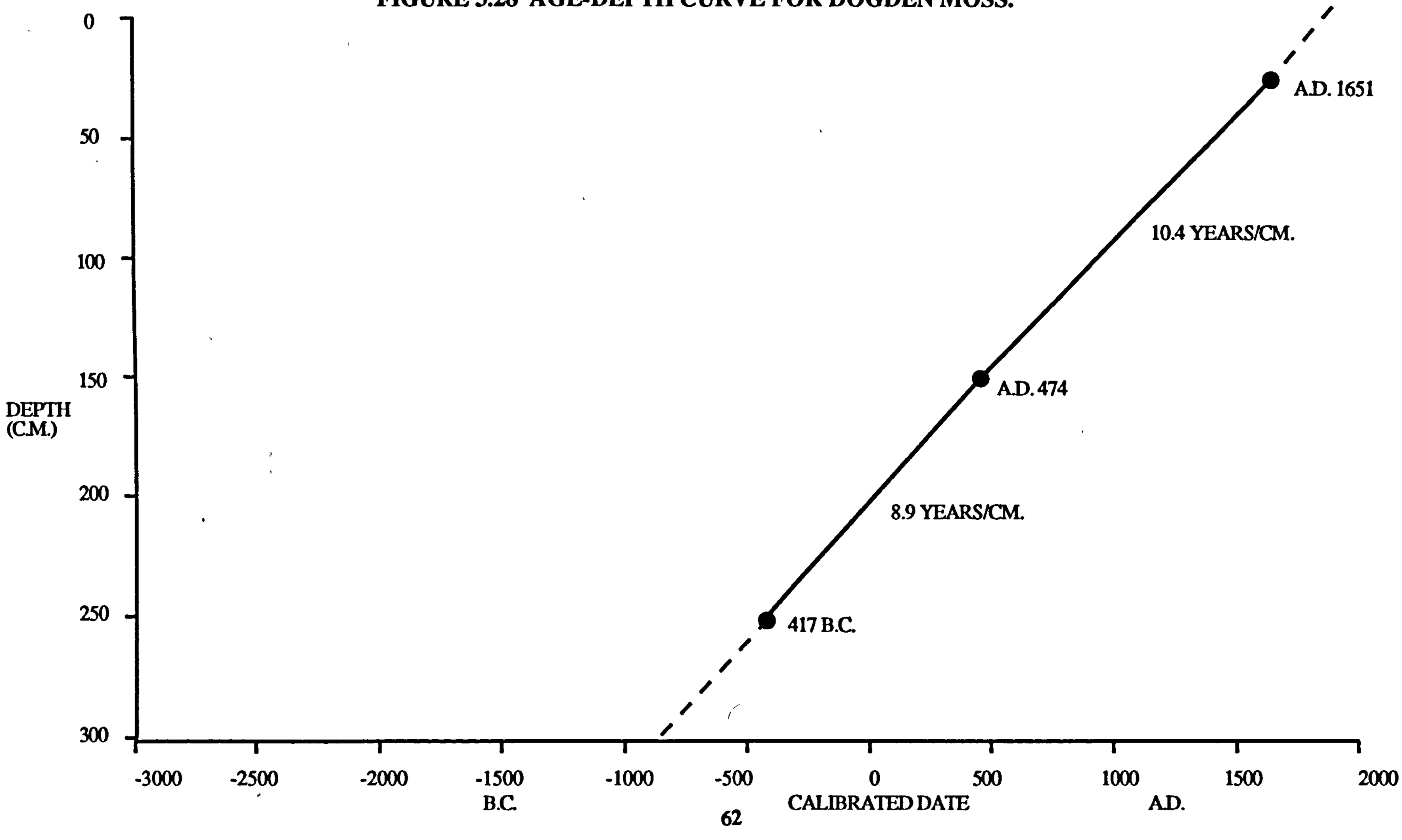


FIGURE 3.29 AGE-DEPTH CURVE FOR CRANLEY MOSS.

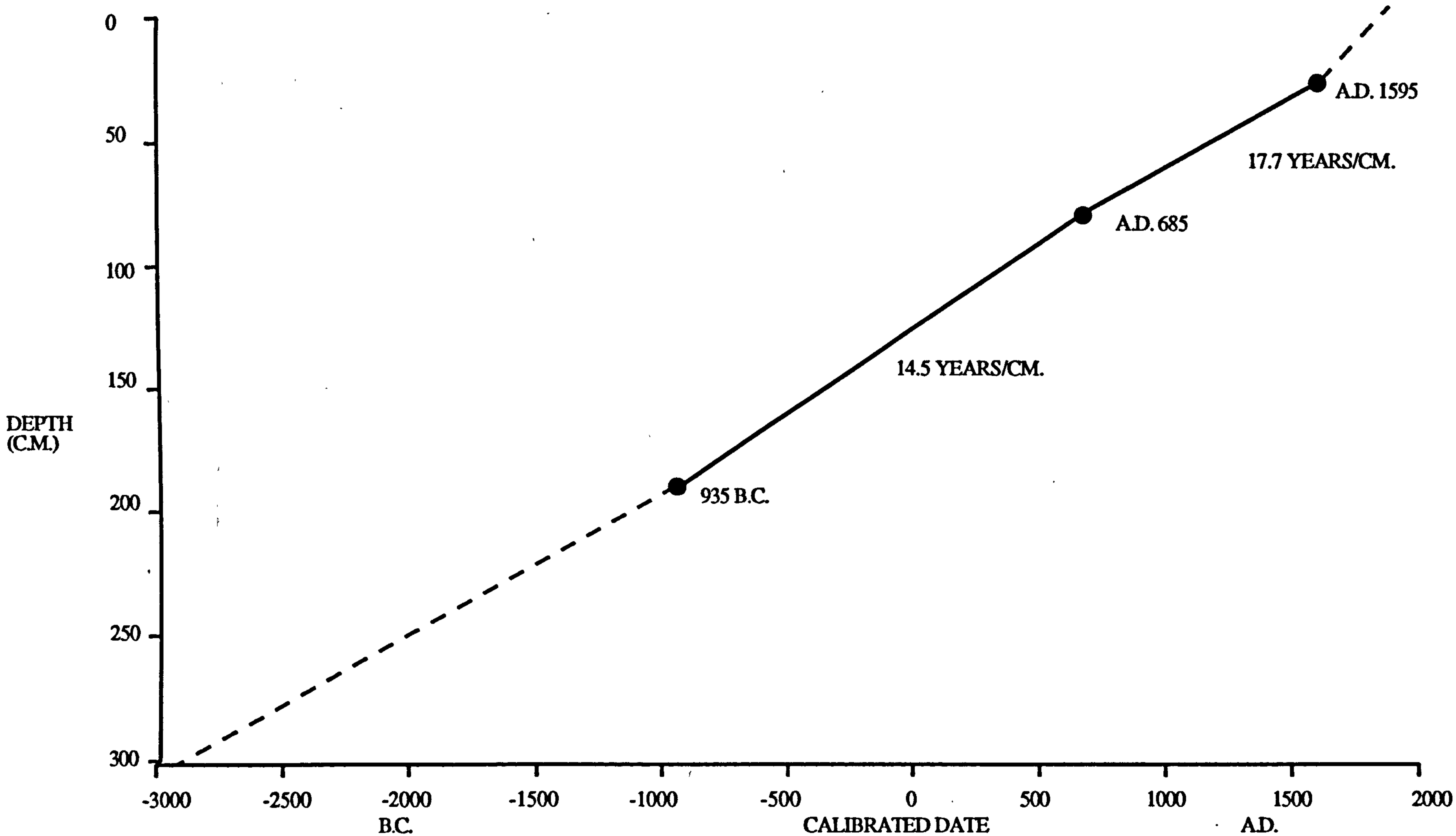


FIGURE 3.30 AGE-DEPTH CURVE FOR CARSEGOWAN MOSS.

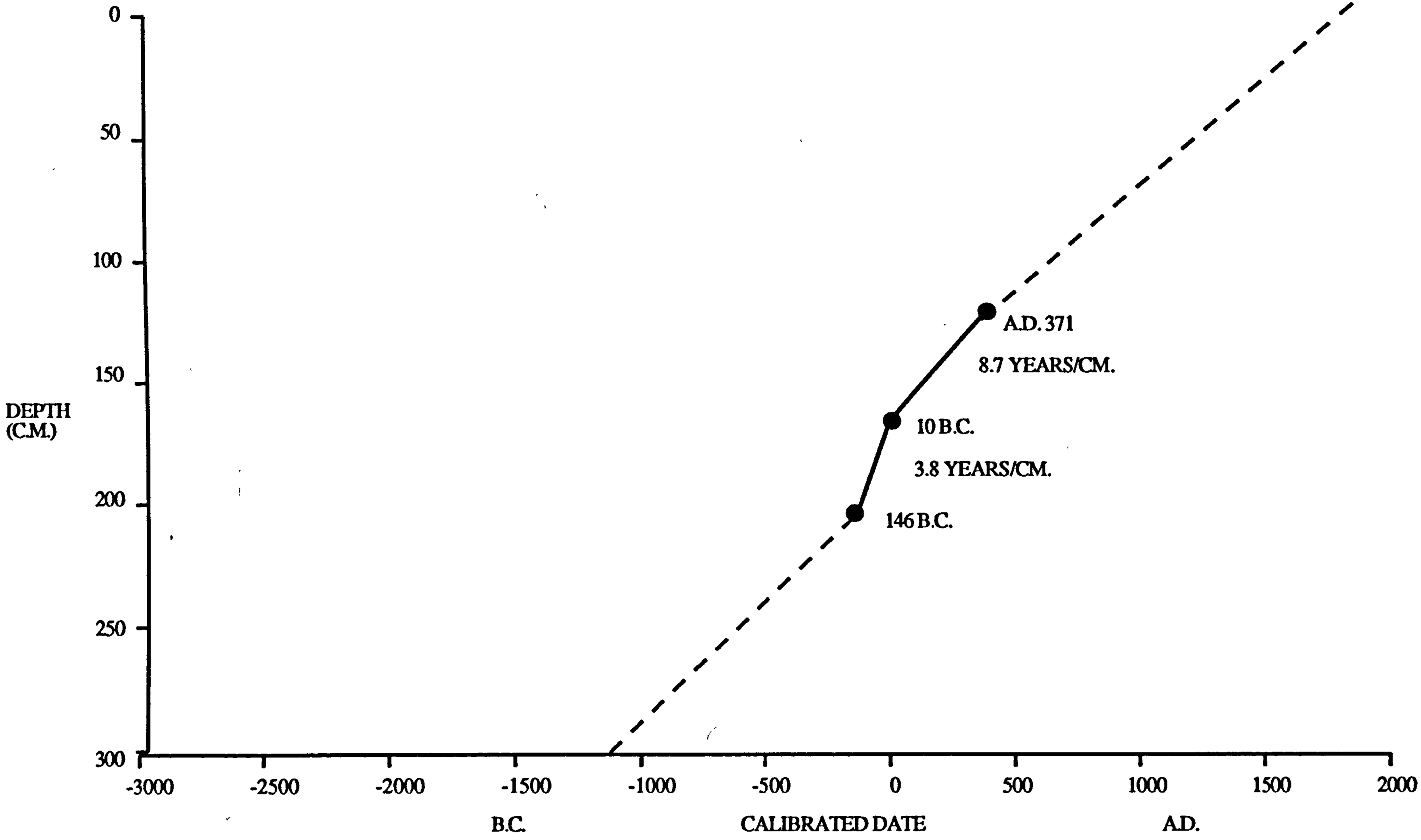
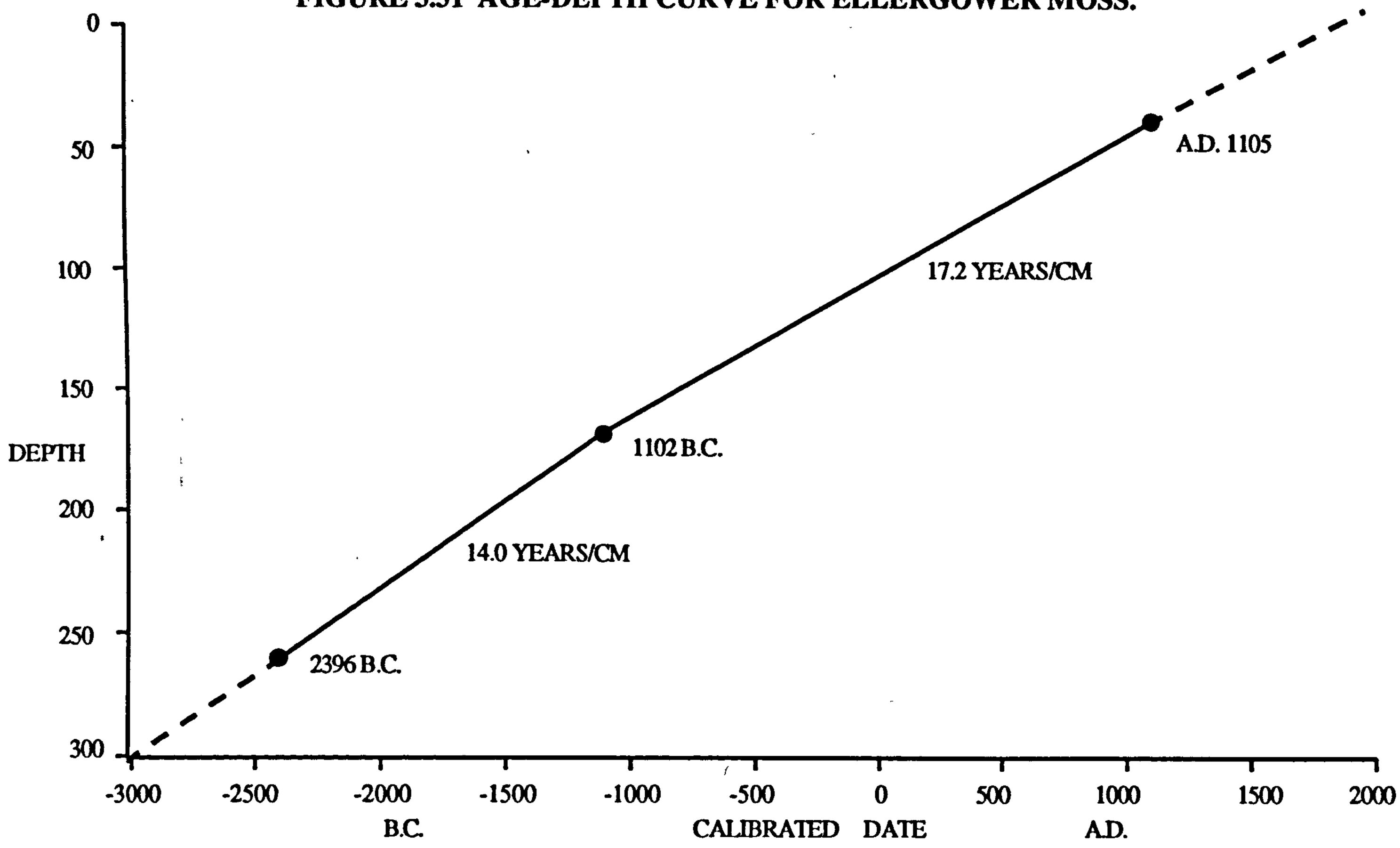


FIGURE 3.31 AGE-DEPTH CURVE FOR ELLERGOWER MOSS.



CHAPTER 4.

POLLEN DIAGRAM DESCRIPTION.

For the purposes of pollen diagram description, only those taxa which are affected by and related to anthropogenic impact on vegetation are described. Therefore, changes in the *Sphagnum* spp., Cyperaceae and Ericaceae curves are not discussed. The phases are summarised in Tables 4.1 to 4.9 and Figure 4.1.

4.1 Walton Moss.

4.1.1 WLMa 300-226cm..

Phase WLMa is divided into two sub-phases - $WLMa_1$ and $WLMa_2$ - based upon a decline in arboreal pollen to 90%.

The earliest pollen spectra at this site ($WLMa_1$ 300-258cm.) are dominated by arboreal pollen, which does not fall below 95%. This is composed predominantly of Coryloid, which fluctuates around 30-40%, with *Betula*, *Quercus* and *Alnus* each around 15-30%. *Fraxinus*, *Pinus*, *Fagus*, *Salix* and *Ulmus* are present, but all below 5%. Gramineae does not rise above 5%, whilst other herb types and *Pteridium* are barley present.

Phase $WLMa_2$ (258-226cm.) is differentiated from phase $WLMa_1$ by a fall in arboreal pollen to 90%. This fall in arboreal pollen is accounted for by a decline in Coryloid from 65% to 50%. *Betula*, *Alnus* and *Quercus* remain more or less constant at 20 - 30%. *Fraxinus*, *Ulmus* and *Pinus* are present. Gramineae rises from 2% to 10% and the pollen of non-arboreal plants begins to appear. *Triticum* type occurs at 256 cm. and 252cm., whilst *Rumex* spp. are present for the first time. The *Plantago* spp. curve becomes continuous and remains around 2%. *Artemisia*, Compositae tub., Cruciferae, Rosaceae and Ranunculaceae occur sporadically throughout the phase.

4.1.2 WLMb 226-197cm..

Phase WLMb (226-197cm.) is characterised by a further steady fall in arboreal pollen from 90% to 80%. This is accounted for by a fall in Coryloid to 45% and a decrease in *Betula* to 10%. Gramineae, *Pteridium* and *Plantago* spp. continue to rise to 20%, 5% and 5% respectively. Non-arboreal pollen types occur more frequently and include *Artemisia*, Caryophyllaceae, *Centauria*, Chenopodiaceae, *Filipendula*, Papilionaceae, *Rumex* spp. and Ranunculaceae. Cereals are absent.

4.1.3 WLMc 197-173cm..

WLMc opens with a pronounced decline in arboreal pollen to 40%. The phase has been divided into two based upon changes in Gramineae pollen.

$WLMc_1$ (197-185cm.) is a period in which arboreal pollen declines rapidly to 48%, although there is a slight upsurge to 65% in the middle of this phase. All arboreal pollen types decline. *Betula* falls below 10%, *Quercus* and *Alnus* to 15% and Coryloid from 50% to 25%. Gramineae rises rapidly from 10% to

POLLEN DIAGRAM DIVISION.

Table 4.1 Division of the Walton Moss Pollen Diagram.

PHASE	DEPTH IN CM	^{14}CDATE	PERIOD
WLMa1	300-258	1490-930 BC	E. BRONZE
WLMa2	258-226	930-510 BC	L. BRONZE
WLMb	226-197	510-115 BC	E. IRON
WLMc1	197-185	115BC-AD5	L. IRON
WLMc2	185-173	AD5-70	L. IRON
WLMd	173-162	AD70-125	ROMAN
WLMe1	162-146	AD125-395	ROMAN
WLMe2	146-134	AD395-570	CELTIC
WLMf	134-108	AD570-955	ANGLIAN
WLMg	108-90	AD955-1220	SCANDINAVIAN
WLMh	90-66	AD1220-1580	MEDIEVAL
WLMi	66-44	AD1580-1840	MEDIEVAL
WLMj	44-18	AD1840-1930	IMPROVEMENT
WLMk	18-0	AD1930-1990	MODERN

Table 4.2 Division of the Glasson Moss Pollen Diagram.

PHASE	DEPTH IN CM	^{14}CDATE	PERIOD
GLMa1	300-274	1085-800BC	E. BRONZE
GLMa2	274-250	800-550BC	L. BRONZE
GLMb1	250-222	550-270BC	E. IRON
GLMb2	222-188	270BC-AD125	L. IRON
GLMc	188-170	AD125-285	ROMAN
GLMd	170-132	AD 285-635	ROMAN
GLMe	132-115	AD635-795	CELTIC
GLMf	115-106	AD795-890	ANGLIAN
GLMg	106-72	AD890-1235	SCANDINAVIAN
GLMh	72-52	AD1235-1445	MEDIEVAL
GLMi	52-34	AD1445-1630	MEDIEVAL
GLMj	34-0	AD1630-1985	IMPROVEMENT +MODERN

Table 4.3. Division of the Fozy Moss Pollen Diagram.

PHASE	DEPTH IN CM	^{14}CDATE	PERIOD
FZMa1	300-279	2800-2385BC	NEOLITHIC
FZMa2	279-234	2385-1575BC	NEOLITHIC
FZMb	234-202	1575-835BC	E. BRONZE
FZMc1	202-190	835-590BC	L. BRONZE
FZMc2	190-178	590-345BC	E. IRON
FZMc3	178-162	345-15BC	L. IRON
FZMc4	162-152	15BC-AD185	INVASION
FZMd1	152-142	AD185-370	ROMAN
FZMd2	142-131	AD370-580	ROMAN
FZMe	131-119	AD580-800	ANGLIAN
FZMf	119-102	AD800-1085	SCANDINAVIAN
FZMg	102-90	AD1085-1205	ANGLO-SAXON
FZMh1	90-80	AD1205-1290	MEDIEVAL
FZMh2	80-50	AD1290-1555	MEDIEVAL
FZMi	50-25	AD1555-1770	MEDIEVAL
FZMj	25-12	AD1770-1885	IMPROVEMENT
FZMk	12-0	AD1885-1990	MODERN

Table 4.4 Division of the Letham Moss Pollen Diagram.

PHASE	DEPTH IN CM.	^{14}CDATE	PERIOD
LTMa	180-164	735-610BC	BRONZE
LTMb1	164-150	610-390BC	E.IRON
LTMb2	150-136	390-160BC	M.IRON
LTMc1	136-120	160-15BC	L.IRON
LTMc2	120-106	15BC-AD120	INVASION
LTMd1	106-100	AD120-170	ROMAN
LTMd2	100-90	AD170-280	ROMAN
LTMe	90-68	AD280-600	ROMAN
LTMf	68-56	AD600-780	CELTIC
LTMg	56-39	AD780-1170	ANGLIAN
LTMh	39-30	AD1170-1390	MEDIEVAL
LTMi	30-15	AD1390-1790	IMPROVEMENT
LTMj	15-0	AD1790-1980	MODERN

Table 4.5 Division of the Fannyside Muir Pollen Diagram.

PHASE	DEPTH IN CM	^{14}CDATE	PERIOD
FSMa	300-254	2455-1775BC	NEOLITHIC
FSMb	254-214	1775-1180BC	E.BRONZE
FSMc1	214-189	1180-810BC	M.BRONZE
FSMc2	189-173	810-575BC	L.BRONZE
FSMd	173-158	575-350BC	E.IRON
FSMe	158-135	350BC-AD75	L.IRON
FSMf1	135-117	AD75-200	ROMAN
FSMf2	117-110	AD200-255	ROMAN
FSMg	110-89	AD255-475	ROMAN
FSMh	89-68	AD475-860	CELTIC
FSMi	68-50	AD860-1160	SCANDINAVIAN
FSMj	50-35	AD1160-1410	MEDIEVAL
FSMk	35-15	AD1410-1740	MEDIEVAL
FSMl	15-0	AD1740-1991	IMPROV/MOD

Table 4.6 Division of the Dogden Moss Pollen Diagram.

PHASE	DEPTH IN CM	^{14}CDATE	PERIOD
DGMa	300-257	850-420BC	BRONZE
DGMb	257-232	420-235BC	E.IRON
DGMc1	232-210	235-20BC	L.IRON
DGMc2	210-194	20BC-AD120	INVASION
DGMd	194-186	AD120-195	ROMAN
DGMe	186-153	AD195-475	ROMAN
DGMf1	153-130	AD475-690	CELTIC
DGMf2	130-98	AD690-1060	MONASTIC
DGMg	98-82	AD1060-1270	MEDIEVAL
DGMh	82-66	AD1270-1390	MEDIEVAL
DGMi	66-36	AD1390-1675	MEDIEVAL
DGMj	36-29	AD1675-1845	IMPROVEMENT
DGMk	29-0	AD1845-1990	MODERN

Table 4.7 Division of the Cranley Moss Pollen Diagram.

PHASE	DEPTH IN CM	^{14}CDATE	PERIOD
CYMa	300-242	2565-1650BC	NEOLITHIC
CYMb	242-218	1650-1285BC	E.BRONZE
CYMc1	218-189	1285-935BC	M.BRONZE
CYMc2	189-174	935-660BC	L.BRONZE
CYMc3	174-146	660-255BC	E.IRON
CYMd	146-129	255-140BC	L.IRON
CYMe	129-113	140BC-AD210	ROMAN
CYMf	113-90	AD210-555	ROMAN
CYMg	90-66	AD555-950	CELTIC
CYMh	66-52	AD950-1160	NORSE
CYMi	52-44	AD1160-1300	MEDIEVAL
CYMj	44-20	AD1300-1670	MEDIEVAL
CYMk	20-0	AD1670-1990	IMPROVEMENT +MODERN

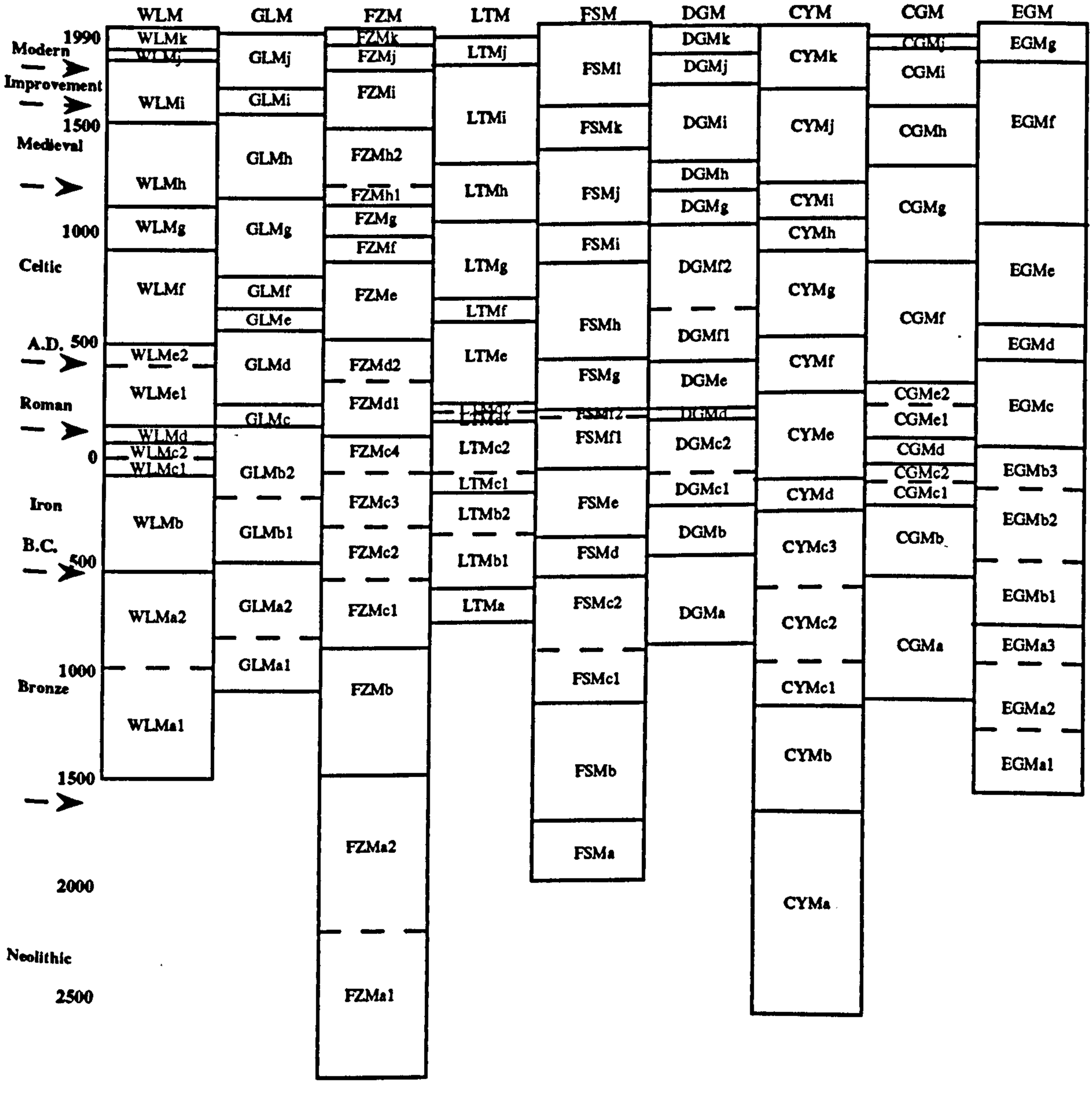
Table 4.8 Division of the Carsegowan Moss Pollen Diagram.

PHASE	DEPTH IN CM	^{14}CDATE	PERIOD
CGMa	300-242	1135-540BC	BRONZE
CGMb	242-214	540-250BC	E.IRON
CGMc1	214-198	250-150BC	M.IRON
CGMc2	198-174	150-10BC	L.IRON
CGMd	174-154	10BC-AD110	INVASION
CGMe1	154-138	AD110-235	ROMAN
CGMe2	138-125	AD235-370	ROMAN
CGMf	125-95	AD370-785	CELTIC
CGMg	95-52	AD785-1365	SCANDINAVIAN
CGMh	52-36	AD1365-1585	MEDIEVAL
CGMi	36-5	AD1585-1915	IMPROVEMENT
CGMj	5-0	AD1915-1955	MODERN

Table 4.9 Division of the Ellergower Moss Pollen Diagram.

PHASE	DEPTH IN CM	^{14}CDATE	PERIOD
EGMa1	200-189	1520-1385BC	BRONZE
EGMa2	189-158	1385-930BC	BRONZE
EGMa3	158-150	930-790BC	BRONZE
EGMb1	150-130	790-450BC	E.IRON
EGMb2	130-114	450-170BC	E.IRON
EGMb3	114-100	170BC-AD70	L.IRON
EGMc	100-75	AD70-410	ROMAN
EGMd	75-68	AD410-620	CELTIC
EGMe	68-40	AD620-1105	SCANDINAVIAN
EGMf	40-20	AD1105-1770	MEDIEVAL+IMP ROVEMENT
EGMg	20-0	AD1770-1990	IMPROVEMENT +MODERN

FIGURE 4.1 POLLEN PHASES PLOTTED AGAINST AGE.



30% with a similar trend apparent in the *Plantago* spp. and *Rumex* spp. curves which rise to 10% and 5% respectively. The curves of *Triticum* type, *Artemisia*, Caryophyllaceae, Chenopodiaceae, Compositae lig., Cruciferae and Ranunculaceae become more or less continuous. Compositae tub. appears for the first time and *Polygonum*, Labiatae, Rubiaceae, *Urtica* and Rosaceae are present.

$WLMc_2$ (185-173cm.) opens with a further rapid fall in arboreal pollen to 40%. This is accounted for by the continued decline in Coryloid to 20% and *Quercus* to 10%. *Pinus*, *Ulmus*, *Salix* and *Fraxinus* become more frequent. Gramineae continues to rise and reaches a peak of 48%. *Plantago* spp. reach their acme level for the whole diagram - 15%. The other non-arboreal pollen types continue from phase $WLMc_1$, whilst *Pteridium* declines to 3%.

4.1.4 WLMd 173-162cm..

Phase WLMd (173-162cm.) is differentiated from $WLMc_2$ by a rapid rise in arboreal pollen to 90%. *Betula*, *Quercus*, *Alnus* and Coryloid rise to 10%, 25%, 24% and 50% respectively. A break in the *Pinus*, *Salix* and *Fraxinus* curves occur. There are scattered occurrences of *Hedera* and *Ilex*. Gramineae falls to 10% and *Plantago* spp. and *Rumex* spp. to below 5%. *Secale cereale* and *Triticum* type are present. Caryophyllaceae and Chenopodiaceae continue to occur from the previous phase, but other non-arboreal pollen types, such as *Artemisia*, Compositae lig., Compositae tub., *Filipendula* and Ranunculaceae, disappear throughout the phase.

4.1.5 WLMe 162-134cm..

Phase WLMe is divided into 2 sub-phases.

Phase $WLMe_1$ (162-146cm.) is distinguished from WLMd by a steady fall in arboreal pollen to 50%. *Betula* falls to just 2%, Coryloid to 30% and *Alnus* to 10%. *Quercus* remains virtually constant. The curves of *Fraxinus* and *Pinus* become continuous again. Gramineae recovers and reaches 40% by the end of the phase. *Plantago* spp. rise to 10% and remain at this level throughout. *Triticum* type, but no *Secale cereale*, is present. *Rumex* spp. and other non-arboreal pollen types, including Compositae lig., *Filipendula*, Caryophyllaceae, Chenopodiaceae, Papilionaceae and Ranunculaceae, become more frequent.

Phase $WLMe_2$ (146-134cm.) begins with a further sharp decrease in arboreal pollen to 25%, though *Fraxinus* peaks at 3%. Gramineae rises to its highest level yet - 60% and after a slight decline, *Plantago* spp. increase to 10%. Cereals occur only at the top of the phase. Other non-arboreal pollen types continue from phase $WLMe_1$. Papilionaceae and Chenopodiaceae increase slightly and Compositae tub. and *Epilobium* recur.

4.1.6 WLMf 134-108cm..

A large fall in Gramineae to 40% marks the beginning of this phase. It is accompanied by a corresponding rise in arboreal pollen to 53%. Coryloid rises to 35% and *Betula* reaches 5% for the first time since Phase WLMc. *Fraxinus* continues to rise to 5% and there are scattered occurrences of *Carpinus*, *Picea*, *Pinus* and *Ulmus*. By the end of this phase, Gramineae reaches 45% and arboreal pollen falls to 50%. *Plantago* spp. remain around 8%, though *Rumex* spp. decline. *Triticum* type and *Secale cereale* are present and *Cannabis* type occurs for the first time. Other herbs are present - *Artemisia*, *Centauria*, Caryophyllaceae, Compositae

lig., Papilionaceae, Umbelliferae and *Urtica* - though are less frequent than in Phase WlMe$_2$. *Pteridium* also declines.

4.1.7 WLMg 108-90cm..

This short phase begins with a further fall in non-arboreal pollen as arboreal pollen rises to 75%. Coryloid rises to 50% and *Alnus* to 18%, whilst *Quercus* actually falls to 7%. Gramineae sinks to 18% and *Plantago* spp. to below 5%. *Rumex* spp. rise to 5%. *Triticum* type and *Secale cereale* also occur. Other non-arboreal pollen types, which include *Filipendula*, Compositae lig., Compositae tub., Cruciferae and Ranunculaceae, are scarce.

4.1.8 WLMh 90-66cm..

This phase is marked by a rise in Gramineae to 25%, *Triticum* type to 8%, *Plantago* spp. to 5% and *Rumex* spp. to 5%. *Secale cereale* is present. Other non-arboreal pollen types present include Caryophyllaceae, *Artemisia*, Compositae lig., *Filipendula*, Umbelliferae, Rosaceae and Compositae tub.. By the end of the phase, arboreal pollen has declined to 54%, with *Alnus* falling to 10% and Coryloid to 30%. *Quercus* remains stable at 15%.

4.1.9 WLMi 66-44cm..

This phase is characterised by the last dramatic rise in arboreal pollen, which reaches 75%. *Betula* rises to 20% for the first time since phase WLMb, *Quercus* increases to 20%, *Alnus* to 15% and Coryloid to 40%. Gramineae declines to 15% and *Plantago* spp. to 5%. *Triticum* type rises throughout the phase reaching 5%. After an initial decline, *Rumex* spp. rise to 8%. *Cannabis* type and *Secale cereale* occur for the last time. Other non-arboreal pollen types include *Artemisia*, Chenopodiaceae, Papilionaceae, Saxifragaceae, Rosaceae, Caryophyllaceae, Compositae tub., *Filipendula* and Ranunculaceae, which all rise towards the end of the phase.

4.1.10 WLMj 44-18cm..

During this phase, arboreal pollen falls to 20%. Both *Betula* and *Alnus* fall to 5% and Coryloid to 8%. The most distinct feature of this phase is the rise in *Pinus* to 10%. *Ulmus* rises to 5% and both *Fagus* and *Fraxinus* increase. Gramineae increases to its highest level in the diagram - 68% and *Plantago* spp. increase to 10%. *Rumex* spp., Ranunculaceae and *Triticum* type decline and although other non-arboreal pollen types occur, no species reaches 5%. These include *Artemisia*, Caryophyllaceae, Chenopodiaceae, Compositae lig., Compositae tub., Cruciferae, *Filipendula* and Papilionaceae.

4.1.11 WLMk 18-0cm..

This phase begins with a gradual rise in arboreal pollen to 50%. This rise is associated with the continued rise in *Pinus* to 40% and *Fagus* to 10%. Other arboreal pollen types remain low. Gramineae declines slightly (45%) and all other non-arboreal pollen types, including *Plantago* spp. and *Rumex* spp., fall below 5%. The non-arboreal pollen types include Chenopodiaceae, Compositae lig., Compositae tub., Cruciferae, Ranunculaceae, *Filipendula* and Rubiaceae. *Triticum* type rises to 5% at the beginning of this phase, but has fallen by the end of the diagram.

4.2 Glasson Moss.

4.2.1 GLMa 300-250cm..

This phase is divided into two sub-phases based upon a marked decline in arboreal pollen from 90% to 80%.

The earliest pollen spectra at this site ($GLMa_1$ 300-274cm.) are characterised by uniformly high values of arboreal pollen, which do not fall below 90%. *Betula* (10%), *Quercus* (13%), *Alnus* (28%) and Coryloid (45%) are the dominant arboreal species. However, *Ulmus* and *Fraxinus* do occur. Gramineae is low, remaining below 10%. No other non-arboreal pollen types occur, except for scattered grains of *Plantago* spp., Ranunculaceae and *Rumex* spp..

Phase $GLMa_2$ (274-250cm.) opens with a fall in arboreal pollen which declines to 88% by the end of the phase. Most of this decline is attributable to a fall in *Betula* to 10%, Quercus to 10% and *Alnus* to 14%, whilst Coryloid fluctuates between 30-45%. *Fraxinus* and *Ulmus* are present in low quantities. Gramineae (8%) rises slightly and *Plantago* spp. are present. The Ranunculaceae and *Pteridium* curves become continuous, but neither reaches 5%. Other herbs include *Artemisia*, Chenopodiaceae, Compositae lig. and *Filipendula*.

4.2.2 GLMb 250-188cm..

This phase is divided into two sub-phases based upon a fall in arboreal pollen to 60%.

Phase $GLMb_1$ (250-222cm.) opens with a decline in arboreal pollen to around 85%. *Betula* rises slightly to 20%, but *Quercus*, *Alnus* and Coryloid fluctuate around 10%, 14% and 30% respectively. Gramineae rises to 10% and both *Plantago* spp. and Pteridium reach 5%. *Triticum* type and *Rumex* spp. appear for the first time. *Artemisia*, Caryophyllaceae Chenopodiaceae, Compositae tub., Ranunculaceae, Saxifragaceae and *Succisa* occur.

A sudden drop in arboreal pollen to 60% marks the beginning Phase $GLMb_2$ (222 - 188cm.) and the decline continues with a further gradual fall to 55%. The decline is most marked in the curves of *Coryloid* (21%) and *Betula* (5%). The decline is not as marked in *Alnus* and *Quercus* which both stabilise around 15%. The curves of *Pinus*, *Fraxinus*, *Ulmus* and *Salix* become continuous. Whilst arboreal pollen declines, Gramineae rises to 40% by the end of the phase. There is also a rise in *Plantago* spp. (10%) and in *Rumex* spp. (5%). *Triticum* type and *Secale cereale* occur, along with *Artemisia*, Caryophyllaceae, Chenopodiaceae, Compositae lig., Compositae tub., Cruciferae, *Filipendula*, Papilionaceae, Ranunculaceae, Umbelliferae and *Knautia*.

4.2.3 GLMc 188-170cm..

Phase GLMc begins with a rise in arboreal pollen to 75%, though this is followed by a further decline to 45%. The decline in *Quercus* (6%) and *Alnus* (10%) are most marked. Coryloid falls to 25% and *Betula* to 10%. *Pinus* rises to a small peak of 3% and *Fraxinus* to 5%. There are no cereals present, besides *Plantago* spp. (10%), other herbs are few. There are scattered occurrences of *Artemisia*, Chenopodiaceae, Compositae lig., Compositae tub., *Filipendula* and *Rumex* spp.. *Pteridium* also rises to 8%.

4.2.4 GLMd 170-132cm..

GLMd is characterised by a gradual increase in arboreal pollen to 80%. Coryloid increases to 45%, *Alnus* to 15% and *Betula* to 25%, whilst *Quercus* remains constant (10%). *Pinus*, *Fraxinus* and *Salix* continue to increase slightly. Gramineae remains around 35% and *Plantago* spp. decline below 5%. *Artemisia*, Compositae lig., *Filipendula*, Cruciferae, Ranunculaceae, Umbelliferae and *Rumex* spp. are present, but disappear by the end of the phase.

4.2.5 GLMe 132-115cm..

During this short phase, arboreal pollen declines slightly (65%). *Betula* declines to 10% and Coryloid to 35%. *Quercus* continues to be stable at 10%, whilst *Alnus* rises to 20%. Gramineae increases to 25%, *Plantago* spp. to 5% and *Pteridium* to 3%, with *Cannabis* type appearing for the first time. *Triticum* type reoccurs along with the pollen of Compositae lig., Cruciferae, *Filipendula*, Labiatae, *Polygonum*, Ranunculaceae and *Rumex* spp..

4.2.6 GLMf 115-106cm..

This is a very short phase in which arboreal pollen rises to 75%. *Betula* and Coryloid increase to 20% and 35% respectively, *Quercus* remains at 10% and *Alnus* declines to 15%. Gramineae sinks to 14%, but *Plantago* spp. increase to 7% and *Pteridium* to 3%. *Triticum* type occurs and other non-arboreal pollen types such as Ranunculaceae, *Rumex* spp., Saxifragaceae and *Succisa* are present in low percentages.

4.2.7 GLMg 106-72cm..

Phase GLMg is distinguished from the previous phase by a gradual fall in arboreal pollen to 55%, followed by a rise to 62% by the end of the phase. *Betula* and *Quercus* both fluctuate around 15%, *Alnus* around 18% and Coryloid around 34%. Gramineae falls from 36% to 30%. *Plantago* spp. remain around 8% and both *Cannabis* type and *Triticum* type occur. Other non-arboreal pollen types are sparse, but *Artemisia*, *Rumex* spp., Caryophyllaceae, Compositae lig., *Filipendula*, Labiatae, Ranunculaceae and Umbelliferae are scattered throughout the phase.

4.2.8 GLMh 72-52cm..

This phase is characterised by a fall in arboreal pollen to 40%. Whilst *Quercus* (13%) remains stable, *Betula* (5%), *Alnus* (10%) and Coryloid (20%) decline. However, by the end of GLMh, Coryloid and *Alnus* have risen again to 33% and 13% respectively. Gramineae rises to 45% and *Plantago* spp. to 10%. *Triticum* type occurs, though *Cannabis* type is absent. *Artemisia*, Chenopodiaceae, Cruciferae, Compositae lig., Compositae tub., Ranunculaceae, *Rumex* spp. and Saxifragaceae are present in low quantities. *Pteridium* increases slightly after its decline in the previous phase.

4.2.9 GLMi 52-34cm..

An increase in arboreal pollen to 45% marks the beginning of this phase, though after this initial rise, it falls to 20%. *Betula*, *Quercus* and Coryloid rise by a few percent, but *Alnus* declines to 7%. Gramineae falls to 35%. *Triticum* type rises to 4% and *Plantago* spp. to 10%. Ranunculaceae reaches 4% and *Rumex* spp.

3%. Other herb types are common and include *Artemisia*, Caryophyllaceae, Chenopodiaceae, Compositae lig., Compositae tub., Saxifragaceae, Cruciferae, *Filipendula* and Rubiaceae.

4.2.10 GLMj 34-0cm..

This phase is characterised by a gradual decline in arboreal pollen to 20%. *Quercus* and *Alnus* both fall below 5% and Coryloid to 14%. *Betula* remains around 10%. *Pinus* begins to rise, reaching 5% and there are small increases in *Ulmus* and *Fraxinus*. Gramineae rises rapidly to 65%, its highest level in the diagram. After an initial rise to 15%, *Plantago* spp. drop to 8%. *Triticum* type remains around 4% and *Cannabis* type occurs for the last time. *Rumex* spp., Compositae lig., Chenopodiaceae, *Helianthemum*, Rosaceae, Saxifragaceae, Umbelliferae, Compositae tub., *Filipendula*, Ranunculaceae and occur.

4.3 Fozy Moss.

4.3.1 FZMa 300-234cm..

This phase is one in which arboreal pollen does not fall below 85%. It is divided into two sub-phases - $FZMa_1$ and $FZMa_2$ - which are distinguished by a decline in arboreal pollen below 95%.

$FZMa_1$ (300-279cm.) is a period in which arboreal pollen does not fall below 95%. *Betula* remains around 14%, *Alnus* 25%, *Quercus* 20% and Coryloid 53%. Gramineae is only just present and no other herbs occur, besides scattered occurrences of Ranunculaceae, Umbelliferae and *Plantago* spp..

$FZMa_2$ (279-234cm.) opens with a fall in arboreal pollen to 85%. Coryloid declines to 45% and *Betula* to 15%. *Alnus* and *Quercus* remain more or less stable at 30% and 10% respectively. The *Fraxinus* curve becomes continuous, whilst *Ulmus* and *Pinus* occur at a low level. Gramineae fluctuates between 5% and 10% and *Plantago* spp. rise to 5%. *Triticum* type occurs at 264cm.. *Artemisia*, Cruciferae, Compositae tub., Compositae lig., *Filipendula*, Labiatae, Ranunculaceae and *Rumex* spp. occur.

4.3.2 FZMb 234-202cm..

FZMb (234-202cm.) is characterised by a fall in arboreal pollen to 70%. The fall is most marked in the curves of *Alnus* (20%), *Betula* (10%) and Coryloid (30%). *Quercus* remains stable at 10%. Gramineae rises to 22% and *Plantago* spp. to 8%. Other non-arboreal pollen types become more common, but none reach 5%. *Triticum* type occurs and other herbs such as *Artemisia*, Caryophyllaceae, Cruciferae, *Centauria*, Chenopodiaceae, *Urtica*, Compositae tub., Compositae lig., Ranunculaceae, *Polygonum*, *Filipendula*, *Rumex* spp. and Umbelliferae occur. There is a small rise in *Pteridium*.

4.3.3 FZMc 202- 152cm..

This period is divided into 4 sub-phases.

$FZMc_1$ (202-190cm.) is a short sub-phase in which arboreal pollen increases to 90%. This is attributable to a rise in *Quercus* (15%), *Betula* (22%) *Alnus* (30%) and Coryloid (35%). Gramineae declines to 5% and *Plantago* spp. to below 5%. *Artemisia* and Ranunculaceae continue to occur, but there are no other non-arboreal pollen types present.

FZMc$_2$ (190 -178cm.) is characterised by a decline in arboreal pollen to 75%. All major tree taxa are affected - *Alnus* 20%, *Betula* 13%, *Quercus* 9% and Coryloid 33%. Gramineae rises to 15%. *Artemisia*, *Plantago* spp., *Centauria*, Chenopodiaceae, Labiatae, Umbelliferae, Cruciferae, Filipendula, Ranunculaceae and *Rumex* spp. occur.

In FZMc$_3$ (178-162cm.) arboreal pollen rises to 87% - *Betula* to 20%, *Quercus* to 10%, *Alnus* to 23% and Coryloid to 38%. Gramineae falls to 5%. *Triticum* type occurs, along with *Artemisia*, *Centauria*, Compositae lig., *Filipendula*, Labiatae, Ranunculaceae, Cruciferae, and Pteridium, which are present throughout the phase.

FZMc$_4$ (162-152cm.) is another sub-phase in which arboreal pollen gradually declines to 80%. This decline is most obvious in *Betula* (3%) and *Quercus* (8%). *Alnus* and Coryloid rise to 25% and 45% respectively. *Ulmus*, *Fraxinus* and *Salix* continue to occur at low levels. Gramineae rises throughout to 20%. *Triticum* type is present, along with *Artemisia*, Caryophyllaceae, Papilionaceae, Compositae lig., *Filipendula*, Rosaceae, *Rumex* spp. and Saxifragaceae. *Plantago* spp. reach 5%. The *Pteridium* curve becomes continuous.

4.3.4 FZMd 152-131cm..

Phase FZMd has been separated into two sub-phases based upon distinct changes in Gramineae.

The beginning of phase FZMd$_1$ (152-142cm.) is clearly marked by a rapid rise in Gramineae, which reaches 55% by the end of the phase. Arboreal pollen falls to 10%, with the decline being most noticeable in Coryloid and *Quercus*, which fall from 50% to 10% and from 25% to 4% respectively. The curves of *Fraxinus*, *Pinus* and *Salix* become continuous and *Ulmus* becomes more common. Associated with the rise in Gramineae is an increase in *Plantago* spp. to 10%, which reach a peak just earlier than the acme of Gramineae. The Rosaceae curve begins at this point. Cereals include *Triticum* type and *Secale cereale* and other non-arboreal pollen types are frequent. These include *Artemisia*, Campanulaceae, Caryophyllaceae, Chenopodiaceae, Compositae lig., Compositae tub., *Filipendula*, Papilionaceae, Ranunculaceae, Rubiaceae, *Rumex* spp., Saxifragaceae and Umbelliferae.

Phase FZMd$_2$ (142-131 cm.) is separated from FZMd$_1$ by a fall in Gramineae from 70% to 50%. Arboreal pollen begins to rise and reaches 50%. This is composed predominantly of Coryloid which reaches a peak of 30%. Other arboreal pollen types are hardly present and consist of low percentages of *Alnus*, *Betula* and *Quercus*. *Pinus*, *Ulmus*, *Fraxinus* and *Salix* are present. *Triticum* type and *Cannabis* type occur. As Gramineae reaches its peak, *Plantago* spp. fall below 5%, whilst other herbs continue from phase FZMd$_1$ and both *Knautia* and Labiatae recur.

4.3.5 FZMe 131-119cm..

This is a short phase in which non-arboreal pollen rises to 75%. Arboreal pollen falls. Coryloid increases to 35% and then drops to 20%. *Alnus*, *Betula* and *Quercus* remain more or less constant at 8%, 5% and 12% respectively. Whilst Gramineae falls to 31%, other non-arboreal pollen types rise dramatically. *Plantago* spp. rise to 12%, Rosaceae to 10% and *Rumex* spp. to 5%. Other non-arboreal pollen types occur frequently, including *Triticum* type, *Secale cereale*, *Artemisia*, Campanulaceae, Caryophyllaceae, Chenopodiaceae, Compositae lig. and tub., Cruciferae, *Filipendula*, Labiatae, Papilionaceae, Rubiaceae, Umbelliferae and *Urtica*.

4.3.6 FZMf 119-102cm..

Phase FZMf is one in which arboreal pollen remains at a stable level of 35%. *Betula*, *Alnus* and *Quercus* remain at 5%, 10% and 10% respectively. Coryloid falls to 25%. Gramineae rises to 60% and Umbelliferae reaches its highest level - 7%. *Plantago* spp. and Rosaceae both fall to 5% and *Rumex* spp. to 3%. *Triticum* type continues to occur, along with other non-arboreal pollen types such as *Artemisia*, *Centauria*, Chenopodiaceae, Rubiaceae, Caryophyllaceae, *Knautia*, Compositae tub., Compositae lig., Cruciferae, *Filipendula*, Papilionaceae and Ranunculaceae. The *Pteridium* curve is low but continuous.

4.3.7 FZMg 102-90cm..

This short phase is based upon one pollen count, but the changes in the levels of taxa are sufficient to define it as a single phase. It is one in which arboreal pollen rises to 45%. Coryloid rises to 25% and *Quercus* and *Alnus* both to 10% and *Betula* to 7%. Gramineae declines to 41%. *Triticum* type and *Secale cereale* occur, but other non-arboreal pollen types are rare.

4.3.8 FZMh 90-50cm..

This period is divided into 2 sub-phases.

Phase $FZMh_1$ (90-80cm.) is marked by a short-lived decline in arboreal pollen to 35%. *Quercus* (15%), *Alnus* (5%) and Coryloid (15%) are affected, whilst *Betula* rises to 10%. Gramineae rises to 55% and *Plantago* spp. to 10%. *Triticum* type and *Cannabis* type occur. Few other herbs are present, except for Chenopodiaceae, Compositae lig., Rubiaceae, Saxifragaceae, Cruciferae, *Filipendula*, Ranunculaceae, *Rumex* spp. and Umbelliferae.

$FZMh_2$ (80-50cm.) is a phase in which arboreal pollen initially rises to 35%, reaches a peak of 45% and then declines to 20% at the end of the phase. This pattern is reflected in all major arboreal pollen types. *Alnus* declines from 8% to 5%; *Betula* from 15% to 5%; Coryloid to 15% and *Quercus* to 10%. Gramineae declines from 50% to 35% and then rises to 47%. A similar pattern is reflected in the *Rumex* spp. curve, which reaches its peak of 5%. *Triticum* type reaches its highest level - 7% and *Secale cereale* is present. *Plantago* spp. continue to rise to 10%, with small peaks in *Artemisia*, Compositae tub., *Filipendula*, Rosaceae, and Saxifragaceae. Ranunculaceae, Caryophyllaceae and Compositae lig. are also present.

4.3.9 FZMi 50-25cm..

The beginning of this phase is marked by a decline in arboreal pollen to 15%. *Betula* and *Alnus* both fall below 5%, *Quercus* and Coryloid both fall to 8%. *Pinus* begins to rise, reaching 15% by the end of the phase and *Ulmus* reaches 5%. Gramineae rises, reaching a peak of 70% and *Plantago* spp. a maximum of 18%. *Triticum* type, Compositae tub., *Filipendula* and *Rumex* spp. decline. Ranunculaceae, Rosaceae and Umbelliferae rise slightly, whilst Compositae lig., Cruciferae and Saxifragaceae are present.

4.3.10 FZMj 25-12cm..

This phase is one of woodland regeneration, with arboreal pollen increasing to 68%. This is mainly attributable to a continued rise in *Pinus* to 20%. Other arboreal pollen types also show smaller rises - *Betula* to 10%, *Alnus*, *Quercus* and Coryloid all to 7% and *Ulmus* to 8%. *Fagus* rises to 5% for the first

time. Gramineae falls to 25% and other herbs also decline. There are a few occurrences of *Artemisia*, Compositae lig., Chenopodiaceae, Compositae tub., Cruciferae, *Filipendula*, Ranunculaceae and Umbelliferae.

4.3.11 FZMk 12-0cm..

The final phase of the diagram is one in which Gramineae rises to 50% and arboreal pollen falls to 45%. *Betula*, *Alnus*, Coryloid and *Quercus* fall to 5%, 5%, 10% and 7% respectively. *Pinus* reaches its peak of 60%, before falling to 40%. *Triticum* type is present, but other herbs remain relatively low, including *Plantago* spp., Compositae lig., Umbelliferae and Cruciferae.

4.4 Letham Moss.

4.4.1 LTMa 180-164cm..

LTMa (180-164cm.) has high but declining values of arboreal pollen. Arboreal pollen declines from 95% to 83%. Coryloid declines from 50% to 30%, *Quercus* to 12% and *Pinus* to 6%. *Betula*, *Fraxinus* and *Salix* are low. The *Pteridium* curve is characterised by small peaks of 5%. Gramineae rises to 15% and few herbs are present. There are scattered occurrences of *Artemisia*, Caryophyllaceae, Labiatae, *Plantago* spp. and *Rumex* spp..

4.4.2 LTMb 164-136cm..

Phase LTMb has been divided into two sub-phases.

$LTMb_1$ (164-150cm.) opens with a rise in arboreal pollen to 90%, after which it declines back to 80%. *Alnus* remains stable at 20% and Coryloid fluctuates around 50%. *Quercus* declines to 10% and *Pinus*, after an initial rise to 15%, falls to 5%. *Betula* remains very low. Gramineae rises steadily to 20% and again there are few other herbs. Only Chenopodiaceae, Papilionaceae, *Plantago* spp., Ranunculaceae and *Rumex* spp. are present. *Pteridium* reaches 5%.

During $LTMb_2$ (150-136cm.) arboreal pollen fluctuates between 90% and 70%. This is mainly attributable to fluctuations in Coryloid between 50% and 30%. *Alnus* rises slowly to 35% and *Betula* to 7%. *Pinus* falls to 3% and *Quercus* to 5%. *Hedera* is present. Gramineae fluctuates between 20% and 55%, whilst *Plantago* spp. rise to 5%. *Artemisia*, Caryophyllaceae, *Centauria*, Chenopodiaceae, Compositae lig., *Filipendula*, Labiatae, Rosaceae, *Polygonum*, *Rumex* spp. and *Knautia* occur. *Pteridium* reaches 7%.

4.4.3 LTMc 136-106cm..

Phase LTMc is divided into two sub-phases - $LTMc_1$ and $LTMc_2$.

The beginning of Phase $LTMc_1$ (136-120cm.) is clearly marked by a pronounced decline in arboreal pollen to 30%. All arboreal pollen types are affected. Coryloid sinks to 15%, *Alnus* to 10% and *Quercus* to 5%. *Betula* increases to 8%. *Fraxinus*, *Ulmus*, *Fagus* and *Salix* become more common. Gramineae is high, rising to 50% and *Plantago* spp. rapidly reach 10%. Other non-arboreal pollen types become more common. *Triticum* type and *Secale cereale* begin to occur and other herbs include *Artemisia*, *Filipendula*, Caryophyllaceae, Chenopodiaceae, Compositae lig., Compositae tub., Cruciferae, Labiatae, Papilionaceae,

Ranunculaceae, Rosaceae, Rubiaceae, *Rumex* spp., Saxifragaceae, Umbelliferae and *Urtica*. *Pteridium* falls to 2%.

$LTMc_2$ (120-106cm.) is a phase in which arboreal pollen increases very slowly from 30% to 40%. Much of this rise is accounted for by an increase in Coryloid from 20% to 30%. *Alnus* remains around 10%, *Quercus* at 10% and *Betula* at 5%. *Ulmus*, *Pinus*, *Fraxinus*, *Carpinus* and *Ilex* occur. Gramineae remains virtually stable at 45%, whilst *Plantago* spp. decline to 6%. *Triticum* type, *Artemisia*, Caryophyllaceae, Chenopodiaceae, *Urtica*, Compositae tub., Compositae lig., *Filipendula*, Labiatae, Papilionaceae, Ranunculaceae, Rosaceae, Saxifragaceae and *Rumex* spp. continue to occur, but are generally lower than in LTMb.

4.4.4 LTMd 106-90cm..

LTMd is divided into two sub-phases - $LTMd_1$ and $LTMd_2$.

$LTMd_1$ (106-100cm.) is a short sub-phase, separated from $LTMc_1$ by a short-lived rise in arboreal pollen to 50%. Coryloid and *Alnus* rise to 30% and 15% respectively, whilst Gramineae falls to 35%. Other taxa remain more or less at the same levels as in $LTMc_1$. Herbs include *Artemisia*, Caryophyllaceae, *Filipendula*, Ranunculaceae, *Plantago* spp., Rosaceae, *Urtica* and *Rumex* spp..

During $LTMd_2$ (100-90cm.) arboreal pollen falls to 30%. Coryloid drops to 20% and *Alnus* to 7%. *Quercus* and *Betula* actually rise slightly to 7% and 5% respectively. *Pinus*, *Ulmus*, *Fagus*, *Fraxinus* and *Salix* are present. There is a pronounced rise in Gramineae to 57%. Non-arboreal pollen types include *Triticum* type, Caryophyllaceae, *Filipendula*, *Rumex* spp., Rubiaceae, Umbelliferae, *Urtica* and Saxifragaceae. *Plantago* spp. decline slightly to 7%.

4.4.5 LTMe 90-68cm..

This phase has rising values of arboreal pollen throughout. Arboreal pollen rises gradually from 45% to 70%. Coryloid rises most dramatically - from 30% to 45%. *Quercus* rises to 10%, whilst *Alnus* is more or less stable at 15%. *Betula* fluctuates between 5% and 10%. There are small rises to 3% in both *Pinus* and *Salix*.. *Hedera*, *Ulmus*, *Fagus*, *Fraxinus* and *Carpinus* occur. Gramineae slowly falls from 40% to 30% and *Plantago* spp. from 10% to only just being present. *Cannabis* type occurs for the first time. *Artemisia*, Caryophyllaceae, Compositae lig., Compositae tub., *Filipendula*, Ranunculaceae and *Rumex* spp. occur, at very low levels.

4.4.6 LTMf 68-56cm..

This phase is one in which arboreal pollen stabilises at 85%. This is attributable to Coryloid stabilising at 60% and *Quercus* at 15%. *Betula* and *Alnus* are at 8% and 10% respectively. Gramineae falls to 15% and very few other herbs occur. There are scattered grains of Caryophyllaceae, *Plantago* spp., Ranunculaceae, *Rumex* Spp. and *Urtica*.

4.4.7 LTMg 56-39cm..

The beginning of a fall in arboreal pollen marks the start of this phase. Arboreal pollen gradually declines from 80% to 60% and *Quercus* and *Betula* are most affected, falling to 7% and 3% respectively. *Alnus*

fluctuates around 15% and 20% and Coryloid falls to 4%. Gramineae rises and stabilises at 25%. *Triticum* type and *Secale cereale* occur for the first time since phase LTMe. *Plantago* spp. rise to 5%, whilst *Artemisia*, Caryophyllaceae, Compositae tub., *Filipendula*, Papilionaceae, Ranunculaceae, Rubiaceae, *Rumex* spp., Saxifragaceae and Umbelliferae occur. *Pteridium* rises to 3%.

4.4.8 LTMh 39-30cm..

The trend of falling arboreal pollen continues and accelerates during LTMh. Arboreal pollen rapidly falls to 40%. Coryloid and *Alnus* fall to 25% and 15% respectively. *Quercus* continues at the same level as the previous phase and *Betula* rises to 5%. The Gramineae curve shows a sharp increase to 40% and *Pteridium* to 5%. *Triticum* type and *Secale cereale* are present, along with *Artemisia*, *Filipendula*, Caryophyllaceae, Chenopodiaceae, Cruciferae, Labiatae, Ranunculaceae and *Rumex* spp.. *Plantago* spp. continue at 6%.

4.4.9 LTMi 30-15cm..

During LTMi arboreal pollen begins to increase, reaching 65% by the end of the phase. Coryloid rises to 40%, *Quercus* to 15% and *Alnus* to 15%. *Betula* falls by a few percent to 4%. *Pinus*, *Fraxinus* and *Salix* occur at low levels. Gramineae falls to 25%. *Triticum* type, *Artemisia*, Caryophyllaceae, Chenopodiaceae, *Filipendula*, *Plantago* spp., *Rumex* spp., Rubiaceae, Saxifragaceae and Umbelliferae are present.

4.4.10 LTMj 15-0cm..

The final phase is one in which arboreal pollen falls rapidly to 20%. *Quercus*, *Alnus* and Coryloid fall to 9%, 10% and 11% respectively. *Betula* falls to 5% and then disappears by the end of the phase. Despite the decline in these taxa, *Pinus* and *Ulmus* increase to 10% and 8% respectively. Gramineae rises profoundly to 55%, *Triticum* type to 5% and *Rumex* spp. to 2%. Other herbs, such as *Artemisia*, Chenopodiaceae, Compositae lig., *Plantago* spp. and Saxifragaceae, slowly disappear.

4.5 Fannyside Muir.

4.5.1 FSMa 300-254cm..

The earliest pollen spectra at this site are dominated by arboreal pollen, which does not fall below 95%. Coryloid (40-60%), *Alnus* (20%), *Betula* (10%), *Quercus* (15%) and *Pinus* (5-10%) are the dominant arboreal species, although scattered grains of *Ulmus*, *Fraxinus* and *Salix* occur. Gramineae occurs at low levels of 5% and the only non-arboreal pollen types present are very low levels of *Plantago* spp. and *Rumex* spp.. *Pteridium* remains around 2%.

4.5.2 FSMb 254-214cm..

Phase FSMb is distinguished from phase FSMa by a fall in arboreal pollen from 95% and 85%. Coryloid declines to and then fluctuates around 40%, *Alnus* to 25%, *Betula* to 7% and *Pinus* to 6%, whilst *Quercus* continues at 15%. Gramineae rises and fluctuates around 10%. Non-arboreal pollen taxa are more common, including *Triticum* type, Caryophyllaceae, Cruciferae, *Filipendula*, Labiatae, *Plantago* spp., Ranunculaceae, Rosaceae, *Rumex* spp. and *Urtica*.

4.5.3 FSMc 214-173cm..

FSMc is divided into 2 sub-phases - $FSMc_1$ and $FSMc_2$.

$FSMc_1$ (214-189cm.) opens with a further decline in arboreal pollen to 80%. Coryloid drops to 35%, *Quercus* to 10%, *Betula* to 8% and *Pinus* to 1%. *Alnus* actually increases to 31%. Scattered grains of *Salix*, *Fraxinus*, *Fagus* and *Ulmus* occur. Gramineae increases to 15% and both *Plantago* spp. and *Pteridium* to 5%. Other non-arboreal pollen types are scarce, though sporadic grains of *Artemisia*, Caryophyllaceae, Chenopodiaceae, Cruciferae, *Filipendula*, Ranunculaceae and *Rumex* spp. occur.

After an initial rise to 90% arboreal pollen declines back to 85% during $FSMc_2$ (189-173cm.). Coryloid rises to 50% and then drops to 40%, and *Alnus* falls to 22%. *Quercus* rises by a few percent to 12% and *Betula* increases to 10%. *Pinus* rises to 8%. *Hedera*, *Salix*, *Carpinus*, *Fraxinus*, *Fagus* and *Ulmus* occur. Gramineae increases from 5% to 10%. *Triticum* type, Caryophyllaceae, *Filipendula*, Rosaceae and Ranunculaceae are the only herbs present.

4.5.4 FSMd 173-158cm..

Phase FSMd opens with a short-lived decline in arboreal pollen to 76%. Coryloid decreases to 32%, *Quercus* to 10%, Alnus to 32% and *Betula* decreases to 15%. Gramineae rises to 20%, *Plantago* spp. to 5% and *Pteridium* to 5%. Again few other herbs are present. *Artemisia*, Caryophyllaceae, Compositae lig., Cruciferae, *Filipendula*, Ranunculaceae, *Rumex* spp. and *Urtica* are scattered throughout.

4.5.5 FSMe 158-135cm..

After an initial increase to 85%, arboreal pollen declines to 65%. Coryloid, *Alnus* and *Betula* fluctuate around 45%, 20% and 10% respectively. *Quercus* declines to 10% and *Pinus* to 2%. Gramineae rises and eventually reaches 25%, *Pteridium* increases to 7% and *Plantago* spp. to 5%. Again there are few herbs present. Caryophyllaceae, Chenopodiaceae, Cruciferae, Papilionaceae, Ranunculaceae, *Rumex* spp. and Umbelliferae occur.

4.5.6 FSMf 135-110cm..

FSMf is divided into two sub-phases.

$FSMf_1$ (135-117cm.) is a short sub-phase in which arboreal pollen falls rapidly to 40%. Coryloid and *Alnus* fall to 20% and 10% respectively. *Betula* and *Quercus* remain stable, both at 10%. *Pinus* continues at 3%. *Ulmus*, *Carpinus*, *Fraxinus*, *Fagus* and *Salix* are present. Gramineae quickly rises to 4% and *Plantago* spp. to 8%. *Artemisia*, Caryophyllaceae, *Thalictrum*, Chenopodiaceae, Compositae lig., Cruciferae, Labiatae, Papilionaceae, Ranunculaceae, *Rumex* spp. and *Urtica* are present.

$FSMf_2$ (117-110cm.) is a shorter sub-phase where arboreal pollen remains at 47%. Coryloid remains at 30% and *Alnus*, *Betula*, and *Quercus* remain at similar levels to $FSMf_1$. Gramineae is at 40% whilst *Plantago* spp. decline to 30%. *Triticum* type occurs for the first time since phase FSMd and *Cannabis* type is present for the first time. Caryophyllaceae, Cruciferae, *Filipendula*, Papilionaceae, *Rumex* spp., Umbelliferae and *Urtica* occur.

4.5.7 FSMg 110-89cm..

Rising levels of arboreal pollen to 80% are the main characteristic of this phase. Coryloid, *Alnus* and *Betula* increase to 45%, 20% and 15% respectively. Gramineae declines to 18%, *Pteridium* to 3% and *Triticum* type, *Secale cereale* and *Cannabis* type occur. Other herbs include *Artemisia*, Caryophyllaceae, Chenopodiaceae, Compositae lig., Compositae tub., *Filipendula*, Ranunculaceae, *Rumex* spp. and *Urtica*.

4.5.8 FSMh 89-68cm..

Arboreal pollen (80%) is stable throughout this phase. Coryloid and *Quercus* stabilise at 45% and 10% respectively. *Alnus* increases to 30% and *Betula* declines from 20% to 15%. *Salix*, *Fraxinus*, *Fagus*, *Ulmus* and *Pinus* occur. Gramineae falls to and remains at 10% and *Plantago* spp. drop to very low levels. *Triticum* type, Chenopodiaceae, Ranunculaceae, Rosaceae, *Rumex* spp. Ranunculaceae and Euphorbiaceae occur.

4.5.9 FSMi 68-50cm..

This is a short phase in which arboreal pollen declines very sharply to 45%. Coryloid, *Alnus* and *Betula* fall to 20%, 18% and 8% respectively. *Quercus* continues at similar levels to FSMh. Gramineae rises rapidly to 40% and *Plantago* spp. to 7%. Few other herb types are present except for a few occurrences of *Secale cereale*, *Triticum* type, Ranunculaceae, *Filipendula*, Compositae lig. and Compositae tub..

4.5.10 FSMj 50-35cm..

After an initial rise to 70%, arboreal pollen declines to 45%. Coryloid drops from 35% to 22% and *Alnus* increases to 20%. *Quercus* increases to 15% and *Betula* to 8%. Gramineae falls to 25% and *Plantago* spp. to 5%. *Rumex* spp. and *Triticum* type both rise to 3%. Other non-arboreal pollen types present include *Secale cereale*, *Cannabis* type, *Artemisia*, Chenopodiaceae, Compositae tub., Cruciferae, *Filipendula*, Labiatae, Ranunculaceae and *Urtica*.

4.5.11 FSMk 35-15cm..

Phase FSMk is one in which arboreal pollen rises again, this time to 50%. Coryloid, *Alnus* and *Quercus* increase to 20%, 15% and 10% respectively. *Betula* declines to 7%. There are small peaks in *Fraxinus* and *Pinus*. Gramineae decreases from 50% to 30% and *Plantago* spp. and *Rumex* spp. both to 5%. *Triticum* type, *Secale cereale*, *Artemisia*, *Centauria*, Chenopodiaceae, Compositae lig., Compositae tub., *Filipendula*, Papilionaceae, *Polygonum*, Ranunculaceae and Saxifragaceae are present.

4.5.12 FSMl 15-0cm..

The main characteristic of this phase is the massive decrease in arboreal pollen to 15%. Gramineae rises to 75%, before decreasing to 55%. *Plantago* spp. and *Rumex* spp. both fall to 3%. *Triticum* type, Artemisia, Compositae lig., Compositae tub., Cruciferae, Labiatae, Ranunculaceae, Rosaceae, Saxifragaceae, Umbelliferae and *Urtica* occur. Except for *Pinus* which increases to 25%, all other arboreal pollen types decline to between 7% and 5%.

4.6 Cranley Moss.

4.6.1 CYMa 300-242cm..

This is a phase which has high values of arboreal pollen throughout (80-90%). Arboreal pollen is predominantly composed of Coryloid which is stable around 50%, *Alnus* at 20% and *Quercus* at 10%. *Betula* increases slightly throughout this phase - from 7% to 10%. *Fraxinus*, *Pinus* and *Ulmus* are present in low quantities. Gramineae remains at approximately 15% throughout. There are scattered occurrences of *Triticum* type and Caryophyllaceae, Compositae lig., Cruciferae, *Filipendula*, Papilionaceae, Ranunculaceae, Rubiaceae, Rosaceae, *Rumex* spp. and *Urtica* occur. *Pteridium* is present at 3%.

4.6.2 CYMb 242-218cm..

This phase is characterised by a pronounced rise in Coryloid from 30% to 60%. Total arboreal pollen remains at 70%. *Alnus* and *Betula* fall to 15% and 10% respectively and then rise to 30% and 20%. Gramineae increases to 20% and *Plantago* spp. to 8%. Non-arboreal pollen types become more common and include *Artemisia*, Caryophyllaceae, Chenopodiaceae, Cruciferae, *Filipendula*, Papilionaceae, Rosaceae, Rubiaceae, *Rumex* spp., Saxifragaceae and Umbelliferae. *Secale cereale* and *Triticum* type occur.

4.6.3 CYMc 218-146cm..

CYMc is divided into three sub-phases.

The beginning of $CYMc_1$ (218-189cm.) is marked by an increase in arboreal pollen to 90%. This is accounted for by an increase in *Alnus* to 30% and *Betula* to 15%, after which *Alnus* declines to 20% and *Betula* continues to rise to a maximum of 20%. *Quercus* remains more or less constant at 10%. Coryloid increases steadily from 30% to 50%. *Salix*, *Fraxinus*, *Pinus* and *Ulmus* occur at very low levels. *Plantago* spp. decline dramatically and are only just present. *Triticum* type and *Secale cereale* are present along with *Artemisia*, Caryophyllaceae, Chenopodiaceae, Cruciferae, *Filipendula*, Papilionaceae, Ranunculaceae, Rosaceae and *Rumex* spp..

$CYMc_2$ (189-174cm.) is distinguished from the previous sub-phase by a decrease in arboreal pollen to 65%. Coryloid sinks to 40% and *Betula* to 7%. *Quercus* and *Alnus* fluctuate around 5% and 20% respectively. Gramineae rises to 25% and *Plantago* spp. to 5%. *Triticum* type and *Secale cereale* continue and other non-arboreal pollen types are few. There are scattered grains of *Artemisia*, Ranunculaceae, Rosaceae, *Urtica*, *Rumex* spp. and Papilionaceae.

After a decrease at the end of the previous sub-phase Gramineae rises steadily to 30% during $CYMc_3$ (174-146cm.). *Plantago* spp. increase to 9%. Cereals are no longer present. *Artemisia*, Caryophyllaceae, Chenopodiaceae, Compositae lig., Compositae tub., Cruciferae, Ranunculaceae, *Rumex* spp. and Umbelliferae continue to occur. Arboreal pollen declines steadily from 90% to 65% throughout. Coryloid declines from 65% to 40% and *Betula* from 15% to 8%. *Quercus* and *Alnus* remain virtually constant at 8% and 20% respectively. *Pinus*, *Fraxinus* and *Ulmus* are also present.

4.6.4 CYMd 146-129cm..

Phase CYMd opens with a pronounced fall in arboreal pollen to 40%. All arboreal pollen types are affected. Coryloid falls to 25%, *Alnus* to 10%, *Betula* to 7% and *Quercus* to 5%. Gramineae simultaneously rises and reaches 55% by the end of the phase. *Triticum* type reappears, whilst *Plantago* spp. continues to rise and are sustained at 10%. Other non-arboreal pollen types include *Artemisia*, Caryophyllaceae, Chenopodiaceae, *Filipendula*, Compositae tub., Cruciferae, Fumariaceae, Ranunculaceae, Rosaceae, *Rumex* spp., Saxifragaceae and Umbelliferae.

4.6.5 CYMe 129-113cm..

Phase CYMe is characterised by an initial increase in arboreal pollen to 55% followed by a decline to 45%. Coryloid generally fluctuates around 35%, *Alnus* 15%, *Quercus* 8% and *Betula* 5%. Gramineae slowly rises to 35%. *Plantago* spp. continue at a steady 7% and *Secale cereale* is present. Other herbs include *Artemisia*, Caryophyllaceae, Chenopodiaceae, *Filipendula*, Ranunculaceae, *Rumex* spp. and Umbelliferae.

4.6.6 CYMf 113-90cm..

The beginning of this phase is marked by a rise in arboreal pollen to 75%. Coryloid increases to 50%, *Alnus* declines to 17%, *Quercus* to 9% and *Betula* to 25%. *Pinus*, *Fraxinus*, *Ulmus* and *Salix* are present, but their curves are not continuous. Gramineae falls throughout the phase and reaches 14%. Accompanied with this is the disappearance of *Plantago* spp.. Other non-arboreal pollen types become scarce. *Triticum* type and *Cannabis* type occur and there are scattered grains of Caryophyllaceae, Chenopodiaceae, Compositae lig., *Filipendula*, Papilionaceae, Rosaceae, *Rumex* spp. and *Urtica*.

4.6.7 CYMg 90-66cm..

This phase is one of declining arboreal pollen, which gradually falls from 75% to 45%. Coryloid and *Alnus* are constant at 50% and 20% respectively. *Quercus* declines gradually to 10%, *Betula* falls more rapidly to 5%. There is a rise in Gramineae to 25% and in *Plantago* spp. to 5%. *Triticum* type is present, along with scattered grains of Caryophyllaceae, Chenopodiaceae, Cruciferae, *Filipendula*, Rosaceae and *Rumex* spp..

4.6.8 CYMh 66-52cm..

Arboreal pollen continues to fall in CYMh and reaches 30%. *Alnus* and Coryloid are affected most, sinking to 20% and 7%. *Quercus* drops to 9% and *Betula* actually rises to 10%. The *Pinus* curve becomes continuous again. Gramineae proceeds to rise to a peak of 55% with *Plantago* spp. reaching their highest level in the diagram - 10%. *Rumex* spp. increase to 5% and other herbs present are *Artemisia*, Compositae lig., Compositae tub., Cruciferae, *Filipendula*, Ranunculaceae, Rosaceae and Umbelliferae.

4.6.9 CYMi 52-44cm..

Although this phase is based upon one count, the changes in the pollen types are distinct enough to delimit the period as a separate phase. The phase opens with a profound increase in arboreal pollen to 57%. Coryloid jumps to 30%, *Alnus* to 15%, *Quercus* to 10% and *Betula* to 10%. Gramineae falls to 28% and *Plantago* spp. to 3%. *Triticum* type and *Rumex* spp. continue at a level similar to that in CYMh. *Cannabis* type occurs for the last time. *Artemisia*, Compositae lig., *Filipendula* and Papilionaceae are also present.

4.6.10 CYMj 44-20cm..

At the beginning of CYMj arboreal pollen rises to reach its highest level of 85%. Gramineae climbs to a peak of 75%, *Rumex* spp. to 5% and *Plantago* spp. to 10%. *Triticum* type declines from the higher levels of the previous phase. Few other herbs are present except for Compositae lig., Compositae tub., *Filipendula* and Cruciferae. One of the most obvious features of CYMj is the rise in *Pinus* from 2% to 10%. *Alnus*, Coryloid, *Betula* and *Quercus* all decline sharply, each to 5%.

4.6.11 CYMk 20-0cm..

After such a sharp decline in the previous phase arboreal pollen begins to rise slowly to 35%. This rise is attributable to a further increase in *Pinus* to 30%, *Ulmus* to 3% and *Fagus* to 3%. Coryloid and *Betula* both reach 7% but *Quercus* falls further to 3%. Gramineae also declines to 55%. *Triticum* type occurs, but few other herbs are present. There are scattered occurrences of *Artemisia*, *Plantago* spp., *Urtica*, Compositae tub., Ranunculaceae and Rubiaceae.

4.7 Dogden Moss.

4.7.1 DGMa 300-257cm..

The earliest pollen spectra at this site are dominated by Coryloid which is present at 45%. Total arboreal pollen is generally around 75% and besides Coryloid, *Alnus* (15%), *Quercus* (10%) and *Betula* (15%) are present. *Salix* and *Fraxinus* both occur at 3%. Gramineae is low but constant at 20%. The only other non-arboreal pollen types present are *Filipendula*, *Plantago* spp. and *Rumex* spp..

4.7.2 DGMb 257-232cm..

DGMb is characterised by a decline in arboreal pollen from 70% to 30%. Coryloid falls quite sharply to 25% and *Alnus* falls less rapidly to 8%. *Quercus* and *Betula* both decline but then remain more or less stable at 10%. *Ilex* occurs. Gramineae rises to 50% and *Plantago* spp. and *Rumex* spp. increase to 11% and 5% respectively. Other herbs are common and include the first appearances of *Triticum* type, *Artemisia*, Caryophyllaceae, Chenopodiaceae, Compositae lig., Compositae tub., Cruciferae, Papilionaceae, Ranunculaceae, *Polygonum* and Umbelliferae. *Urtica* and *Filipendula* are also present.

4.7.3 DGMc 232-194cm..

DGMc is divided into 2 sub-phases on the basis of a fall in arboreal pollen.

$DGMc_1$ (232-210cm.) is distinguished from phase DGMb by a slight recovery in arboreal pollen after which it remains virtually constant at 40%. Coryloid stabilises around 25%, *Betula* at 7%, *Quercus* at 9% and after an initial decline, *Alnus* at 10%. Gramineae and *Plantago* spp. increase slightly and remain at 45% and 10% respectively. *Rumex* spp. continue at levels similar to DGMb. *Triticum* type is present and *Secale cereale* occurs for the first time. *Artemisia*, Ranunculaceae, Caryophyllaceae Chenopodiaceae, Compositae lig., Cruciferae, *Filipendula*, Papilionaceae, Rubiaceae, *Urtica* and Umbelliferae occur.

$DGMc_2$ (210-194cm.) opens with a rise in Gramineae to 60%. Coryloid drops to 15%, before increasing to 30% by the end of the phase. *Quercus*, *Betula* and *Alnus* all remain stable at 70%, 7% and 10%

respectively. *Fraxinus*, *Fagus* and *Pinus* are scattered throughout. *Plantago* spp. fall to 10% whilst *Rumex* spp. continue at 3%. No cereals are present but *Artemisia*. Caryophyllaceae, Chenopodiaceae, Compositae lig., Cruciferae, *Filipendula*, Ranunculaceae and Umbelliferae occur.

4.7.4 DGMd 194-186cm..

The beginning of this phase is characterised by a further decrease in arboreal pollen to 30%. Coryloid falls to 25% and *Quercus* to 7%. *Betula* remains at 7%. After an initial decline, Gramineae rises to 55% and *Plantago* spp. to 15%. *Triticum* type is present along with Caryophyllaceae, Chenopodiaceae, Compositae lig., Compositae tub., *Filipendula*, Labiatae, Ranunculaceae, Rosaceae, Rubiaceae, *Rumex* spp. and Umbelliferae.

4.7.5 DGMe 186-153cm..

Rising values of arboreal pollen are a characteristic of this phase. Arboreal pollen gradually increases to 65% and this is mainly attributable to a rise in Coryloid to 50%. Other arboreal pollen types rise very slightly. *Betula* increases to 15%, *Quercus* to 10% and *Alnus* to 12%. *Fraxinus*, *Salix* and *Pinus* are more common. Gramineae declines very slowly reaching 25%. *Plantago* spp. fall to 5% and *Rumex* spp. to 2%. *Triticum* type occurs but other herbs are few. Caryophyllaceae, Chenopodiaceae, Compositae lig., Cruciferae, *Filipendula*, Ranunculaceae, Rosaceae, Rubiaceae and Umbelliferae continue at very low levels.

4.7.6 DGMf 153-98cm..

DGMf is a long period which is divided into 2 sub-phases.

$DGMf_1$ (153-130cm.) is almost the reverse of DGMe and is a phase in which arboreal pollen begins to fall to 40%. This decline is most marked in the Coryloid curve, which declines to 30%. *Quercus* drops slightly to 8%, whilst *Betula* and *Alnus* remain constant at 13% and 10% respectively. Gramineae begins to rise very slowly, eventually reaching 35%. *Plantago* spp. increase to 10%, though Rumex *spp.* fall until they are only just present. Other non-arboreal pollen types include the first appearance of *Cannabis* type and also Chenopodiaceae, Compositae lig., Compositae tub., Cruciferae, *Filipendula* and small peaks of Ranunculaceae, Rosaceae, Rubiaceae and Umbelliferae.

After an initial increase in arboreal pollen, the trend begun in the previous phase continues through $DGMf_2$ (130-98cm.). At the beginning of $DGMf_2$ arboreal pollen rises to 53%, but falls to 31% by the end of the phase. After an initial rise to 30%, Coryloid falls to 20%. Other arboreal pollen types remain constant. Gramineae continues to increase to 50% and *Plantago* spp. to 11%. *Rumex* spp. begin to rise again reaching 8%. *Triticum* type reoccurs with *Cannabis* type, Caryophyllaceae, *Filipendula*, Papilionaceae, Rubiaceae, Rosaceae, Ranunculaceae, Saxifragaceae and Umbelliferae.

4.7.7 DGMg 98-82cm..

All major arboreal pollen species and Gramineae remain stable throughout this phase, though there is a very slight rise in *Betula*. *Plantago* spp. fall and other herb types continue to occur from the previous phase.

4.7.8 DGMh 82-66cm..

A further rise in arboreal pollen marks the beginning of this phase. Arboreal pollen reaches 60% with Coryloid rising to 35%, *Alnus* to 15% and *Betula* to 20%. *Quercus* is stable at 10%. There are small peaks in *Salix* and *Pinus*. Gramineae falls to 30%, *Plantago* spp. to 6% and *Rumex* spp. to 2%. *Triticum* type is common and occurs along with *Cannabis* type, *Artemisia*, Caryophyllaceae, *Filipendula*, Cruciferae, Ranunculaceae, Rosaceae, Rubiaceae and Umbelliferae.

4.7.9 DGMi 66-36cm..

DGMi is similar to $DGMf_2$. Again it is a period in which arboreal pollen declines to 25% which is most marked in the Coryloid curve (15%). *Alnus* falls to 8%, *Betula* to 5%, whilst *Quercus* actually increases slightly to 10%. *Fraxinus* and *Juglans* are present. One of the major characteristics of this phase is the significant rise in *Triticum* type (7%), *Plantago* spp. (9%) and *Rumex* spp. (10%). Smaller peaks of *Artemisia*, Caryophyllaceae, Compositae lig., Compositae tub., *Filipendula* and *Urtica* occur. There are also scattered occurrences of Campanulaceae, Chenopodiaceae, Cruciferae, Papilionaceae, Ranunculaceae, Rosaceae and Umbelliferae. *Cannabis* type occurs for the last time.

4.7.10 DGMj 36-29 cm.

The beginning of this phase is characterised by virtually stable arboreal pollen, though towards the end values decline slightly. *Betula*, *Alnus*, *Quercus* and Coryloid all fall to 5%. *Pinus* begins to rise to 8% and *Fagus* to 5%. Gramineae increases, along with *Triticum* type and Compositae tub.. *Plantago* spp. and *Rumex* spp. fall to 5%. Euphorbiaceae, Saxifragaceae, Ranunculaceae, Cruciferae, Compositae lig., Chenopodiaceae, Caryophyllaceae and *Artemisia* occur.

4.7.11 DGMk 29-0cm..

The final phase of this diagram is one in which arboreal pollen increases to 45%. This increase is associated with a further rise in *Pinus* to 28%. *Ulmus* increases to 20% for the first time and *Fagus* to 3%. Other arboreal pollen types are very low - Coryloid at 6%, *Alnus* at 2%, *Quercus* at 3% and *Betula* at 2%. Gramineae fluctuates but is generally around 60%. *Triticum* type declines along with *Plantago* spp. (3%) and *Rumex* spp. (2%). Other herbs include Compositae tub., *Filipendula*, Papilionaceae and Rosaceae.

4.8 Carsegowan Moss.

4.8.1 CGMa 300-242cm..

This diagram begins with high values of arboreal pollen which do not fall below 80%. This is predominantly composed of Coryloid which fluctuates between 30% and 65%. *Alnus* fluctuates between 30% and 15%; *Quercus* between 17% and 8%; and *Betula* 25% and 5%. Very low levels of *Salix*, *Fraxinus*, *Ulmus*, *Pinus*, *Ilex* and *Fagus* occur. *Pteridium* is present at 5% and Gramineae declines from 15% to 3%. Non-arboreal pollen types are present but no individual taxa rise above 5%. There are scattered occurrences of *Artemisia*, Caryophyllaceae, *Centauria*, Chenopodiaceae, Compositae tub., *Filipendula*, *Plantago* spp., Ranunculaceae, Rubiaceae and Umbelliferae.

4.8.2 CGMb 242-214cm..

Phase CGMb is distinguished from phase CGMa by a small decrease in arboreal pollen to 82%, after which it rises to 90%. All arboreal pollen types continue to fluctuate around values similar to the previous phase. After an initial increase to 11%, Gramineae stabilises at 5%. The *Plantago* spp. curve begins to rise though only to 3%. *Artemisia*, Caryophyllaceae, Chenopodiaceae, Compositae lig., Ranunculaceae and *Rumex* spp. are scattered throughout the phase.

4.8.3 CGMc 214-178cm..

CGMc is divided into 2 sub-phases on the basis of a decline in arboreal pollen.

$CGMc_1$ (214-198cm.) opens with a marked decline in arboreal pollen from 90% to 68%. The decline is most marked in the Coryloid curve which decreases from 70% to 35%. *Alnus* decreases to 10%, *Quercus* remains stable at 10% and *Betula* fluctuates between 5% and 12%. Gramineae and *Plantago* spp. rise to 25% and 6% respectively. Other herbs include *Artemisia*, Campanulaceae, Caryophyllaceae, Chenopodiaceae, Compositae lig., *Filipendula*, Papilionaceae, Saxifragaceae and *Urtica*. *Pteridium* rises to 4%.

$CGMc_2$ (198-174cm.) is distinguished from $CGMc_1$ by a further decrease in arboreal pollen, this time to 55%. Coryloid declines to 35% and then stabilises. *Quercus* and *Betula* both stabilise at 10% and *Alnus* rises from 9% to 21%. Gramineae continues to increase to 27% and *Plantago* spp. rise to 10%. *Triticum* type and *Secale cereale* occur for the first time along with Caryophyllaceae, *Artemisia*, *Centauria*, Chenopodiaceae, Compositae lig., Compositae tub., *Filipendula*, Papilionaceae, Ranunculaceae, Rubiaceae and Umbelliferae. *Pteridium* drops to 3%.

4.8.4 CGMd 174-154cm..

CGMd is almost the reverse of $CGMc_1$ and arboreal pollen generally increases to 75%. Coryloid rises to 40%, *Alnus* to 20%, *Quercus* to 15%, *Betula* to 15%, *Ulmus* to 10% and *Fraxinus* to 3%. There are scattered occurrences of *Pinus*, *Tilia*, *Fagus*, *Carpinus*, *Hedera* and *Salix*. Gramineae declines from 25% to 20% and *Plantago* spp. from 6% to 3%. *Triticum* type continues to occur along with *Artemisia*, Caryophyllaceae, Chenopodiaceae, Compositae lig., Cruciferae, *Filipendula*, Papilionaceae, Ranunculaceae and *Rumex* spp.. *Pteridium* reaches a peak of 6% after which it declines.

4.8.5 CGMe 154-125cm..

Phase CGMe is separated into two sub-phases - $CGMe_1$ and $CGMe_2$.

During $CGMe_1$ (154-138cm.) arboreal pollen continues to rise reaching 90%. Coryloid, *Alnus*, *Quercus*, *Betula* and *Fraxinus* all increase to 50%, 20%, 15%, 16% and 4% respectively. *Ulmus* declines but there are sporadic occurrences of *Carpinus*, *Hedera*, *Ilex* and *Salix*. Gramineae declines to 10%. *Triticum* type occurs and other herb types are few. Caryophyllaceae, *Filipendula*, Ranunculaceae, Rubiaceae, *Rumex* spp., *Plantago* spp., Saxifragaceae and *Thalictrum* are present.

In sub-phase $CGMe_2$ (138-125cm.) there is a further increase in *Alnus*, *Betula* and *Quercus*. Non-arboreal pollen declines, especially Gramineae and *Plantago* spp. Other herbs types from the previous sub-phase become more sporadic and disappear.

4.8.6 CGMf 125-95cm..

This is a phase in which all the pollen spectra remain virtually stable. Arboreal pollen remains at 90% throughout and is composed of Coryloid (90%), *Alnus* (15%), *Betula* (15%), *Quercus* (20%) and *Fraxinus* (3%). The Gramineae curve declines slightly from 10% to 5%. The are no cereals present and except for scattered grains of *Artemisia*, Papilionaceae, Ranunculaceae, *Plantago* spp. and Labiatae, no other non-arboreal pollen types occur.

4.8.7 CGMg 95-52cm..

Phase CGMg is characterised by a decline in arboreal pollen to 75%. *Alnus*, *Betula*, *Quercus* and Coryloid fall to 15%, 10%, 10% and 55% respectively. There are scattered occurrences of *Ulmus*, *Fagus*, *Fraxinus*, *Salix* and *Hedera*. Gramineae increases gradually to 20% and after an initial decline, the *Plantago* spp. curve stabilises at 3%. Again there are few herbs present. *Triticum* type, *Artemisia*, Caryophyllaceae, Compositae tub., *Filipendula*, Labiatae, *Rumex* spp. and Rubiaceae occur.

4.8.8 CGMh 52-36cm..

This phase is based upon one pollen count but the changes in the pollen curves are distinct. There is a profound rise in arboreal pollen to 87% and almost all arboreal species rise simultaneously. *Alnus* increases to 20%, *Betula* and *Quercus* both to 15% and Coryloid declines slightly to 45%. Gramineae falls to 10% and *Plantago* spp. are the only herbs present.

4.8.9 CGMi 36-5cm..

Arboreal pollen declines for the last time in phase CGMi. Total arboreal pollen declines to 25% and all species are affected. Coryloid, *Alnus*, *Quercus* and *Betula* fall to 3%, 10%, 5% and 5% respectively. The Gramineae curve sharply rises to 47%. *Plantago* spp. reach their acme level of 20% and *Triticum* type rise to 5%. *Pteridium* rises to 10%. *Cannabis* type, *Artemisia*, Campanulaceae, Caryophyllaceae, *Centauria*, Chenopodiaceae, Compositae lig., Compositae tub., *Filipendula*, Ranunculaceae, Rubiaceae and Saxifragaceae occur.

4.8.10 CGMj 5-0cm..

The final level of this diagram is marked by a large rise in *Pinus* to 35%. *Betula* also increases to 25%, but *Quercus* (10%) and *Alnus* (3%) decline. Gramineae falls to 40% and *Triticum* type, Compositae tub., *Filipendula*, *Plantago* spp., *Rumex* spp., Saxifragaceae and Umbelliferae are only just present.

4.9 Ellergower Moss.

4.9.1 EGMa 200-150cm..

The first phase at this site is divided into 3 sub-phases.

$EGMa_1$ (200-189cm.) opens with a fall in arboreal pollen from 100% to 79%. This fall is most pronounced in the Coryloid curve which falls from 65% to 45%. Other arboreal pollen types are constant with *Alnus*, *Quercus*, and *Betula* at 20%, 15% and 5% respectively. *Fraxinus*, *Salix*, *Ulmus* and *Pinus* are present in

low quantities. Gramineae rises to 15%, *Plantago* spp. to 5% and *Pteridium* to 7%. There are scattered occurrences of *Artemisia*, Chenopodiaceae, Compositae lig., Papilionaceae, *Rumex* spp. and Rubiaceae.

$EGMa_2$ (189-158cm.) is a phase in which arboreal pollen rises and remains at 90%. Coryloid fluctuates between 40% and 60%, *Alnus* between 30% and 15% and *Betula* between 10% and 5%. *Quercus* remains stable at 15%. The curves of *Ulmus* and *Fraxinus* are continuous and sporadic grains of *Salix* and *Pinus* occur. Gramineae is stable at 10%. *Triticum* type occurs but there are few other herbs except for low values of *Artemisia*, *Plantago* spp., *Filipendula*, *Rumex* spp. and Rosaceae. *Pteridium* falls to 2%.

$EGMa_3$ (158-150cm.) is a phase based upon a short-lived fall in arboreal pollen to 80%. *Betula* declines to 5%, *Quercus* to 10%, Coryloid to 5% and *Alnus* remains at 15%. Gramineae increases to 15% and *Plantago* spp. to 4%. Few other herbs occur, except for *Filipendula*, Ranunculaceae, *Rumex* spp. and a small peak in *Pteridium* (5%).

4.9.2 EGMb 150-100cm..

EGMb is divided into 3 sub-phases.

$EGMb_1$ (150-130cm.) is a phase during which arboreal pollen slowly begins to decline. Arboreal pollen drops from 90% to 84%. *Betula* declines to 8% and *Alnus* to 17%, whilst *Quercus* remains stable at 10% and Coryloid rises to 55%. Gramineae also rises to 6% and *Plantago* spp. to 3%. There is a small peak in *Pteridium* at 3%. Few other herbs occur except for scattered occurrences of Caryophyllaceae, Chenopodiaceae, Cruciferae, Ranunculaceae and *Rumex* spp..

$EGMb_2$ (130-114cm.) is divided from $EGMb_1$ by a further decline in arboreal pollen to 75%. Coryloid falls very gradually to 50% and *Quercus* to 10%. *Alnus* and *Betula* increase to 20% and 10% respectively. There are small peaks in *Ulmus*, *Fraxinus*, *Salix* and *Ilex*. Gramineae slowly rises to 15% and *Plantago* spp. to 5%. Again few non-arboreal pollen types occur and only *Artemisia*, Caryophyllaceae, *Filipendula* and Rubiaceae are present. *Pteridium* increases to 8%.

The decline in arboreal pollen continues into $EGMb_3$ (114-100cm.). Whilst *Quercus* remains at a level similar to the previous phase, all other arboreal pollen types decline - Coryloid to 45%, *Alnus* to 10% and *Betula* to 5%. *Fraxinus*. *Pinus Hedera*, *Salix* and *Ulmus* continue to occur. Gramineae rises to 20% and *Plantago* spp. to 7%. *Pteridium* declines to 4%. Herb types include *Artemisia*, Compositae lig., *Filipendula*, Ranunculaceae, Rosaceae, *Rumex* spp. and *Urtica*.

4.9.3 EGMc 100-75cm..

EGMc opens with a rise in arboreal pollen which gradually increases to 90%. Much of this rise is a result of an increase in Coryloid to 60%. *Quercus*, *Alnus* and *Betula* stabilise at 10%, 15% and 5% respectively. Gramineae falls to 15% and *Plantago* spp. to 2%. There are scattered grains of *Artemisia*, Campanulaceae, Chenopodiaceae, Cruciferae, *Filipendula*, Papilionaceae, Rosaceae and *Rumex* spp.. *Pteridium* rises to 5%.

4.9.4 EGMd 75-68cm..

Phase EGMd is one during which arboreal pollen is virtually constant at 85%. *Alnus* and *Quercus* continue from the previous phase and Coryloid fluctuates around 65% and 45%. *Betula* rises to 15%, *Fraxinus* to 3%

and *Salix* and *Ulmus* occur. Gramineae stabilises at 7%. The only herbs present are Chenopodiaceae, *Filipendula*, Papilionaceae, *Plantago* spp., Rubiaceae and *Rumex* spp..

4.9.5 EGMe 68-40cm..

This phase has declining values of arboreal pollen which falls to 50%. The fall in Coryloid to 45% is most marked. *Betula* decreases to 5%, whilst *Quercus* and *Alnus* remain virtually constant. *Salix*, *Hedera*, *Fraxinus* and *Fagus* occur. Gramineae increases to 20% and *Plantago* spp. to 5%. *Secale cereale*, Compositae lig., Compositae tub., Papilionaceae, *Filipendula*, *Rumex* spp., Rubiaceae, Saxifragaceae and Umbelliferae occur.

4.9.6 EGMf 40-20cm..

The trend begun in EGMe continues into this phase as Coryloid continues to fall to 3% and *Betula* and *Quercus* remain at 5% and 15% respectively. *Alnus* increase to 15%. Total arboreal pollen is 45%. The curves of *Fraxinus* and *Salix* are no longer continuous but *Ilex* occurs. Gramineae continues to rise to 30% and *Plantago* spp. to 10%. *Artemisia*, *Triticum* type, Chenopodiaceae, Compositae tub., Ranunculaceae, *Rumex* spp. and Umbelliferae occur.

4.9.7 EGMg 20-0cm..

This final phase is characterised by a sudden increase in *Pinus* to 55% which causes total arboreal pollen to rise to 60%. Other arboreal pollen types fall - *Betula* to 5%, *Alnus* to 5% and *Quercus* and Coryloid both to 10%. Gramineae increases to 50% and then falls to 27% and *Plantago* spp. decrease to 3%. There are scattered occurrences of *Triticum* type, *Filipendula*, Labiatae, Papilionaceae, Ranunculaceae, *Rumex* spp., Saxifragaceae and Euphorbiaceae.

CHAPTER 5.

RESULTS AND INTERPRETATION.

5.1 Vegetation Change In Northern Britain During The Middle And Late Neolithic - *c*.2800-1600 B.C..

Unless otherwise stated, the dates quoted in this chapter are derived from the extrapolation of the average peat accumulation rates (see Section 3.5 and Figures 3.23 to 3.31). As extrapolation was based on the mid-point of the calibrated date range with the highest probability, then the extrapolated date must also lie within a range and therefore the dates stated below must be considered as approximate, rather than precise.

Although each site has an earlier pollen record this discussion begins with the earliest phases analysed in the present project. Most changes in the pollen spectra involve fluctuations in Coryloid, *Betula and* Gramineae, and to a lesser extent, *Alnus* and *Quercus*. The pollen diagrams inserted in the text are summary diagrams used to illustrate the major features of vegetation change and the full diagrams should also be referred to (Figures 3.13 to 3.21).

5.1.1 Cranley Moss, Fannyside Muir And Fozy Moss - Small Temporary Clearances.

The definition of small temporary clearances, extensive clearance and complete clearance follow the criteria set by Turner (1965). Small temporary clearances are defined as those where non-arboreal pollen reaches 15%, after which trees soon regenerate and the woodland becomes as it had been before. This level has been used to define small temporary clearances as, in this study, values of non-arboreal pollen above 15% are usually associated with further, accelerating clearance. The pollen diagram for Cranley Moss, begins during the middle Neolithic, somewhat earlier than the other sites analysed. The first phase (CYMa) dates to between *c*. 2565 B.C. and 1650 B.C. (Figure 5.1), at which time the forest canopy was to some extent already open, but gradually regenerated throughout the period. Gramineae rises and pastoral agriculture is indicated by *Plantago* spp., Compositae tub., Cruciferae, *Filipendula*, Papilionaceae and Ranunculaceae. Although pastoral land uses predominate, there was some arable agriculture practised, as indicated by the presence of *Triticum* type and *Rumex* spp.. Although no evidence for Neolithic settlement has been found in this area, the pattern of small openings in the forest, in which limited agriculture was practised, agrees with the ideas postulated in the archaeological literature. It is thought that the Neolithic was a period in which small groups of people inhabited settlements, cultivated cereals and practised pastoralism in areas of the forest which had been cleared (Dickinson, 1961; Duncan, 1978). Small temporary clearances also seem to have been common across Scotland during the Neolithic and pollen diagrams from Threepwood Moss, Melrose (Mannion, 1978 a), Linton Loch, Roxburghshire (Mannion, 1978 b), Linwood Moss, Renfrewshire (Boyd, 1986) and a number of sites in the Upper Eddleston Valley (Newey, 1976) all indicate that small temporary clearances occurred.

At Fannyside Muir FSMa) an almost completely forested landscape probably occurred between *c*. 2455 and 1775 B.C. (Figure 5.2). Very small short temporary clearances occur which are probably associated with small groups of people clearing forest for settlement and agriculture and although there is no direct evidence for Neolithic settlement, chambered cairns, burial mounds and standing stones are distributed throughout the area (MacPhail, 1962,1).

FIGURE 5.1 CRANLEY MOSS - SELECTED CURVES FOR THE NEOLITHIC.

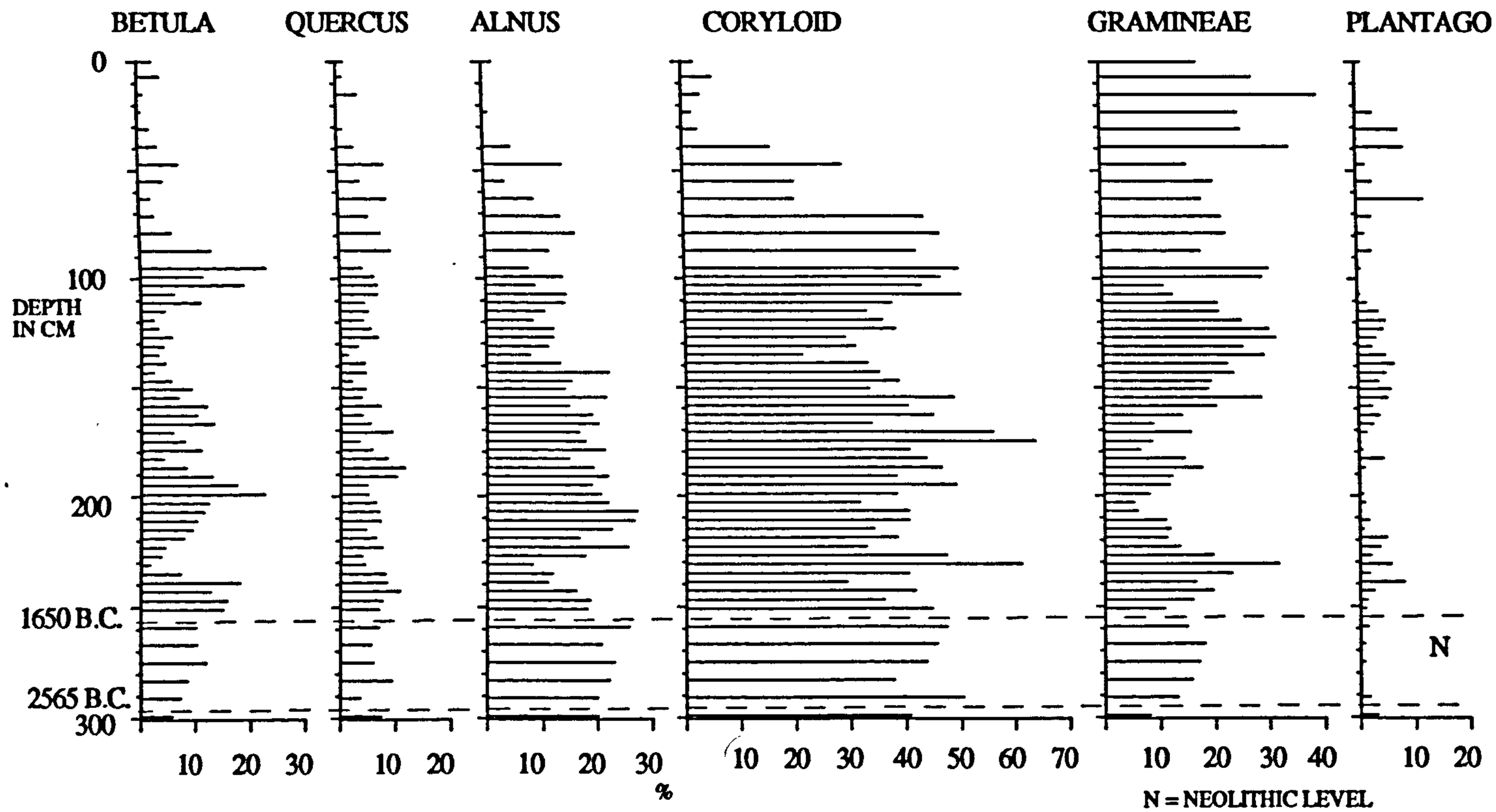
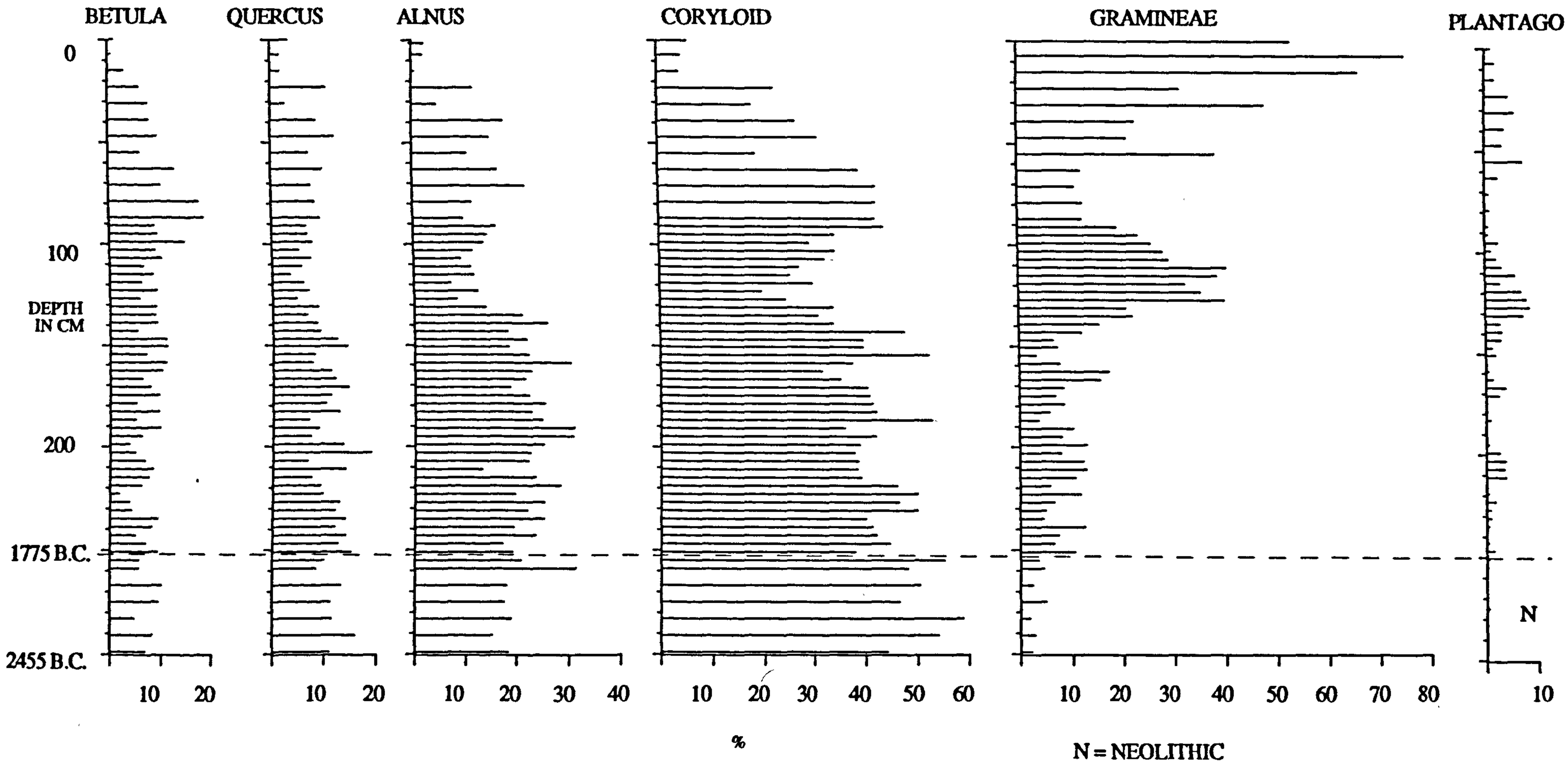


FIGURE 5.2 FANNYSIDE MUIR - SELECTED CURVES FOR THE NEOLITHIC.



N = NEOLITHIC

At Fozy Moss ($FZMa_1$) a complete, perhaps undisturbed, forest canopy occurred between *c.* 2800 B.C. and 2385 B.C. (Figure 5.3). The species which are predominant are Coryloid, *Betula*, *Alnus* and *Quercus* and no Gramineae or herbs are present. However, from around 2385 B.C. to 1575 B.C. (SRR-4540) ($FZMa_2$) the canopy becomes more open though the landscape is still predominantly forested. Coryloid was probably preferentially cleared as the curve shows more variability when compared to those of other tree species and as the canopy was opened light demanding species such as *Fraxinus*, *Salix* and *Ulmus* occur more frequently. Small peaks in Gramineae, *Plantago* spp. and *Pteridium* and herbs such as *Triticum* type, *Artemisia*, *Rumex* spp., Cruciferae, *Filipendula*, Compositae tub., Labiatae and Ranunculaceae indicate that low levels of both arable and pastoral agriculture was practised. Archaeological evidence for the distribution of Neolithic population in Northumbria is sparse, but a limited number of burial mounds and artefacts have been identified. Evidence for settlement is found in the form of urns, food vessels and beakers, mostly discovered north of the River Tyne and north-east of Haltwhistle (Burgess, 1984, 154; Clack and Gosling, 1976). However, the population that was involved in such activity was very small (Higham, 1986, 43) and they had very little impact on the vegetation. Clearances indicated by the pollen evidence from Fozy Moss agrees with the archaeological evidence for low population density and with other pollen evidence from Northumbria. At both Coom Rigg Moss (Chapman, 1964) and Midgeholme Moss (Innes, unpub.) small temporary clearances associated with shifting pastoralists occur throughout the Bronze Age.

Although the Neolithic landscape was more open at Cranley Moss and Fannyside Muir than at Fozy Moss, small temporary clearances in which small-scale pastoral and arable agriculture was practised, followed by woodland regeneration occurred at all sites. Although these could be interpreted as the registration of larger clearances at some distance from the site, they are similar in nature to the *landnam* phases identified in pollen diagrams by Iversen (1949). A single *landnam* phase lasted a hundred years or more and can be divided into three stages. The first is the initial clearance when trees decrease and grass and herbs increase, followed by a second phase when the pollen of cereals, pastoral and arable weeds are present associated with farming. Regeneration of the forest could also be underway. The final stage is one in which arboreal pollen recovers and the forest regenerates almost to its pre-*landnam* constitution as the occupants moved to a new area and began clearance anew. According to Iversen (1949) and Turner (1965) such a phase lasted about 50 years but Smith (1981) records such clearings lasting between 100 to 400 years, but clearance of this duration probably reflects aggregate clearance activity. Detection of such clearance in pollen diagrams very much depends on their duration, the resolution and counting interval of the pollen diagram. If clearances are single, short term events, they would barely be reflected in the pollen diagram. Clearance at some distance from the sampling site would also not be registered so strongly as a closer clearance, because of the nature of pollen grain transport (Tauber, 1965; Edwards, 1982). Without a knowledge of pollen source areas, pollen transport and dispersal ability and detailed knowledge of archaeological distributions, the exact nature of small clearances in pollen diagrams and their spatial significance cannot be interpreted.

5.2 Vegetation Change in Northern Britain During The Early And Mid Bronze Age *c.* 1700 B.C. - 900 B.C..

5.2.1 Walton Moss And Glasson Moss - Stable Forest.

Between approximately 1490 B.C. and 930 B.C. (Phase $WLMa_1$), a largely forested landscape occurred around Walton Moss (Figure 5.4). Small-scale pastoral agriculture is indicated by the presence of Gramineae, *Pteridium*, *Plantago* spp. and Compositae tub. and where clearances occur, light demanding trees and shrubs, such as *Fraxinus* and *Salix* were more common. No cereal cultivation was detected. A similar situation of virtually intact forest existed at Glasson Moss (Phase $GLMa_1$) (Figure 5.5) between around 1085 B.C. and

FIGURE 5.3 FOZY MOSS - SELECTED CURVES FOR THE NEOLITHIC.

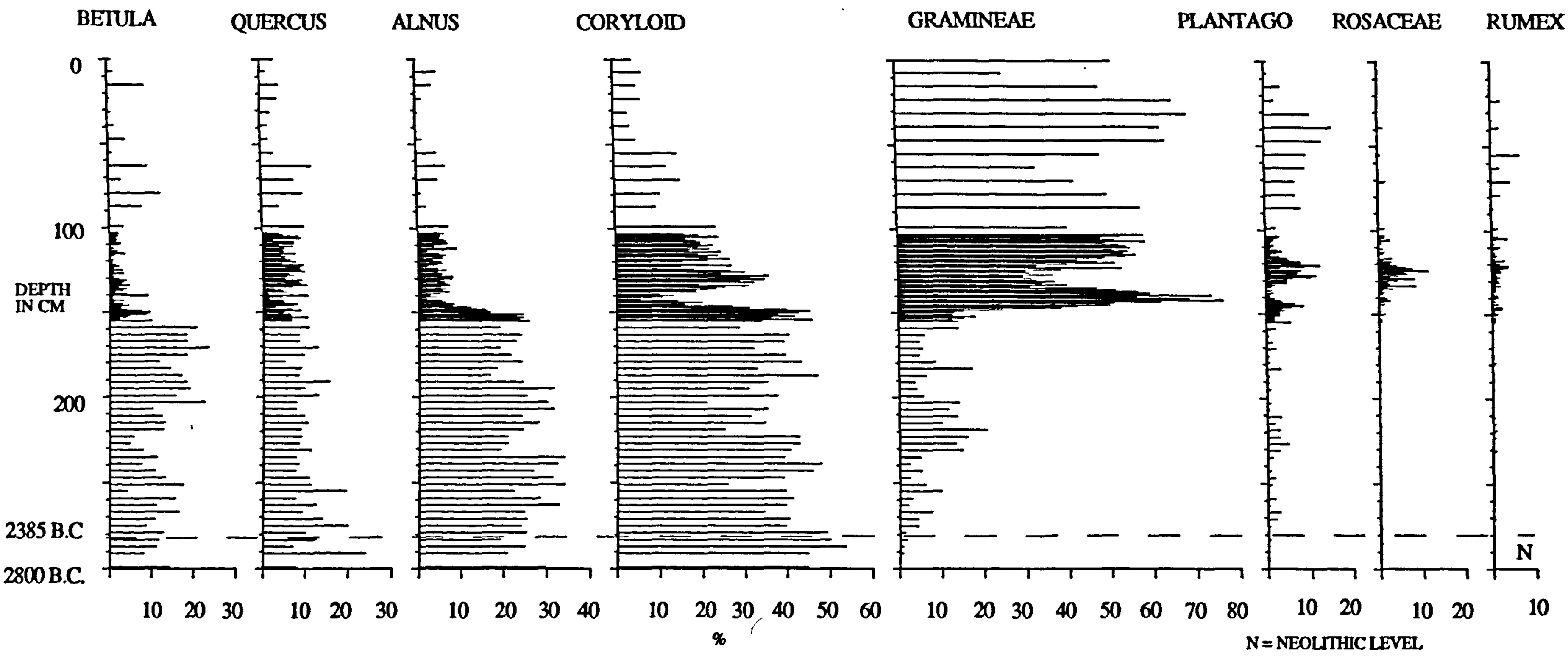
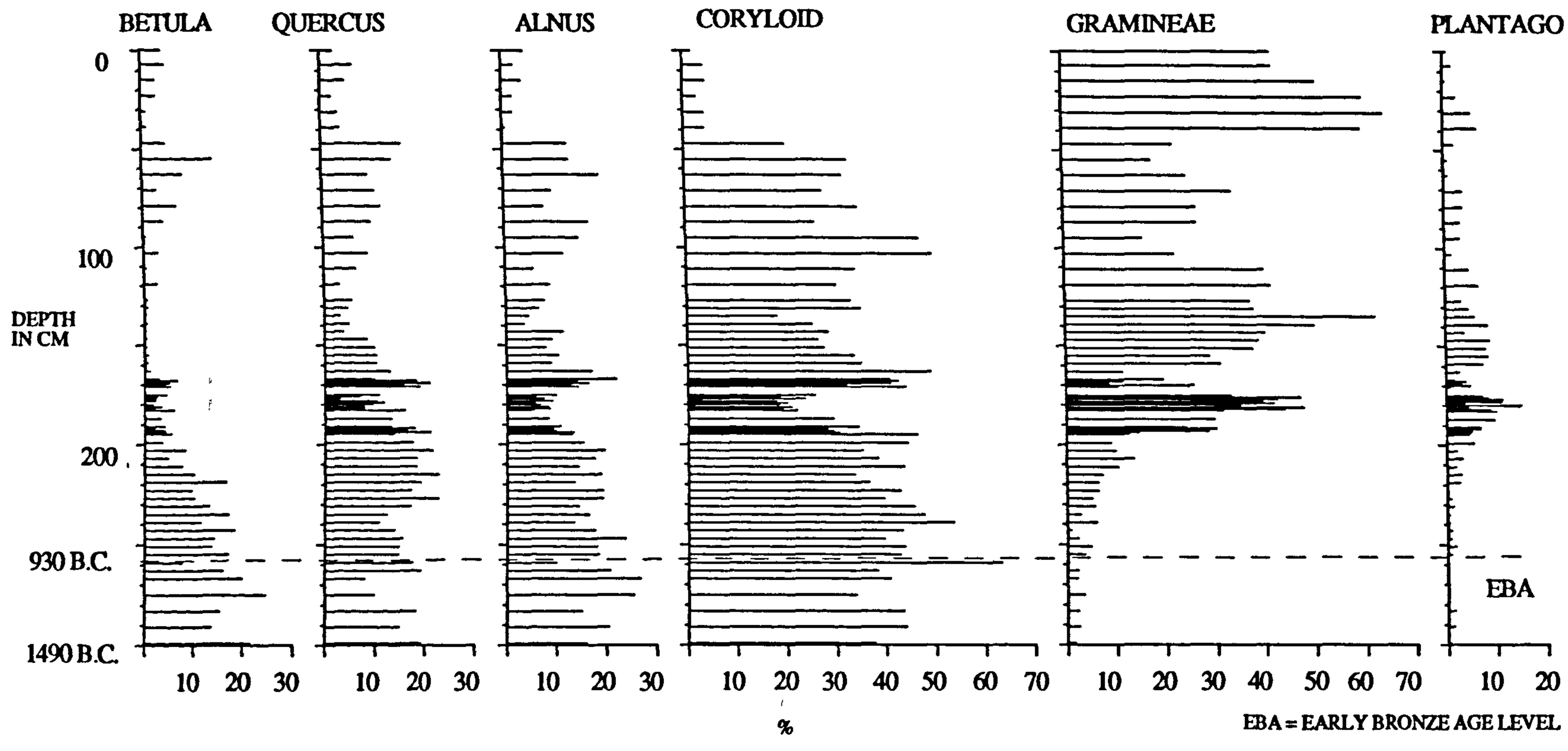
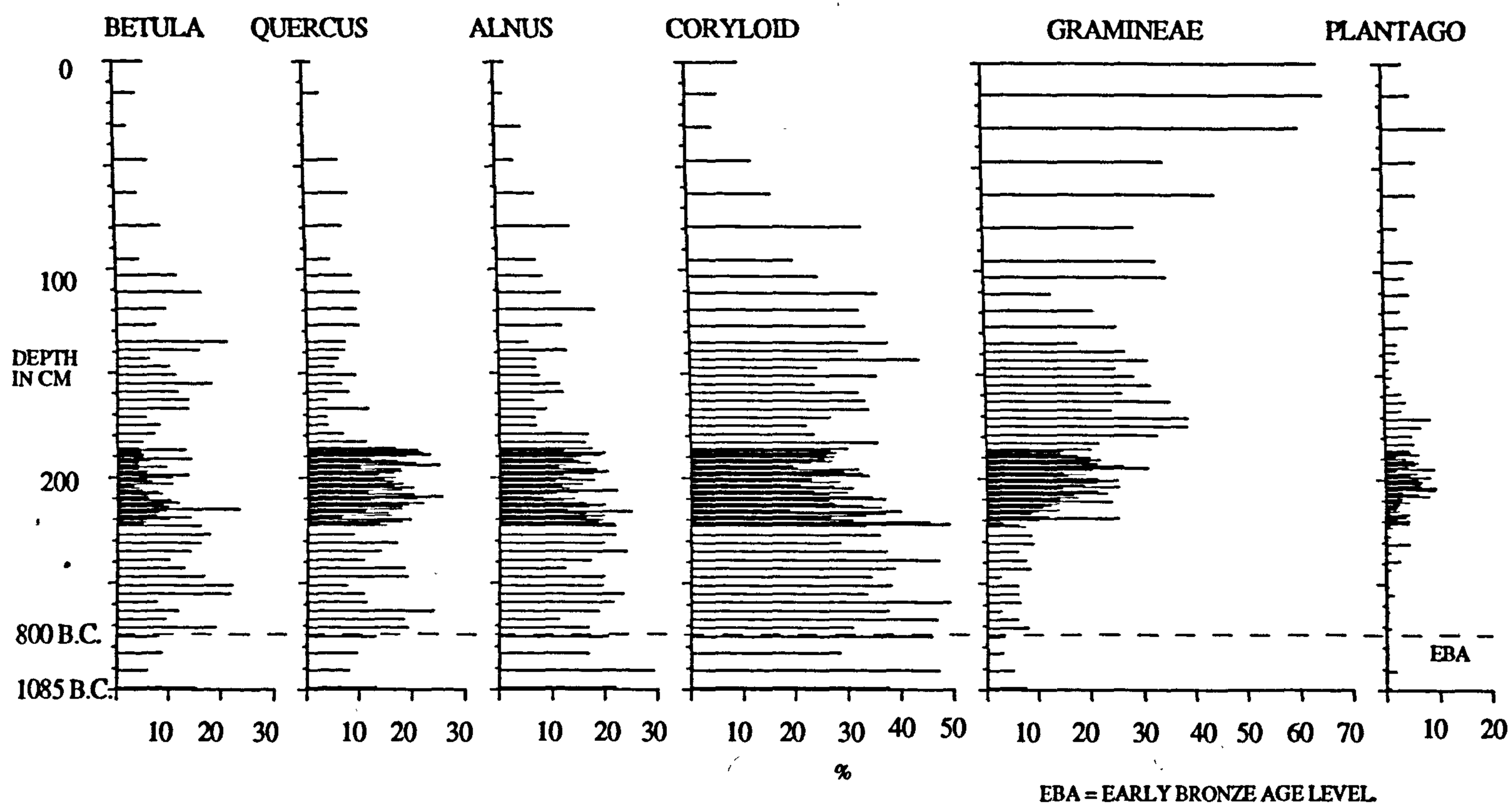


FIGURE 5.4 WALTON MOSS - SELECTED CURVES FOR THE EARLY BRONZE AGE.



EBA = EARLY BRONZE AGE LEVEL

FIGURE 5.5 GLASSON MOSS - SELECTED CURVES FOR THE EARLY BRONZE AGE.



EBA = EARLY BRONZE AGE LEVEL.

800 B.C., thus continuing later than at Walton Moss. Here, the forest canopy was still largely closed, though slightly less so than at Walton Moss.*Ulmus* is a local component of the woodland canopy and openings in the canopy are indicated by *Fraxinus*, *Hedera* and *Salix*. Predominant pastoral land-use is suggested by the absence of cereal pollen and the presence of Gramineae, *Plantago* spp., Compositae tub., Ranunculaceae and *Pteridium*.

The low level of clearance at both sites implies low population densities and archaeological evidence for the Bronze Age in northern Britain is scarce (Higham, 1986, 85), most knowledge of the period being derived from burial sites and associated artefacts. Although artefacts and burial cairns indicate that people were present in an area, very few settlements, houses or field-systems dating to the Bronze Age have been discovered (Burgess, 1974, 165; Fowler, 1983, 73; Taylor, 1983; Higham, 1986, 92). Maps showing the distribution of evidence for Bronze Age settlement (Clack and Gosling, 1986; Maxwell, 1983; Higham and Jones, 1985, 4; Higham, 1986, 127) indicate that there is no evidence for settlement around Walton or Glasson Mosses, though a limited number of bronze axes have been discovered in the Walton Moss area (Higham, 1986, 98). The pollen evidence from Walton and Glasson Mosses is also in accord with that from other sites. At Bowness Common, only 3.5 km. away from Glasson Moss, small temporary clearances occur from around 1000 B.C. and are associated with pastoral and arable activity (Walker, 1966). At Bolton Fell Moss, 1 km. north of Walton Moss, similar small temporary clearances, with evidence for pastoralism and no cereals occurred (Barber, 1981, 111).

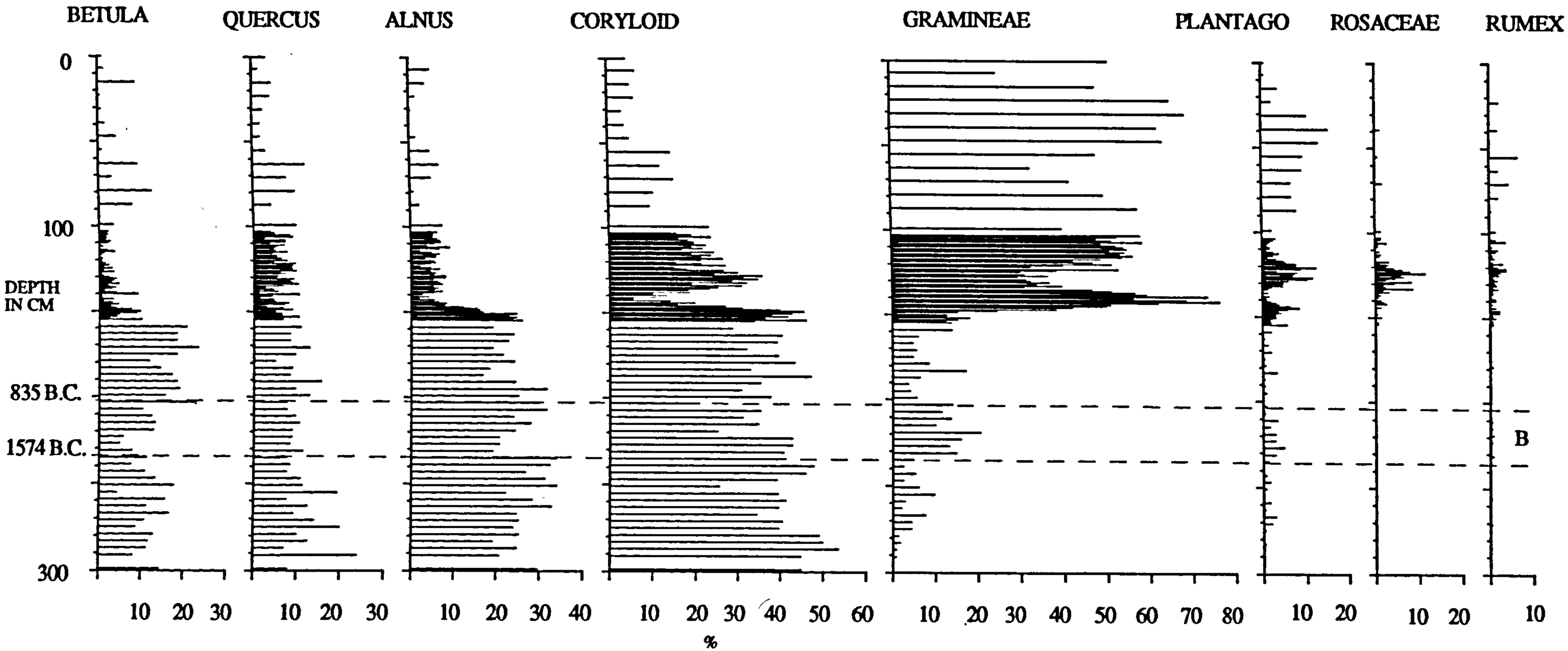
5.2.2 Carsegowan Moss And Ellergower Moss - Stable Forest.

At Carsegowan Moss a predominantly forested landscape was in existence between about 1135 B.C. and 535 B.C. (Phase CYMa). There are very low percentages of Gramineae, and small amounts of *Pteridium*, Caryophyllaceae, *Plantago* spp. and Ranunculaceae indicate a very low level of pastoral agriculture. There are no cereals present, but the occurrence of *Artemisia*, Chenopodiaceae, *Rumex* spp. and Umbelliferae suggest that some arable activities might have been practised. The only break in the forest canopy occurred at the beginning of the phase where a small temporary clearance is indicated by small peaks in Gramineae, *Plantago* spp. and *Pteridium*. The early and mid Bronze Age periods at Ellergower Moss (Phase EGMa$_1$ and a$_2$) are ones during which there are minimal effects on the forest. Between *c.* 1520 B.C. and 930 B.C., arboreal pollen is high, the forest canopy is closed and virtually stable. Gramineae is low and small-scale pastoral activity is indicated by the presence of Caryophyllaceae, *Filipendula*, *Plantago* spp. and *Pteridium*. One small temporary clearance occurs around 1380 B.C. and is similar in scale to that at Cranley Moss. At both Carsegowan Moss and Ellergower Moss, the level of clearance and interference with the forest canopy is small, but similar to that at Walton Moss and Glasson Moss. Besides a limited number of cairns (Yates, 1984), little archaeological evidence for Bronze Age groups has been found in south-west Scotland (Jobey, 1985) and the pollen evidence reported here agrees with that from other published pollen diagrams. At a series of sites in south-west Scotland small temporary clearances with cereals occurred during the Bronze Age (Nichols, 1967; Birks, 1972; 1975).

5.2.3 Fozy Moss And Cranley Moss - Forest Clearance.

In contrast, at Fozy Moss (Phase FZMb) the forest canopy becomes increasingly open between *c.* 1575 B.C. (SRR-4540) and 835 B.C. (Figure 5.6). During this period, arboreal pollen declines and then slowly rises back to former levels. All major tree types seem to have been affected, and Gramineae rises along with *Plantago* spp. and *Pteridium*. Other herb species occur, suggesting that pastoral and arable agriculture was practised and the presence of *Triticum* type indicates that cereals were cultivated. This was probably a result

FIGURE 5.6 FOZY MOSS - SELECTED CURVES FOR THE BRONZE AGE.



B = BRONZE AGE LEVEL

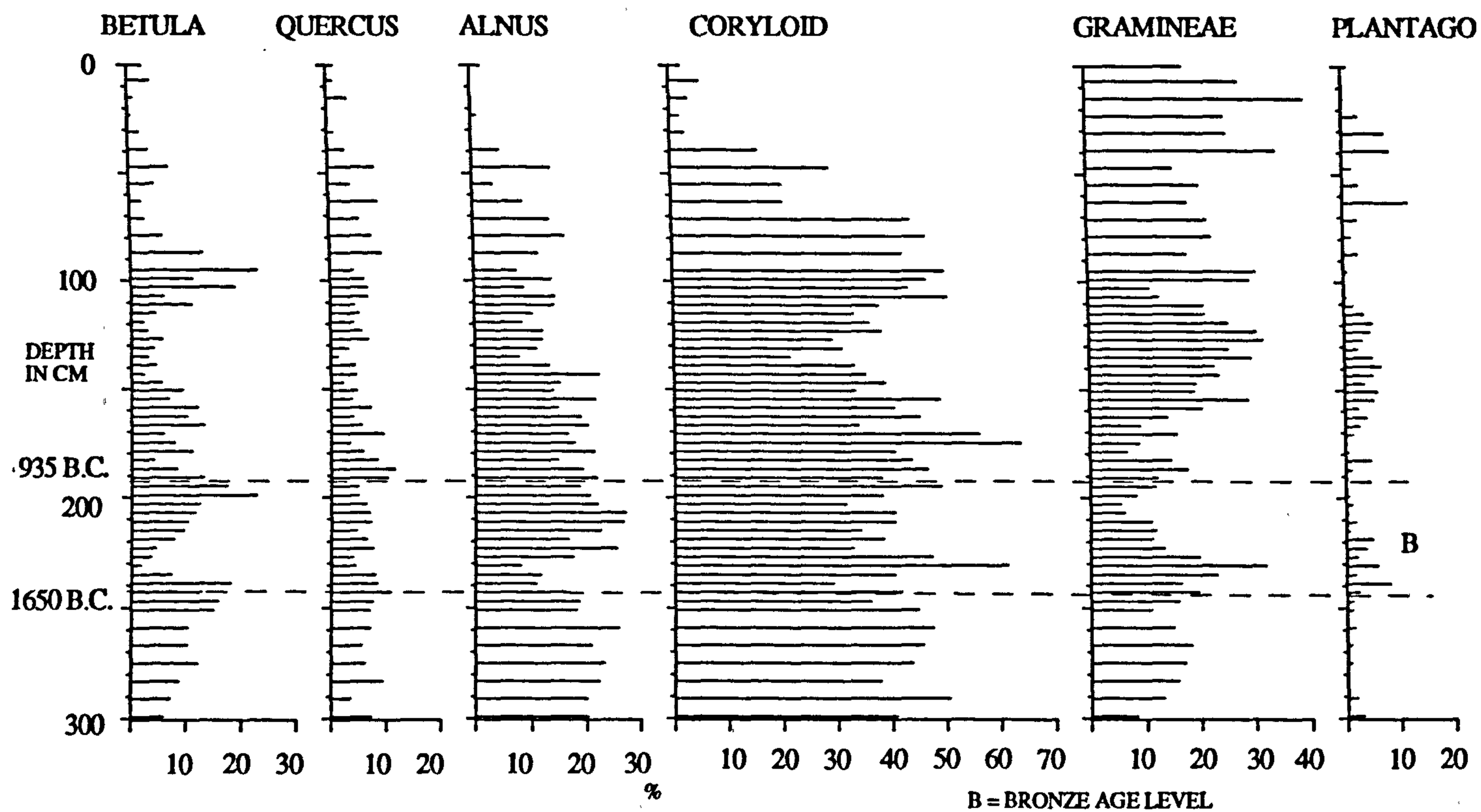
of local population groups clearing the forest, utilising the land for agriculture, abandoning the clearing and the tree species regenerating. The time span over which this occurred (*c.* 700 years) is longer than the small temporary clearances of the previous Neolithic phase, suggesting more permanent settlement and agriculture.

Although recent interest has focused upon the identification of upland settlements, it is apparent from the distribution of artefacts, burials and monuments that major areas of settlement existed along river valleys and the well drained lowlands of Northumbria, the most notable feature of settlement in the north being an extension of Bronze Age activity both in the lowlands and in areas intermediate between the lowlands and uplands (Higham, 1986, 82; Annable, 1987). Bronze Age settlement and artefact distribution maps (Clack and Gosling, 1976; Higham, 1986, 98), indicate that there was a small cluster of axe hoards and settlements around the area of Fozy Moss and the pollen evidence may indicate that the people occupying these settlements were obviously clearing the forest, using the timber to construct settlements and practising a mixture of pastoral and more settled arable agriculture in the cleared areas. This clearance was more substantial than in the Neolithic and at Walton and Glasson Mosses. The evidence from Fozy Moss is supported by pollen evidence from other sites in Northumbria. At Coom Rigg Moss (Chapman, 1964), Midgeholme Moss (Innes, unpub.), Broad Moss, Steng Moss, Camp Hill Moss and Fellend Moss (Davies and Turner, 1979) small temporary clearances seem to have been widespread. This also is in accord with Wilson's (1983) conclusion that small temporary clearances occurred throughout north-eastern England during the Bronze Age.

At Cranley Moss (CYMb), a renewed attack on the forest between approximately 1650 B.C. and 1285 B.C. (Figure 5.7) is indicated by a further fall in arboreal pollen. *Betula*, *Quercus* and *Alnus* decline, whilst Coryloid actually rises, perhaps suggesting that primary rather than secondary forest was being cleared. Light demanding species increase, such as *Fraxinus* and *Salix* . *Corylus* produces more pollen, whilst in a more open environment, there is an increased representation of species possessing poor pollen dispersal abilities such as *Fagus* (Moore *et al.*, 1991, 182). Gramineae, *Plantago* spp. and *Pteridium* rise, which along with Caryophyllaceae, *Filipendula*, Papilionaceae and Ranunculaceae, indicate pastoralism. The presence of *Triticum* type, *Artemisia*, Cruciferae, *Rumex* spp. and Umbelliferae also indicates arable practices. This early Bronze Age clearance at Cranley Moss occurred over a period of around 400 years, after which the forest began to regenerate. Population numbers were probably high enough to cause a larger forest clearance than those at Walton, Glasson and Fozy Mosses or clearance occurred nearer the mire. In Lanarkshire the dense concentration of Bronze Age finds in the head-waters of the Clyde, suggests penetration of people from the west and the distribution of cairns, axes and therefore possibly settlements, appear to be on the periphery of a wider distribution. This suggests that the adjacent lowlands were areas of prime settlement location and that settlements in the Cranley Moss area were a result of expansion, and were therefore prone to abandonment in the event of contraction. A transhumance role is also suggested by their distribution (Piggott, 1951; R.C.H.A.M.S., 1978; Halliday, 1985; McDonnell, 1988).

However, after the initial clearance, forest regeneration, followed by a number of small temporary clearances occurred in the mid Bronze Age ($CYMc_1$) between approximately 1285 B.C. and 935 B.C.. The forest reverts to Neolithic levels and the regeneration of *Betula*, *Alnus* and *Quercus* are most noticeable. Small temporary clearances are indicated by fluctuations in arboreal pollen. Grass declines as the forest regenerates, though rises slightly during the clearance phases. Generally, other herbs are lower than in the early Bronze Age, but the presence of *Triticum* type,*Centauria cyanus*, *Rumex* spp., Umbelliferae, *Plantago* spp., Ranunculaceae and *Urtica* indicates that some agriculture continued. The pollen evidence therefore indicates that the population in the area around Cranley Moss declined or that the area was abandoned. The small temporary clearances suggest the presence of smaller groups or groups clearing at a greater distance from the mire.

FIGURE 5.7 CRANLEY MOSS - SELECTED CURVES FOR THE BRONZE AGE.



5.2.4 Fannyside Muir - Small Temporary Clearances.

Arboreal pollen begins to decline at Fannyside Muir between around 1775 and 1180 B.C. (FSMb) and small temporary clearances become more common as *Betula* and Coryloid fluctuate and Gramineae begins to increase. Herbs become more frequent and include *Triticum* type, Caryophyllaceae, *Filipendula*, *Plantago* spp., Labiatae, Papilionaceae, Ranunculaceae, Rosaceae and *Rumex* spp.. This indicates that both pastoral and arable agriculture was practised in the forest clearings. Between *c.* 1180 and 810 B.C. ($FSMc_1$) slightly larger clearances occur and arboreal pollen declines further. Although the landscape is still predominantly forested, Gramineae and *Pteridium* increase and herbs such as *Artemisia*, Caryophyllaceae, Chenopodiaceae and Ranunculaceae become more frequent. There are no cereals present and pastoral land use probably dominated. Increasing population and settlement probably led to increased clearance around Fannyside Muir and although direct evidence for settlement is uncommon, a large number of cairns, urns and vessels have been found (MacPhail, 1962, 2).

5.2.5 Conclusion.

The pollen evidence for the early and middle Bronze Age indicates that at each site a different pattern of vegetation change occurred. These inter-site variations can be explained by the archaeological record of each area. The more or less stable forest, though with evidence for limited pastoralism, at Walton, Glasson, Ellergower and Carsegowan Mosses can be accounted for by limited archaeological evidence for Bronze Age settlement in those areas. Obviously a limited number of people with low population densities were utilising the forest for small-scale pastoralism, but not having a profound effect on the vegetation. The vegetation record at Fannyside Muir, Fozy Moss and Cranley Moss, as reflected in the pollen diagrams, suggests that forest was cleared for pastoral and arable agriculture. This evidence for clearance is in agreement with the archaeological record of a higher number of settlements, axe hoards and therefore population in Lanarkshire, Strathclyde and Northumbria.

5.3 Vegetation Clearance In Northern Britain During The Late Bronze Age *c.* 900 B.C. - 500 B.C..

5.3.1 Walton Moss And Glasson Moss - Gradual Clearance.

At Walton Moss from *c.* 900 B.C. to 500 B.C. (Phase $WLMa_2$), there is a gradual reduction in the forest cover, with some small temporary clearances. Coryloid and *Betula* are most affected and opening of the forest is also indicated by increasing Gramineae. *Plantago* spp. become continuous and along with Labiatae, Papilionaceae, Ranunculaceae and Rosaceae, indicate that pastoral agriculture was practised. The first occurrence of *Triticum* type and *Rumex* spp., along with *Artemisia* and Cruciferae provides evidence for the cultivation of crops. Therefore, the forest was gradually cleared during the late Bronze Age and the cleared land used for small-scale arable and pastoral agriculture.

At Glasson Moss ($GLMa_2$) there is an initial slight decline in the forest cover after which it remains more or less stable, attaining levels similar to the early Bronze Age. This occurs between *c.* 800 B.C. and 550 B.C. (SRR-4534). As the landscape becomes open, *Betula*, Coryloid, *Alnus* and *Quercus* all decline and light demanding species (*Fraxinus* and *Salix*) and those with poor pollen dispersal abilities such as *Tilia* and *Fagus*, occur. *Pinus* is present and the opening of the canopy probably allowed more regional pollen to be recorded. Small fluctuations in the arboreal species suggest that the forest was cleared for small temporary clearances, after which trees were allowed to revert. Gramineae increases and pastoral agriculture is indicated

by *Plantago* spp., *Pteridium*, Ranunculaceae, *Filipendula*, and Compositae lig.. Arable agriculture is suggested by the occurrence of *Succisa*, Chenopodiaceae, *Polygonum* and *Artemisia*.

The pollen evidence for a low population, gradually clearing the forest and practising pastoral and arable agriculture in small temporary clearances corresponds with the archaeological evidence. From the end of the 10th Century until the middle 8th Century B.C., Britain south of the Humber was served by bronze smiths casting new implements, but these new innovations did not penetrate the north and in these areas old traditions remained dominant. The archaeological evidence indicates continuity, with a conservative society, which shows little sign of any form of innovation or inventiveness. Burial rites, settlement patterns and ceramic technology changed little (Cunliffe, 1991, 54). Archaeological evidence for population distribution is largely restricted to the distribution of Late Bronze Age metalwork and a variety of unenclosed settlements (Wilson 1983; Annable, 1987). The artefacts in the north indicate a low level of productivity and groups failed to generate major cultural developments and metallurgy. Instead they copied artefacts from neighbouring groups (Higham, 1986, 99) and it was not until the Sixth Century and Seventh Century B.C. that a well defined bronze working tradition - the Heathery-Burn tradition - served the north of England (Higham, 1986, 102; Cunliffe, 1991, 100). However, at this time, the population of Cumbria remained impoverished and there is only very sparse evidence for settlement (Fowler, 1983, 73; Higham, 1986, 82), which may explain the palynological evidence for a predominantly forested landscape.

5.3.2 Dogden Moss And Cranley Moss - Forest Clearance.

Between around 850 B.C. and 420 B.C. at Dogden Moss (DGMa), the forest was already more open than at Walton and Glasson Mosses, the opening being similar to, but more stable than that at Fozy Moss. Thus, by the late Bronze Age, a significant reduction in the forest cover had already taken place and further clearance occurred affecting Coryloid, *Betula* and *Alnus*. Gramineae increased as well as *Pteridium*, *Plantago* spp., Compositae lig., Compositae tub., *Filipendula*, *Rumex* spp., Umbelliferae, *Urtica* and Ranunculaceae which suggests that small-scale agriculture was practised in the forest clearings. This is supported by the archaeological evidence. Piggott (1951) identifies a concentration of bronze artefacts, burials, beakers and food vessels in the Dogden Moss area and it is thought that around 1700 B.C. bands of invaders landed on the shores of south-east Scotland from the Low Countries and the Rhine (Clack and Gosling, 1976; Burgess, 1986) which may explain why the forest was already open at Dogden Moss. These people brought elaborate pottery which has been found stretching from the Firth of Forth, through Berwickshire into the Tweed area and its distribution along with the distribution of burial cairns suggests that there was perhaps a shift in population westwards from the Berwickshire coast to East and Mid Lothian into areas previously considered marginal for settlement (Ritchie and Ritchie, 1972, 22; Donaldson, 1974; Megaw and Simpson, 1979, 178). The routes of penetration inland were by means of river valleys, and this is shown in Berwickshire by the distribution of cairn fields in Lauderdale and the Whiteadder and Blackadder valleys adjacent to Dogden Moss (Piggott, 1951; Halliday, 1985). A trade route probably crossed the Lammermuir Hills and reached the Tweed via the Gala Water, but by 1000 B.C., it is thought that coastal settlement had thinned and the areas around Whiteadder and Blackadder had lost their earlier importance (Jobey, 1985). Between 900 B.C. and 500 B.C., sustained clearance at Dogden Moss is probably due to the fact that the Scottish Bronze industry slowly expanded, adopting new techniques and producing new types of weapons and tools. The area was served by the Traprain-Hownam tradition, making locally manufactured bronzes (Cunliffe, 1991, 101). Trading contacts with Europe expanded and foreign products were assimilated in the north (Donaldson, 1978; Ritchie and Ritchie, 1981, 89; Cunliffe, 1991, 102). These changes are also in accord with the results from other pollen diagrams in south-east Scotland. During the Bronze Age, a similar reduction in forest cover occurred at Threepwood Moss, Melrose (Mannion, 1978 a), Linton Loch, Roxburgh (Mannion, 1978 b), Din Moss,

Roxburghshire (Hibbert and Switsur, 1976), The Dod (Shennan and Innes, 1986) and Linwood Moss, Renfrewshire (Boyd, 1986).

At Cranley Moss (Phase $CYMc_2$) a renewed attack on the forest occurred between 935 B.C. and 660 B.C.. The decrease in forest cover is on a smaller scale than the early Bronze Age and probably represents a small temporary clearance. The decrease in arboreal pollen is predominantly due to a decline in Coryloid, *Quercus* and *Betula*, with an associated increase in Gramineae. Despite the clearance being smaller than those in the early Bronze Age, higher levels of *Plantago* spp. and *Pteridium*. indicate that agriculture was either more intense or covered a greater area of the total clearance. The levels of Papilionaceae, Ranunculaceae and *Urtica* indicate a predominance of pastoral agriculture, but limited arable activity is indicated by the presence of *Triticum* type, *Secale cereale*, *Artemisia*, Cruciferae, *Rumex* spp. and Chenopodiaceae, also suggesting a more settled population. Piggott (1951), identifies a concentration of Bronze Age artefacts and burials in the Cranley Moss area. The west, including the Firth of Clyde, was occupied by communities capable of producing distinctive pottery of high quality (Cunliffe, 1991, 104) and this area is thought to have supported a sizable population residing in unenclosed settlements (Ritchie and Ritchie, 1981, 86; Stevenson, 1985, 12). The Lanark region also profited from connections with the west coast by means of the Clyde (Jobey, 1985). At Bloak and Kennox Mosses, Ayrshire (Turner, 1965, 1975) small temporary clearances also occur and a pollen diagram from the Carstairs Kames (Dickson, 1980) indicates that small temporary clearances followed by gradual forest opening occurred during the Bronze Age, although these are not radiocarbon dated.

5.3.3 Fozy Moss - Forest Regeneration.

At Fozy Moss (Phase $FZMc_1$), a marked regeneration in trees occurs between *c.* 835 B.C. and 590 B.C. when the forest regenerates to levels comparable with the Neolithic as represented by an increase in Coryloid, *Quercus* and *Betula* and a decrease in Gramineae and *Plantago* spp.. That some agriculture occurred is indicated by the continued limited presence of *Artemisia* and Ranunculaceae, but it seems that the area was abandoned and agriculture decreased around 835 B.C.. There are conflicting ideas regarding the archaeological evidence for this area. Cunliffe (1991, 50) discusses how archaeological remains provide evidence for well established communities in family-sized units occupying unenclosed settlements (Jobey, 1980). Parts of northern England and Scotland exhibited some degree of cultural unity, which can be defined through the distribution of locally manufactured bronze implements, and the distribution of bronze implements and beakers in Northumbria also being compatible with an exchange system centred upon eastern Scotland (Megaw and Simpson, 1979, 179). However, the pollen evidence from Fozy Moss indicates that woodland regenerated and it might be that occupation in the area around Fozy Moss declined, as groups abandoned land and moved away. This could be due to the climatic deterioration between *c.* 800 B.C. and 500 B.C. (Barber, 1981) which would have had a greater impact on groups in this semi-upland with poor soils. The situation indicated by the pollen evidence seems to relate more closely to the ideas of Jobey (1985) who suggests that in most areas of the north settlement seems to have been relatively sparse, the material culture poor and pottery and bronzes little used. However, at Callaly Moor in northern Northumbria clearance and soil erosion were underway in the middle and late Bronze Age (Macklin *et al.*, 1991).

5.3.4 Fannyside Muir - Small Temporary Clearances.

After a slight forest regeneration, a renewed small clearance occurs at Fannyside Muir between approximately 810 and 575 B.C. ($FSMc_2$) as *Quercus* and *Betula* remain virtually stable whilst *Alnus* and Coryloid fluctuate. Gramineae decreases and then increases, though not to such high levels as in the early Bronze Age. *Triticum* type, Caryophyllaceae, Rosaceae and Rubiaceae occur whilst *Plantago* spp. decline. There is little

archaeological literature pertaining to this area. Forest regeneration is probably a result of a decline in population and settlement in the area as groups abandoned land and the beginning of renewed clearance is perhaps due to population increase or a new population group moving into the area, clearing forest for settlement and agriculture.

5.3.5 Letham Moss, Carsegowan Moss And Ellergower Moss - Stable Forest.

At Letham Moss (LTMa) a slight opening in what seems to be an almost complete forest canopy, occurs between *c.* 735 B.C. and 610 B.C.. This small temporary clearance is similar to contemporaneous clearances at Walton and Glasson Mosses. Gramineae, *Pteridium* and *Plantago* spp. are present, but not in any significant quantity and very limited pastoral agriculture is also indicated by the presence of Labiatae and Caryophyllaceae. Although there are no cereals present, arable activity may be indicated by *Rumex* spp., *Polygonum* and *Artemisia*. This low level of clearance fits with the limited archaeological evidence. A few ring ditches (Maxwell, 1983) and bronze axes (Piggott, 1951) are found in the Letham Moss area and no cairns have been discovered (Jobey, 1985). At Ellergower Moss, between approximately 930 B.C. and 450 B.C. (Phase $EGMa_3$ and $EGMb_1$) there was only very slight human interference with the vegetation. The clearance is similar to the earlier clearance which occurred around 1380 B.C., with a decline in arboreal pollen and an associated increase in Gramineae. There is less agriculture with some pastoralism indicated by *Filipendula*, *Plantago* spp. and *Pteridium*. The rest of the Bronze Age is characterised by a regeneration until the later stages of phase $EGMb_1$ when *Betula* and *Alnus* decline slightly. Grass declines throughout and there are fewer herbs, though limited pastoral agriculture continues. At Carsegowan Moss a similar situation exists, with the vegetation remaining virtually unaltered from the early Bronze age. During the Sixth and Seventh Centuries B.C. south-west Scotland remained impoverished and with populations continuing to use the stone axe-hammer as a local and cheap alternative to Bronze (Higham, 1986, 103). This is in contrast to clearance identified at other sites on the Solway shore (Nichols, 1967; Birks, 1975; Walker, 1984).

5.3.6 The Agricultural Economy In Northern Britain During The Bronze Age.

The human impact on the vegetation in northern Britain during the Bronze Age was small-scale and this can now be related to the situation which occurred in the rest of Britain. Similar small temporary clearances occurred in a number of other areas including Tregaron Bog, west Wales (Turner, 1970), over much of Cheshire and Lancashire (Simmons and Tooley, 1981), Valley Bog, Teesdale (Chambers, 1978), in Derbyshire (Hicks, 1971), and at Fen Bog, north Yorkshire (Atherden, 1976 a, b). However, in other areas the forest was extensively cleared, especially many areas of southern England (Godwin, 1967), in Shropshire (Barber and Twigger, 1987), on Dartmoor (Simmons and Cundill, 1974), at a number of sites on the North Yorkshire Moors (Tinsley, 1975, 1976), the Lake District (Pennington, 1970), and the Pennines (Donaldson and Rackham, 1984; Tinsley, 1975). Conversely, no human interference in the vegetation is apparent at Flanders Moss in the Forth Valley (Turner, 1965), but large clearances occurred at Black Loch, Fife (Whittington *et al.*, 1990; 1991). Considerable debate in the literature has centred around the nature of the agricultural economy in northern Britain during the Bronze Age. Until recently, Fox's (1932) highland/lowland division where a predominantly pastoral highland zone was thought to contrast with a more arable lowland zone in southern Britain, has been applied to the Bronze Age.

The elusiveness of settlement evidence led to the belief that the majority of the people in the north were nomadic pastoralists (Cunliffe, 1974 b; Burgess, 1984, 166). However, seed remains (van der Veen, 1985) and archaeological evidence indicate that during the Bronze Age, small-scale arable activity was practised in southern Scotland (Feacham, 1973). Remains of ancient agriculture occur in three forms - first, amorphous

walled enclosures associated with hut-circles and clearance cairns; secondly, systems of small irregular plots formed by banks and lynchets associated with timber buildings occupied from the later part of the second millennium B.C. to the mid first millennium B.C.; and thirdly, more regular fields which were used from the late first millennium B.C. until the Roman period. The evidence is dispersed and it seems that arable agriculture was only a local occurrence, mainly confined to the uplands of Lanarkshire and south-west Scotland (Stevenson, 1985, 11). Similar landscape features probably of Bronze Age date, have been recognised in the north of England and are well represented in Northumbria. In Cumbria, although cairn fields have been recorded, there is little evidence for other types of field boundary and settlements comparable to those found in Northumberia (Annable, 1987).

The recognition of settlement types and field systems of Bronze Age date in northern England and Scotland is beginning to provide evidence of domestic sites and agricultural practices, but one problem with the interpretation of settlement and economy from these sites is the pronounced upland bias in their distribution. Other archaeological evidence, such as early Bronze Age burials, metalwork and tools would suggest contemporary occupation and arable farming in the lowlands, where Bronze Age settlement sites are as yet unrecognised (Annable, 1987). The upland bias in settlement evidence for the occupation of the north in the 2nd to 1st millennium B.C. and the existence of archaeological evidence for arable agriculture above present day levles, focuses attention on the probable effects of climatic deterioration at the end of the Bronze Age (Tinsley, 1981). Climatic deterioration might have led to ruinous agricultural strategies as the soil probably deteriorated and was capable of supporting limited agriculture before consequent soil erosion (Annable, 1987) The inefficiencies of agricultural strategies in the uplands may indicate that they were originally developed in lowland environments and this hypothesis is consistent with the presumed spread of population in the late second millennium. The uplands were cleared for extensive grazing and the area subsequently used for arable agriculture against a background of environmental deterioration, which led to eventual abandonment of the marginal uplands but continued use of the lowlands (Higham, 1986, 95).

The debate in the archaeological literature can to some extent be resolved by assessing the palynological evidence for agriculture at each site. If arable agriculture was practised in an area where archaeological evidence for field systems occurs, then this should be recorded in the pollen diagram. Indeed, where archaeological evidence is absent, the palynological record can be used to discover areas where such land use occurred.

Small temporary clearances or *landnam* phases are identifiable in the pollen record at all sites, though the scale and date of such clearance does vary. According to the literature, these clearances are associated with shifting agriculture, mainly of a pastoral nature (Iversen, 1949; Tinsley, 1981) and the short time over which they are reflected in the pollen diagrams (*c.* 50-200 years) indicates their temporary nature. Pastoralism was perhaps the predominant element in the agricultural economy and pastoral indicators such as *Plantago* spp., Compositae lig., and Compositae tub. are found in all the pollen diagrams. Unequivocal evidence for Bronze Age arable agriculture is found in the form of *Triticum* type pollen at Fozy Moss, Fannyside Muir, Ellergower Moss, Walton Moss, Cranley Moss and Dogden Moss. Herbs associated with arable agriculture such as *Artemisia*, *Polygonum*, Chenopodiaceae and *Rumex* spp. (Turner, 1964) are also found at these sites as well as Carsegowan, Glasson and Letham Mosses. Thus, that arable agriculture was practised to some extent is indicated by the pollen evidence, but probably at a greater intensity at Cranley Moss, Fannyside Muir, Dogden Moss and Letham Moss (Feacham, 1973; Stevenson, 1985, 11).

From the archaeological and palynological evidence it seems that during the Bronze Age communities lived

by a mixed farming economy, which allowed a standard of living sufficiently above subsistence level (Cunliffe, 1991, 50). The economy was largely dependent on pastoralism, whilst cereal production played a lesser, but significant part and a transition from a seasonal to a more permanent settlement is mirrored in a transition from an economy based on hunting and gathering to one based on more settled agriculture (Parry and Slater, 1980, 33; Roberts, 1990, 8).

5.3.7 Conclusion.

By the late Bronze Age the pollen evidence suggests that gradual clearance of the forest was underway at Walton Moss and Glasson Moss and that both small-scale pastoralism and arable practises were undertaken. Although developments in Bronze Age society occurred elsewhere in Britain at this time, the archaeological evidence for Cumbria indicates that population was sparse and the limited clearances in the pollen diagrams may reflect this. At Dogden and Cranley Mosses and Fannyside Muir, the larger opening of the forest, with palynological evidence for pastoral and arable agriculture, agrees with the archaeological evidence for higher population densities and settlement in Berwickshire and Lanarkshire and for the development of the Scottish bronze industry. Despite the earlier clearance at Fozy Moss, the Late Bronze Age is characterised by forest regeneration and at Fannyside Muir small temporary clearances are replaced by regeneration in the later Bronze Age. The pollen evidence seems to indicate a decline in population numbers or an abandonment of the area around Fozy Moss, thus allowing the forest to regenerate, and at Letham Moss, Carsegowan Moss and Ellergower Moss the pollen diagrams seem to indicate that the forest was virtually unaltered by late Bronze Age groups. This implies a low amount of settlement in the area and is in agreement with the limited archaeology.

5.4 Vegetation Change In Northern Britain During The Early Iron Age - *c.* 600 B.C. - 100 B.C..

5.4.1 Walton Moss - Gradual Clearance.

At Walton Moss (WLMb) a continued gradual opening of the forest occurs between *c.* 510 B.C. and 115 B.C., when total arboreal pollen declines slightly. Correspondingly there is a continuous rise in Gramineae, *Pteridium* and *Plantago* spp. and although cereals are absent, the presence of other pastoral and arable indicators provides evidence for settled agriculture. From the pollen evidence it seems that at Walton Moss small-scale settlement and agriculture occurred with a small but slowly increasing population which caused a gradual decline in forest cover.

5.4.2 Glasson Moss - Small Temporary Clearances.

The period between approximately 550 B.C. and 270 B.C. (SRR-4534) at Glasson Moss ($GLMb_1$) is again one of declining tree pollen though to a smaller extent than at Walton Moss. The trend of small temporary clearances seems to have continued from the late Bronze Age but on a larger scale. Light demanding species, such as *Fraxinus*, *Salix* and species which have poor pollen dispersal abilities, such as *Hedera helix*, appear as the forest is cleared. Again Gramineae, *Plantago* spp. and *Pteridium* rise, the *Rumex* spp. curve begins and cereals with other pastoral and arable indicator species provide unequivocal evidence for settled agriculture. The pollen diagram seems to suggest that a low population density occurred and that small population groups cleared small areas of woodland, settling and farming the land on a small-scale. The area was then abandoned allowing the regeneration of woodland and although small temporary clearances occurred the percentage of arboreal pollen at Glasson Moss is higher than at Walton Moss.

The low amount of clearance at both Glasson and Walton Mosses can be explained by the archaeological evidence which suggests that compared to southern Britain, Iron Age society in Cumbria was characterised by a sparse aristocracy, a lower population density and a less well developed settlement hierarchy (Higham, 1986, 133). The spread of iron technology throughout Britain in the Seventh Century B.C. had little immediate impact on population in northern England (Cunliffe, 1974 b, 236) and it seems that the area remained rooted in Bronze Age traditions. Glasson Moss and Walton Moss are both situated in Piggott's (1956, 1966) Solway-Clyde Province, which corresponds to Cunliffe's (1974 b, 255) northern category of settlement, the characteristic of this Province being the fact that settlement evidence is rare. Palisaded settlements, multivallated defences and hillforts are uncommon (Clack and Gosling, 1976; Megaw and Simpson, 1979, 291) and small defensive sites are only thinly distributed. They are mainly concentrated on the north-west Cumbrian coastal plain where a group of settlements exist (Ritchie and Ritchie, 1981, 91; Morrison, 1983; Annable, 1987). This is therefore in agreement with the palynological evidence for low clearance and the small temporary clearances at Glasson Moss. The only archaeological evidence for settlement around Walton Moss are small finds of metal artefacts, thus implying sparse settlement (Higham, 1986, 5) and limited clearance.

5.4.3 Ellergower Moss And Carsegowan Moss - Gradual Forest Clearance.

Between around 450 B.C. and 170 B.C. at Ellergower Moss ($EGMb_2$) gradual removal of the forest is indicated by a slow decline in arboreal pollen and as the forest is removed small but distinct increases in *Ulmus*, *Fraxinus* , *Pinus*, *Ilex* and *Salix* occur. As tree cover declines, open land increases and Gramineae, *Pteridium* and *Plantago* spp. rise whilst few other herbs are present. Low levels of arable and pastoral agriculture are suggested by *Artemisia*, *Filipendula*, Papilionaceae and Caryophyllaceae. A predominantly wooded landscape with slow gradual clearance for settlement and agriculture existed.

The phase representing the early Iron Age at Carsegowan Moss (CGMb) opens with a small temporary clearance followed by a period of forest regeneration between *c.* 540 B.C. and 250 B.C., clearance being indicated by a decline in Coryloid, whilst other arboreal species remain constant. The forest opening and small-scale agriculture are represented by a small peak in Gramineae, *Pteridium* and *Plantago* spp. and the presence of *Artemisia*, Ranunculaceae and *Rumex* spp..

Following the small clearance episode, trees, especially Coryloid and *Alnus*, regenerate to their former Bronze Age levels. Gramineae, *Plantago* spp. and *Pteridium* decline and other herbs are few, thus implying that the forest cover was more or less complete but following this, a renewed attack on the forest occurred between *c.* 250 B.C. and 150 B.C. (SRR-4537) ($CGMc_1$). A sustained forest clearance is represented by declining arboreal pollen and a concurrent rise in Gramineae and *Pteridium* and the pollen evidence seems to indicate that small temporary clearances with temporary settlement and agriculture occurred. This was followed by abandonment of the area , forest regeneration and then renewed clearance occurred as groups settled the area and practised small-scale agriculture.

The palynological evidence for low, but gradual forest clearance agrees with the archaeological evidence. In south-west Scotland ceramic traditions rooted in the Neolithic continued to play an important part in the material culture (Cunliffe, 1974 b, 236) and humans possessed a limited capacity to alter the vegetation. This area is part of Piggott's Solway-Clyde Province of low settlement density but there is a concentration of small settlements and forts in Kirkcudbright and along the coasts of Galloway and Dumfries (Ritchie and Ritchie, 1981, 91; Morrison, 1983; Annable, 1987). Crannogs or lake dwellings, were built (e.g. Milton Loch, Kirkcudbrightshire) and occupied throughout the Iron Age and since these were often constructed from

oak (Morrison, 1983; Millman, 1975, 51; Parry and Slater, 1980, 38).

5.4.4 Fannyside Muir - Clearance.

Between *c.* 575 and 350 B.C. a small short clearance occurs at Fannyside Muir (FSMd) (Figure 5.8) as all arboreal species, especially Coryloid, decrease and Gramineae rises. *Artemisia*, Caryophyllaceae, Compositae lig., *Rumex* spp., *Urtica* and Ranunculaceae occur and *Plantago* spp. increase. This suggests that both pastoral and arable agriculture was undertaken. This small clearance is probably a result of population and settlement expansion in the Fannyside Muir area. There is little archaeological literature pertaining to this area, but MacPhail (1962) and Cumbernauld and Kilsyth District Council (1982) have identified a series of forts and some crannogs which perhaps explains the clearance. Although this area is situated in Piggott's (1965) Tyne-Forth Province of dense settlement, limited clearance is perhaps a reflection of the fact that the upland environment was less amenable to settlement and agriculture, especially in the light of the late Bronze Age climatic deterioration (Tinsley, 1981).

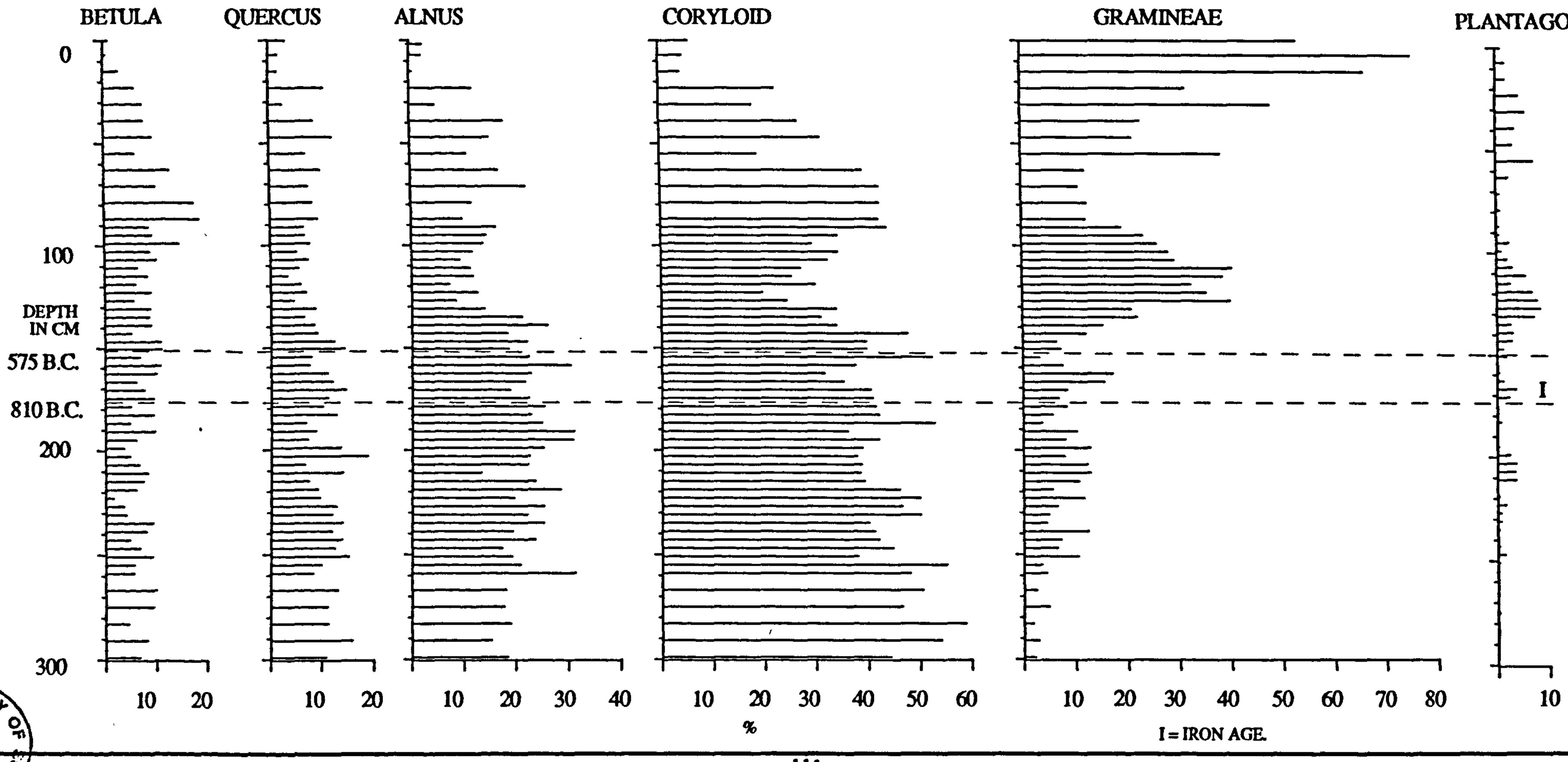
5.4.5 - Dogden Moss - Rapid Forest Clearance.

A sudden rapid clearance of the forest for agriculture occurs at Dogden Moss (DGMb) between approximately 420 B.C. (SRR-4552) and 235 B.C. (Figure 5.9) when *Betula*, *Alnus*, *Quercus* and especially Coryloid all fall rapidly and as the forest is cleared, *Salix*, *Fraxinus*, *Fagus*, *Pinus* and *Ulmus* all occur at low levels. Gramineae, *Plantago* spp. and *Rumex* spp. rise rapidly and *Artemisia*, Caryophyllaceae, *Triticum* type, Chenopodiaceae, Compositae lig, Cruciferae, Papilionaceae and Rosaceae begin to occur in abundance. Along with the presence of other herbs this suggests that for the first time at Dogden Moss the forest was rapidly cleared for relatively large-scale settled agriculture.

A massive and rapid clearance as indicated by the pollen evidence was probably attributable to large-scale settlement and agriculture in this Tyne-Forth Province (Piggott, 1966), the distinctive character of which is the large number of homesteads, palisaded settlements and forts which show that a sequence of structural developments and evolution from open to enclosed sites. The climatic deterioration at the end of the Bronze Age led to land degradation and abandonment of marginal sites (Tinsley, 1981), growing population pressure, territorial awareness and investment in physical security. This is reflected by palisaded sites occupying defensive and well drained areas (Stevenson, 1985,12; Higham, 1986, 117) which were commonly occupied from the Eigth Century onwards (Cunliffe, 1991, 281) and constructed from oak which declines drastically at Dogden Moss - approximately 1 to 2 hectares of prime forest had to be cut for the construction of a single site (Higham, 1986, 122). These palisaded settlements replaced unenclosed sites and represent a fundamental reappraisal of the needs of the society, changes in the structure of the economy, and a greater emphasis on defence during the second half of the first millennium B.C. (Cunliffe, 1991, 539).

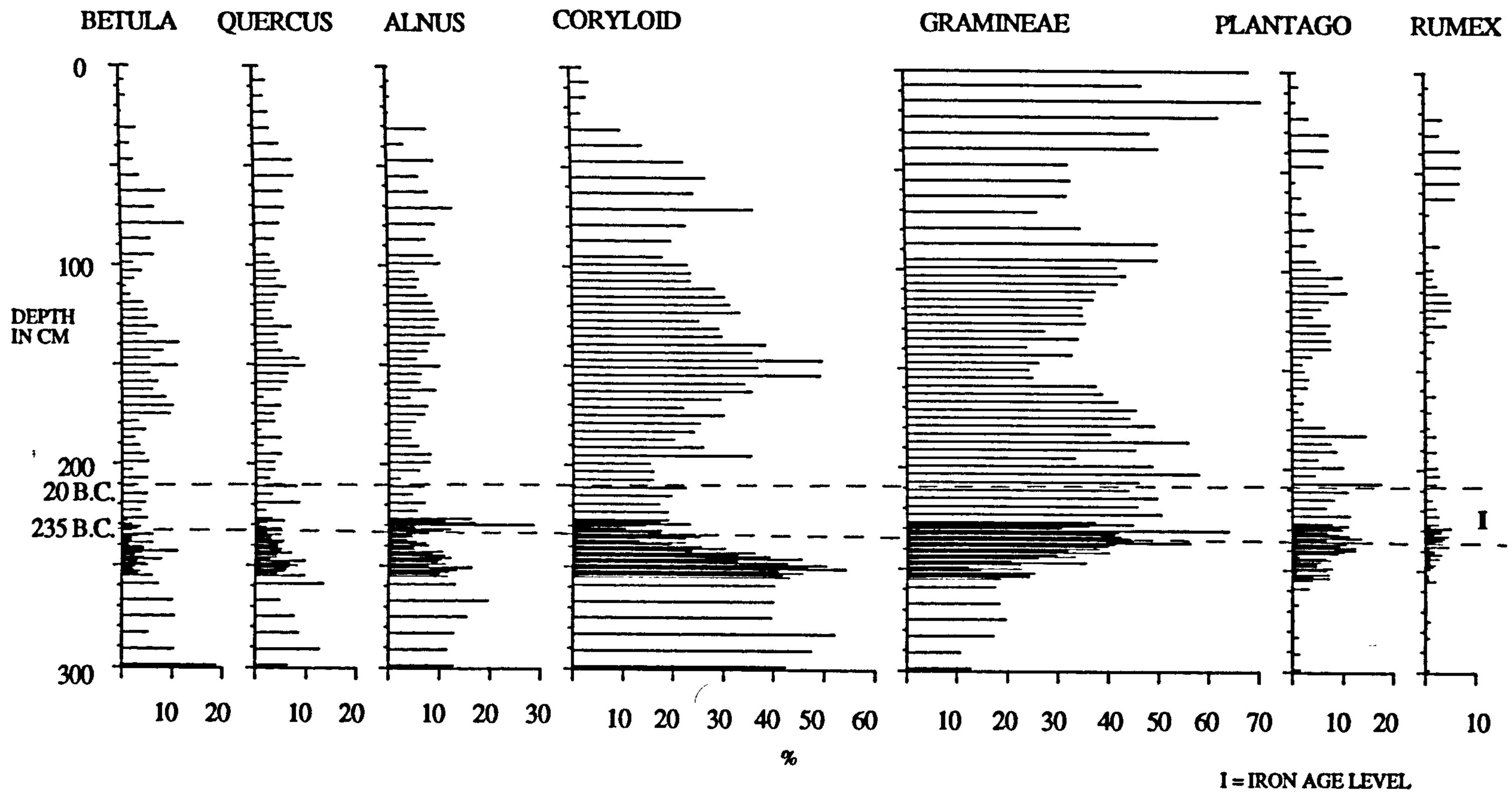
Throughout the Iron Age there was a further general trend towards enclosure, reflected in increasing clearance and occupation of more defensive situations (Jobey, 1985). After the mid-first millennium the major palisaded sites were being superseded by hillforts, and although palisaded sites were occupied at broadly the same time as forts, there is evidence to show that they were often the first stage in a structural sequence that led on to either earthen or stone-walled forts (Cunliffe, 1974 a, 219; Ritchie and Ritchie, 1981, 95). From around 500 B.C. hillforts were built and according to Feachem (1966) represent colonisation and expansion, providing evidence for the evolution of political cohesion, growth and transformation from a semi-nomadic to a settled lifestyle. They are generally between 1-4 acres in size and range between individual homesteads to

FIGURE 5.8 FANNYSIDE MUIR - SELECTED CURVES FOR THE IRON AGE.



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FIGURE 5.9 DOGDEN MOSS - SELECTED CURVES FOR THE IRON AGE.



I = IRON AGE LEVEL

larger agglomerations of huts (Jobey, 1966a; Cunliffe, 1974 a, 237). The larger forts such as Eildon Hill and Traprain Law are large enough to have been native centres or tribal capitals (Halliday, 1985). Hillforts are distributed throughout the north but are primarily located in south-east Scotland around Peebles and between the Lammermuir Hills and Tweed Basin (Piggott, 1951; Millman, 1975, 52; Ritchie and Ritchie, 1981, 91; Cunliffe, 1974 b; Morrison, 1983; Annable, 1987). Hill fort occupation spanned a long period of time and did not come to an end until the middle of the first century A.D. (Clack and Gosling, 1976).

The evolution, acceleration and concentration of settlement in south-east Scotland must have relied on vast quantities of timber for the construction of the buildings and their defences and the above archaeological evidence is in accord with the pollen evidence for large-scale deforestation and the practice of fairly extensive agriculture. Wood was also required for charcoal to be used in the smelting of iron. This pattern of clearance is also shown in other diagrams from all over south-east Scotland. At Yetholm Loch, near Kirk Yetholm, a near-total clearance with intense farming occurs c.250 (cal.) B.C. (Tipping, pers. comm.). At Swindon Hill, Upper Bowmont Valley, a phase of woodland reduction associated with pastoralism occurred from 590 B.C. (Tipping, forthcoming, 1992) and at Over Rig, Upper Eskdale, a gradual clearance is attributed to the occupation of Iron Age settlements in the area (Tipping, pers. comm.). Gradual clearance also occurs at Din Moss, Roxburghshire (Hibbert and Switsur, 1976) and intensified clearance occurs at a number of sites in the Upper Eddlestone Valley (Newey, 1976).

5.4.6 Cranley Moss - Forest Clearance.

Following a period of late Bronze Age regeneration at Cranley Moss, a forest clearance extends from around 660 B.C. to 255 B.C. (CYMd), intensifying further between *c.* 255 B.C. and 140 B.C. (CYMe), opening of the forest being indicated by a rise in Gramineae, which reaches a level not attained again until the A.D. 1600s. During this period of massive deforestation, fairly intensive agriculture was practised and the continued rise in *Plantago* spp. along with the presence of *Triticum* type, *Secale cereale*, *Artemisia*, Caryophyllaceae, Chenopodiaceae, Compositae lig. and tub., *Rumex* spp., Cruciferae, Ranunculaceae, Saxifragaceae and Umbelliferae indicates that both pastoral and arable practices occurred.

The timber removed from the forest was probably used for construction of settlements and the land used for pastoral and arable agriculture around Cranley Moss. Archaeological evidence suggests that there is a concentration of early Iron Age unenclosed settlements and forts in the Clyde valley and Lanarkshire (R.C.H.A.M.S., 1978; Jobey, 1985; Ritchie and Ritchie, 1979; 1981, 91; Morrison, 1983). The area around Cranley Moss is on the periphery of the south-east Scotland settlement concentration and much of the development which has been discussed in Section 5.4.5 also applies to the Cranley Moss area. Whilst the sequence of settlement evolution is similar, the lower concentration of settlements here would therefore explain why the magnitude of clearance is lower than at Dogden Moss. Few pollen diagrams with which the Cranley Moss diagram can be correlated have been produced form this area. A diagram from the Carstairs Kames records a period in which the forest was gradually opened, correlated with archaeological evidence to *c.* 550 B.C. (Dickson, 1980). This estimation is more or less in accord with the dates attached to the clearance at Cranley Moss though the Cranley Moss clearance is more intense.

5.4.7 Letham Moss - Gradual Forest Clearance.

Between *c.* 610 and 390 B.C. the forest at Letham Moss ($LTMb_1$) was slowly cleared. Trees typical of dry and therefore usable land were cleared. Gramineae and *Pteridium* rise gradually and few other herbs are present. Scattered occurrences of *Plantago* spp., *Rumex* spp., Chenopodiaceae and Ranunculaceae suggest that pastoral

and perhaps arable agriculture was practised on a very small-scale. However, between about 390 B.C. and 160 B.C. (SRR-4543) ($LTMb_2$) the arboreal pollen curve indicates that there was a slight regeneration of forest followed by a small temporary clearance and a second period of forest regeneration. During the clearance Gramineae rises and evidence for both pastoral and arable agriculture is in the form of small peaks in *Artemisia*, *Polygonum*, *Plantago* spp., and *Pteridium* and in the scattered occurrences of Compositae lig., *Centauria cyanus*, Chenopodiaceae, *Rumex* spp., *Filipendula*, Labiatae and *Urtica*. As the area reverts to forest, agricultural indicators decline.

The pollen evidence suggests that at Letham Moss small-scale settlement with a low, slowly increasing population practising limited agriculture occurred causing a gradual decline in the forest. This is in accord with the archaeological literature. Stirlingshire is on the periphery of Piggott's Tyne - Forth Province and although there are some Iron Age forts in Stirlingshire the concentration is much lower than in Lanarkshire and Berwickshire (Piggott, 1951; Ritchie and Ritchie, 1979). Duns and brochs are also widely distributed across the area (Ritchie and Ritchie, 1981, 108). Pollen evidence for gradual clearance is in accord with archaeological evidence for limited occupation of the area.

5.4.8 Fozy Moss - Small Temporary Clearances.

At Fozy Moss ($FZMc_2$) arboreal pollen falls and then rises rapidly to its former levels between approximately 590 B.C. and 345 B.C., reflecting a short forest clearance. Evidence for the use of the clearing for pastoral and arable agriculture is displayed by the corresponding sharp increase in Gramineae and the presence of agricultural indicator species, though cereals are absent. The pollen diagram seems to suggest that a low population density occurred and that these small population groups cleared small areas of woodland, settled and farmed the land on a small-scale and then abandoned the area allowing the regeneration of woodland. The density of hillforts is lower in this area - there being none in the region around Fozy Moss, whilst palisaded settlements are the most common form of site and form a homogeneous group with those in south-east Scotland (Clack and Gosling, 1976; Megaw and Simpson, 1979, 291) and unenclosed platform settlements associated with clearance cairns are common (Annable, 1987). The settlement distribution maps (Clack and Gosling, 1976) suggest that perhaps a greater forest clearance should be expected with the density of settlements displayed. The fact that this is not recorded in the pollen diagram could be a result of clearances being at a distance from the site and that woodland was not being cleared from the bog margins causing filtration of pollen and preventing its registration in the diagram (Tauber, 1965; Turner, 1975; Edwards, 1988). This seems to be a possibility as the mire would not have been a favourable situation for settlement and there would have been no incentive to clear woodland from its margins.

The small temporary clearances are probably the result of short small-scale occupation of palisaded or unenclosed settlement and the clearance at Fozy Moss is higher than those at Walton and Glasson Mosses probably because settlement distribution in Northumbria was slightly higher. In some respects settlements in Northumbria do not conform to the types which have been recognised in Cumbria and the contrast was perhaps a result of a larger population in Northumbria. The area also survived the climatic deterioration more successfully, emerging with a dense and organised population (Higham, 1986, 133).

5.4.9 Conclusion.

The clearance and settlement pattern of the early Iron Age period is broadly dissimilar throughout northern Britain. At Walton Moss gradual clearance continues later than that at Glasson Moss and although larger openings and small temporary clearances occur in the forest canopy at Glasson Moss (supported by the

presence of settlements) the overall level of forest cover is higher than at Walton Moss. At Carsegowan and Ellergower Mosses a similar pattern of vegetation change occurs with the temporary clearances at Carsegowan Moss being similar to those at Glasson Moss and greater than those at Walton Moss. At Letham Moss and Fozy Moss gradual clearance occurs which is interrupted by temporary clearances, larger than those at Glasson Moss and explained by the higher population in the east of the country. Small-scale clearance occurs at Fannyside Muir related to the smaller number of settlements in the area. Rapid, large-scale clearance is apparent at Dogden and Cranley Mosses, attributable to the large numbers of settlements in the area. The archaeological evidence indicates that there is a contrast between an eastern zone of fortified settlements and an western zone of open settlements and this is reflected by the levels of clearance in the pollen diagrams. Variations on a regional basis can be seen and it is possible to suggest that differences in the way of life between groups was coming into existence. Greatest clearance occurs at sites situated in the zone characterised by dense fortified settlements whilst the other sites lie on the periphery of this area where settlement distribution is not so dense, or in the western zone of limited settlement.

5.5 Vegetation Change In Northern Britain During The Late And Pre-Roman Iron Age - *c.*150 B.C. - A.D. 40.

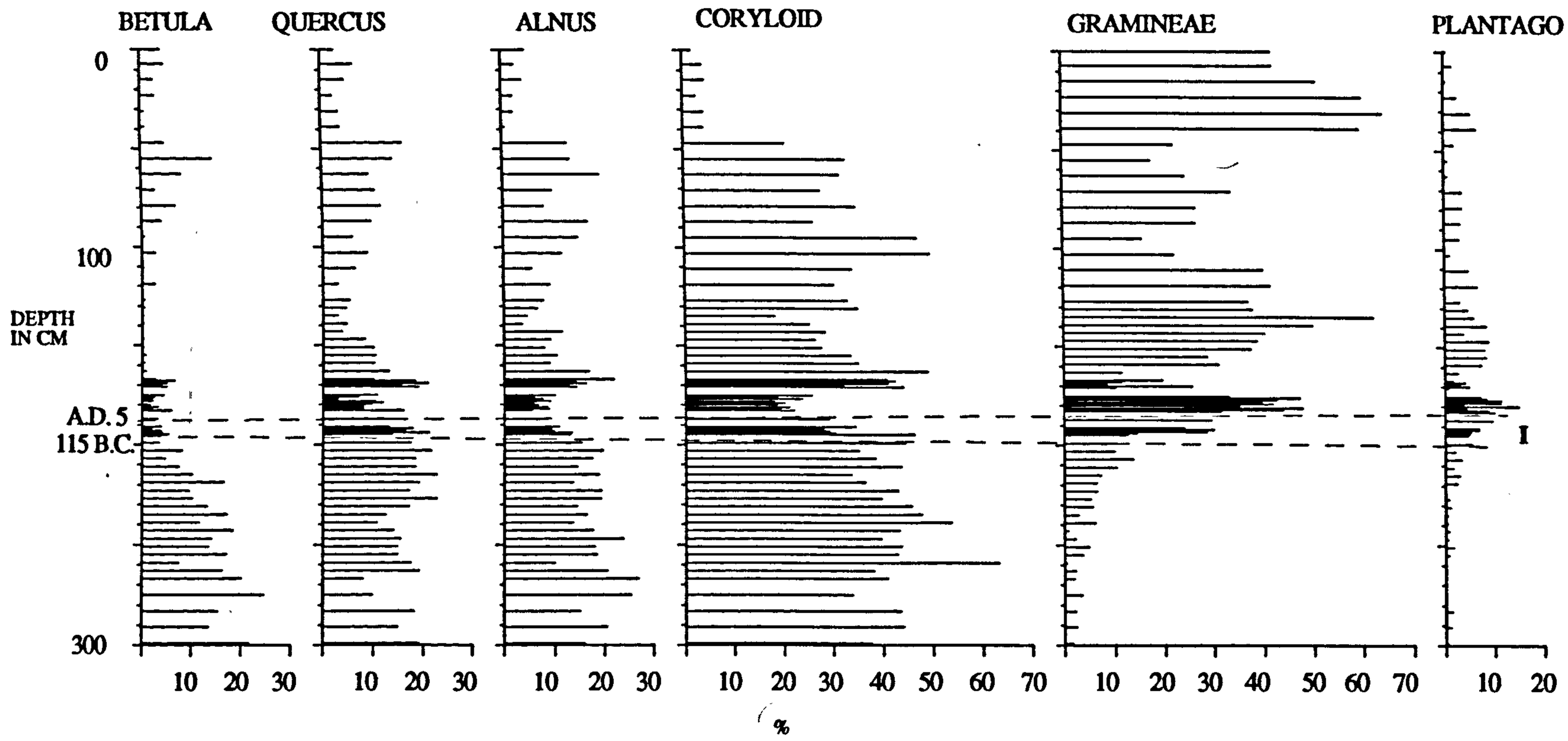
5.5.1 Walton Moss - Rapid Forest Clearance.

The late Iron Age is characterised by the first sudden and rapid forest clearance between approximately 115 B.C. and A.D. 5. ($WLMc_1$) (Figure 5.10) as indicated by the dramatic fall in arboreal pollen. This decline occurs quickly, over approximately 15-30 years. All arboreal species are affected. *Fraxinus*, *Salix*, *Ulmus* and *Pinus* occur at low levels which, along with a rapid rise in Gramineae, *Plantago* spp. and *Pteridium*, indicate that wholesale clearance of the forest occurred. *Triticum* type is present for the first time since the late Bronze Age and an increase in *Artemisia*, *Rumex* spp., Chenopodiaceae, *Polygonum*, Cruciferae, *Thalictrum* and *Succisa* indicate that arable agriculture was significant and pastoralism is indicated by Compositae lig. and tub., Ranunculaceae, Saxifragaceae and *Urtica*. A period of massive deforestation is suggested by the pollen diagram and the clearance was probably the result of population groups inhabiting the area, clearing forest for settlement and agriculture and the nature of clearance suggests that activity was a result of the existing population expanding and extending its settlement and agricultural area (Edwards, 1979).

The initial clearance continues and intensifies during the pre-Roman Iron Age, when between *c.* A.D.5 and A.D. 70 (SRR-4530) ($WLMc_2$) the arboreal pollen curve falls further and then stabilises before increasing again. This indicates that clearance accelerated, was sustained at a particular level and then regeneration occurred as population declined or groups began to move out of the area. Different tree species respond in different ways during this period and whilst *Betula* and Coryloid continue to decline before stabilising, *Alnus* increases slightly and then remains at this level and *Quercus* decreases, increases and then falls again. Gramineae rises as *Plantago* spp. and *Rumex* spp. rise further, before declining slightly and *Pteridium* falls. The presence of arable and pastoral agriculture is indicated by the continuation of the herbs from the previous phase, though the rise in *Plantago* spp. and *Rumex* spp. suggests that it might have been practised on a slightly larger scale. Thus the first period of deforestation is followed by further intensified forest clearance, and this is probably the result of increased population, the demand for timber to be used in iron smelting and the construction of buildings. Clearance then stabilises, perhaps as population numbers levelled, before a decrease in settlement and the beginning of forest regeneration.

This pattern of rapid clearance followed by a period in which clearance intensity increased further can to some

FIGURE 5.10 WALTON MOSS - SELECTED CURVES FOR THE IRON AGE.



extent be related to the archaeological evidence. The north of England was far removed from the influences of the southern Belgic communities and remained out of contact with the cross-channel trade which modified and expanded the material culture there in the late Iron Age. Coin evidence, along with literary references, show that distinct tribal entities had crystallized and the degree of internal warfare had increased (Cunliffe, 1974 a, 71). Of these tribal groupings, the Brigantes were the dominant force and occupied a vast territory in northern Britain, stretching from the Pennines into Cumbria and from the Irish to the North Seas (Cunliffe, 1991, 189). Relatively little is known of the settlement pattern or economy. Around Carlisle and the Irthing valley recent urbanisation and agriculture have destroyed evidence of archaeological sites, but those settlement enclosures which have been found are in most cases single ditched and banked enclosures. Those closer to the Solway had more considerable defences (Higham and Jones, 1985, 78). There are indications that the landscape began to fill up and by the late Iron Age, population expansion seems to have been occurring in the Eden valley with the associated constant growth in the density of settlements (Cunliffe, 1991, 540/541). Some indication of a small expansion of population in individual settlements may be found in the agglomeration of existing settlement structures into later enclosures (Clack and Gosling, 1976).

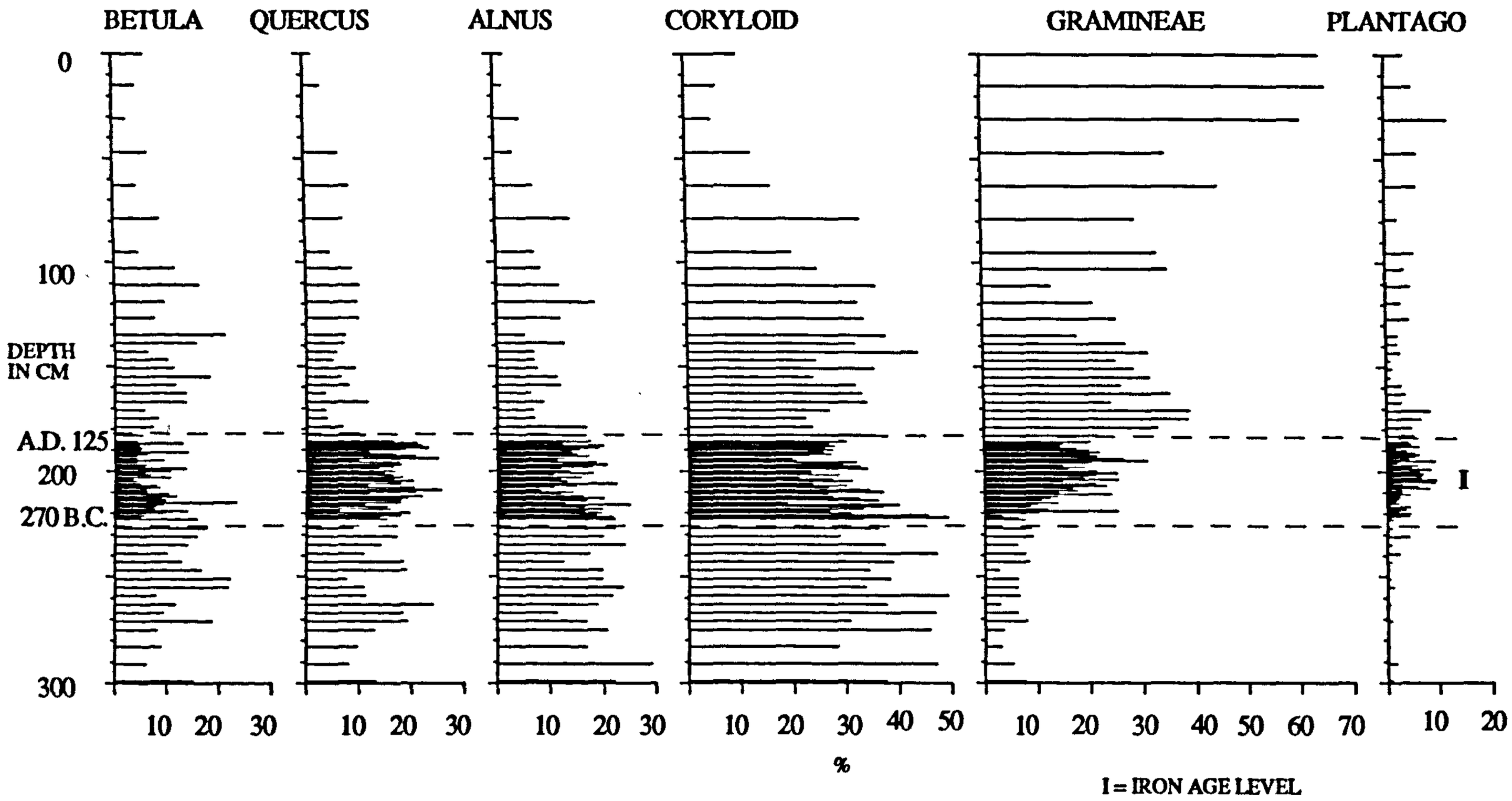
The vegetation record at Walton Moss corresponds with that in southern Cumbria (Wimble, 1986), but is not in accord with that from Bolton Fell Moss (Barber, 1981, 112), where a very gradual clearance with some settled agriculture occurs between *c.* 840 to 160 B.C.. This is coincident with a sparse population and low settlement density. The lack of correspondence between the diagrams is probably attributable to the fact that Bolton Fell Moss has been drained and therefore the peat has shrunk restricting the resolution of the diagram. Because of shrinkage of the peat at Bolton Fell Moss the peat accumulation rate is only 34 years/cm. compared with 15 years/cm. at Walton Moss. This combined with a poor counting resolution at this point in the Bolton Fell Moss diagram (1 cm. at Walton Moss compared to 5 cm. at Bolton Fell Moss), possibly indicates that the clearance has not been covered by the pollen analysis undertaken. These differences might also be due to natural variability in the pollen record and the clearance at Walton Moss might be a result of a very localised clearance not being recorded further away at Bolton Fell Moss. This problem can only be resolved by increasing the counting resolution at Bolton Fell Moss and obtaining more radiocarbon dates.

Although relatively little is known about Brigantian settlement in Cumbria, the pollen evidence for intensifying clearance at Walton Moss supports the idea of supposed growth of population and settlement. Clearance is far larger than would be expected from the available settlement evidence alone and the size of the clearance in the pollen diagram would suggest a higher population and settlement density and evidence for these settlements has subsequently been destroyed by urbanisation or agriculture.

5.5.2 Glasson Moss - Forest Clearance.

Between 270 B.C. (SRR-4534) and A.D. 125 (SRR-4533) a general, almost continuous, trend towards forest clearance occurs at Glasson Moss ($GLMb_2$) (Figure 5.11). This is reflected by a steady decline in arboreal pollen but the trend towards deforestation is not completely smooth and numerous small revertences occur. This might reflect variations in the intensity of occupation in the area, or the over-representation of local pollen rain. As the canopy is opened, peaks of *Fraxinus*, *Salix*, *Ilex aquifolium*, *Fagus*, *Pinus* and *Ulmus* occur, whilst Gramineae, *Plantago* spp. and *Pteridium* rise simultaneously. Levels of arable agriculture are higher than in the early Iron Age as indicated by increase in *Triticum* type and *Rumex* spp., the presence of *Secale cereale*, Umbelliferae, Cruciferae and Fumariaceae, with continued *Artemisia* and Chenopodiaceae. *Plantago* spp., Papilionaceae, Ranunculaceae, *Urtica*, Saxifragaceae, Compositae lig. and tub., *Helianthemum*, *Filipendula*, and Campanulaceae indicate increased pastoralism. Thus it seems that the area around Glasson Moss was steadily and increasingly cleared, with an increase in agriculture and this is

FIGURE 5.11 GLASSON MOSS - SELECTED CURVES FOR THE IRON AGE.



confirmed by the archaeological literature.

The tribe known as the Carvetti occupied western Cumbria, especially the coastal plains and the river valleys of the Solway basin. The Solway Plain is an extensive area of low ground and despite the presence of extensive mosses there is much valuable agricultural land (Higham and Jones, 1985, 8). According to Bewley (1984) the Carlisle and Solway plain was potentially the richest settlement area in pre-Roman times, but was almost completely unoccupied with only a scatter of sites in the area. However, a programme of aerial photography began in 1974 and now over 200 sites can be recognised. The fundamental nature of land use in this area was established in the Neolithic, and the settlement sites, dominated by round huts and enclosures, continue in existence from the Bronze Age (Bewley, 1984 ; Higham and Jones, 1985, 8; Higham, 1986, 187). The pattern is one of intensive settlement of all terrains capable of supporting a peasant population with a concentration of sites on low-lying workable soils. Settlement sites cluster on sand and gravel ridges between the mosses, and along the eastern banks of the Wampool river 22 sites occur over only 4,000 acres of land. East and south of the mosses the terrain is slightly higher and the clay and loam soils are less sensitive to aerial reconnaissance, but large numbers of sites have still been located often in sufficient density to suggest a fully settled landscape (Higham and Jones, 1985,73/74). This archaeological evidence for increasing settlement and population is in accord with the pollen evidence for steady forest clearance and the timber removed from the forest was probably used for settlement construction and charcoal, and the cleared land farmed. The clearance at Glasson Moss begins earlier, ends later and is not as large or intense as that at Walton Moss.

5.5.3 Fozy Moss - Forest Regeneration And Gradual Clearance.

At Fozy Moss ($FZMc_3$) a period of forest regeneration occurs between around 345 B.C. and 15 B.C., as indicated by the rise in all arboreal species. Gramineae subsides and open ground indicators become few. Scattered occurrences of *Triticum* type, *Centauria cyanus*, Cruciferae and *Artemisia* indicate that some arable agriculture was practised, though no *Rumex* spp. are present. *Plantago* spp., Compositae lig., Cruciferae, *Filipendula*, Labiatae and Ranunculaceae occur, but in lower quantities suggesting reduced pastoralism. The pollen diagram therefore suggests that this period represents a time when the forest regenerated and some agriculture was practised which, in turn indicates a smaller population occupying the area. The area lies within Brigantian territory and the population in the north remained largely isolated from external influences until the Roman campaigns in 79 A.D.. Until this time there is little change and little is known of their settlement or economy.

However, between *c.* 15 B.C. and A.D. 129 (SRR-4539) at Fozy Moss ($FZMc_4$), a small renewed clearance of the forest begins and is followed by a slight forest regeneration. Arboreal pollen, including *Betula*, Coryloid and *Alnus*, begins to decline as the forest is cleared and Gramineae slowly increases and then remains stable throughout. There is a small rise in *Plantago* spp., Ranunculaceae and *Filipendula* suggesting limited pastoralism. *Triticum* type, *Artemisia*, *Rumex* spp. and Umbelliferae indicate small-scale arable agriculture. However, after this small clearance a slight regeneration in the forest occurred, arboreal pollen increases slightly and all species except for *Betula* regenerate. Gramineae remains at its former levels but other open ground indicators are relatively sparse. Clearance is perhaps due to increased population caused by natural increase or migration and small numbers of late Iron Age palisaded settlements, unenclosed settlements (Clack and Gosling, 1976; Megaw and Simpson, 1979, 291; Annable, 1987) and some late Iron Age rectilinear and curvilinear settlements have been discovered around Fozy Moss (Higham, 1986, 187).

The pollen evidence from Fozy Moss is confirmed by other pollen diagrams from Northumbria. At Steng

Moss, Broad Moss and Camp Hill Moss the palynological evidence suggests that the Iron Age landscape was characterised by a series of small temporary clearances (Davies and Turner, 1979). Radiocarbon dated diagrams from all over north-east England show that during most of the Iron Age, the landscape was well forested and that breaks in the canopy occurred for small temporary clearances and grazing (Donaldson and Tuner, 1977; Tuner, 1979). Only at Bishop Middleham, near Durham, is there pollen evidence for a substantial amount of forest clearance associated with better soils (Bartley *et al.*, 1976).

5.5.4 Fannyside Muir - Regeneration And Clearance.

After slight forest regeneration a gradual but marked clearance occurs at Fannyside Muir between around 350 B.C. and A.D. 75 (FSMe) when Coryloid, *Alnus*, *Quercus* and *Pinus* decrease whilst *Betula* remains stable. Gramineae and *Plantago* spp. increase gradually and Caryophyllaceae, Chenopodiaceae, Cruciferae, Papilionaceae, Ranunculaceae, Umbelliferae and *Rumex* spp. indicate that both pastoral and arable agriculture were practised. Increasing settlement and population probably led to clearance and although there is little archaeological information for the area, some forts continued to be occupied into the late Iron Age (MacPhail, 1962, 2). The upland environment would make the area less amenable for settlement and agriculture and clearance is apparently lower than at the other sites studied.

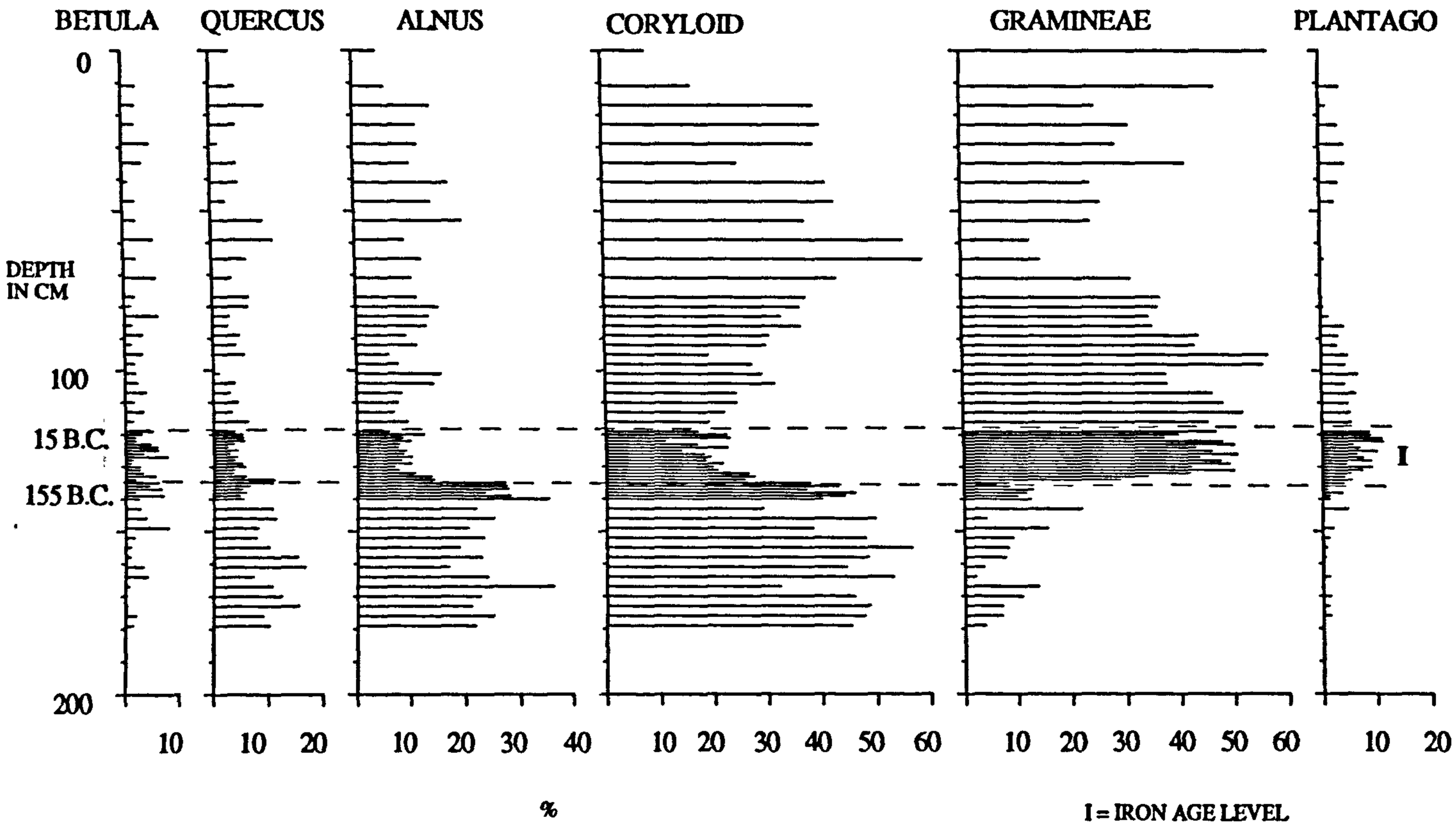
5.5.5 Letham Moss - Rapid Forest Clearance.

Between 155 B.C. (SRR-4543) and 15 B.C. at Letham Moss ($LTMc_1$) (Figure 5.12) a large and rapid forest clearance occurs and arboreal pollen suddenly falls over two pollen spectra (counted at 1 cm. intervals). All tree species are affected drastically and Gramineae and other open ground indicators rise rapidly. Large-scale pastoralism is indicated by a massive rise in *Plantago* spp. and increased Ranunculaceae, Compositae lig. and tub., *Filipendula*, Papilionaceae and *Urtica*. Cereals occur for the first time and immediately the *Triticum* type curve becomes continuous. *Artemisia*, Cruciferae, Chenopodiaceae, *Rumex* spp., Labiatae and Umbelliferae become more frequent.

Between 15 B.C. and A.D. 120 at Letham Moss ($LTMc_2$), the clearance begun in the previous phase is sustained, though some gradual forest regeneration does occur by the end of the phase when *Betula* and *Alnus* remain at a similar level as Coryloid and *Alnus* begin to slowly increase. Gramineae continues to increase, before decreasing very slightly at the end of the phase and despite the landscape remaining relatively open agriculture seems to have declined somewhat. *Triticum* type, *Artemisia*, Chenopodiaceae and *Rumex* spp. become less common and *Plantago* spp., Compositae lig. and tub., Papilionaceae, Ranunculaceae and *Filipendula* also decline, indicating a decrease in both pastoral and arable practices in the pre-Roman Iron Age.

The clearance at Letham Moss is similar in scale and pattern to the early Iron Age clearance at Dogden Moss and it might be that a similar settlement of the Letham Moss area began later. By this time, the Venicones occupied Stirlingshire and lived in large numbers of defended settlements, duns, fortlets and occasionally, brochs (Hanson and Maxwell, 1983, 161; Cunliffe, 1991, 194). Settlement increased as the late Iron Age population expanded and the landscape began to fill up (Cunliffe, 1991, 540), consequently the clearance at Letham Moss is sustained. A series of ditch infills and turves from a series of forts from the Antonine Wall have been analysed and show that the late Iron Age landscape was open and land use was dominated by pastoral activities. Although such diagrams reflect the local environment, the similarities in the diagrams from Barhill, Mollins, Bearsden, Wilderness Enclosure, Croy Hill and Shiels, suggests that the situation might have been widespread (Boyd, 1984 a and b; 1985; Dickson *et al.*, 1985; Dickson and Dickson, 1988).

FIGURE 5.12 LETHAM MOSS - SELECTED CURVES FOR THE IRON AGE.



There are no published regional diagrams from the Antonine Wall area.

5.5.6 Dogden Moss - Sustained Forest Clearance.

Sustained clearance occurs at Dogden Moss ($DGMc_1$) between 235 B.C. and 20 B.C.. A slight regeneration occurs at the beginning of this phase indicated by a small rise in arboreal pollen, after which renewed clearance occurs. The forest opening is then maintained at this level. Tree species stabilise and Gramineae and *Plantago* spp. become more or less constant. Unequivocal evidence of arable agriculture is in the presence of *Triticum* type, *Secale cereale*, *Artemisia*, Chenopodiaceae, *Rumex* spp., Cruciferae and Umbelliferae. Pastoral agriculture also occurred as indicated by *Plantago* spp., Compositae lig. and tub., *Thalictrum*, *Filipendula*, Papilionaceae, Ranunculaceae and *Urtica*.

By around 20 B.C. renewed forest clearance occurred ($DGMc_2$), indicated by a sharp decline in arboreal pollen. Gramineae and *Plantago* spp. rise, cereals are absent, but the continuation of arable agriculture is suggested by the presence of *Artemisia*, *Rumex* spp., Cruciferae and Chenopodiaceae. Increased pastoralism is indicated by the rise in *Filipendula*, Compositae lig. and tub., Papilionaceae, Ranunculaceae and *Urtica*. This suggests that an increased population gave a new impetus to clearance and agriculture. Indeed Hoskins (1955) suggests that the population of Scotland had grown to 300,000 - 400,000 by the late Iron Age. The tribe known as the Votadini occupied the eastern coastal region between the Tyne and Forth (Cunliffe, 1991, 194) and these people continued to occupy hillforts from the early Iron Age, right through to the Roman period.

5.5.7 Cranley Moss - Forest Regeneration.

A period of forest regeneration occurs between *c.* 140 B.C. and A.D. 35 at Cranley Moss (first part of CYMf). Regeneration is indicated by an increase in arboreal pollen, reflected in all species, and by a fall in Gramineae. Other open ground indicators do not seem to be affected and both pastoral and arable agriculture is indicated by the herb assemblage. This might indicate that population decreased or land was abandoned in this area, though some continued occupation is suggested by presence of species indicating agriculture. The Damonii occupied the area between the west coast and the Clyde and at this time they probably abandoned the unenclosed settlements and hill forts, allowing forest regeneration (Cunliffe, 1991). There is little in the archaeological literature which relates to this area.

5.5.8 Carsegowan Moss And Ellergower Moss - Forest Clearance.

At Carsegowan Moss ($CGMc_2$) the clearance which began in the early Iron Age continued between *c.* 145 B.C. (SRR-4537) and 10 B.C. (SRR-4536). After a slight forest regeneration at the end of the previous phase, a slow decline in tree pollen occurs, representing a gradual forest clearance and is followed by a second regeneration. Coryloid seems to have been preferentially cleared whilst *Betula*, *Alnus* and *Quercus* remain virtually stable and as the forest is cleared Gramineae increases, but *Pteridium* decreases from the previous phase. The predominance of pastoral agriculture is indicated by a substantial rise in *Plantago* spp. and the presence of other pastoral indicator species such as Ranunculaceae, Compositae lig. and tub. and Papilionaceae. *Triticum* type and *Secale cereale* appear for the first time and other arable indicators such as *Artemisia*, *Rumex* spp., Chenopodiaceae and Umbelliferae form a significant part of the herb flora.

Between around 10 B.C. (SRR-4536) and A.D. 110 (CGMd), regeneration which had begun in the previous phase ($CGMc_2$) continues, followed by renewed smaller clearance After a decline in agriculture during the regeneration phase, agricultural indicators increase, but only scattered occurrences of *Triticum* type,

Artemisia and Chenopodiaceae are present. The unequivocal palynological evidence for an increase in arable and pastoral agriculture in a landscape which was becoming continually more open is probably attributable to the continued settlement and population growth in the area.

During the late Iron Age at Ellergower Moss ($EGMb_3$) a continued gradual clearing of the forest between 170 B.C. and A.D. 70 is indicated by a slow decline in arboreal pollen and as the forest canopy continued to be opened small peaks in light demanding species (*Fraxinus* and *Salix*) occur, as well as *Hedera helix*, *Pinus* and *Ulmus*. Gramineae continues to rise slowly, although *Pteridium* falls. Continued pastoral agriculture is indicated by an increase in *Plantago* spp. and the occurrence of Compositae lig., *Filipendula*, Ranunculaceae and *Urtica*. Limited arable agriculture is suggested by the presence of *Artemisia* and *Rumex* spp., but no cereals occur.

The Novantae occupied Galloway and Dumfriesshire (Cunliffe, 1991, 194) and north of the Solway aerial survey has identified 70 new settlement sites. Settlements were identified along the routes to Birrens fort and some are associated with field systems suggesting intensive arable land use. Major forts were located east of Dumfries and to the west, areas of high ground such as Criffell and the Stewartry uplands delimit and break up areas suited to peasant settlement. The majority of settlements lie on the coastal fringe and particularly around the estuaries, Wigtown Bay, the Water of Fleet and a few around Newton Stewart (Higham and Jones, 1985, 76/77) which may explain why clearance is greater at Carsegowan Moss.

There are marked differences between the number of archaeological sites north and south of the Solway and also differences in clearance indicated by the larger clearances at Glasson Moss. Among the southern sites elliptical univallate and sub-rectangular sites are most common, though some bivallate sites occur. Settlement density is 1/3.6 kilometre^2. North of the Solway there are fewer settlements with a density of 1/10.5 kilometre^2. Sub-rectangular sites are less common with most sites being multivallate (Higham and Jones, 1985, 79/80). This would explain the differences in clearance and although the arboreal pollen falls to 60% at both Carsegowan and Glasson Moss, the clearance is more sustained at Glasson and is attributable to the higher population densities.

Few pollen diagrams have been published from this area and those which have been published do not discuss the nature of the human impact on the vegetation in any detail (e.g. Moar, 1969; Birks, 1970; Boatman, 1983). Pollen evidence from blanket peat near Loch Dee in the Galloway Hills (virtually adjacent to Ellergower Moss) shows that limited opening of the forest occurred from c. 650 B.C. (cal.) and continued throughout the Iron Age (Edwards *et al.*, 1991). This clearance also appears in the pollen diagrams from Loch Dungeon and Snibe Bog, Galloway and although no radiocarbon dates are available, the clearance is interpreted as being a result of Iron Age groups residing in low lying areas and occasionally occupying the hills (Nichols, 1967; Birks, 1972; 1975). These results are therefore in accord with those from Ellergower and Carsegowan Mosses.

5.5.9 Date And Intensity Of Iron Age Clearance.

It is clear from the pollen evidence and radiocarbon dates that the timing and intensity of Iron Age clearance varies between sites. If the percentage of non-arboreal pollen is taken as a measure of clearance, then a descending intensity occurs - Dogden Moss (75%), Letham Moss and Walton Moss (65%), Cranley Moss (60%), Glasson Moss and Carsegowan Moss (40%), Fannyside Muir (25%), Fozy Moss and Ellergower Moss (20%) (Figure 5.13). Similar changes are also seen in the Gramineae curves (Figures 5.14). The nature of clearance also differs. The clearances at Dogden, Letham, Glasson and Walton are large and sustained but at

FIGURE 5.13 ARBOREAL POLLEN VERSUS NON-ARBOREAL POLLEN FOR THE IRON AGE.

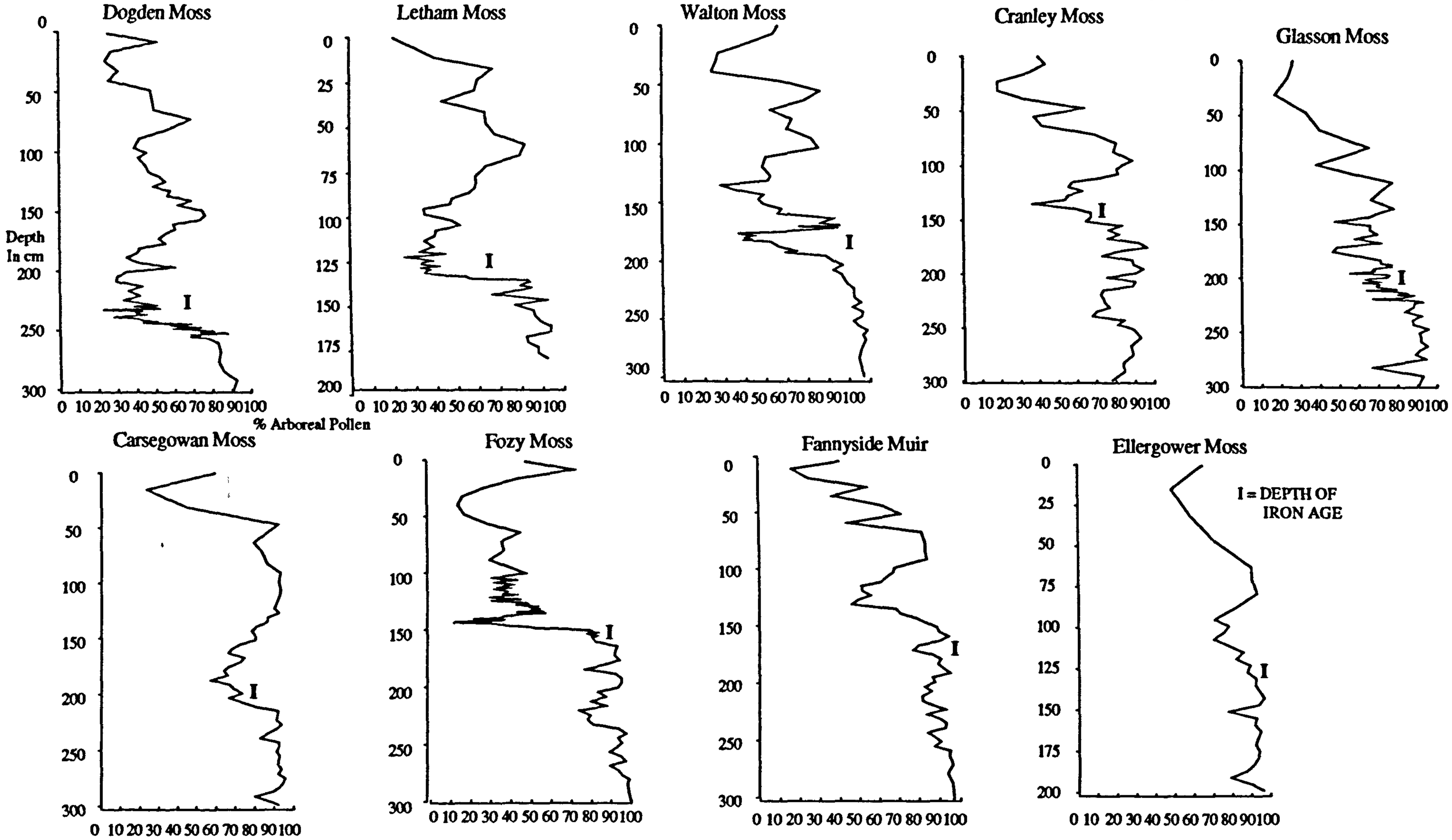
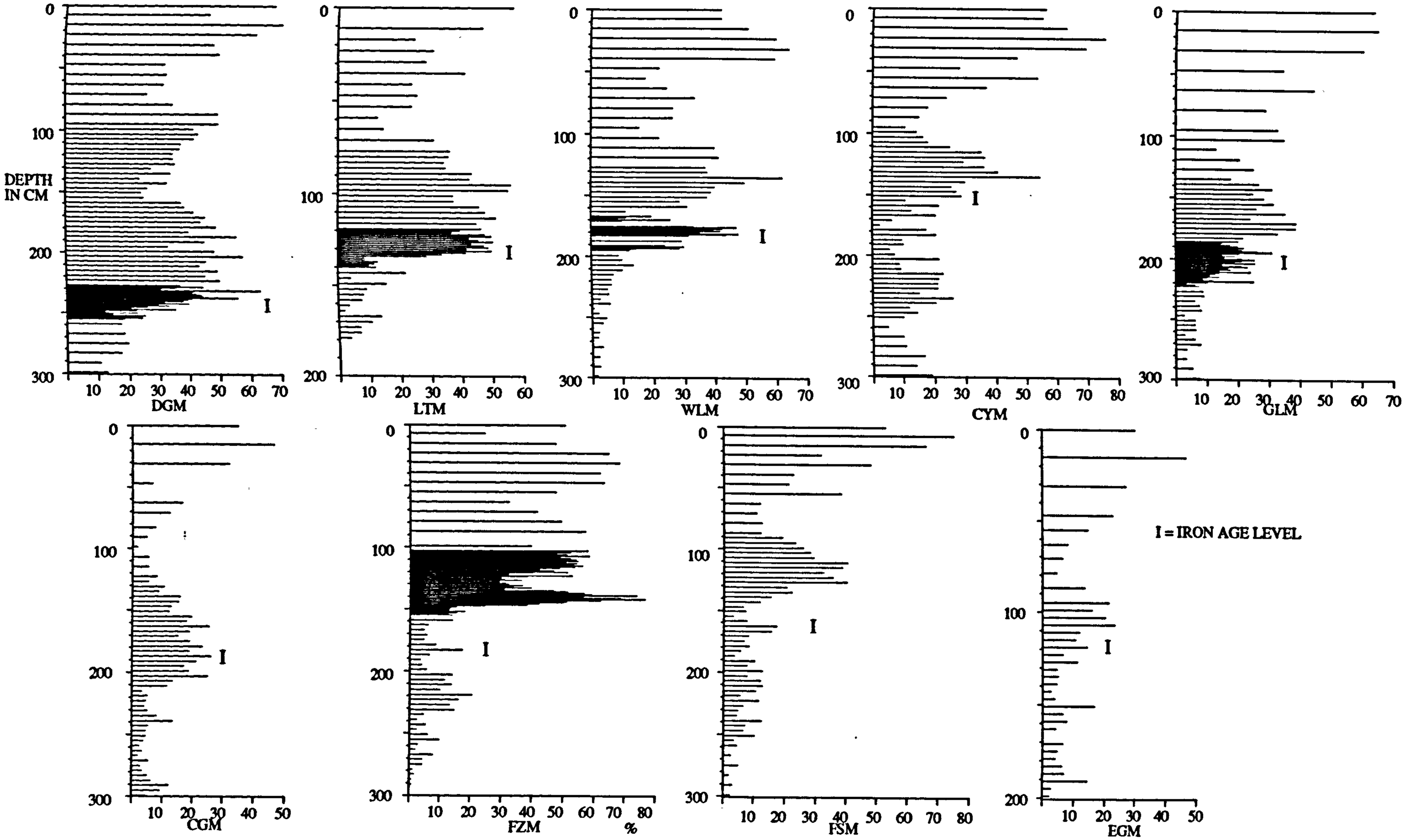


FIGURE 5.14 GRAMINEAE CURVES SHOWING IRON AGE LEVELS.



Fannyside Muir, Carsegowan, Ellergower, Cranley and Fozy Mosses clearance is shorter and sharper with more rapid regeneration afterwards. The approximate timing and length of the phase during which clearance occurs.as indicated by the radiocarbon dates, also differs (Table 5.1). Early Iron Age clearance occurs at Ellergower and Dogden Mosses and at other sites clearance begins during the late Iron Age, sometime between 265 B.C. and 115 B.C.. The differences in the time and scale of clearance are related to the archaeology as discussed above.

Table 5.1 Dates And Duration Of Iron Age Clearance.

SITE	DATE OF CLEARANCE	DURATION OF CLEARANCE (YEARS)
CRANLEY MOSS	660-255 B.C.	405
DOGDEN MOSS	420-20 B.C.	400
GLASSON MOSS	270 B.C.-A.D.125	395
LETHAM MOSS	155 B.C. - A.D. 120	275
ELLERGOWER MOSS	170 B.C.-A.D.70	240
FOZY MOSS	835-590 B.C.	245
FANNYSIDE MUIR	350-275 B.C.	225
WALTON MOSS	115 B.C.-A.D. 65	180
CARSEGOWAN MOSS	145-10 B.C.	135

Clearance at these sites can now be compared with the situation which existed elsewhere in the British Isles at this time. Pollen evidence indicates that from the early Iron Age extensive clearance seems to have dominated the landscape in most areas including south-east England (Turner, 1981 a), on Exmoor (Merryfield and Moor, 1974), Dartmoor (Simmons, 1964) and Derbyshire (Hicks, 1971; Tallis and Switsur, 1973). Sustained clearance occurred in the north Yorkshire Moors (Tinsley, 1975; 1976; Simmons and Cundill, 1974), at Fen Bog (Atherden, 1976 a) and in Teesdale (Chambers, 1978). Forest clearance was well under way in most areas. North of the Antonine Wall large Iron Age clearances are recorded in pollen diagrams from Black Loch, Fife (Whittington, *et al.*, 1990;1991) and Dubh Lochan near Loch Lomond (Stewart *et al.* 1984).

5.5.10 Assessment Of The Agricultural Economy In Northern Britain During The Iron Age.

The basic economy of the north during the Iron Age is not well understood. The writings of Caesar when he invaded Britain in B.C. 54 indicate that:

> " the people of the interior for most of the part do not sow corn, but live on milk and meat and dress in skins."

Later in 200 A.D., Cassius Dio records the natives as:

> "possessing neither walled places nor towns nor cultivated lands, but living by pastoral pursuits and by hunting and on certain kinds of berries....they live in tents" (from Megaw and Simpson, 1979, 491).

The traditional view of the economy in northern Britain during the Iron Age is therefore one of pastoralism:

> "Doubtless the Romans found Scotland a land whose flat and potentially fertile tracts were either covered with trees or scrub or else were morasses. It follows that there was little land which could be conveniently cultivated. To the Romans, Britain was a formidable country of impenetrable forests, great lakes, huge morasses, deep-cut valleys and

high frowning mountains" (Symons, 1959, 8).

The wealth of the tribes was reckoned in cattle and sheep and very large areas were required for pasturage, so that tribal lands might be wide but not heavily populated. The people may have been semi-nomadic as they accompanied their flocks and herds in search of fresh pasture (Frere, 1987, 4).

The idea that the economy of the north was largely one of pastoralism has now been abandoned. Direct evidence for systems of food production between the Tyne and the Forth is seldom available, but the evidence is sufficient to suggest arable practices (Cunliffe, 1991, 400). Finds of rotary querns suggest that cereal cultivation was practised, or at least that cereals were processed in the north. Seed remains indicate that Iron Age groups were also cultivating crops (Boyd, 1982; van der Veen, 1985). As the population rose, intensive agriculture became the basis for the economy, though the bulk of the population were still only peasant farmers.

However, more recently evidence of cord rig cultivation, ard marks and cultivation terraces found in an Iron Age context, suggest that the practise of arable agriculture was greater than originally supposed (Halliday *et al.*, 1981; Welfare, 1985, 1986; Turner, 1984; Topping, 1989). In substantial areas of Northumbria and the Borders, cord rig - a very narrow ridged cultivation system arranged in plots and fields - and cultivation terraces are associated with prehistoric settlement sites. By 1989, over 150 cord rig sites had been identified in Northumbria, thus dispelling the concept of a predominantly pastoral economy in the Tyne-Forth Province during the Iron Age. It is now apparent that arable regimes formed a significant part of the local economy and that indigenous communities were accomplished cultivators (Topping, 1989). In Cumbria, Northumbria, Berwickshire and Lanarkshire, cord rig, ard marks and field systems underlie sites of Roman age and in most cases the archaeological evidence suggests abandonment on or before the construction of the overlying Roman structures and this also offers the possibility that the Romans built their frontier across an open arable landscape (Topping, 1989).

The nature of the Iron Age agricultural economy is reflected in the pollen diagrams and can be related to the archaeological evidence. At all sites arable practices are denoted by the presence of cereals and arable indicators. The practise of tillage was certainly more widespread across the north than originally supposed, with greater arable cultivation at Dogden, Letham and Walton Mosses, as indicated by the greater frequency of cereals and arable herbs, and lower amounts around Cranley and Glasson Mosses. A few scattered cereal grains occur at Fozy, Ellergower and Carsegowan Mosses suggesting limited tillage. At Fannyside Muir, no cereals, but herbs indicative of arable agriculture occur. However, at all sites the percentage of herbs indicating pastoralism far outweigh the percentage of arable herbs, suggesting that pastoralism was the more significant part of the economy.

Pastoral/arable indices using the formulae devised by Turner (1964) and Riezebos and Slotboom (1976) have been calculated (Figure 5.15 and 5.16). These indicate that at each site pastoralism predominates, though arable phases occur. According to Turner's index, arable land use at Dogden Moss, Cranley Moss, Letham Moss and Fozy Moss is greater than at the other sites and according to Riezebos and Slotboom's index, Glasson Moss, Fozy Moss, Dogden Moss and Letham Moss and Fannyside Muir are more arable.

The pollen diagrams show that at all sites herbs which indicate both pastoral and arable agriculture increase significantly during the Iron Age. This might be a result of the need for production to feed the increasing population, but the introduction of iron working also had major implications for the farmer with the provision of stronger and more efficient equipment improving output and efficiency (Higham, 1986, 140).

FIGURE 5.15 PASTORAL/ ARABLE INDICES FOR THE IRON AGE AFTER TURNER.

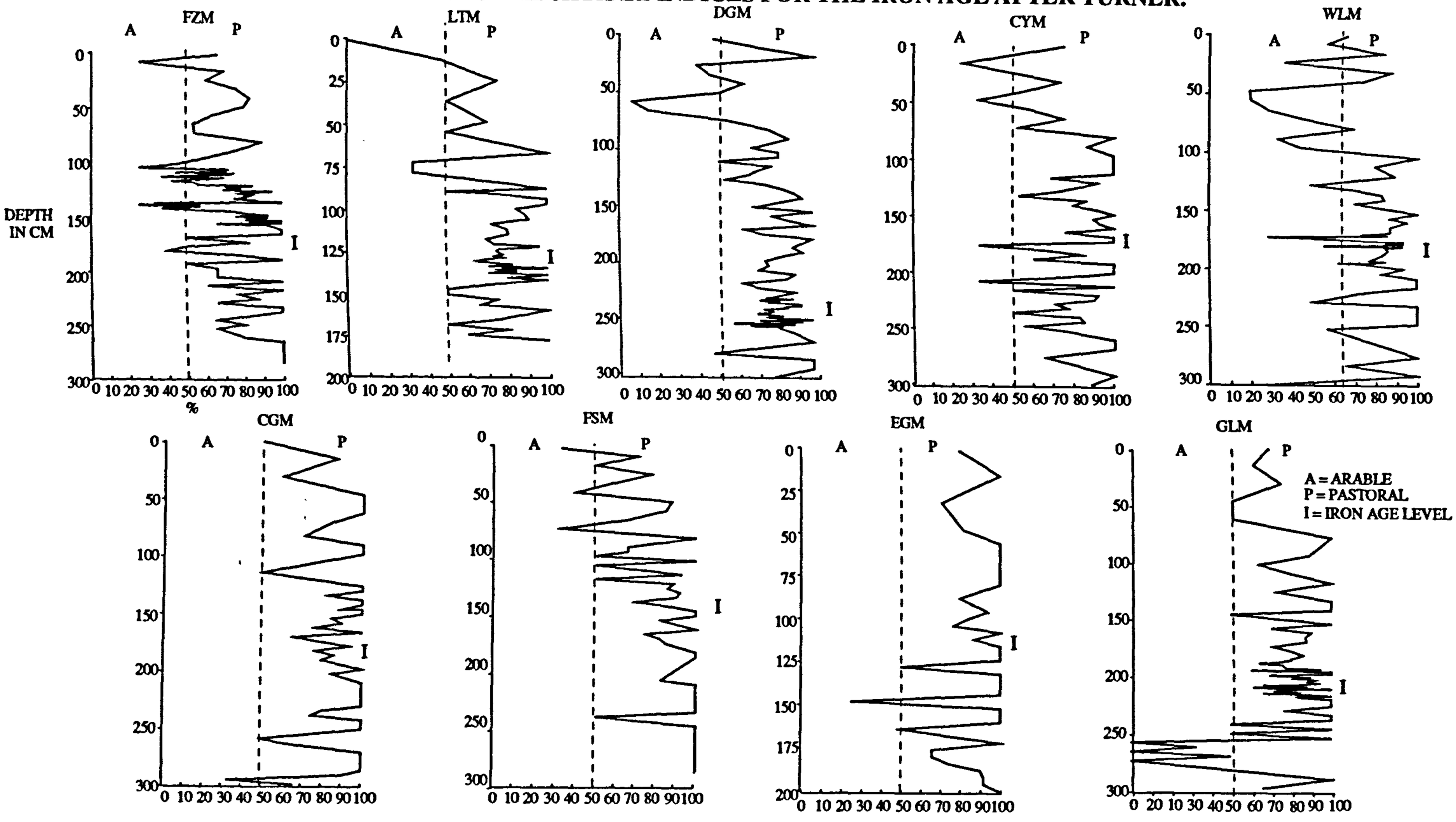
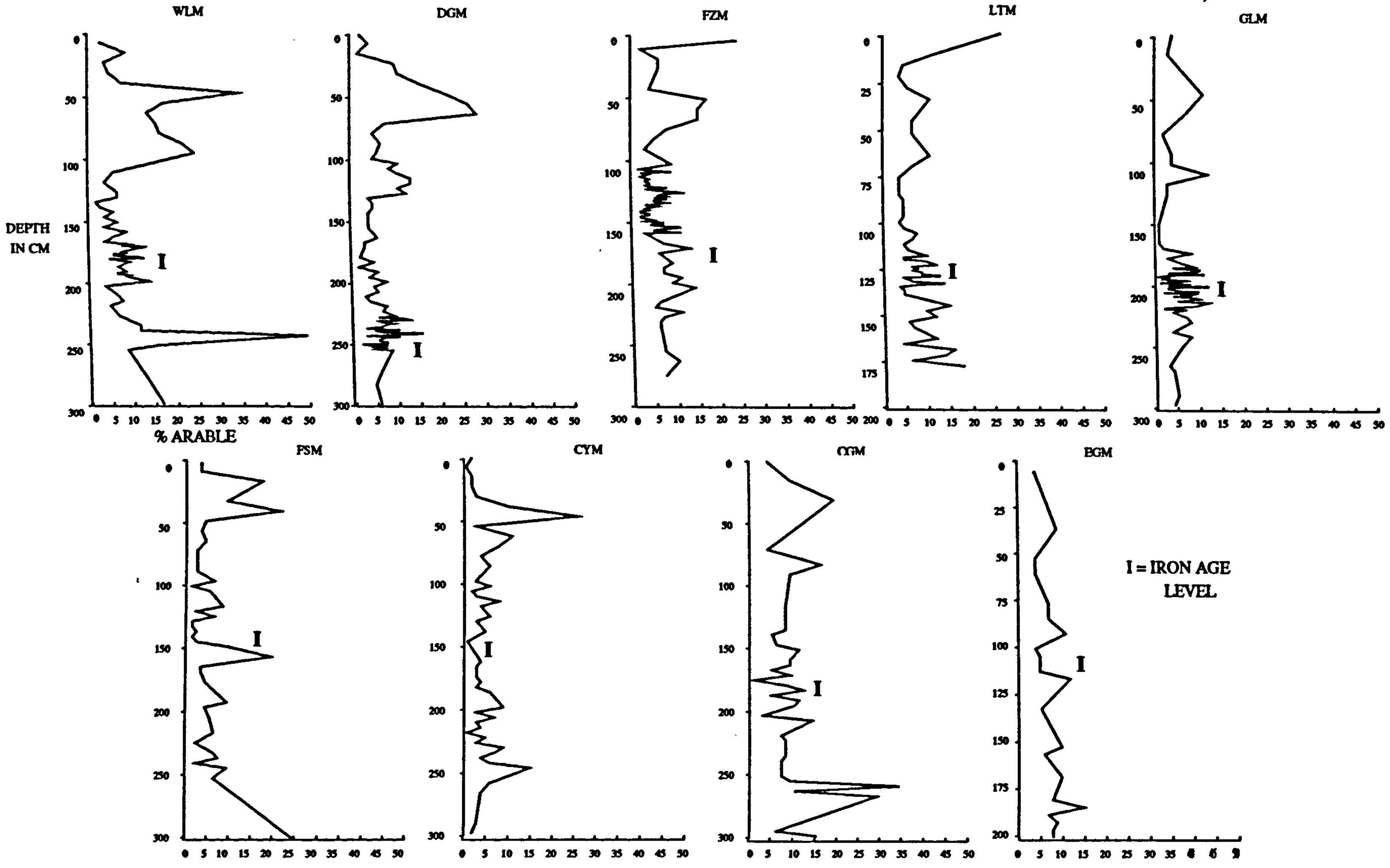


FIGURE 5.16 ARABLE INDICES FOR THE IRON AGE AFTER RIEZEBOS AND SLOTBOOM, 1978.



The pollen evidence from Fozy Moss can be related more closely to the archaeological evidence. An extensive area of cord rig is found at Greenlee Lough, Northumberland, just 5 km. to the west of Fozy Moss. Narrow-ridged cultivation underlies a Roman camp and was associated with a pre-existing planned Iron Age farm where ard marks also indicate the use of the plough (Welfare, 1985, 1986). Cereals and arable indicators are present in small amounts in the Fozy Moss diagram, but due to the limited pollen dispersal abilities of such species, pollen from Greenlee Lough would probably not be registered in the diagram. The archaeological and pollen evidence can only be used as far as demonstrating that an arable element to the economy in Northumbria was present.

The pollen evidence destroys the concept of a pastoral economy in northern Britain during the Iron Age. Although pastoralism seems to have perhaps dominated the agricultural scene, the presence of cereal pollen at all sites provides unequivocal evidence for arable agriculture. This is in agreement with the ideas postulated in the more recent archaeological literature and it could perhaps be possible to envisage an upland-lowland integrated economy based upon the products of lowland arable agriculture and upland grazing.

5.5.11 Conclusion.

During the late Iron Age, the clearance pattern is markedly different across the north British sites reported here. At Walton Moss rapid deforestation and clearance occurred from 115 B.C., intensifying further until A.D. 70. At Glasson Moss, a continuous clearance trend occurred from 265 B.C. to A.D. 125. Clearance at Glasson corresponds to an increase in settlement on the Solway plain, but this clearance is smaller than that at Walton Moss where virtually no settlement evidence occurs. A sustained clearance occurs between 235 and 20 B.C. at Dogden Moss and is a result of the continued occupation of the hillforts. At Letham Moss, rapid forest clearance occurs between 155 to 15 B.C. on the same scale as that at Dogden Moss, which is in agreement with the settlement evidence. Gradual clearance occurs at Ellergower and Carsegowan Mosses and Fannyside Muir. The greater clearance at Carsegowan is probably a result of a higher settlement density around the coast compared to the mountainous districts. The regeneration at Cranley Moss and regeneration followed by gradual clearance of forest at Fozy Moss is in accord with the low amount of settlement evidence for the area. There was also an imbalance in the distribution of iron-smiths with very few in Cumbria and many in Scotland, which might also explain the differences in clearance. Deforestation was a combined result of increased demand for land for settlement and more developed permanent agriculture in response to increased population numbers, the widespread availability of iron tools and the demand for charcoal for smelting (Roberts, 1990). Although environmental factors must have been important, differences in clearance are explained by variation in the archaeology and the main reason for differentiation is probably the different tribal entities and settlement pattern which had evolved from the earlier Iron Age.

5.6 The Effect Of The Roman Invasion Of Northern Britain On Vegetation *c.* A.D.67 - A.D. 122.

5.6.1 Walton Moss - Rapid Forest Regeneration.

At Walton Moss (WLMd) between about A.D. 70 (SRR-4530) and A.D. 125 a marked and rapid forest regeneration occurs, though there are some minor fluctuations. After the initial rapid revertence a very sudden small clearance occurs over 2 pollen spectra (1 cm. interval counts), the forest then immediately regenerates for a similar period and then another small clearance occurs followed by a further regeneration. These trends are mirrored by the Gramineae curve and to a lesser extent the *Plantago* spp. curve. A decrease in agriculture is suggested by a fall in Gramineae and open ground indicators. Arable agriculture slowly ceases and during

this period *Triticum* type, *Artemisia* and *Rumex* spp. disappear but pastoral indicators continue at a lower level. Forest regeneration at Walton Moss is probably the result of the Roman invasion and campaigns of Cerialis and Agricola from around A.D. 71 to A.D. 122. This agrees with the idea that Brigantian resistance was strong and it is likely that land was abandoned as the tribe attempted to resist Roman raiding and presence (Breeze, 1985; Hanson and Campbell, 1986; Higham, 1987; Cunliffe, 1991, 207). The small clearances which occur within the overall pattern of regeneration could be the result of the Romans felling trees to acquire land for the construction of roads and timber for marching camps and forts such as Brampton, Nether Denton and Carlisle (Breeze and Dobson, 1987, 21).

5.6.2 Glasson Moss - Slight Regeneration.

At Glasson Moss ($GLMb_2$) the invasion period cannot be differentiated from the general trend of forest clearance which began in the late Iron Age (Section 5.5.2). However, there is a very slight increase in forest and decrease in Gramineae and *Plantago* spp. around A.D. 125 (SRR-4533) probably as a result of the Romans campaigns between A.D. 70 and A.D. 122. Forest regeneration might be the result of native peoples abandoning their land in wake of the Roman advance. Regeneration was lower at Glasson Moss than Walton Moss probably because Glasson Moss was at a distance from the major routes of Roman advance and campaigning areas. The pollen evidence is in accord with Higham and Jones' (1985) view that the Carvetti offered less resistance to the Romans and that the Roman presence was less intense. The Carvetti were the subject of a Agricola's separate campaign in A.D. 78 (Higham, 1986,156) and the only Roman structure to be built in the area was the fort at Kirkbride 4 km. south of the moss.

5.6.3 Fozy Moss - Sustained Clearance.

At Fozy Moss the invasion period cannot be differentiated from the late Iron Age period of gradual clearance which continued until *c.* A.D. 130. This date lies at the lower end of the range of A.D. 130 and A.D. 245, the mid-point of which is A.D. 185. It is statistically valid to state that the date of A.D. 130 can just as validly lie anywhere within the range (See Section 3.5), and the date of A.D. 130 has been used in the interpretation so that the vegetation record would then be in accord with well documented archaeological events.

Accelerated clearance occurs at the end of phase $FZMc_4$ indicated by a continued decrease in arboreal pollen and increase in Gramineae and other herbs. This record of continued clearance is different to Glasson and Walton Mosses and could be because continued clearance occurred during the campaigns, or because of the significantly slower peat accumulation rate at Fozy Moss (20.5 years/cm.) meaning that such a short period of revertence is not registered in the pollen diagram. The moss is in the area over which the Romans campaigned and if continued clearance did occur then there was not a disruption in the native way of life. The native population in the Fozy Moss area offered less resistance to the invasion, perhaps because settlement and therefore population density, as indicated by Clack and Gosling (1976), in the area was low. Continued clearance might also have been attributable to the building of the Roman road which ran between the Tyne and the Solway and the Agricolan forts of Vindolanda, Newbrough and Corbridge on the Stanegate are situated 3 km. south of Fozy Moss (Breeze and Dobson, 1987, 21).

5.6.4 Letham Moss - Sustained Clearance.

At Letham Moss ($LTMc_2$) sustained clearance continued until around A.D. 120, though there is some

evidence for forest regeneration and a decline in agriculture before the end of this phase. Sustained clearance at Letham Moss indicates that the native way of life was perhaps not disrupted by the Roman presence. Roman troops did not reach this area until A.D. 78 and Selgovian resistance was minimal (Higham, 1986, 156). Tacitus records that the tribes were too terrified to resist and a victory monument or tomb, Arthur's O'on, which possibly dates from this period was constructed (Keppie, 1986, 144). During the A.D. 80s the population in this part of Scotland was suppressed and although under Roman control, was for most of the time left to run its own affairs. The area was passive enough to remain under control with a reduced Roman presence and continued clearance is probably the result of the continued native way of life as well as the timber removed for the construction of the road between the Forth and Clyde and the fort at Camelon (Keppie, 1986, 144; Hanson and Breeze, 1991).

5.6.5 Dogden Moss - Regeneration And Sustained Clearance.

At Dogden Moss ($DGMc_2$) a short forest revertence occurs around A.D. 90. Gramineae and, to a lesser extent, *Plantago* spp. and *Rumex* spp. decrease, whilst Coryloid and *Alnus* increase. Revertence is probably a result of the natives abandoning land and settlements when the Romans invaded the area despite the archaeological evidence suggesting that settlements continued to be occupied (Cunliffe, 1991, 194). The following renewed clearance was probably a result of reoccupation of the settlements since the Votadini were already a client kingdom of Rome and were not harshly treated during the campaigns of A.D. 70-80s (Robertson, 1976; Hanson and Breeze, 1991). Clearance was probably accentuated by the presence of the Romans and the construction of roads and forts such as Newstead on Dere Street.

5.6.6 Cranley Moss - Renewed Clearance.

At Cranley Moss (middle of CYMf) renewed clearance occurs between approximately A.D. 35 and A.D. 90 and cereals are absent, though *Artemisia*, *Rumex* spp. and Umbelliferae suggest some arable agriculture. Pastoralism is suggested by the continued presence of *Plantago* spp., Compositae lig., *Filipendula* and Ranunculaceae. As described in the literature (Section 2.2.1) Agricola campaigned in Selgovian territory during this time and tribal resistance was minimal explaining the lack of regeneration and the continued agriculture at Cranley Moss. Renewed clearance is probably the result of continued tribal presence as well as the proximity of the site to the route of the Romans taken north through the Clyde valley and east-west from Loudin Hill to Newstead. A fort and number of marching camps dating to the Agricolan period were established at Castledykes (Keppie, 1986, 91) only 3.5 km. from the moss itself. Timber was probably removed for road and fort construction.

5.6.7 Fannyside Muir - Stable Forest and Clearance.

At Fannyside Muir (latter part of FSMe) a period of forest stability followed by the start of a renewed clearance occurs around A.D.75. As described in the literature (Section 2.2.1) Cerialis and Agricola campaigned in the area around this time and Selgovian resistance was minimal supporting the lack of regeneration. Renewed clearance is perhaps a result of need for timber to construct temporary camps and roads between the Forth and Clyde (Hanson and Maxwell, 1980).

5.6.8 Carsegowan Moss And Ellergower Moss - Regeneration.

At Carsegowan Moss (end of phase CGMd) forest regeneration occurs around A.D. 60, continuing until A.D. 110, whilst at Ellergower Moss (EGMc) forest regeneration begins between around A.D. 5 and A.D. 70. The

archaeological literature suggests that south-west Scotland was at a distance from the major Roman campaigning areas and was subject to a separate campaign in A.D. 82 (Robertson, 1976). The Novantae are also considered to have been a troublesome tribe having at times allied with the Brigantes and therefore, forest regeneration might have been a result of the natives abandoning land as the Romans advanced. Roman coins dating to this period have been found throughout the area, an Agricolan fort was built at Gatehouse of Fleet, and a road ran as far as Stranraer. Ellergower and Carsegowan Mosses are at a distance from the structures and renewed clearance did not occur.

5.6.9 Assessment Of The Impact Of The Roman Invasion On Vegetation And Iron Age Settlement.

Romanisation is the impact of Roman forces and culture upon the native population, the agents of such a process being the influence of the soldiers, colonies of Roman citizens, Roman traders and governors, language and currency (Jones, 1984; Frere, 1987, 296; Millett, 1990, 1). To this end the countryside in northern Britain cannot be seen as purely native or purely Roman and the link between them has to be seen through administrative, financial and political structures (Clack, 1982). The minimalist view of Romanisation is that occupation had a limited impact on indigenous economic and social structures; that the direct impact of the army on the native economy was not substantial but that its presence had a number of indirect influences on the population (Millett, 1990). Rivet, (1964) considers that change in the countryside was slow and that any changes made were incidental rather than direct. Alternatively, the Roman occupation of Britain might have had a profound impact on the economic, social and agricultural structures of native society (Higham and Jones, 1985, 13). The palynological evidence and the nature of vegetation change can be used to assess the extent to which the Roman invasion disrupted native settlement and therefore society.

The palynological evidence indicates that during the time of the Roman invasion different patterns of clearance occurred across northern Britain. Rapid forest regeneration at Walton Moss is a result of the proximity of the site to the major campaigning areas in Brigantian territory and is in accord with the idea that there was greater resistance from the Brigantes with Roman raiding and plundering in the area (Cunliffe, 1991, 207). Regeneration occurred to a lesser extent at Glasson Moss - the area being marginal to the major campaigning areas and the Carvetti being a less troublesome tribe (Higham, 1986). At Ellergower Moss and Carsegowan Moss regeneration is again apparent, being on a smaller scale than at Walton Moss and greater than that at Glasson Moss. The Novantae, were believed to have allied with the Brigantes, posed resistance to Roman forces, resulting in plundering and land abandonment. Archaeological evidence indicates that much land was abandoned and the north was in a situation of widespread rebellion (Higham, 1986, 151). Those who were in the occupation of sites required by the army were moved (e.g. sites on the land between the wall and the *vallum*) and the construction of forts and other major military installations may have had a major impact on local communities. The total area of land removed from civilian access was considerable and if the *cordon sanitaire* around each fort is considered, the total figure is estimated to be between 85,000 and 120,000 ha (Higham, 1986, 179). The ideas outlined in the literature are reflected by forest regeneration at Walton, Glasson, Ellergower and Carsegowan Mosses.

Megaw and Simpson (1979, 493) argue that the character of the Roman occupation of the north was essentially military and this meant that the impact on native society was less marked, with many Iron Age cultural traits surviving. This would be indicated by continuity of settlement and culture. In some areas archaeological evidence suggests that Roman practice was to incorporate and adapt existing societies, working through their existing tribal organisation rather than altering them wholesale (Hodder and Millett, 1990; van der Veen, 1991). According to Higham (1986, 172) Romanisation seems to have been attempted at two

levels of society. The aristocracy was encouraged to be acquainted with Roman culture, whilst the general populace were:

> "becoming accustomed to holding markets.... They had not, however, forgotten their old life of independence, or the power derived from arms. Hence, so long as they were unlearning these customs gradually and by the way, as one might say, under careful watching, they were not disturbed by the change in their manner of life, and were becoming different without knowing it" (Dio, LVI, 18, 2 in Higham, 1986, 172).

The palynological evidence suggests that sustained clearance occurred around Fozy Moss and Letham Moss; renewed clearance at Cranley Moss and, after a small regeneration at Dogden Moss and Fannyside Muir. Clearance at Fozy Moss could have been associated with continued native occupation and the building of Roman structures along the Stanegate. The larger and sustained clearances at Fannyside Muir and Dogden and Letham Mosses can again be related to the events outlined in the literature. The Selgovian and Votadini tribes offered little resistance to the Roman presence, they were not harshly treated by the Romans (Higham, 1986, 156) and sustained clearance is possibly a result of natives continuing in their tribal way of life, occupying hillforts and settlements whilst continuing to practise agriculture. The renewed clearance at Cranley Moss occurs at the time of the Roman campaigns and can be related to the building of Castledykes fort. Timber for fort construction was probably obtained from the local forest and although Iron Age settlement continued, the increased clearance is a result of the Roman presence. Figure 5.17 shows percentage arboreal and non-arboreal pollen at each site during the invasion period. This demonstrates variation in clearance between sites and although regeneration was occurring at Glasson Moss, the extent to which the landscape was open is greater than in the areas where sustained clearance was occurring. Despite the trend of either clearance or regeneration during the invasion the extent of open ground is not only related to the events during the invasion and the response of the tribes, but also the density of previous Iron Age settlement.

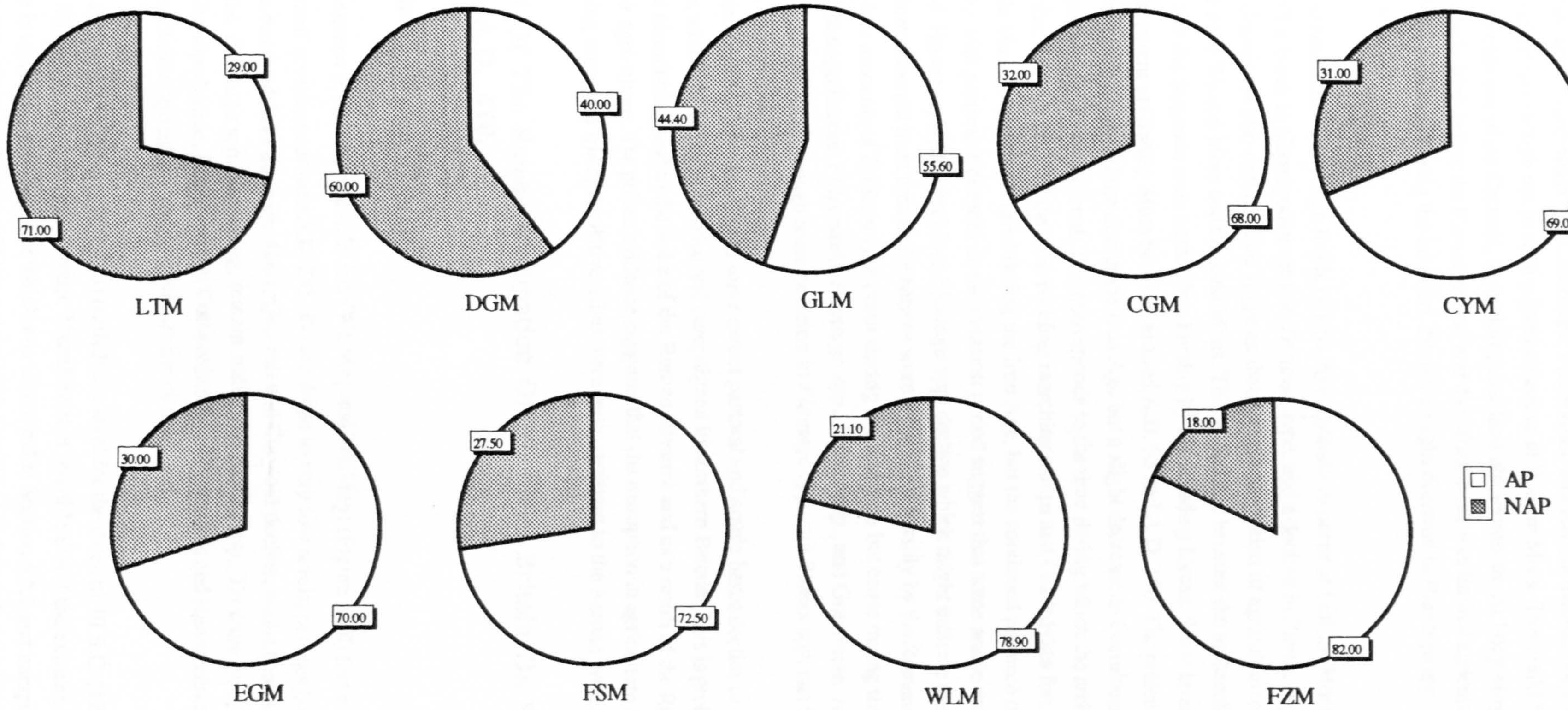
Two situations occurred in northern Britain during the invasion period. At Walton, Glasson, Carsegowan and Ellergower Mosses forest regeneration and land abandonment occurred reflecting the fact that the invasion had a profound effect on native society in the frontier area. Conversely at Dogden, Letham, Fozy and Cranley Mosses little vegetation change occurs implying little disruption, a continued way of tribal life and the slow assimilation of Iron Age society into the Roman way of life.

5.6.10 Assessment Of The Agricultural Economy In Northern Britain During The Roman Invasion.

Debate surrounds the nature of the agricultural economy of northern Britain during the Roman period and its relationship with that of the Iron Age. According to Applebaum (1966) the essential nature of the agricultural economy continued from the Iron Age and there is no well defined dividing line between late Iron Age and Roman farming. The arrival of the Roman army did not necessarily result in a break in agricultural development in the north, but earlier systems probably passed under Roman control (Taylor, 1975, 47). Whether such a break in agriculture occurred can perhaps be determined from the palynological data.

At Walton Moss a distinct break in *Triticum* type and *Artemisia* and a decline in *Rumex* spp. occurs from around A.D. 70 until A.D. 125. Similarly, Compositae lig., Compositae tub., Cruciferae, *Filipendula*, and Ranunculaceae disappear as Gramineae and *Plantago* spp. decline. Herbs do not reoccur or increase until *c.* A.D. 125. This suggests that a break in both arable and pastoral agriculture occurred during the time of the Roman invasion which could be the result of land abandonment by the natives as the Romans raided and plundered the area. Just before A.D. 125 at Glasson Moss, *Triticum* type disappears, though *Artemisia* and

FIGURE 5.17 PERCENTAGE ARBOREAL AND NON-ARBOREAL POLLEN FOR THE INVASION.



Umbelliferae continue to occur. Again *Plantago* spp. and Gramineae decline whilst there is a break in the curves of Compositae tub., Compositae lig., Cruciferae, *Filipendula* and Ranunculaceae. This suggests a similar decline in agriculture though not to such a great extent as at Walton Moss. This could be attributed to the more favourable treatment of the Carvetti, less raiding and land abandonment. At Fozy Moss, agricultural herbs are not particularly high before the Roman period and therefore, there was limited agricultural land which could have been disturbed during the invasion, though a slight decrease in *Plantago* spp. occurs prior to the invasion period.

Before the Roman invasion relatively high levels of Iron Age agriculture occur at Letham Moss, but between A.D. 65 and A.D. 95 a break in Chenopodiaceae and *Triticum* type, and a decline in *Rumex* spp. occur. *Plantago* spp. and Gramineae also decline. This suggests that a slight disruption of agriculture occurred though not as large as at Walton Moss and Glasson Moss. This is perhaps because the archaeological evidence indicates that the Selgovae were treated less harshly by the invading forces. Some break in agriculture is also apparent at Cranley Moss between around A.D. 95 and A.D. 150. The pollen diagram suggests only low amounts of agriculture during the Iron Age but a slight decrease in Gramineae and *Plantago* spp. suggests some break occurred. This corresponds to the time during which the archaeological evidence indicates that Romans invaded the area, building marching camps and Castledykes fort. At Dogden Moss and Fannyside Muir no cereals occurred during the Iron Age, but the continued presence of *Artemisia* and Chenopodiaceae with pastoral indicators in the invasion period suggest that some arable and pastoral agriculture survived. However, at Dogden Moss *Plantago* spp. decline which might indicate that a slight decrease in agriculture occurred in an area as the natives were treated less harshly by the Romans. At Carsegowan Moss low amounts of *Triticum* type occur during the Iron Age but cease during the invasion period along with Chenopodiaceae, *Filipendula*, *Plantago* spp., *Rumex* spp., and Gramineae. At this time, all herbs are low at Ellergower Moss, though some decrease in *Plantago* spp. and *Rumex* spp. can be identified.

At all sites the pollen evidence indicates that to some extent pastoral and arable herbs decline or disappear during the period in which the Romans invaded and campaigned in northern Britain. This is probably the result of the natives abandoning land in the wake of the Roman advance and as a result of the Romans raiding and plundering their agriculture. The pollen evidence suggests that the disruption in agriculture is greater in the main campaigning areas and where the native tribes were more resistant to the Roman presence.

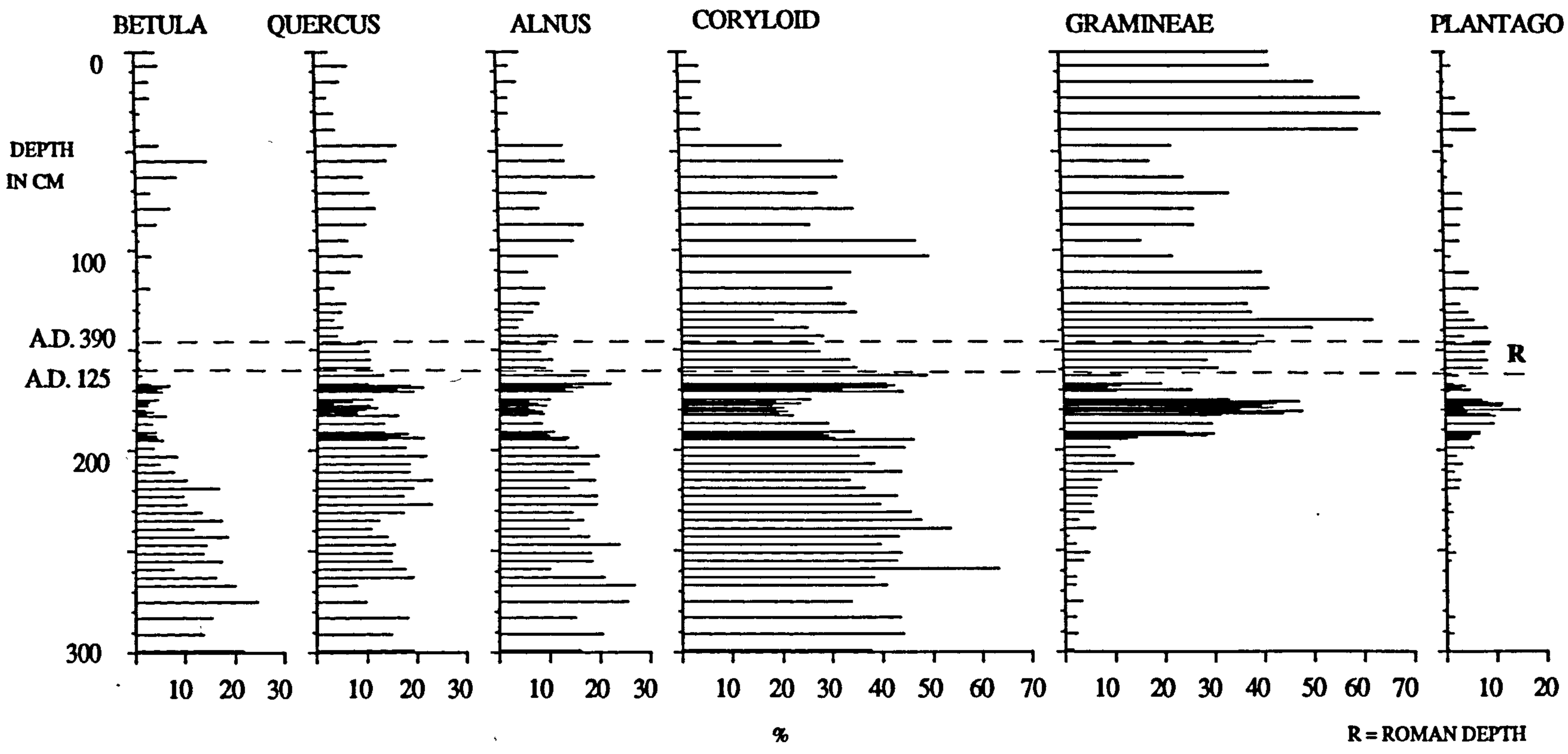
5.7 The Effect Of The Roman Occupation Of Northern Britain On Vegetation - *c.* A.D.80 - A.D. 410.

5.7.1 Walton Moss - Forest Clearance.

At Walton Moss, between *c.* A.D. 70 and A.D. 395 ($WLMe_1$ and $WLMe_2$) (Figure 5.18) forest clearance occurs but with a small revertence around A.D. 245. *Betula* drops to very low levels, perhaps because the rand vegetation was removed from the mire. *Alnus*, *Quercus* and Coryloid decline, whilst Gramineae continues to increase. *Plantago* spp. after rising, remain stable and *Rumex* spp., *Triticum* type, Caryophyllaceae, Chenopodiaceae, Papilionaceae, Compositae lig., *Filipendula* and Ranunculaceae suggest that both pastoral and arable agriculture was practised on the cleared land.

The ranges of the calibrated ^{14}C dates at 98% (2σ) confidence level for the dates of 10 B.C. (120 B.C. to A.D. 80) and A.D. 70 (2 B.C. to A.D. 134) overlap. Therefore it is possible that if the extreme of the range for the 10 B.C. date is taken, the first clearance which was discussed in Section 5.5.1 and interpreted as being Iron Age could in fact be Roman. This would be in accord with the scarcity of Iron Age settlements and with

FIGURE 5.18 WALTON MOSS - SELECTED CURVES FOR THE ROMAN PERIOD.



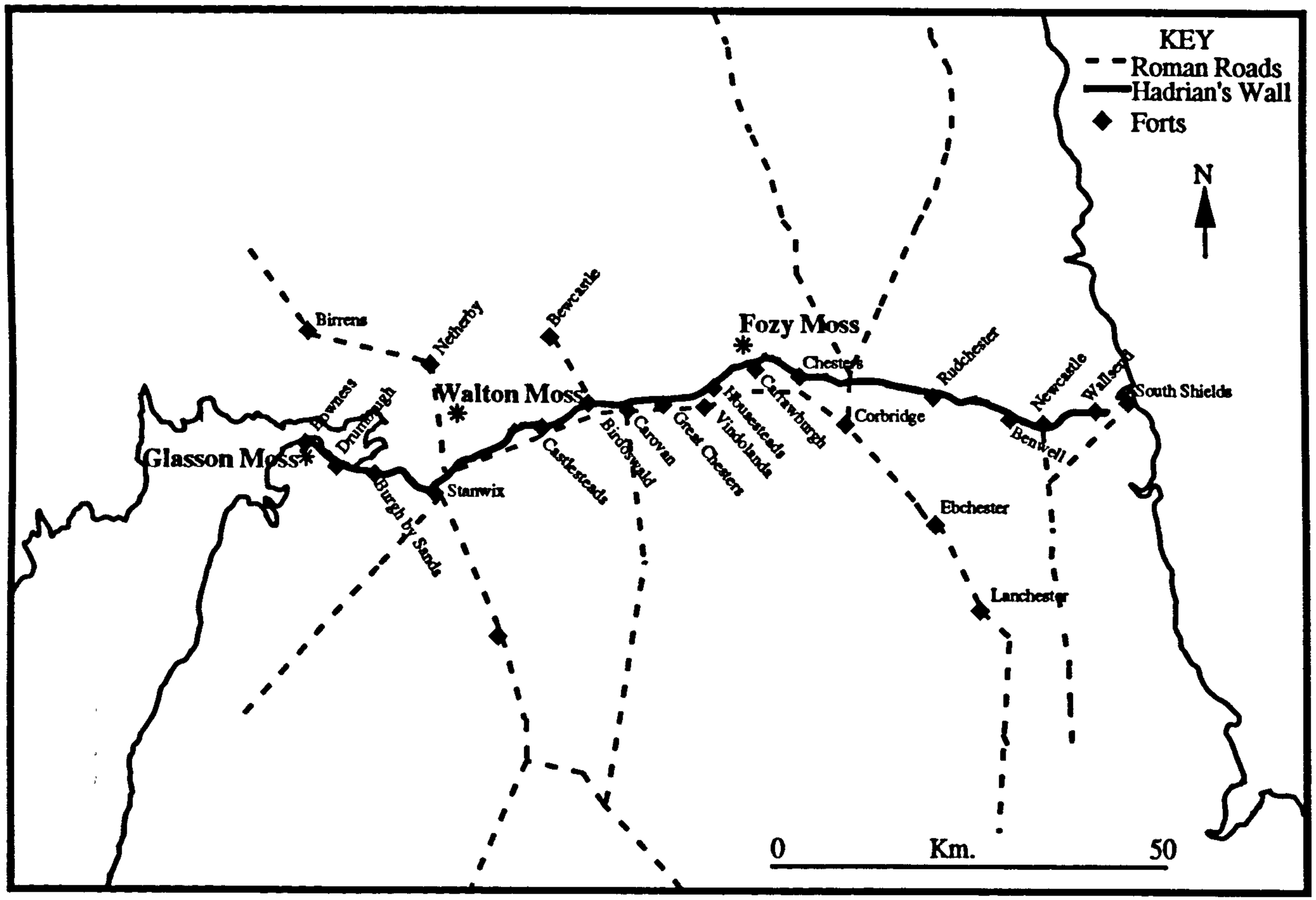
the record from Bolton Fell Moss (Barber, 1981, 112). Justification of using the extrapolated date of A.D. 126 at 68% (1σ) confidence limit is derived form the fact that this clearance correlates with the known date for the building of Hadrian's Wall and similar dated clearances at Glasson and Fozy Mosses.

As discussed in the archaeological literature (Section 2.2.2), this clearance episode corresponds with the building of Hadrian's Wall and its related structures. Walton Moss lies only 2.5 km. north of the wall and the renewed clearance was probably the result of the timber requirements for the wall and forts such as Carlisle, Stanwix, Netherby, Birdoswald, Nether Denton and Castlesteads which all lie within a 10 km. radius of Walton Moss (Ordnance Survey, 1991) (Figure 5.19). The wall in this area was originally built of turf and this implies that if the turf was obtained in the local area (which is probable considering the cost and difficulty of transporting it over land), a considerable amount of open land must have already been in existence, as implied by the earlier Iron Age clearances in the pollen diagram. The continued clearance after the building of the wall is perhaps a result of the more stable conditions during the Third Century (Branigan, 1980; Higham, 1986, 172). After the initial period of trouble when the Brigantes resisted the Roman conquest, the native population probably resettled, continuing a similar way of life and accepting the Roman presence. Troops and Roman civilians occupied and farmed the area around the forts and *vici* (e.g. Carlisle) began to grow.

The slight forest revertence around A.D. 245 could have been the result of natives raiding Hadrian's Wall and the Romans attempting to bring the area back under their control. However, the relative lack of precision in assigning a date to this event using extrapolation, means that a particular event cannot be identified to explain the revertence. The sequence of abandonment of Hadrian's Wall and the occupation of the Antonine Wall cannot be detected in the pollen diagram, perhaps because the counting resolution in the pollen diagram is too poor or because the natives, civilians and troops remaining on Hadrian's Wall were large enough to sustain the clearance. Pollen analysis of the 'desertion layer' at Birdoswald Fort 9 km. east of Walton Moss, indicates that continued opening of the landscape occurred during this period and this is interpreted as being a result of the soldiers left on Hadrian's Wall or natives occupying the fort (Wiltshire, pers. comm.). Although the rate of clearance begins to slow at Walton Moss there seems to have been no forest revertence as troops were withdrawn from the area during the Fourth Century under Constantine, Theodosius and Maximus and as the Picts and Scots raided the wall in the 360s - 380s. This could point to the fact that on the whole, the general way of life for the natives and Roman civilians remained the same as these events took place. The clearance is smaller than the previous Iron Age clearance suggesting a lower population density which is the reverse of the situation to be expected if population in the area had increased due to the presence of troops.

The pollen evidence from Walton Moss can be compared with that from Bolton Fell Moss (Barber, 1981, 113). At Bolton Fell Moss a major clearance occurs at A.D. 90 ± 60. This date has been calibrated (Appendix 1.2) to A.D. 150 within a range of A.D. 80 to A.D. 220. This clearance seems to be Roman and at this point the Bolton Fell Moss record accords very well with that from Walton Moss. Gramineae rises in a similar way and attains a similar level. This clearance is followed by similar forest regeneration associated with the Roman withdrawal. The agricultural regimes also seem to have been similar.

Figure 5.19 Position of Walton, Glasson and Fozy Mosses In Relation to Hadrian's Wall.



Source - Johnson (1989)

5.7.2 Glasson Moss - Forest Clearance.

After a period of slight regeneration at Glasson Moss, renewed forest clearance begins to occur between approximately A.D. 125 (SRR-4533) and A.D. 245 (GLMc) (Figure 5.20), indicated by a massive rapid decline in arboreal pollen, especially *Quercus*, *Alnus* and Coryloid. Gramineae, *Plantago* spp. and *Rumex* spp. rise and *Artemisia*, Caryophyllaceae, Compositae lig. and tub., and Chenopodiaceae occur, suggesting that some agriculture was being practised on the cleared land.

As at Walton Moss the clearance begins around the time during which Hadrian's Wall and its related structures was being built. Glasson Moss lies only 1.25 km. south of the wall and the renewed clearance was probably the result of the timber requirements for building the wall and forts such as Bowness, Burgh by Sands and Drumbrugh which lie within a 10 km. radius of the site (Ordnance Survey, 1991) (Figure 5.19). The wall does not extend around the Solway coast as far as Glasson, but instead a series of milecastles and turrets were built. The level of clearance at Glasson Moss is slightly lower than at Walton Moss and this could be because the Roman occupation of the area was less intense.

The continued clearance after the building of the wall is perhaps a result of the more stable conditions during the Roman occupation. After the initial conquest the native population probably resettled, continuing a similar way of life and accepting the Roman presence. The clearance is greater than that during the Iron Age and the combined presence of the troops and natives resulted in a greater population density. Again the abandonment of Hadrian's wall and occupation of the Antonine Wall cannot be detected in the pollen diagram, perhaps because the counting resolution is too low or because the natives, civilians and troops remaining on Hadrian's Wall were enough to sustain the clearance.

As with Walton Moss, a similar small forest revertence occurs around A.D. 245 and again no precise date can be assigned to the regeneration, but it is more marked at Glasson Moss. The Cumbrian Coast was abandoned earlier by the Romans, although parts of the Wall may still have been occupied and forest regeneration could be a result of the natives attacking the wall in the A.D. 240s, with the troops attempting to regain control by destroying native settlements and fields.

Between A.D. 245 and A.D. 320 (GLMd) renewed clearance occurs similar to but ending earlier than that at Walton Moss. This again might be the result of the return of more stable conditions to the area. Between around A.D. 320 and A.D. 400 small fluctuations in forest cover occur perhaps as a result of the gradual removal of troops from the area or the raiding of the wall by natives. Forts were the only sites to be refurbished in the later stages of the occupation and due to the lower intensity of forts on the Solway the Romans probably did not pay much attention to renovating their military structures there.

5.7.3 Fozy Moss - Rapid Clearance.

At Fozy Moss ($FZMd_1$) a massive rapid forest clearance with an almost totally deforested landscape occurs between *c.* A.D. 185 (SRR-4539) and A.D. 370 (Figure 5.21). All arboreal species fall rapidly to levels indicating an almost totally deforested landscape. Gramineae rises massively to 75% and there are simultaneous rises in *Plantago* spp. and *Rumex* spp.. Other herbs are more frequent and cereals occur, indicating that arable and pastoral agriculture were being practised. The date of A.D. 185 for the beginning of the rise in non-arboreal pollen is too late if the rise were to be associated with clearance attributable to the building of Hadrian's Wall. However, A.D. 185 is the mid-point of the range from A.D. 130 and A.D. 245 with a probability of 99% at 68% (1σ) confidence limit. It is just as likely that the date lies at the lower end

FIGURE 5.20 GLASSON MOSS - SELECTED CURVES FOR THE ROMAN PERIOD.

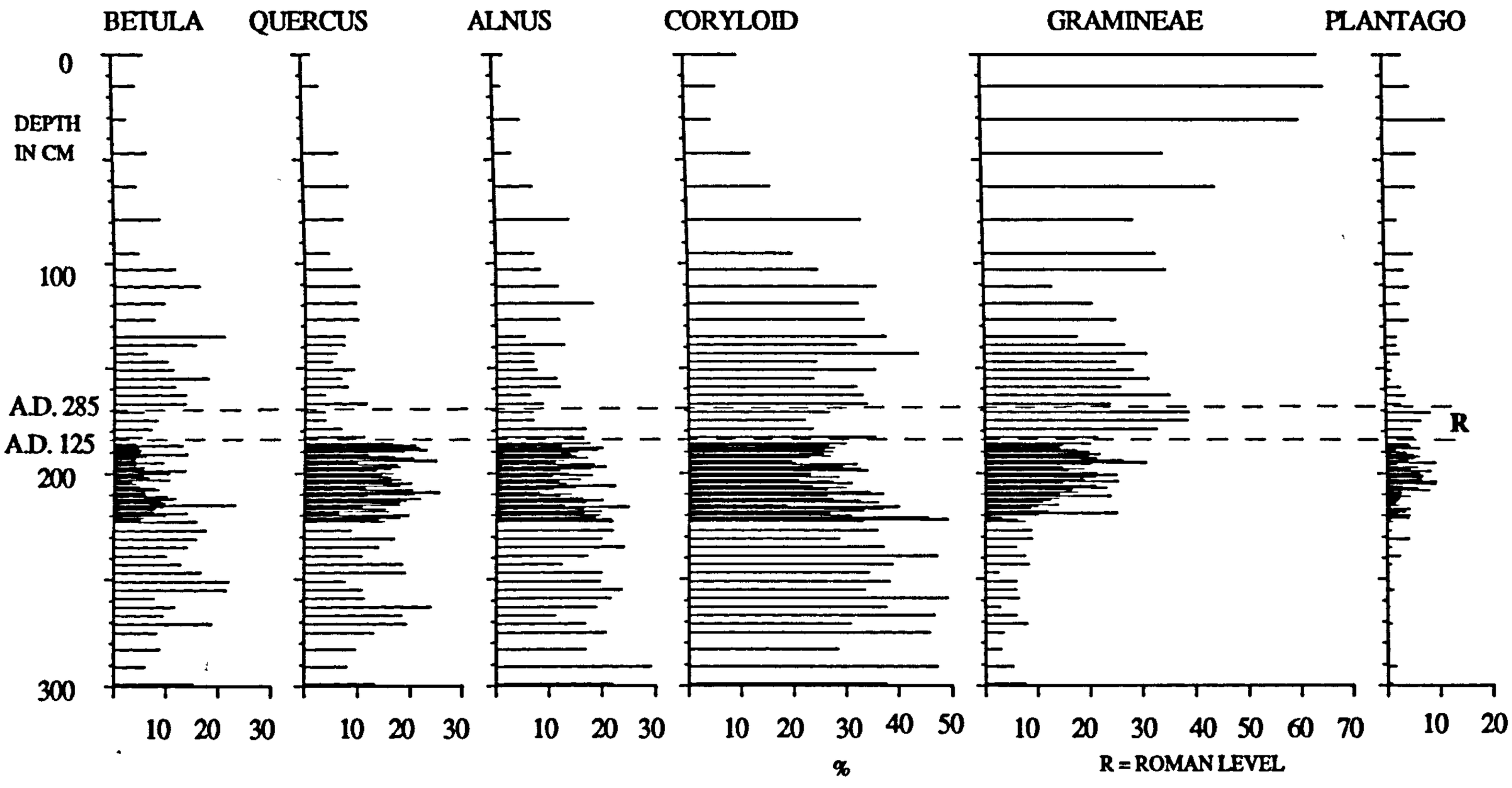
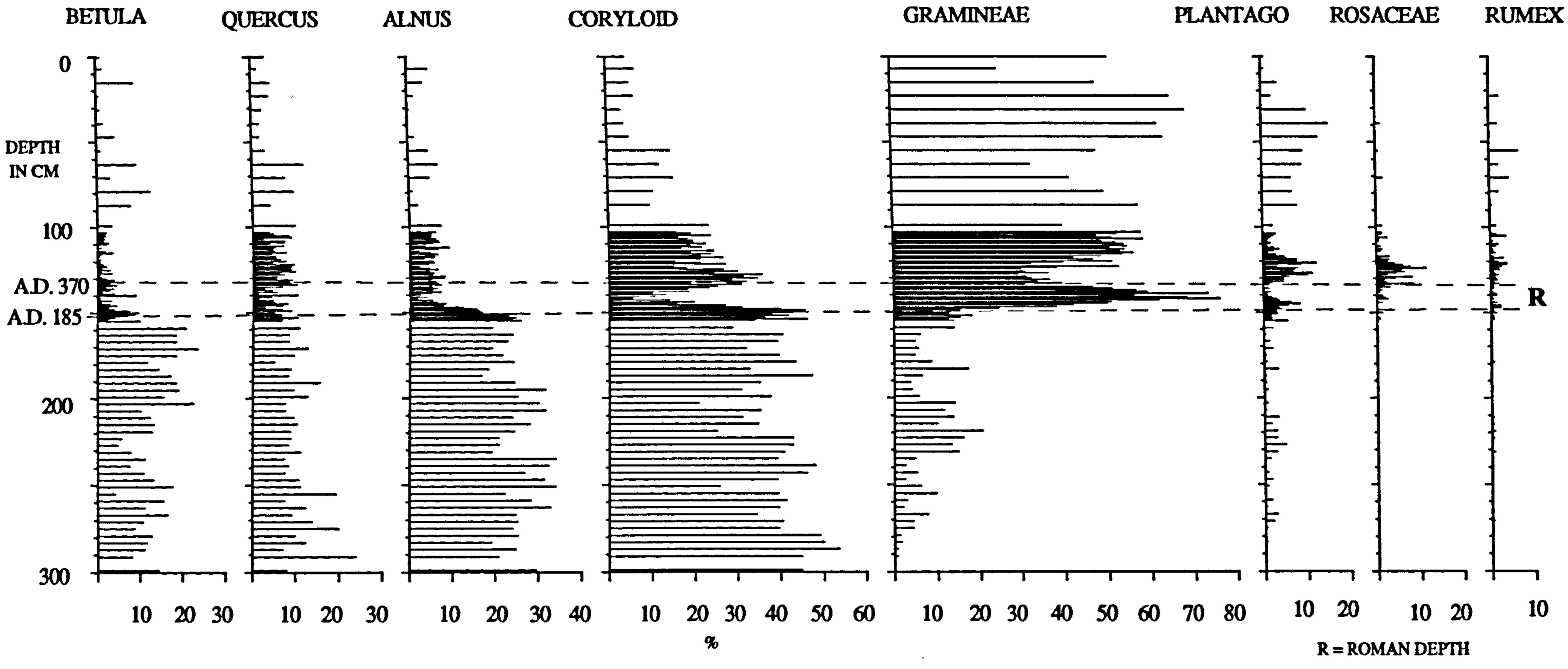


FIGURE 5.21 FOZY MOSS - SELECTED CURVES FOR THE ROMAN PERIOD.



of the range and if a date of A.D. 130 is taken, then the beginning of the clearance occurs around the time at which Hadrian's Wall was being built. Fozy Moss lies only 200 m. north of the wall and Sewing Shields milecastle, so if timber was needed for the construction of these structures and this was obtained from the immediate area, the immense clearance was probably a result of this. Vindolanda, Carrawbrough, Carovan, Great Chesters, Chesters and Housesteads are all within a 10 km. radius of Fozy Moss (Ordnance Survey, 1991) (Figure 5.19) and a considerable amount of wood was probably required for their construction. Large *vici* were associated with both Housesteads and Vindolanda (Salway, 1980), the initial clearance probably being sustained by the continued growth of the *vici* and agriculture as indicated by the rise in pastoral and arable indicator species.

This period of clearance displayed in the pollen diagram, corresponds to a distinct change in the sediment stratigraphy (Figure 3.6) where a prominent layer of inorganic material resembling clay is found within the peat. Frequency dependent and magnetic susceptibilty measurements were undertaken to assess whether the change was related to soil erosion. The results are shown in Figure 3.22 and indicate that an extremely low magnetic signal was recorded. In an area where the doleritic bedrock contains a high proportion of iron bearing minerals the sediment could not have been derived from soil erosion. A similar layer has been found in the peat at Midgeholme Moss, near Birdoswald fort, in association with a Roman wooden track-way and pollen evidence for Roman vegetation clearance (Wiltshire, pers. comm.). Although the magnetic minerals could have been affected by post-depositional dissolution (Williams, 1992), it is more likely that the sediment originates from the in-washing of material used to construct the wall on the southern margin of the moss. This could have occurred as the Wall is elevated above the moss and the moss surface is virtually flat. The period during which Hadrian's Wall was abandoned for the occupation of the Antonine Wall is not recorded by a period of forest revertence and it is therefore likely that sufficient troops, civilians or natives occupied the area and sustained the clearance. Between around A.D. 370 and A.D. 580 (Phase $FZMd_2$), a very sudden and rapid forest regeneration occurs at a time when the archaeological evidence indicates that troops were being withdrawn from the area and the Picts and Scots attacked Hadrian's Wall. As Fozy Moss is so close to Hadrian's Wall, the regeneration must be related to these military events.

Pollen evidence from several other sites in Northumbria indicates a consistent pattern of vegetation change at this time. At Muckle Moss, only 1.6 km. south of Housesteads and therefore in the vicinity of Fozy Moss, the horizon in which *Plantago* spp. and Gramineae rise is associated with the Roman occupation around A.D. 100-200 (Pearson, 1960). Although the diagram has not been radiocarbon dated the clearance accords well with that at Fozy Moss. A similar situation also occurred around Vindolanda.where pollen analysis of a ditch infill from the civilian settlement, indicates that a largely treeless landscape, with cereal cultivation occurred, dated from its archaeological context to A.D. 100-A.D. 125. Similarly, at Fellend Moss, near Lowtown, a massive forest clearance with pastoralism and cereals occurs around A.D. 2 ±45 (cal. A.D. 45). The *vallum* runs along the northern edge of this site and a Roman marching camp occurs to the south. The clearance is interpreted as being a result of native clearance immediately prior to the Roman invasion or to the building of Hadrian's Wall (Davies and Turner, 1979; Turner, 1979).

At Midgeholme Moss (Innes, unpub.) the most intense period of forest clearance associated with cultivation and pastoralism correlates with and is on a scale similar to Fozy Moss. Although the Midgeholme Moss diagram has not been radiocarbon dated, the clearance is assumed to correspond to the building of Hadrian's Wall and Birdoswald fort 1 km. from the moss. Pollen analysis of a series of turves from the defences around Birdoswald is also in accord with the Fozy Moss record and indicates that a dense woodland dominated the landscape until Roman times and that trees were removed as Hadrian's Wall was built (Wiltshire, pers. comm.).

Further afield substantial clearance occurs at Quick Moss, Wear Valley between A.D. 5 (cal.) and A.D. 530 (cal.) (Rowell and Turner, 1985). At Steng Moss in central Northumberland a long extensive clearance begins at *c.* 20 B.C. (A.D. 20 (cal.)), thus in an area well to the north of Hadrian's Wall an open landscape was present (Davies and Turner, 1979; Turner, 1979). In north-east Northumberland a similar clearance at Camp Hill Moss is thought to also have been a result of the Roman occupation. The radiocarbon dates for this diagram are suspected to have been contaminated and the conclusions drawn for this clearance are based upon correlation with other radiocarbon dated diagrams in the area (Roberts *et al.*, 1973; Davies and Turner, 1979; Turner, 1979). Further south a similar massive clearance with pastoralism is recorded and dated at Hallowell Moss, near Durham to 6 ± 70 B.C. (A.D. 80 cal.) (Donaldson and Turner, 1977).

The results from Fozy Moss and the published literature seem to indicate that the north-east was largely deforested during the Roman period, the clearance beginning immediately before the Roman period and being attributable to the actions of native populations, or during the Roman occupation of the area. This accords well with the ideas of Turner (1979), who suggests that at all sites, except for Neasham Fen in the Tees Valley, major forest clearance with an almost totally deforested landscape occurred, being attributable to pre-Roman Iron Age cultures or to the Roman occupation of north-east England.

5.7.4 Letham Moss - Forest Regeneration And Renewed Clearance.

At Letham Moss ($LTMd_1$) the pollen evidence suggests that forest regeneration occurred, possibly around A.D. 150 (Figure 5.22), though this is based on only two pollen counts. All arboreal species except for *Quercus* increase and Gramineae decreases, whilst other herbs such as *Plantago* spp. remain more or less stable. The initial cause of the regeneration might possibly have been a result of the Roman troops withdrawing from Scotland around A.D. 121 when Hadrian's Wall was being built. Regeneration continues into the period during which the Antonine Wall and its associated structures were constructed. The Antonine Wall was constructed from turf, thus implying that if the turf was obtained locally, an open landscape must have already existed. The pollen diagram is in accord with this and indicates that a substantial degree of forest clearance had already occurred and the landscape had already been opened during the Iron Age. Regeneration during the wall building period could thus be a result of the natives abandoning their land as a result of the Roman presence. This also agrees with archaeological evidence where excavation at Camelon has indicated the displacement of native occupation in the vicinity of the fort. At other forts along the Antonine Wall native defences were swept away to provide room for the wall. Archaeological evidence suggests that local disruption caused by the construction of the wall was so great that armed hostility broke out and the addition of further forts to the wall indicates that native hostility had been under-estimated (Hanson and Maxwell, 1983, 164/5). The pollen evidence for regeneration at Letham Moss is also in accord with the results of pollen analysis from a number of Antonine forts. The results indicate that by the time the wall was being constructed, the agricultural landscape was in decay and was being replaced by heath and scrub (Boyd 1984 a, b; Dickson and Dickson, 1988). Letham Moss is 6.7 km. north of the Antonine Wall (Figure 5.23) and the area around the Moss might not have been so directly influenced by wall building activities, but the fact that *Quercus* is the only tree species to decline, this being the preferred wood used by the Romans for building (Hanson and Macinnes, 1981; Boyd, 1984 a and b), suggests that it might have been removed for this purpose. The forts of Mumrills, Camelon, Falkirk, Watling Lodge, Rough Castle and Seabegs occur within a 10 km. radius of Letham Moss (Ordnance Survey, 1991) and the decline in *Quercus* might also be result of felling of timber to construct these sites.

Between around A.D. 180 and A.D. 280 (SRR-4542) a period of intense forest clearance begins ($LTMd_2$) when Gramineae rises suddenly, arboreal pollen declines and other herbs such as *Plantago* spp. remain

FIGURE 5.22 LETHAM MOSS - SELECTED CURVES FOR THE ROMAN PERIOD.

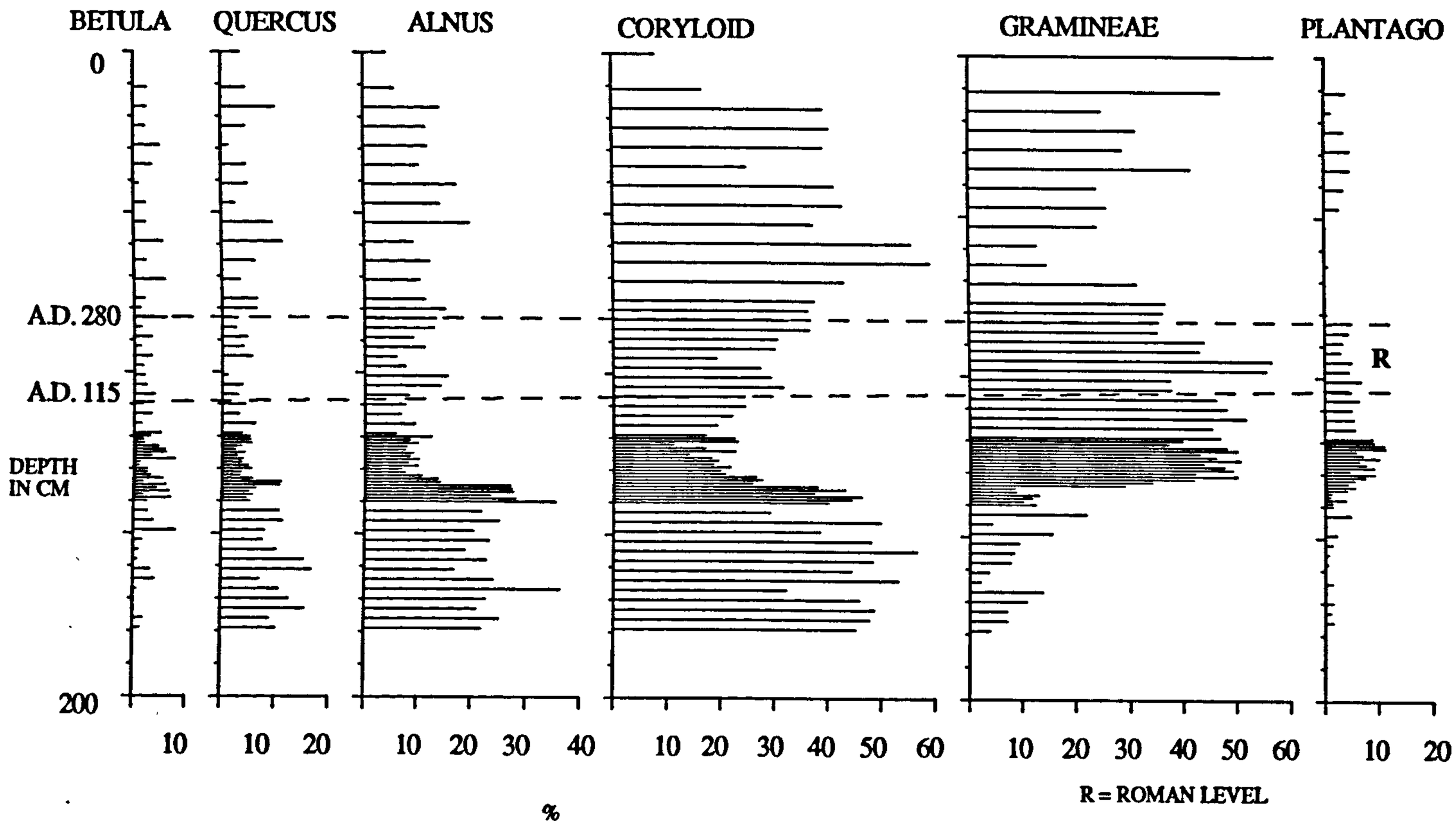
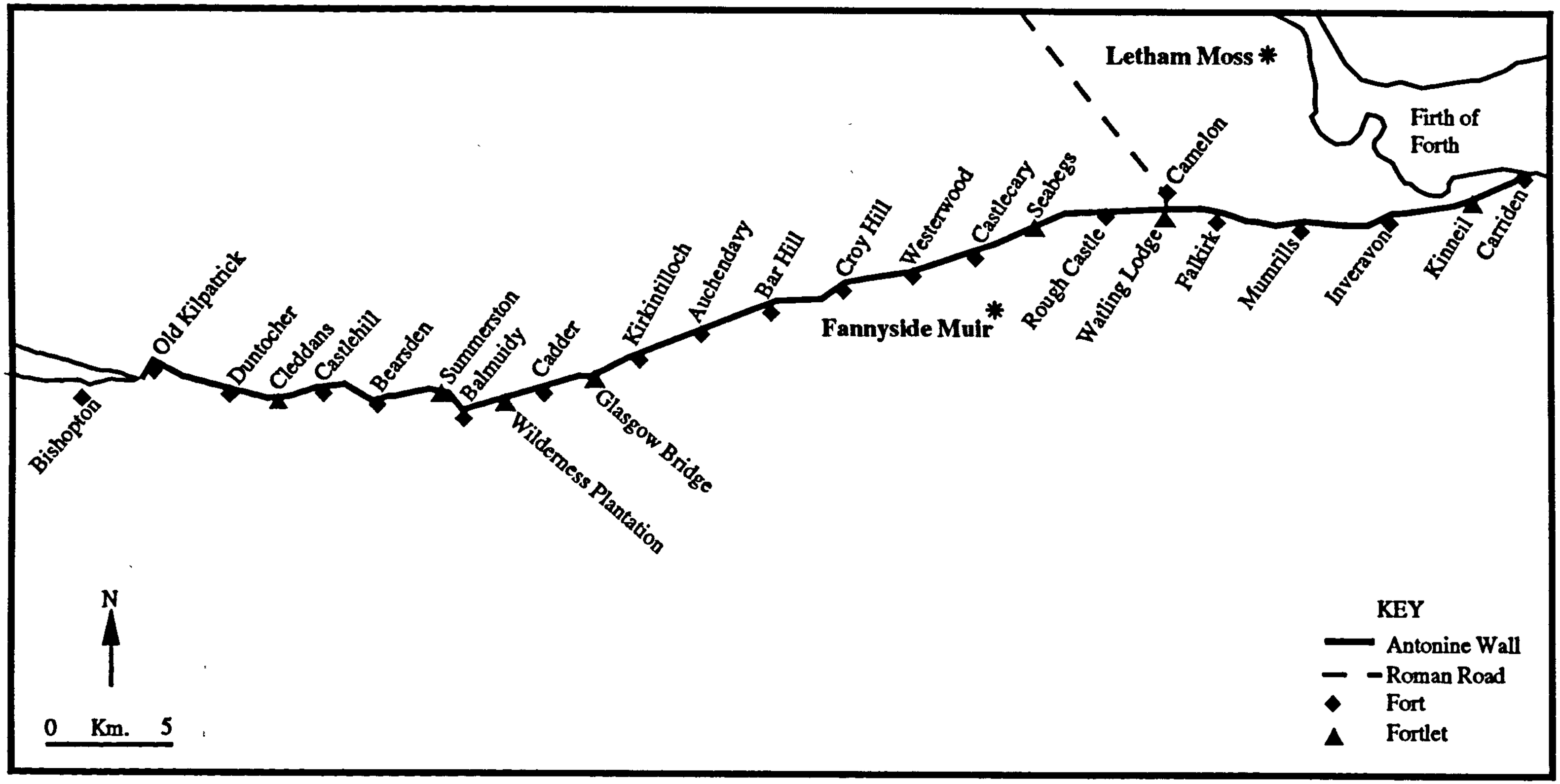


Figure 5.23 The Position of Letham Moss and Fannyside Muir In Relation To The Antonine Wall.



Source - Breeze and Dobson (1987).

virtually stable. These dates lie within the period during which the Antonine Wall had been abandoned for the first time (A.D. 158 - A.D. 184 = 26 years) and then reoccupied (A.D. 184 - A.D. 195 = 11 years) (Mann 1988). The fluctuating frontier situation with abandonment, reoccupation and final abandonment of the Antonine Wall did not cause land desertion and forest regeneration. Clearance could have been a result of the reoccupation of and rebuilding of staging posts and the Antonine structures (e.g. Camelon) with the need to acquire timber at a greater distance from the wall as more local supplies had been exhausted (Keppie, 1986, 144). The fact that there were no *vici* situated on this part of the Antonine Wall points to the fact that clearance and agriculture may to some extent have been undertaken by the natives especially as uninterrupted clearance continues through the period during which the wall was abandoned by troops.

Between A.D. 280 (SRR-4542) and A.D. 405 a period of forest regeneration occurs with a steady increase in arboreal pollen, whilst Gramineae declines slowly and other open ground indicators sink to low levels or disappear. This regeneration is probably a result of the continued withdrawal of Roman troops from Scotland though regeneration is smaller than at the other sites. Regeneration has also been noted in a pollen diagram from a ditch infill at Bearsden fort and is associated with the Roman withdrawal (Knights *et al.*, 1983).

5.7.5 Fannyside Muir-Clearance.

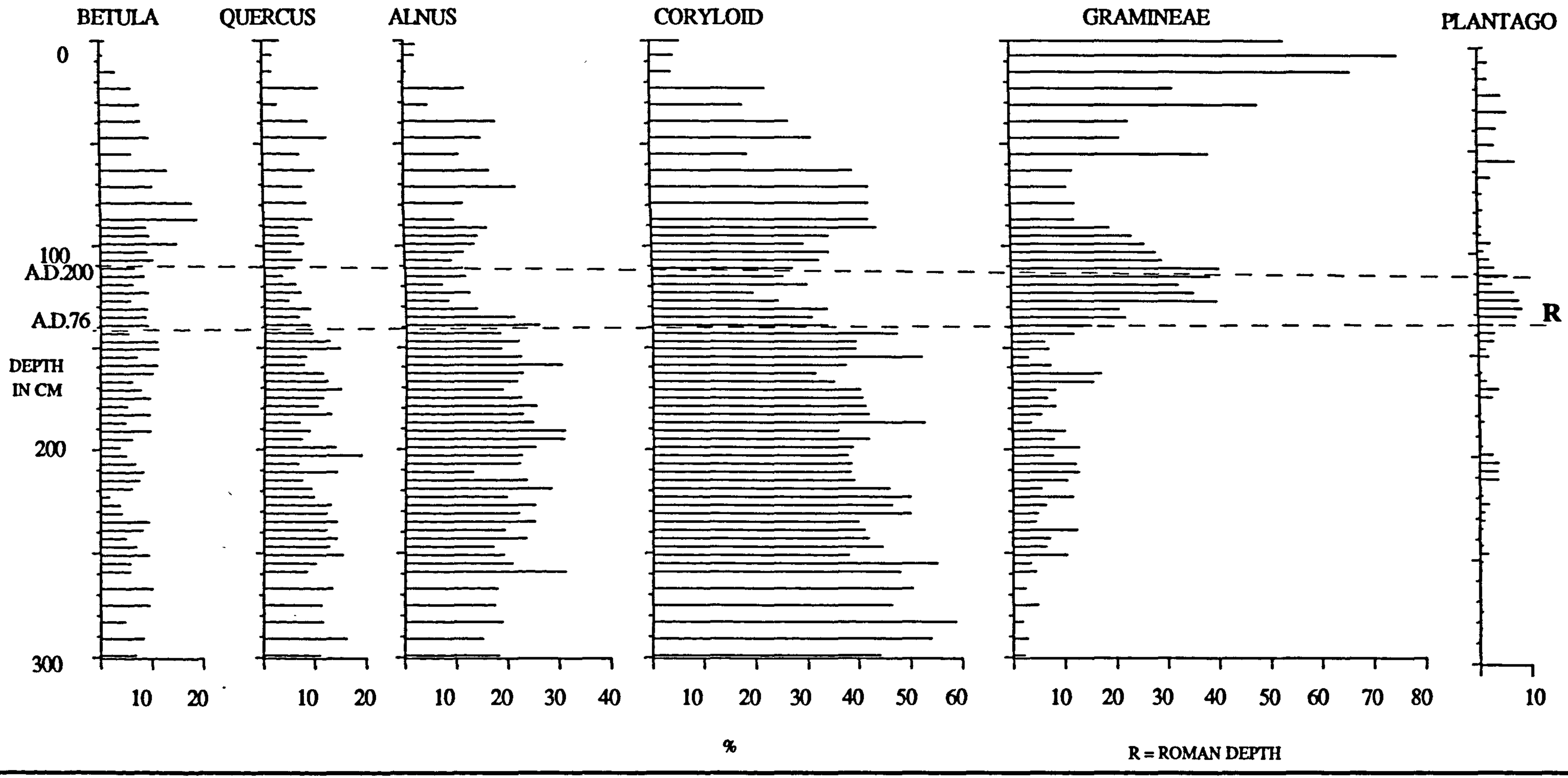
A marked rapid clearance occurred at Fannyside Muir ($FSMf_1$) between approximately A.D. 75 and A.D. 200 (Figure 5.24). Arboreal pollen declines and all species except for *Betula* are affected, Gramineae and *Plantago* spp. rise rapidly and there is an increase in the number of herbs indicating both pastoral and arable agriculture. These include *Artemisia*, Caryophyllaceae, Chenopodiaceae, Cruciferae, Labiatae, Papilionaceae, Ranunculaceae, *Rumex* spp. *Thalictrum* and *Urtica*. This clearance probably began at the time of the Roman invasion of southern Scotland and could be related to the Roman occupation of the area and building of the Antonine Wall in A.D. 140. The wall and associated forts such as Croy Hill and Westerwood are situated only 3 km. away from Fannyside Muir (Keppie, 1986, 126) (Figure 5.23). Timber was required for such construction and woodland was possibly removed from this area.

This clearance is then followed by a short period of regeneration as Coryloid and *Quercus* increase whilst other arboreal species and Gramineae remain more or less stable. This is probably associated with the abandonment of the Antonine Wall between A.D. 158 and the A.D. 180s (Daniels, 1970).

Renewed clearance occurs between about A.D. 200 and A.D. 255 ($FSMf_2$) as Gramineae increases and arboreal pollen declines. *Triticum* type and *Cannabis* type are present along with Caryophyllaceae, Labiatae, Papilionaceae, Ranunculaceae, *Rumex* spp. and Umbelliferae, though *Plantago* spp. decline. The renewed clearance could be a result of the reoccupation of the Antonine Wall after A.D. 195 and the rebuilding of structures such as forts and fortlets (Mann, 1988).

Between *c.* A.D. 255 and A.D. 475 (FSMg) a period of gradual regeneration occurs. Arboreal pollen increases to levels similar to those which occurred during the late Iron Age. Coryloid, *Alnus* and *Betula* increase whilst *Quercus* remains stable. Gramineae and *Plantago* spp. decline and other pastoral and arable indicators such as *Secale cereale*, *Triticum* type *Artemisia*, Caryophyllaceae Compositae lig. and tub. and *Filipendula* become less common. Regeneration is possibly a result of the Roman withdrawal from Scotland during the Third Century when troops were slowly withdrawn from Scotland and military structures abandoned allowing forest regeneration (Higham, 1986, 172).

FIGURE 5.24 FANNYSIDE MUIR - SELECTED CURVES FOR ROMAN PHASE.



5.7.6 Cranley Moss - Forest Clearance And Regeneration.

At Cranley Moss palynological evidence (based on 8 counts at 4 cm. intervals, each count representing *c.* 44 years) indicates that a period of forest clearance continued between *c.* A.D.90 and A.D. 150 (latter half of CYMf) (Figure 5.25) though this is not as intense or as large as the earlier Iron Age clearance. Coryloid and *Alnus* seem to be affected whilst *Betula* and *Quercus* remain more or less constant. Gramineae increases slightly but other herbs indicating both pastoral and arable agriculture remain more or less stable. After the slight regeneration renewed clearance during the occupation might be a result of the need for timber for building the large number of staging posts around Castledykes, Cleghorn, Bankhead and Carstairs (Figure 5.26). Castledykes fort was reoccupied and rebuilt in stone (Keppie, 1986, 91). The clearance might also be due to the natives continuing to occupy and cultivate the area after the initial invasion. No there published pollen diagrams exist for this area, the nearest diagrams being from Bloak Moss and Kennox Moss, Ayrshire, where an intact forest cover occurs until *c.* A.D. 450 (Turner, 1965, 1975).

The clearance episode at Cranley Moss ends around A.D. 150 and is immediately followed by gradual forest regeneration until around A.D. 440 (CYMg), when arboreal pollen, especially Coryloid and *Betula*, rises whilst Gramineae and other herbs decline. This regeneration corresponds to the period when the Romans withdrew from the area. *Cannabis* type is present in the pollen diagram and could be a result of *Cannabis* cultivation. A contemporaneous occurrence of *Cannabis* type in the diagram from Midgeholme Moss, Cumbria, is interpreted as being naturally occurring *Humulus* in the woodland around the site, it probably being too early for the cultivation of *Cannabis* in the area (Innes, unpub.). The archaeological evidence indicates that Castledykes fort was abandoned around A.D. 150 (Keppie, 1986, 91) and from this time onwards Roman troops were withdrawn to occupy Hadrian's Wall, with further withdrawals in A.D. 260-270s, A.D. 340-380s and A.D. 410. The pollen evidence indicates that successive regeneration and declining agriculture occurs around these dates.

5.7.7 Dogden Moss - Renewed Clearance.

At Dogden Moss renewed forest clearance occurs between around A.D. 120 and A.D. 195 (DGMd) (Figure 5.27), the pollen diagram being counted at 4 cm. intervals and, based on the average peat accumulation rate of 9 years/cm., each count represents a period of approximately 32 years. Arboreal pollen decreases and Gramineae rises sharply along with *Plantago* spp. and other pastoral and arable indicators, although cereals are absent. This forest clearance occurs at the time during which the Romans occupied southern Scotland and built the Antonine Wall. Despite Dogden Moss being 77 km. from the Antonine Wall, the Roman fort at Newstead and the large number of marching camps along Dere Street, such as Oxton, St. Boswells, St. Leonards and Kedslie indicate that the Romans were active in this area (Figure 5.26). Newstead was the second largest known permanent Roman site in Scotland and during the Antonine period it grew in size to 14.7 acres, continuing to be used a little after A.D. 180 (Keppie, 1986). The concentration of native hillforts were occupied from the Iron Age through to the Second Century A.D. (Cunliffe, 1991, 194) which probably contributed to clearance.

Between around A.D. 195 and A.D. 230 (DGMe) a slight forest regeneration immediately followed by a renewed clearance occurs. The Coryloid and Gramineae curves reflect these changes and there is a decrease in agriculture shown by a decline in agricultural indicators. *Plantago* spp. fall sharply and there is an obvious break in *Triticum* type. The archaeological evidence suggests that the Romans abandoned the Antonine Wall and withdrew from southern Scotland between A.D. 192 and A.D. 195 (Mann, 1988) and the pollen evidence for forest revertence could be a result of the abandonment of forts and other structures as the Romans

FIGURE 5.25 CRANLEY MOSS - SELECTED CURVES FOR THE ROMAN PERIOD.

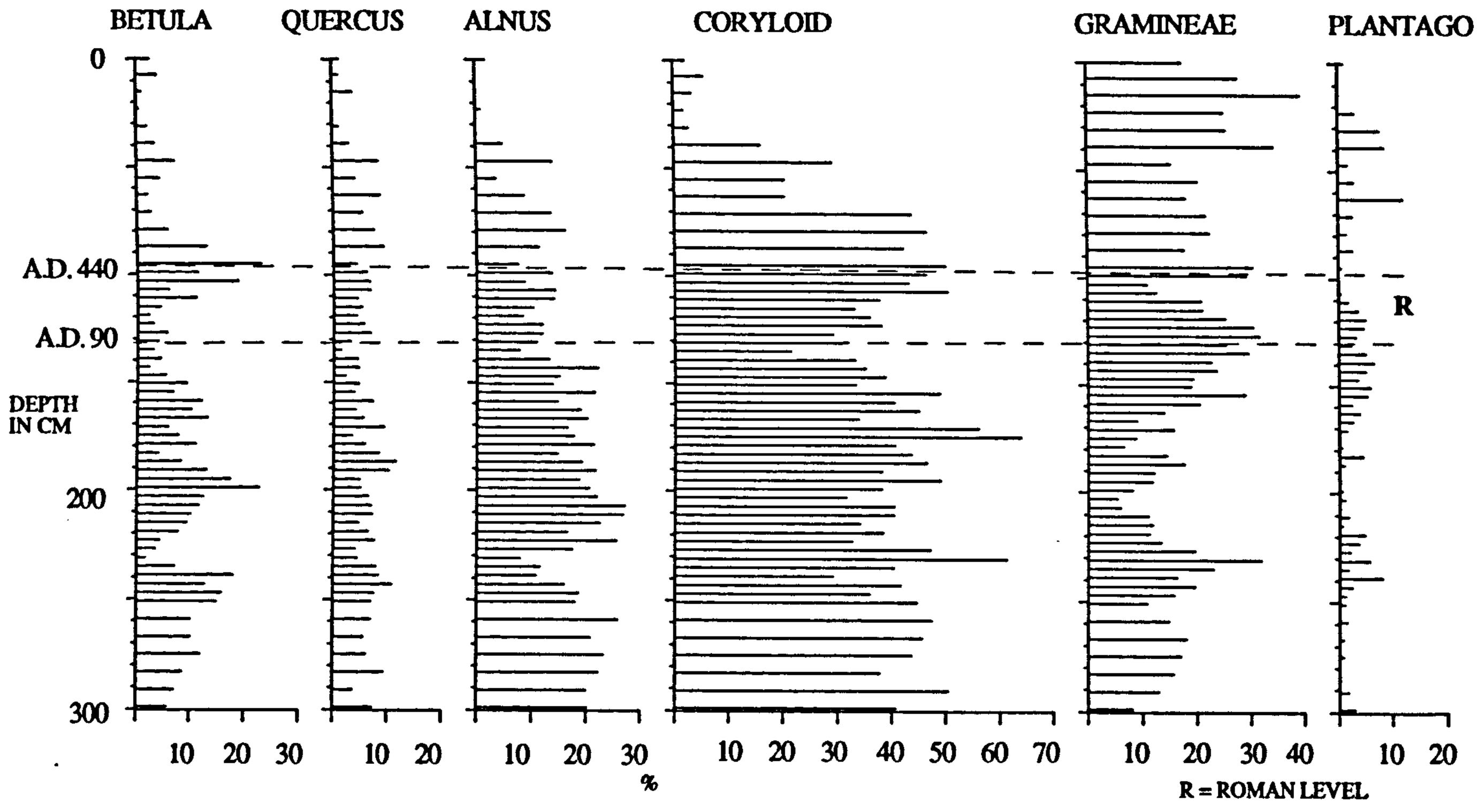
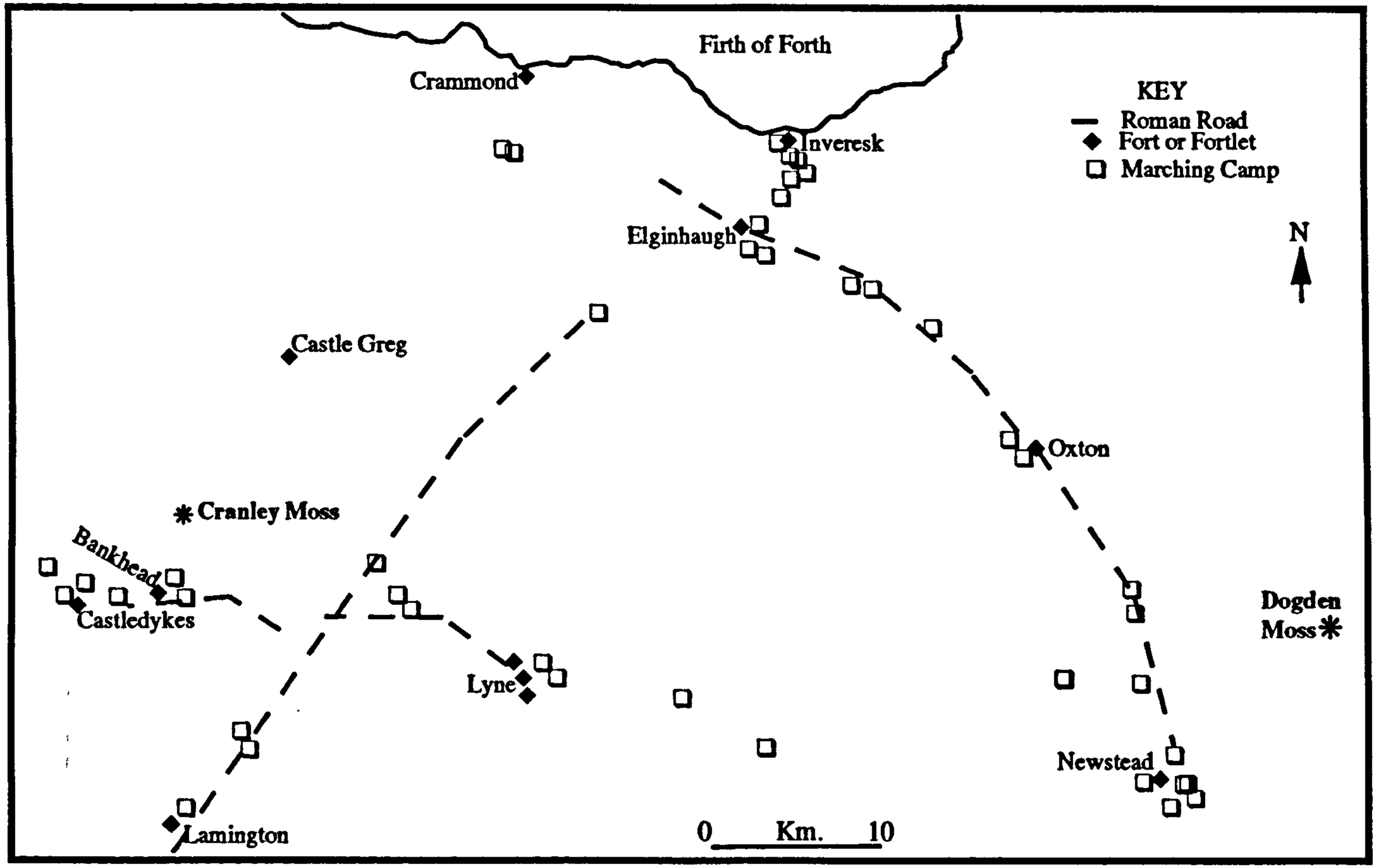
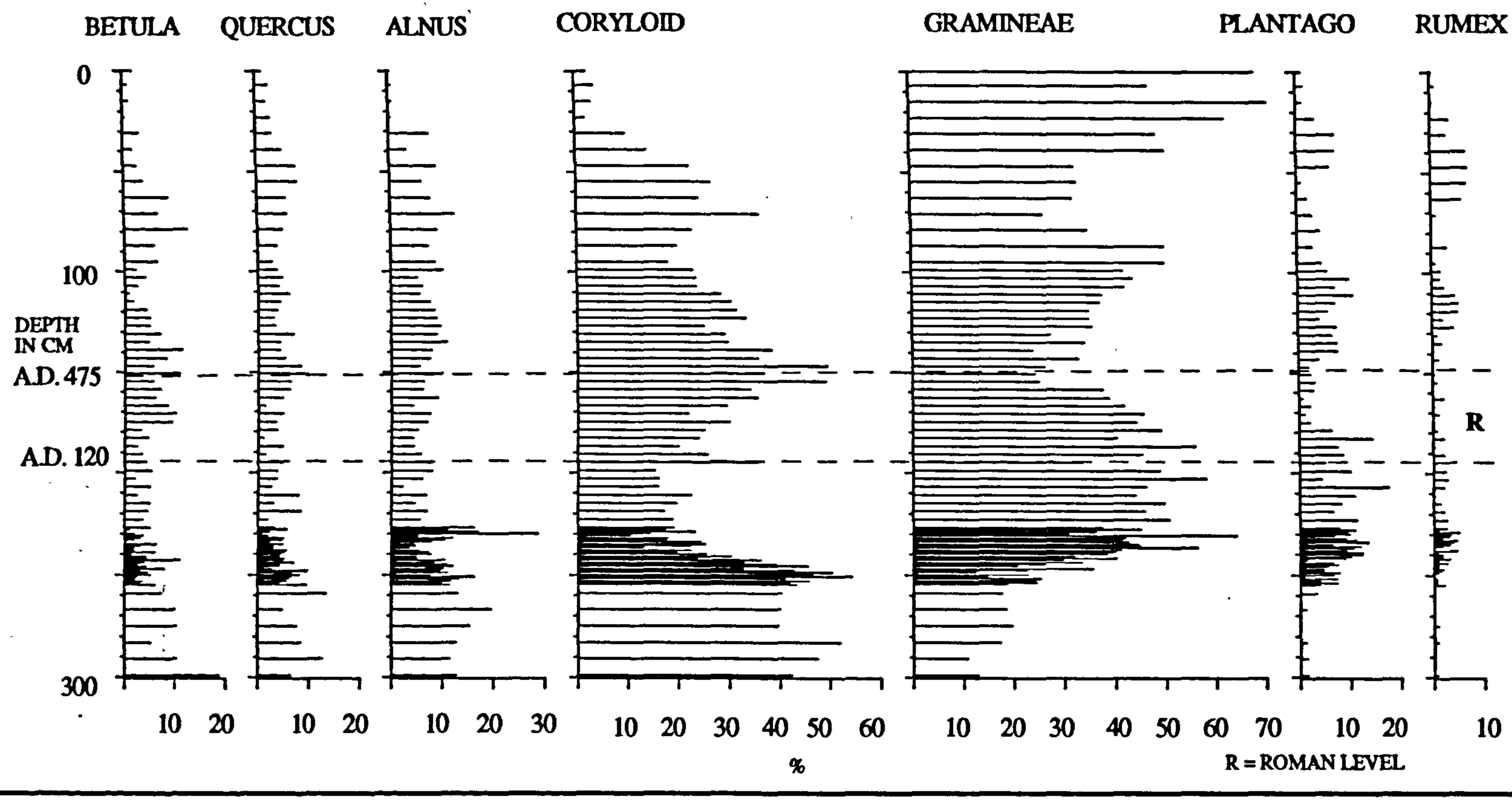


Figure 5.26 Position of Cranley Moss and Dogden Moss In Relation To Roman Structures.



Source - Keppie (1986).

FIGURE 5.27 DOGDEN MOSS - SELECTED CURVES FOR THE ROMAN PERIOD.



withdrew, demolishing their forts on their way (Hanson and Maxwell, 1983, 150). The following renewed clearance could be due to the re-establishment of a tribal way of life.

Clearance at Dogden Moss at this time is in accord with the evidence from other pollen diagrams from the area. At Swindon Hill, near Yetholm Town, clearance continues uninterrupted from the Iron Age (Tipping, forthcoming, 1992) and at Yetholm Loch, near Kirk Yetholm, clearance intensifies from *c.* A.D. 150. Mannion (1978 b) correlates an undated, intensive clearance for pastoralism at Linton Loch as being a result of the Roman occupation.

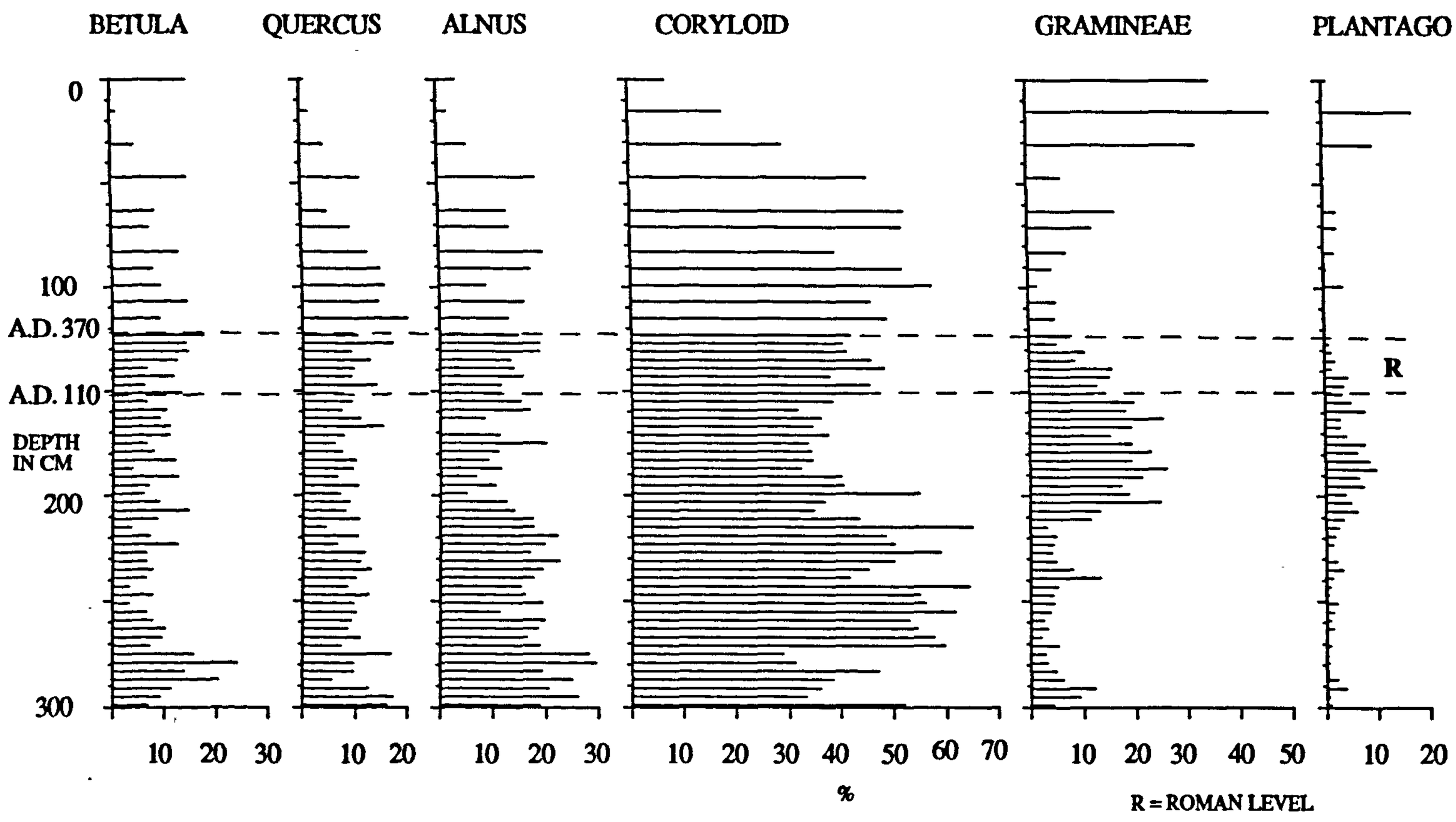
After this short-lived clearance at Dogden Moss a steady decline in Gramineae and increase in trees occurs between *c.* A.D. 229 and A.D. 445 (DGMe). Coryloid regenerates more rapidly than other arboreal species, Gramineae declines and agricultural indicators either sink to low levels (e.g. *Plantago* spp.) or disappear (e.g. Compositae lig. and tub., *Filipendula*). Forest regeneration might be the result of land and agricultural abandonment during the Third Century and early Fourth Century A.D. which was a time when the Roman troops gradually withdrew from the area and Newstead was abandoned under the orders of Caracalla. The area was overseen by Roman forces although troops withdrew further in A.D. 260s - 270s and as the Picts, Scots and Attacotti attacked the area in the 340s - 380s. Regeneration reaches a maximum around A.D. 407, approaching the time when the troops were finally removed from the area.

5.7.8 Carsegowan Moss And Ellergower Moss - Gradual Regeneration.

At Carsegowan Moss ($CGMe_1$) arboreal pollen increases slightly for a short time around A.D. 130 and is followed by a small gradual clearance until A.D. 235 (Figure 5.28). The pollen diagram has been counted at 4 cm. intervals and each count represents a period of approximately 32 years. During the regeneration phase Coryloid, *Betula* and *Quercus* increase, whilst Gramineae and other herbs decrease and Caryophyllaceae and Chenopodiaceae disappear. This corresponds to the period when Hadrian's Wall was built and occupied. After Agricola's campaign in A.D. 82, there is very little in the archaeological literature concerning events in south-west Scotland, but the regeneration suggests that land was abandoned for a short time whilst Hadrian's Wall was being built. This might imply that troops were withdrawn from the area and that native peoples had not reoccupied the land. The following renewed clearance is very small, with Gramineae increasing slightly and trees remaining more or less stable. There were no Roman forts or structures built around Carsegowan Moss, the nearest fortlet being at Gatehouse of Fleet 35 km. away, and the nearest fort being Glenlochar 40 km. away. However, Roman coins and artefacts have been found in the area, indicating that either Roman troops or civilians were present or the natives were undertaking trade with troops further afield, perhaps at Gatehouse of Fleet. (Scott, 1966; Miller, 1982). The renewed clearance is therefore probably the result of the natives reoccupying their land in relatively peaceful conditions away from the more unstable frontier area. Clearance was not as great and agriculture as intense as during the earlier Iron Age period of clearance.

Following the clearance episode, renewed regeneration occurs ($CGMe_2$). Gramineae falls quite quickly as Coryloid, *Alnus*, *Betula* and *Quercus* regenerate and there is a further fall in agricultural indicators occurring between *c.*A.D. 235 and A.D. 370 (SRR-4535). During this period Roman troops were withdrawn from Scotland and the fortlet at Gatehouse of Fleet was probably abandoned. As the troops were withdrawn and the Picts and Scots raided the remaining Roman structures, land abandonment and agricultural decline occurred. Land abandonment could have been a result of a decline in demand for produce as the troops withdrew and as trading links were severed.

FIGURE 5.28 CARSEGOWAN MOSS - SELECTED CURVES FOR THE ROMAN PERIOD.



The pollen diagram from Ellergower Moss has been counted at 8 cm. intervals and based on the average peat accumulation rate, each count represents a period of around 100 years. Although, the diagram is very similar to that from Carsegowan Moss, the poor counting resolution obviously restricts the interpretations which can be made from the Ellergower Moss pollen data. There is a general decrease in forest cover and corresponding increase in Gramineae and herbs between around A.D. 70 and A.D. 140 (EGMc) (Figure 5.29). This corresponds with the period during which Roman troops withdrew from the area after the Agricolan campaigns in A.D. 82 and the building of Hadrian's Wall. No forts were built in the Ellergower Moss area and again the nearest fortlet is Gatehouse of Fleet 30 km. away. Clearance could be a result of natives fleeing to the hills and abandoning lowland areas (hence regeneration at Carsegowan Moss) as a result of the Roman presence or to the expansion of native settlement and farming onto the more marginal hillside areas in response to increase demand for goods by Roman troops. Between *c.* A.D. 140 and A.D. 415 a prolonged period of forest regeneration occurs, as all tree types regenerate and Gramineae and other herbs decline with some becoming absent. The regeneration begins too early to be a result of the Roman withdrawal from Scotland, though the date of abandonment for south-west Scotland is unclear. The increase in regeneration at Ellergower Moss occurs at the same time as clearance at Carsegowan Moss because the natives may have reoccupied and settled lowland areas under the more peaceful conditions during the Third and Fourth Centuries. As with Carsegowan Moss forest regeneration continues in to the A.D. 400s when troops were evacuated from the whole of Scotland.

5.7.9 Assessment Of Roman Clearance.

The palynological evidence can now be used to assess the validity of the hypotheses - that the first large-scale permanent vegetation clearance in the profiles from the area of northern Britain studied occurred during the Roman invasion and occupation of the area and that the intensity of clearance is related to distance from Roman archaeological structures. The classic literary references point to the presence of a vast area of woodland in northern Britain and at the time of the Agricolan campaigns Tacitus describes:

> "perilous depths of woods.....marshes and woods....cover the enemy's retreat" (in Hanson and Macinnes, 1981).

However, the pollen evidence indicates that at all sites, the forest had to some extent been affected by human activity prior to the Roman invasion of northern Britain (Figures 5.30 and 5.31, Table 5.2). Only at Fozy Moss was the first large-scale and permanent clearance related to the Roman occupation of the north. At all other sites the first major clearance occurred at sometime during the Iron Age and the landscape was already relatively open on the eve of the Roman invasion (Section 5.5). These Iron Age clearances are either sustained and continue into the Roman period (Letham Moss, Fannyside Muir, Dogden Moss) or renewed clearance occurred after a break in Iron Age settlement (Glasson Moss, Walton Moss, Carsegowan Moss and Ellergower Moss) or more intense clearance was initiated (Cranley Moss). The date at which clearance occurs also seems to be time transgressive with earlier clearance occurring in coastal areas and south-east Scotland but generally later inland, in the west and in the north (Figure 5.32). In contrast to this, regeneration occurred at a number of sites in Fife and Aberdeenshire (Edwards, 1978; Whittington *et al.*, 1990).

Figures 5.33 and 5.34 show the main arboreal species plotted as a proportion of each other for the Iron Age and at the level of maximum Roman clearance. At all sites except Ellergower and Carsegowan Mosses Coryloid is greater in the Roman period than the Iron Age. This indicates that the Romans preferentially

FIGURE 5.29 ELLERGOWER MOSS - SELECTED CURVES FOR THE ROMAN PERIOD.

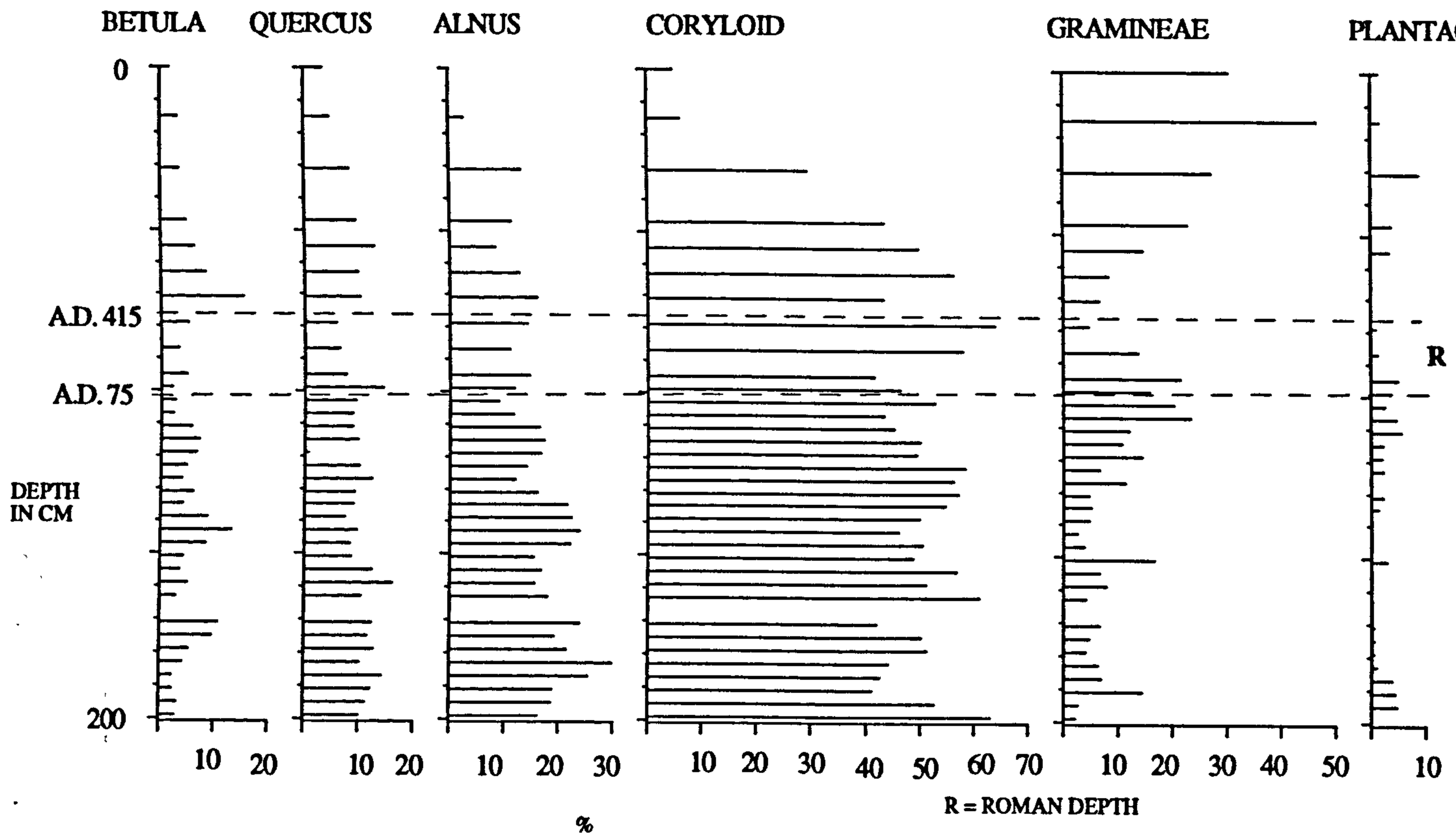


FIGURE 5.30 GRAMINEAE CURVES FOR THE ROMAN PHASE

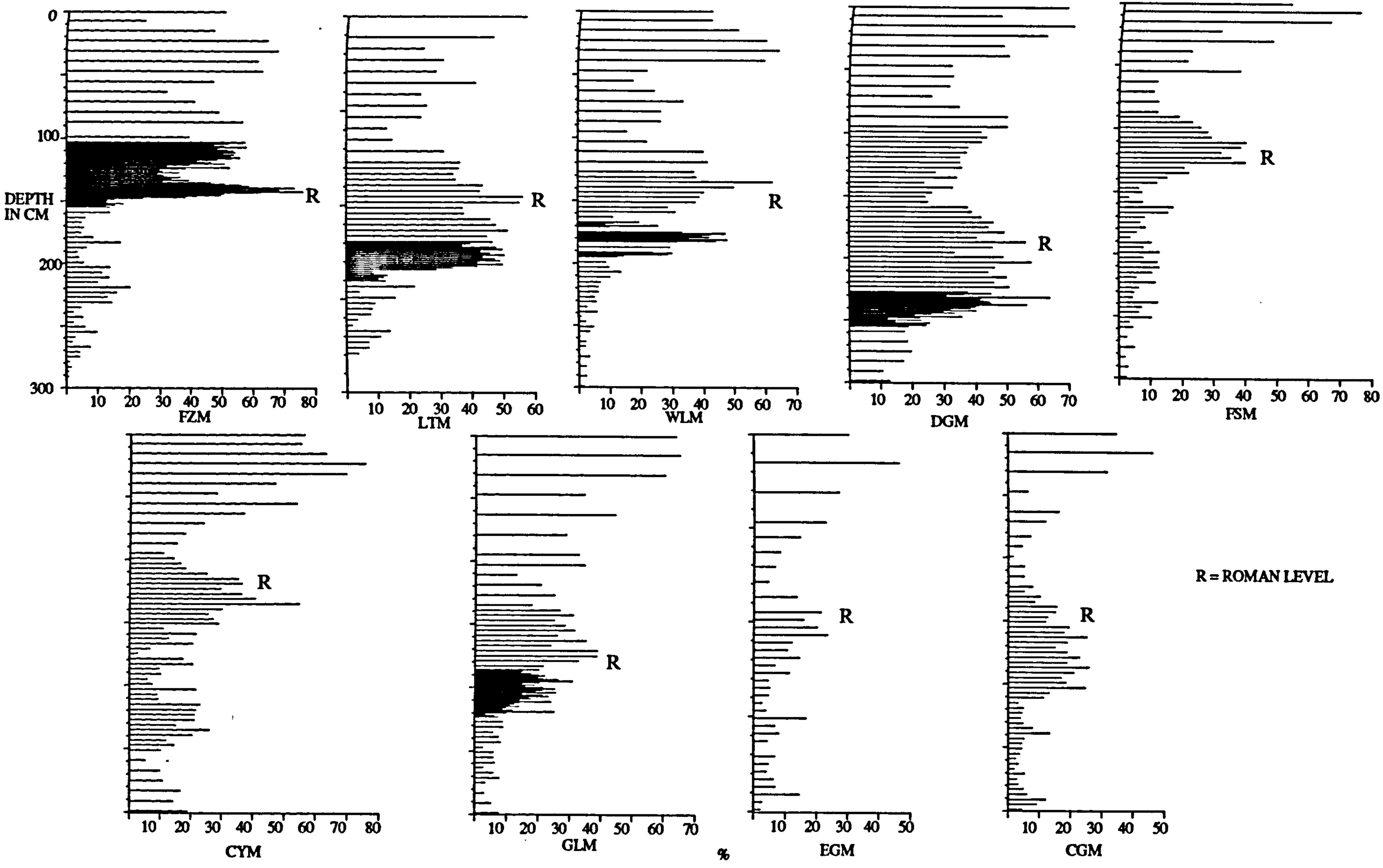


FIGURE 5.31 ARBOREAL POLLEN VERSUS NON-ARBOREAL POLLEN FOR THE ROMAN PERIOD

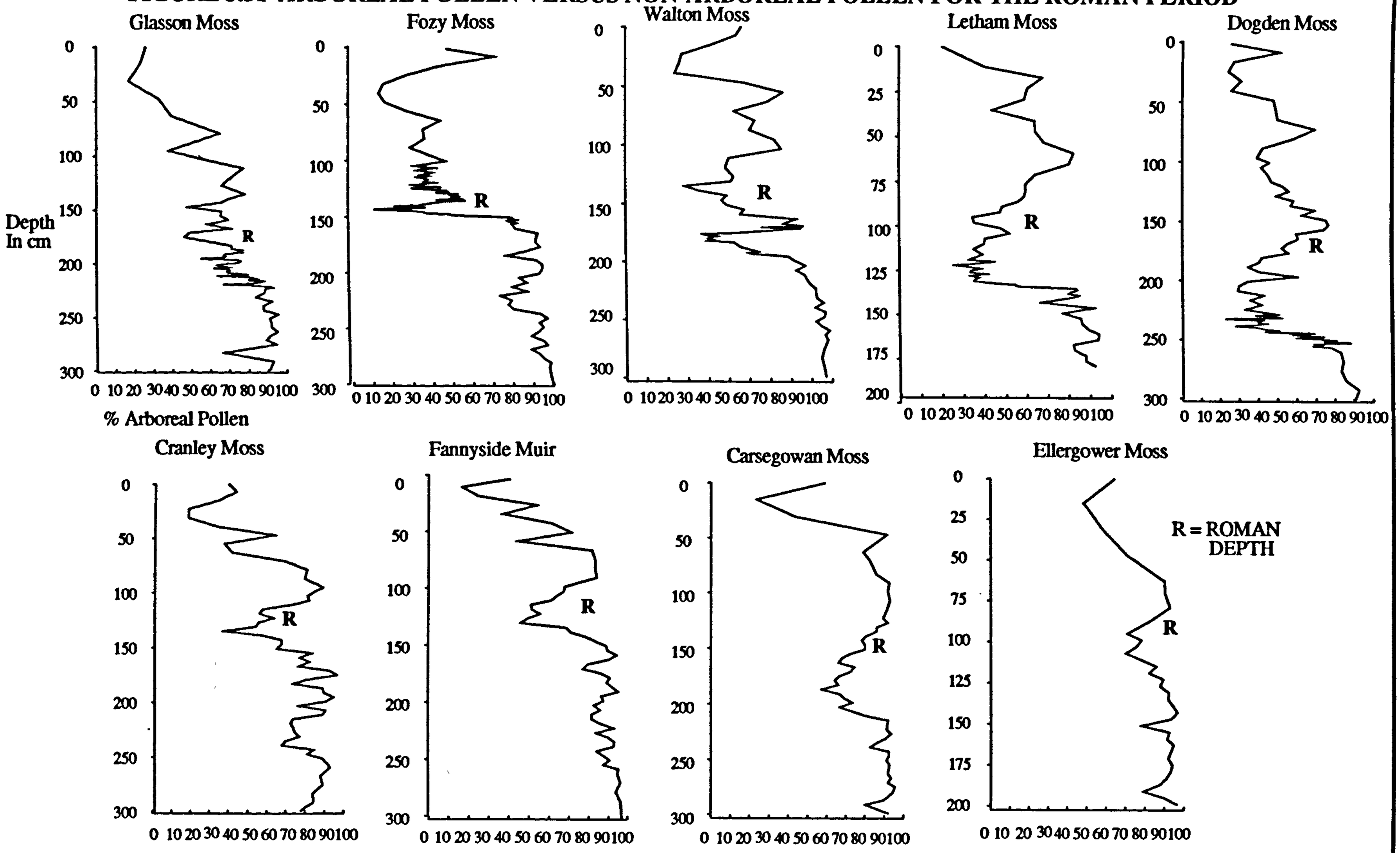
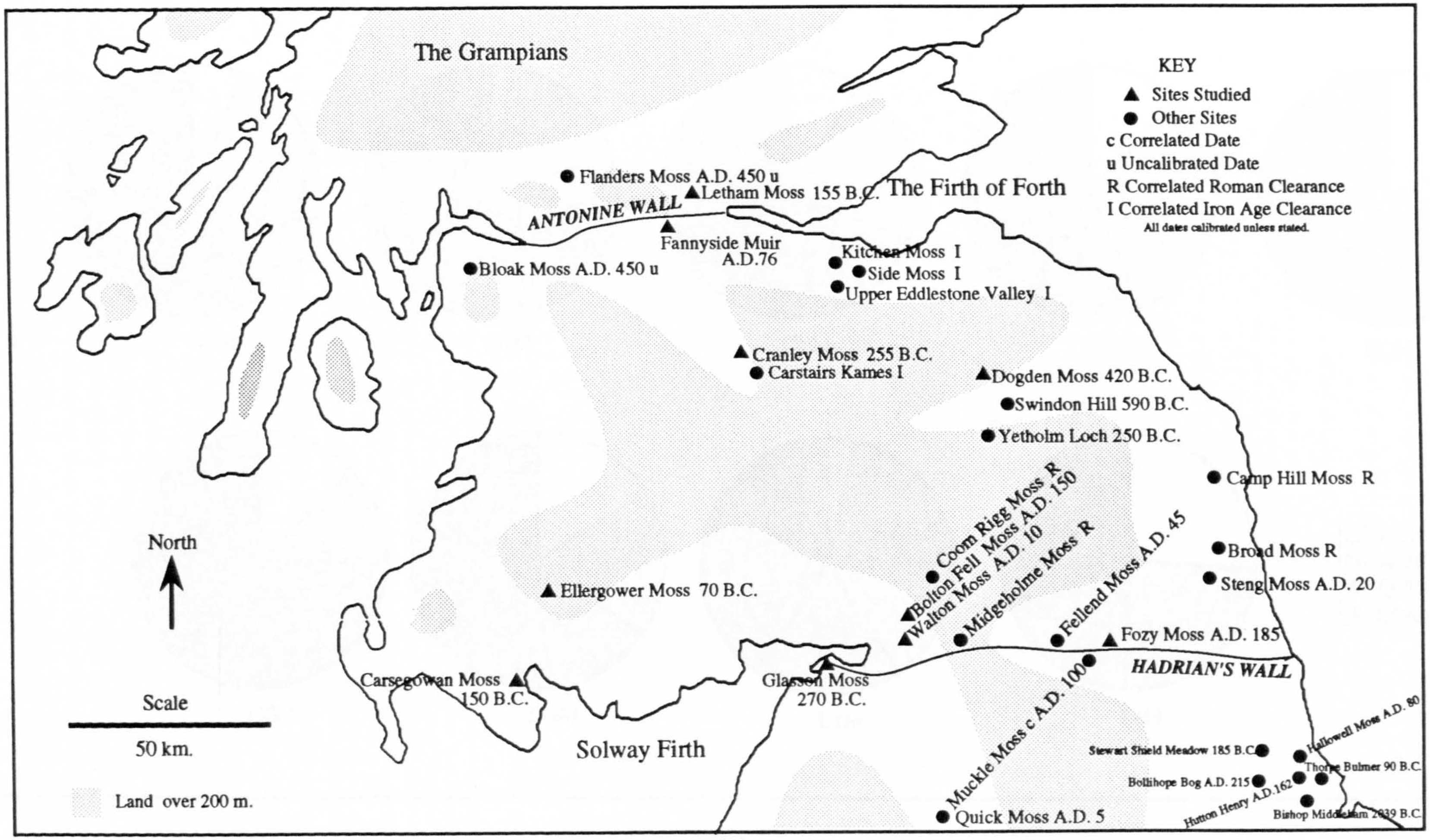


Figure 5.32 Date of First Extensive Clearance.



Source - Various.

FIGURE 5.33 SELECTED TREE SPECIES FOR THE LATE IRON AGE.

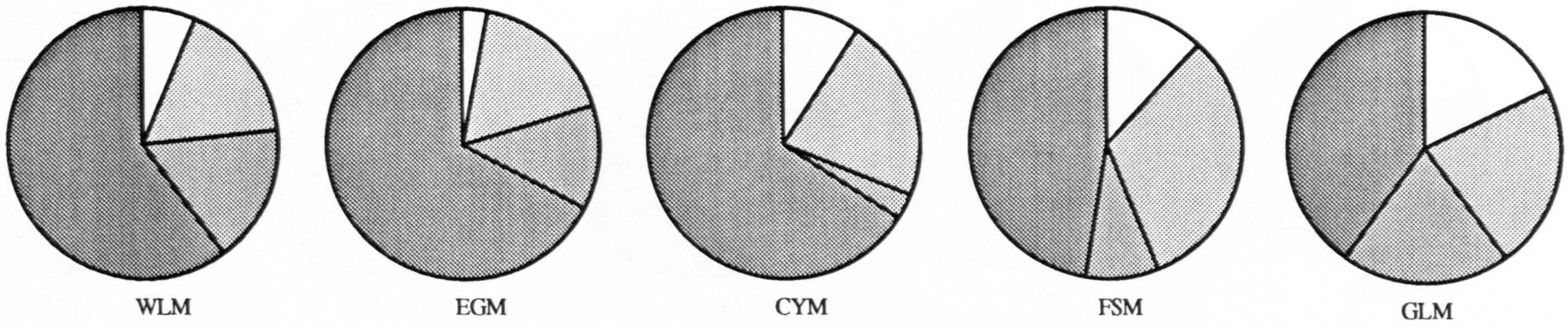
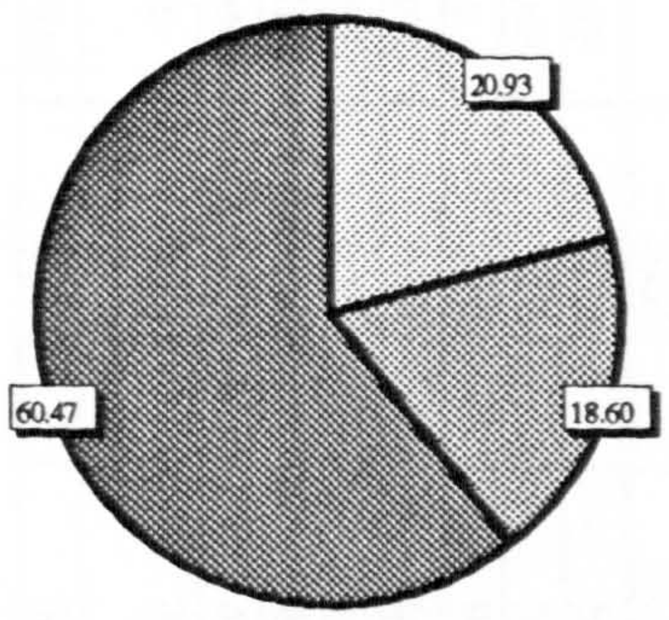
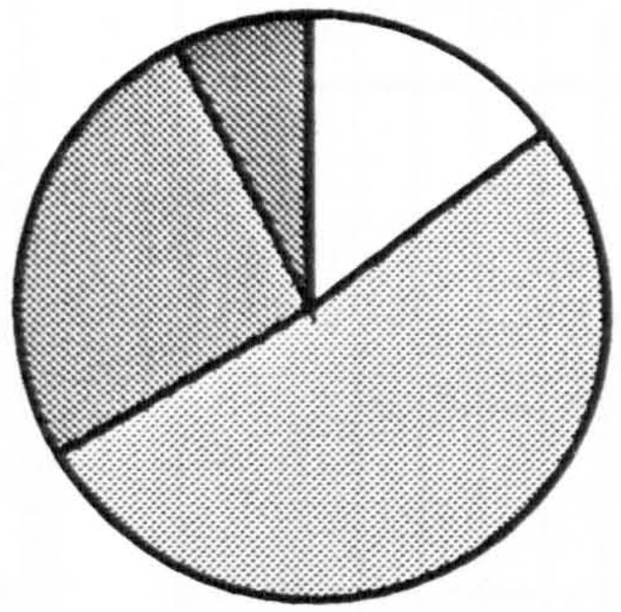


FIGURE 5.34 SELECTED TREE SPECIES FOR LEVEL OF MAXIMUM ROMAN CLEARANCE.



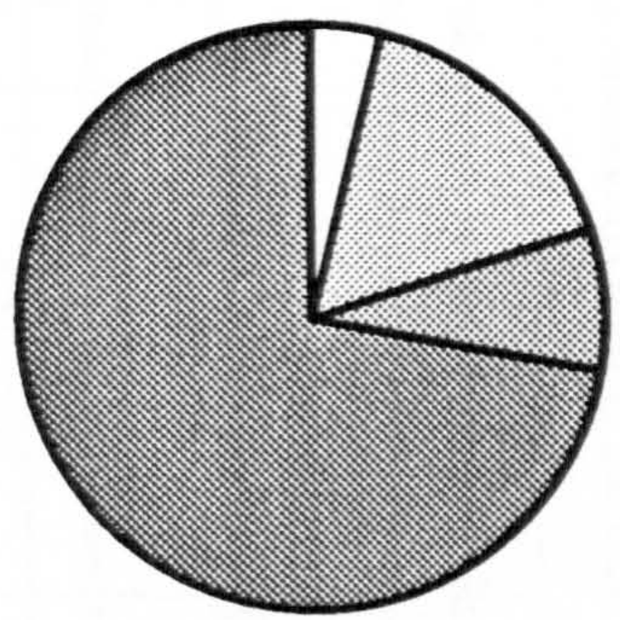
WLM

148 CM = 342 AD



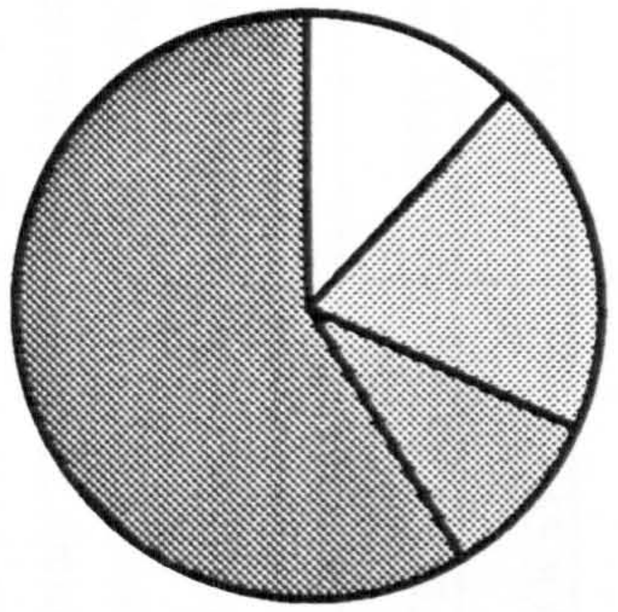
EGM

96 CM = 139 AD



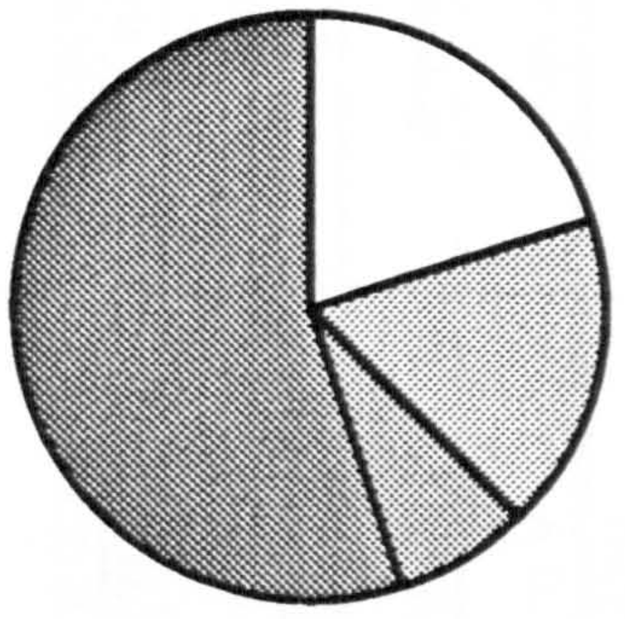
CYM

120 CM = 120 AD



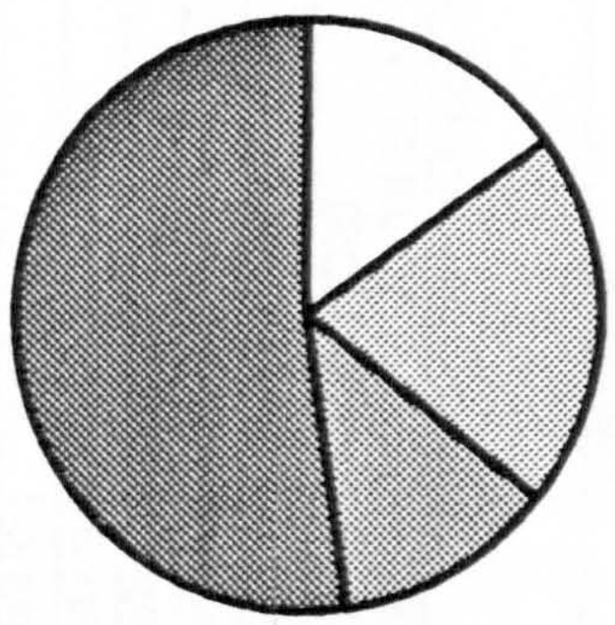
FSM

FSM = 205 AD



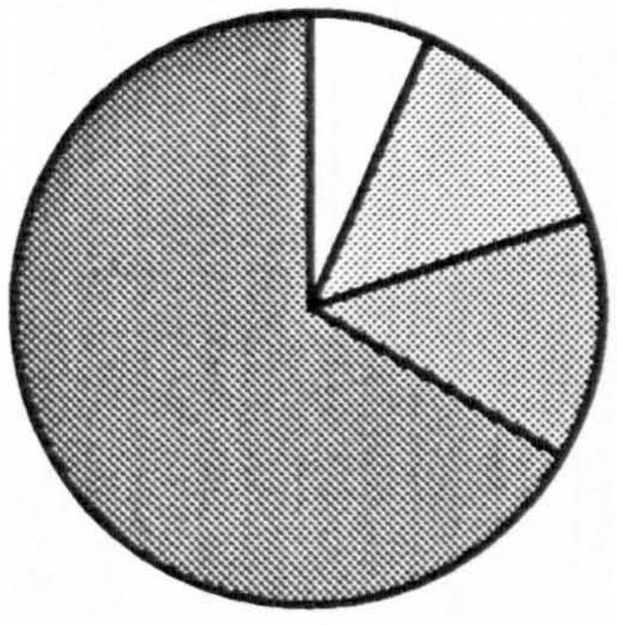
GLM

176 CM = 204 AD



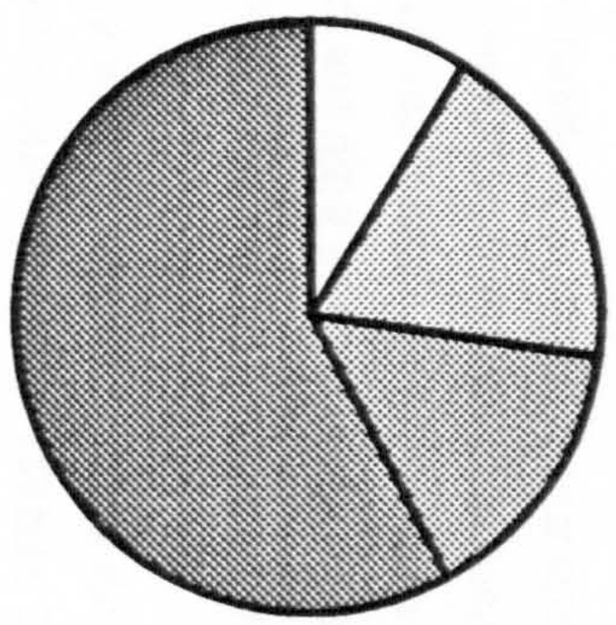
CGM

144 CM = 199 AD



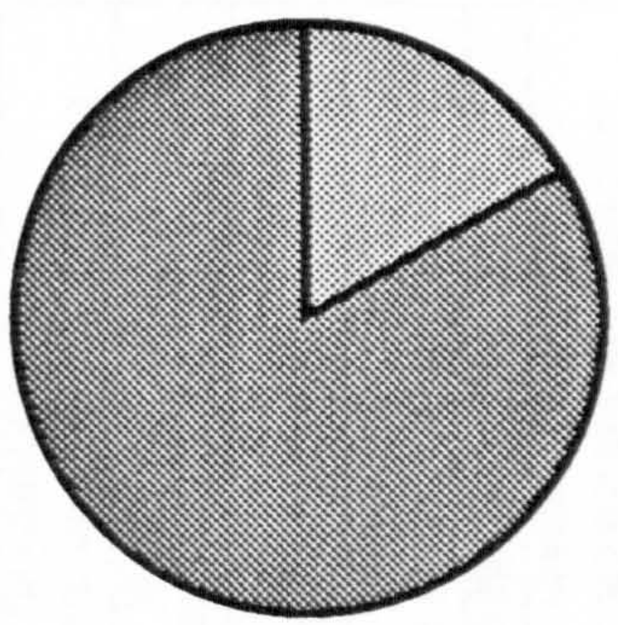
DGM

188 CM = 158 AD



LTM

96 CM = 208 AD



FZM

143 CM = 365 AD

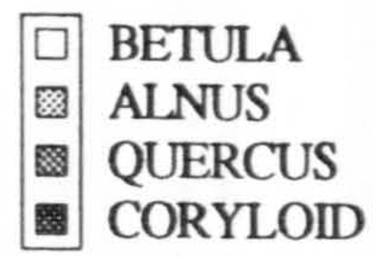


Table 5.2 Date Of The First Major Forest Clearance.

SITE	APPROXIMATE DATE	EVENT
Walton Moss	A.D. 5	Late Iron Age settlement and population expansion.
Glasson Moss	265 B.C.	Late Iron Age settlement and population expansion.
Fozy Moss	A.D. 185 (129)	Building of Hadrian's Wall.
Letham Moss	155 B.C.	Late Iron Age settlement and population expansion.
Fannyside Muir	A.D.75	Roman Invasion.
Dogden Moss	420 B.C.	Late Iron Age settlement and population expansion.
Cranley Moss	255 B.C.	Late Iron Age settlement and population expansion.
Ellergower Moss	65 B.C.	Late Iron Age settlement and population expansion.
Carsegowan Moss	145 B.C.	Late Iron Age settlement and population expansion.

felled *Betula*, *Quercus* and *Alnus*, the relative proportion of hazel-scrub increasing or could be due to the effect of percentage pollen data. At Ellergower and Carsegowan Mosses Roman clearance was lower and the woodland species remained more stable. Archaeological and other botanical evidence has shown that oak was the most commonly used building material, the use of birch and alder being less common (Hanson and Macinnes, 1981). *Alnus* and *Quercus* decrease at all sites, except for Carsegowan and Ellergower Mosses.

Where renewed clearance occurs during the Roman period it is interesting to consider the relation of the clearance to military events and its relation to the previous Iron Age clearance (Tables 5.3 and 5.4).

Table 5.3 Relationship Of Roman Clearance To Military Events.

SITE	DATE OF CLEARANCE	EVENT
Walton Moss	A.D. 125	Hadrian's Wall Built.
Glasson Moss	A.D. 125	Hadrian's Wall Built.
Fozy Moss	A.D. 185 (129)	Hadrian's Wall Built.
Letham Moss	A.D. 180	Last occupation of Antonine Wall.
Fannyside Muir	A.D.75	Roman Invasion
Cranley Moss	A.D. 90	Agricolan invasion and Castledykes built.
Dogden Moss	A.D. 120	Roman withdrawal to Hadrian's Wall and Newstead built.
Ellergower Moss	A.D. 140	Roman occupation and native clearance.
Carsegowan Moss	A.D. 130	Withdrawal of troops to Hadrian's Wall and native reoccupation.

Table 5.4 Comparison Of Roman And Iron Age Clearance.

SITE	% NAP IRON AGE	% NAP ROMAN	NATURE OF ROMAN CLEARANCE c.f. IRON AGE CLEARANCE
Walton Moss	60%	50%	Smaller Longer
Glasson Moss	35%	50%	Greater Shorter
Fozy Moss	22%	90%	Greater Longer
Letham Moss	65%	65%	Equal Shorter
Dogden Moss	65%	65%	Equal Longer
Fannyside Muir	70%	40%	Greater Longer
Cranley Moss	62%	40%	Smaller Shorter
Carsegowan Moss	40%	35%	Smaller Longer
Ellergower Moss	30%	30%	Equal Longer

Therefore, at Fannyside Muir, Glasson and Fozy Mosses Roman clearance is greater than Iron Age clearance, this being related to the proximity of these sites to Hadrian's Wall, the Antonine Wall and the military timber requirement. At Walton Moss, Cranley Moss and Carsegowan Moss Roman clearance is lower than Iron Age clearance, perhaps as natives moved out of the areas during the occupation, and at Ellergower, Letham and Dogden Mosses Roman clearance is equal to Iron Age clearance due to the continuity of Iron Age settlement.

Having considered the nature of Roman clearance, it is necessary to consider why the Romans required timber. Woodland was probably cleared for 5 main reasons - native settlement; the building of the walls, forts, *vici*, turrets and milecastles; to create a military clear zone; to obtain timber for the slaking of lime, pottery furnaces and cooking; and to create land for agriculture.

As discussed in Chapter 2, the dominant use of timber was in the construction of the frontier walls and other structures. The main need for timber would have been for the 6 foot wooden parapet on top of Hadrian's Wall and structures inside the forts on both Hadrian's Wall and the Antonine Wall, such as the barrack blocks, the milecastles and turrets, were constructed from timber (Breeze and Dobson, 1987; Johnson, 1989). Significant amounts of cleared land must have been required to create room for the wall, ditch and vallum and a military clear zone must have been required for spotting raiders and signalling across the wall and to the outpost forts (Woolliscroft, 1989). It is estimated that a fort 4 acres in size would have needed 22,000 cubic feet of timber to construct its internal buildings, granaries, towers and gates (Keppie, 1986, 67) and in terms of vegetation cover, each fort indicates the existence or the creation of a cleared space approximately 2-3 times its own internal area to allow for a military clear zone beyond. The forts in Scotland during the Agricolan period would have required 770-1430 acres of woodland for their construction (Hanson and Macinnes, 1981). It was traditionally thought that the timber required was imported from the south (Richmond and McIntyre, 1939), but this possibility seems unlikely when the cost, labour and time taken to transport the timber are considered. Also the archaeological evidence suggests that the army on campaign was accustomed to the speedy construction of temporary camps and that troops were drilled in the cutting of timber (Hanson, 1975). Therefore, the palynological and radiocarbon evidence for clearance throughout the Roman period and the archaeological evidence, could indicate that deforestation was primarily undertaken for the construction of military structures.

Although military events have been postulated as a cause for the clearances the role which native populations played in generating clearance must not be underestimated and it is recognised that in all areas native occupation of settlement continued and must have influenced the clearance pattern. The prehistoric settlement system was the basis upon which the indigenous and Romano-British settlement was organised, and the Roman settlement pattern therefore must have had Bronze Age and Iron Age origins (Bewley, 1984). Settlement density is higher in the east which is in accordance with palynological evidence for higher clearance than in the west. Iron age hill forts are thought to have required only 1 acre of woodland for their construction, but the large number and widespread distribution of forts probably means that clearance was well underway by the Roman period (Hanson and Macinnes, 1981), as borne out by the palynological evidence for previous Iron Age clearances. During the Roman period the archaeological evidence suggests that three types of native settlement appear to have been in use: the hill town, stone-built villages, and homesteads. The farmsteads and hamlets continued in the same form common as the pre-Roman phase (Clack, 1982; Hodder and Millett, 1990). The first Romano-British site types to be identified in Northumbria were the small, non-defensive, stone-built, enclosures, contemporary with the scooped enclosures of south-west Scotland (Clack and Gosling, 1976). The fact that farmsteads were beginning to be built from stone and the pollen evidence for very low levels of arboreal species, indicates that the quantities of timber available for

building were becoming low.

The archaeological evidence suggests that most native sites were still occupied during the second century and this is indicated in the pollen diagrams by continued clearance at Fozy, Walton, Glasson, Letham and Dogden Mosses. The Roman period was not marked by drastic changes or colonisation by Romans in the Solway area in or Northumbria and there is no evidence to suggest that expansion of native settlement and agriculture took place under the direction of the Roman authorities. Instead the principal causes of settlement expansion were the peaceful conditions provided by the Romans, good communications, an economy with taxation and cash payments and the existence of both military and civilian consumers requiring surplus products (Greene, 1986; Higham, 1986, 198).

Cleared land and timber was also required for Roman civilian settlement. The *vici* situated outside the forts housed a civilian population of retired soldiers, families and craftsmen. Such settlement (e.g. Vindolanda, Housesteads) seem to have their origins in the Second Century A.D., developing quickly and reaching their greatest extent in the Third Century and Fourth Century A.D.. They acted as centres for the provision of market facilities, receipt of produce from the native farmsteads and as administrative centres (Clack, 1982; Bennett, 1983; Snape, 1991). Such sites allowed the dissemination of ideas and trade among the local rural population (Higham, 1986, 175/177) bringing native communities within a wider trading network (Morrison, 1983). Such contacts may have been superficial with local rural settlements outside the *vici* remaining at a distance. The *vici* therefore became:

> "urban islands in a sea of dispersed settlement and their life was limited to an intimate connection with the fort" (Ritchie and Ritchie, 1981, 140; Jones, 1984).

Timber must also have been required for other subsidiary uses. Crow (1991 a, b) discusses how Hadrian's Wall was covered with a layer of lime plaster, timber must have been needed for charcoal used for the slaking process. Pottery furnaces occurred along Hadrian's Wall, for example at Brampton (Ordnance Survey, 1991) and local metal smiths making military and domestic implements must have required charcoal for metal smelting (Breeze and Dobson, 1987). Cleared land must also have been required for both civilian and native agriculture.

5.7.10 Size And Intensity Of Roman Clearance.

The palynological evidence can be used to assess the validity of the second hypothesis - that the size and intensity of clearance is related to the distance from Roman structures such as walls, forts and milecastles. Before considering the relationship of clearance to distance from Roman structures, the nature and intensity of Roman clearance will be assessed. The nature of clearance can be demonstrated using the Gramineae and summary curves (Figures 5.30 and 5.31, Table 5.5).

If the size of clearance is related to the distance of the site from major Roman archaeological structures then greater clearance would occur nearer structures such as the walls and forts and decline with increasing distance from the structures. Figures 5.35 and 5.36 show the proportion of arboreal and non-arboreal pollen, thus allowing a comparison of clearance. The sites marked 'W' (Fozy Moss, Letham Moss, Walton Moss, Fannyside Muir and Glasson Moss) are those close to Hadrian's Wall or the Antonine Wall, which in general have larger clearance. There does seem to be general relationship between proximity of the site to Roman structures. However, this relationship is not clear cut. For example, Glasson Moss is less than 1 km. from Hadrian's Wall and has a relatively low clearance, perhaps due to the lower intensity of forts and

FIGURE 5.35 MEAN ARBOREAL AND NON-ARBOREAL PERCENTAGES FOR THE ROMAN PHASE

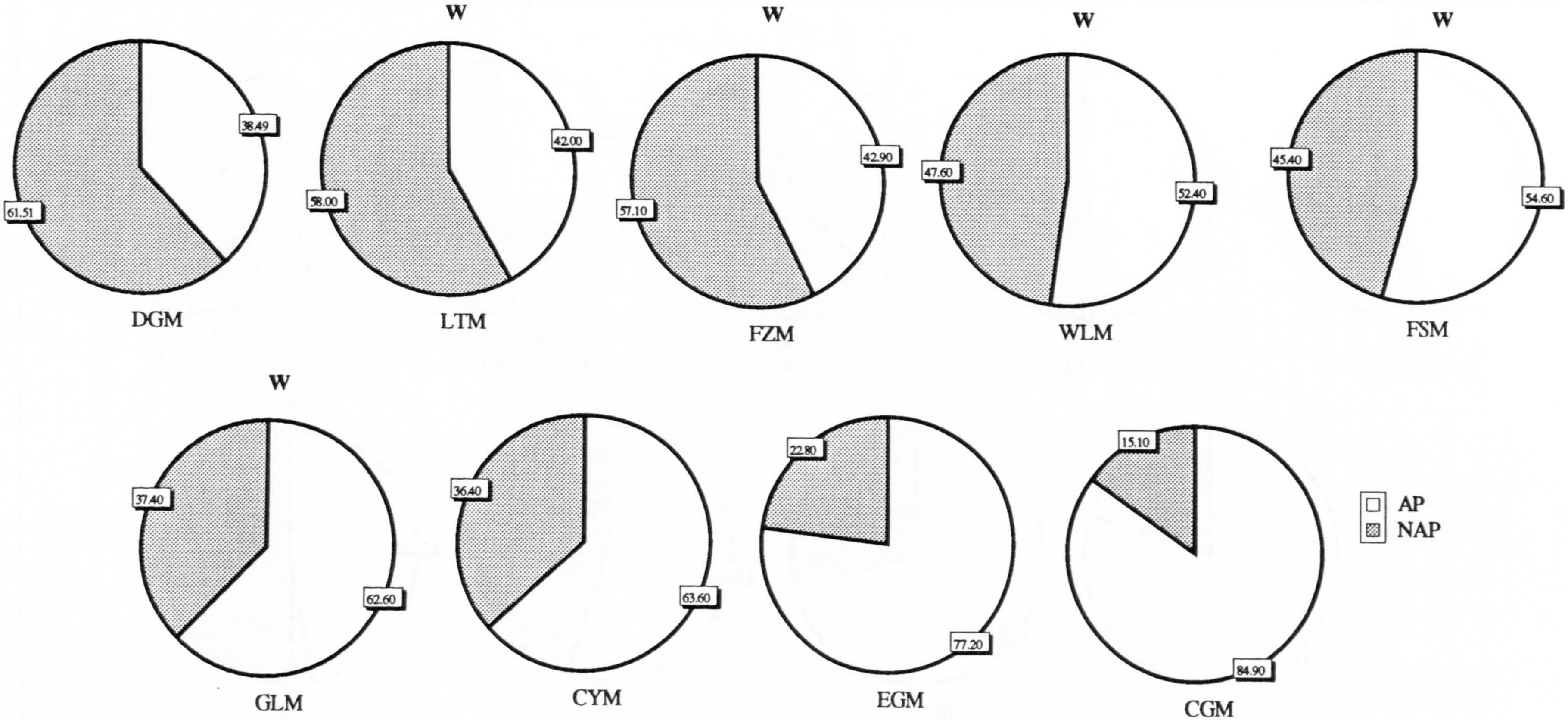


FIGURE 5.36 PERCENTAGE ARBOREAL AND NON-ARBOREAL POLLEN FOR LEVEL OF MAXIMUM ROMAN CLEARANCE

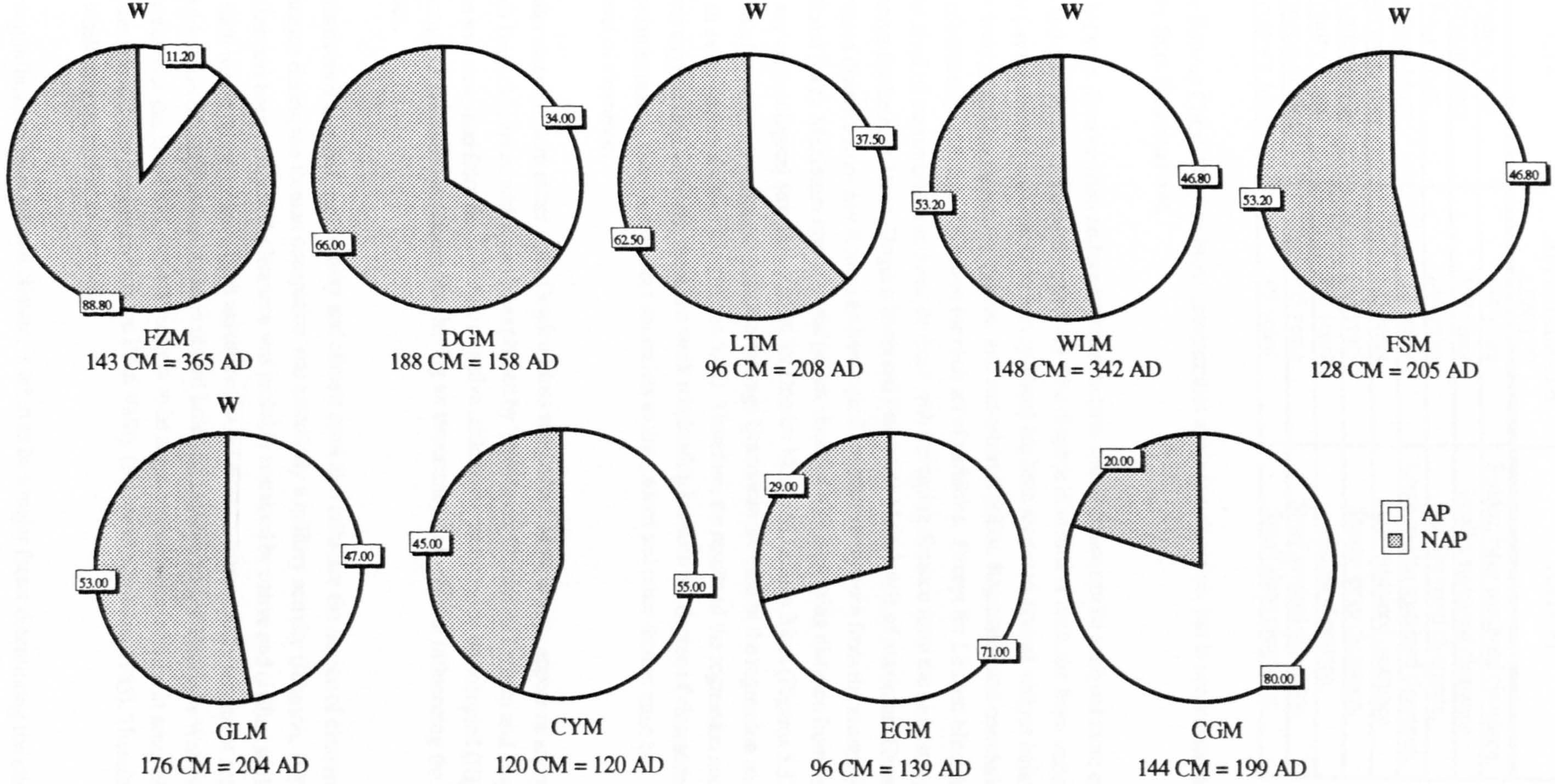


Table 5.5 Nature Of Roman Clearance.

SITE	APPROXIMATE LENGTH	NATURE
Walton Moss	444 years	Sudden, large sustained clearance.
Glasson Moss	157 years	Smaller sustained clearance.
Fozy Moss	244 years	Massive rapid clearance.
Letham Moss	83 years	Large sudden sustained clearance.
Fannyside Muir	125 years	Large sustained clearance
Dogden Moss	143 years	Shorter large clearance.
Cranley Moss	114 years	Shorter clearance.
Carsegowan Moss	105 years	Small gradual clearance.
Ellergower Moss	49 years	Small short clearance.

occupation of the Solway Coast. Dogden Moss demonstrates a massive clearance, but is not located near a wall and is 18 km. from Newstead fort.

The relationship between distance from archaeological structures and clearance can be analysed more closely using regression and correlation (Figures 5.37 to 5.42). The distance in metres of each site from various Roman structures (as measured from Ordnance Survey Maps) has been regressed against various indicies of clearance such as average and maximum Gramineae and non-arboreal pollen. Regression and correlation show a weak negative relationship with low R^2 values for each set of variables. Except for Letham Moss and Dogden Moss, the level of maximum Gramineae declines with increasing distance form the nearest wall (Figure 5.39). Except for Letham Moss, Dogden Moss and Fannyside Muir, levels of maximum Gramineae decline with increased distance from any Roman archaeological structure or distance from the nearest Roman fort (Figures 5.40 and 5.42). Maximum non-arboreal pollen declines with increasing distance from the nearest wall and any archaeological structure, except for Dogden Moss and Letham Moss (Figures 5.37 and 5.38). When values of average non-arboreal pollen or average Gramineae are used in the regression analysis, the results show an even weaker relationship (Figure 5.41). Therefore, the results of the regression and correlation analysis suggest that, although there is a weak relationship between the degree of clearance and distance from Roman structure, there are distinct anomalies to this pattern and other factors must be influencing the level of clearance.

Despite their greater distance from either wall, Dogden Moss and Letham Moss always appear as anomalies to the pattern, with large clearances which can be explained by 'prehistoric' factors. At Letham and Dogden Mosses, clearance was sustained from the Iron Age as native settlements continued to be occupied (Higham, 1986, 156), the nature of previous settlement also having an important part to play in influencing the nature of Roman clearance.

Environmental factors such as relief, soil fertility and climate must also influence the degree of clearance. Even though clearance during the Roman occupation was essentially a military activity (Johnson, 1989), once the native tribes had been conquered, clearance was probably sustained by native and civilian settlement and agriculture which would probably have been maximised in the most environmentally amenable areas. Although the consideration of relief seemed to have played little part in the course of Hadrian's Wall, which crosses rugged terrain over the Whin Sill, there does seem to be some concentration of forts in areas of more favourable relief, climate and soil fertility such as the Eden Valley (Breeze and Dobson, 1985). Therefore, greater clearance would be expected in these areas.

If soil fertility, being influenced by relief and climate, is taken to be a major factor determining the situation of settlement then greater clearance would be expected in areas of better soil fertility. Although there is no

FIGURE 5.37 REGRESSION OF MAXIMUM NON-ARBOREAL POLLEN AND DISTANCE FROM NEAREST ROMAN STRUCTURE

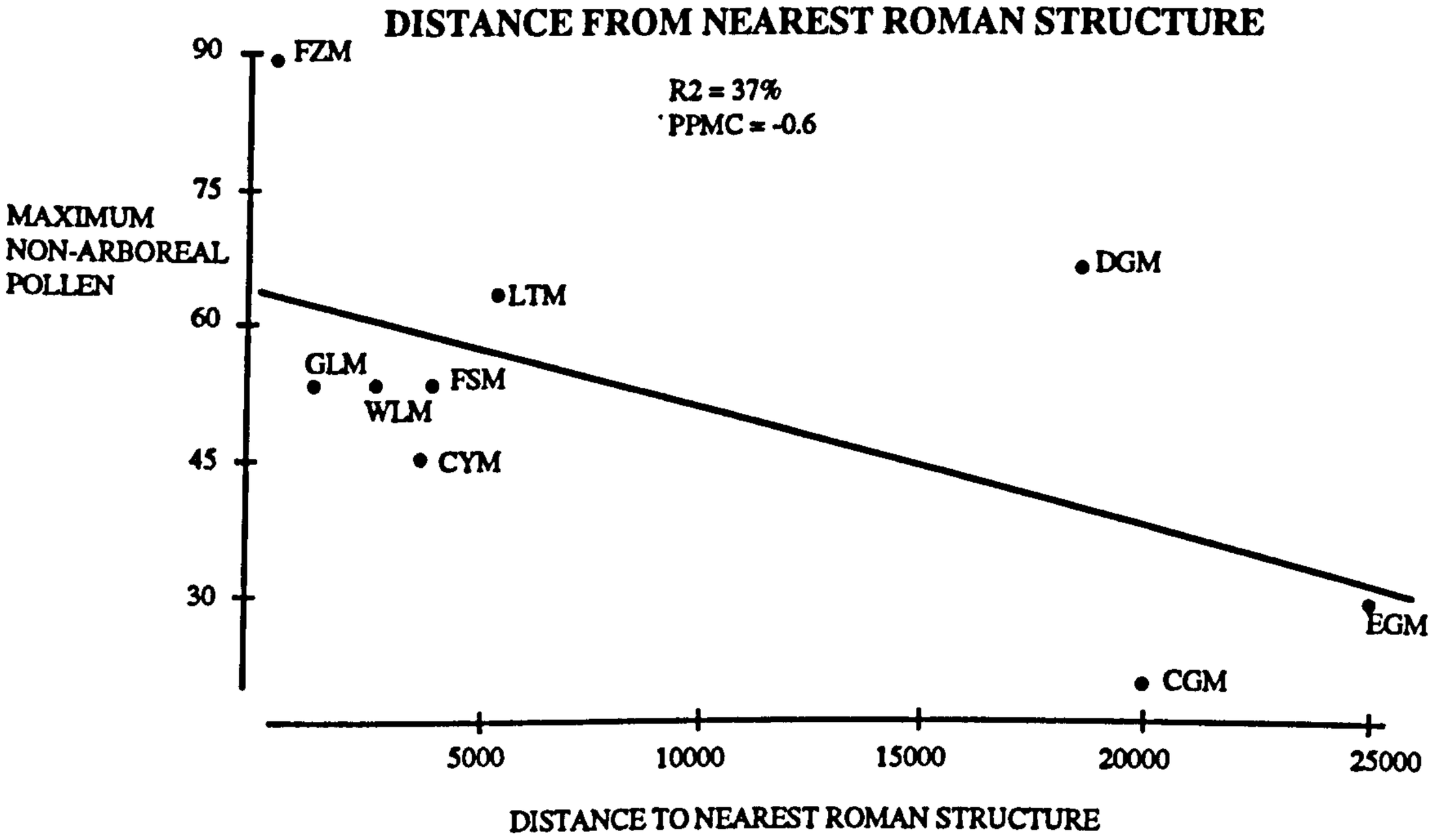


FIGURE 5.38 REGRESSION OF MAXIMUM NON-ARBOREAL POLLEN AND DISTANCE FROM NEAREST WALL

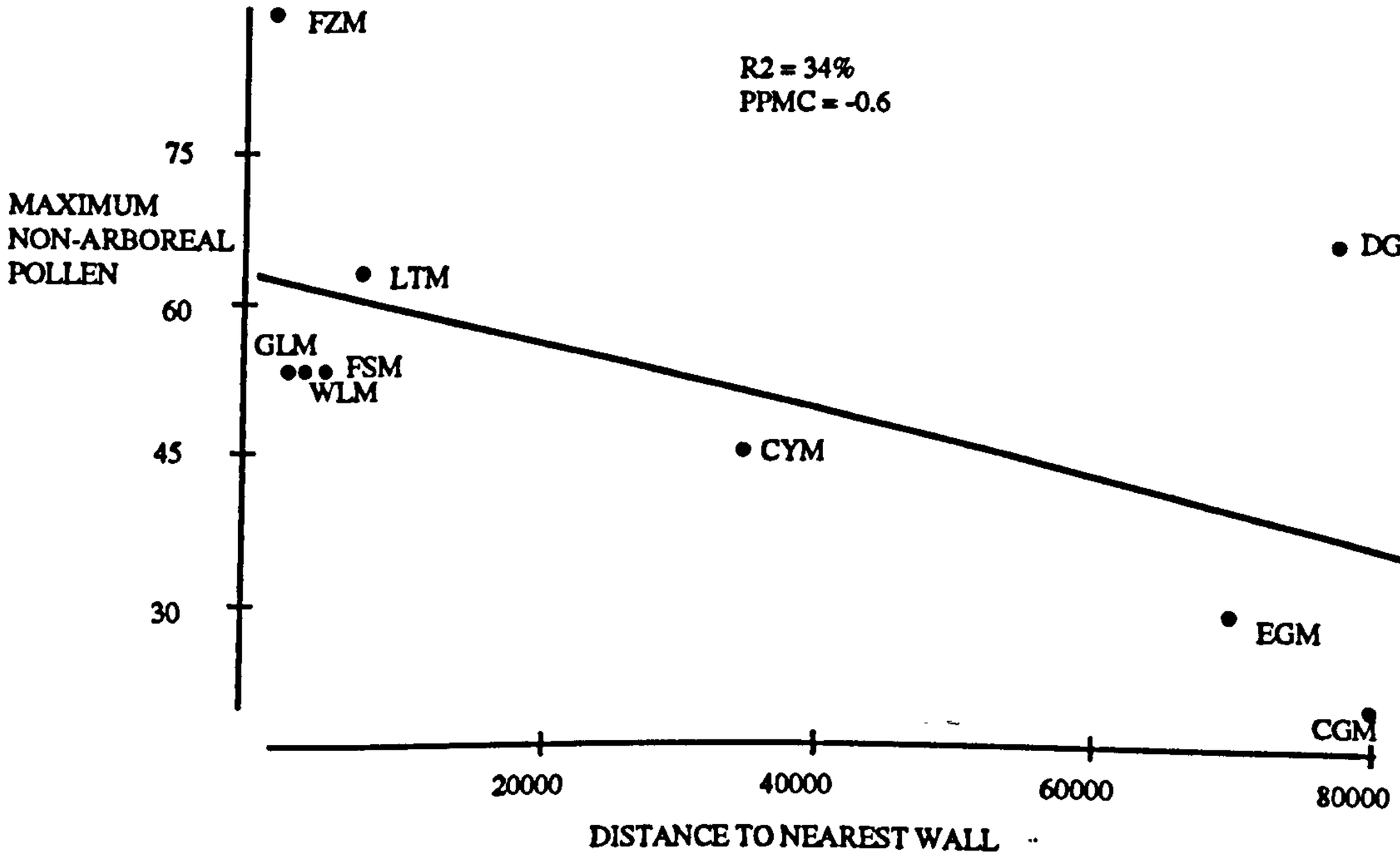


FIGURE 5.39 REGRESSION OF MAXIMUM GRAMINEAE AND DISTANCE TO NEAREST WALL

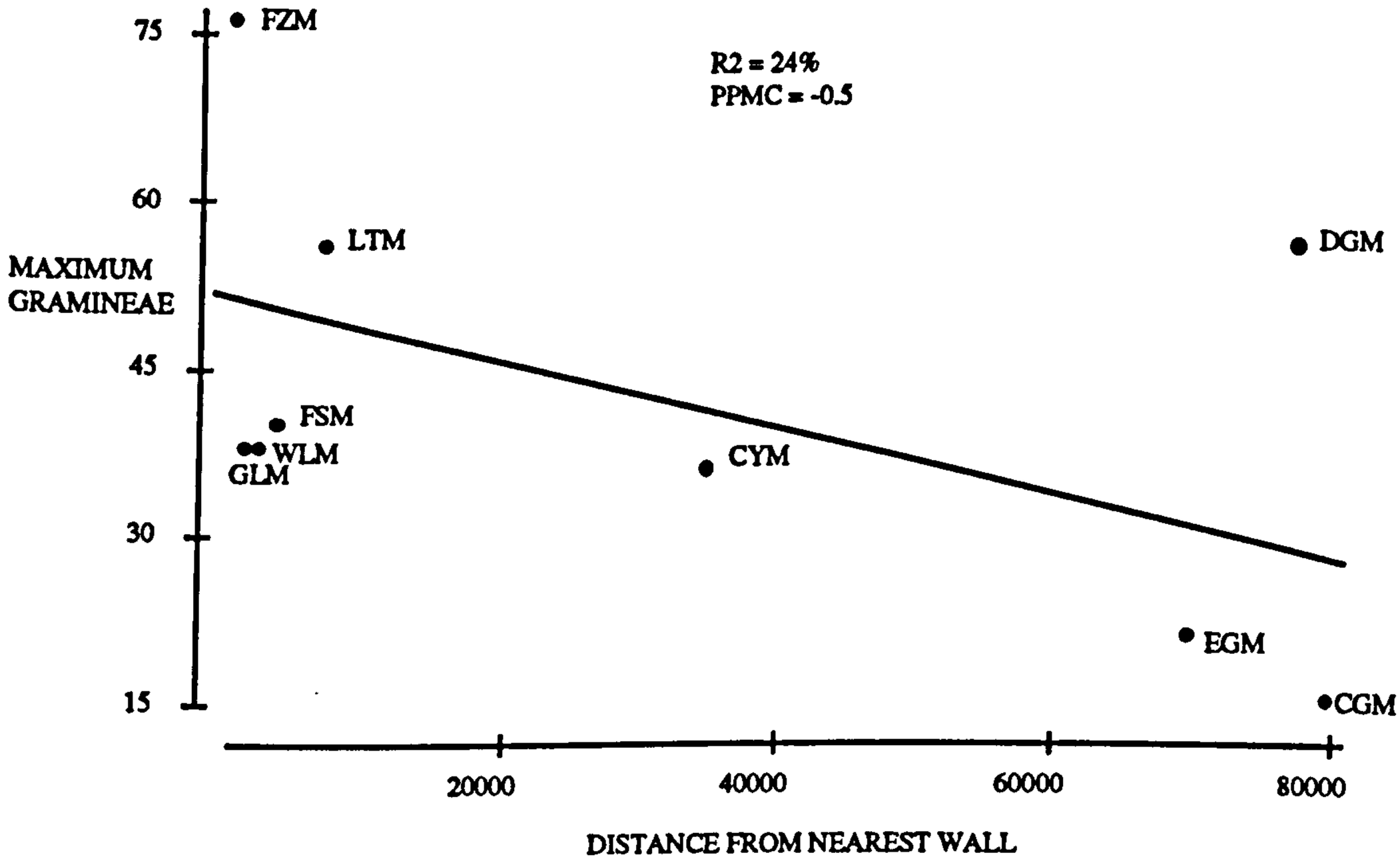


FIGURE 5.40 REGRESSION OF MAXIMUM GRAMINEAE AND DISTANCE TO NEAREST ROMAN STRUCTURE

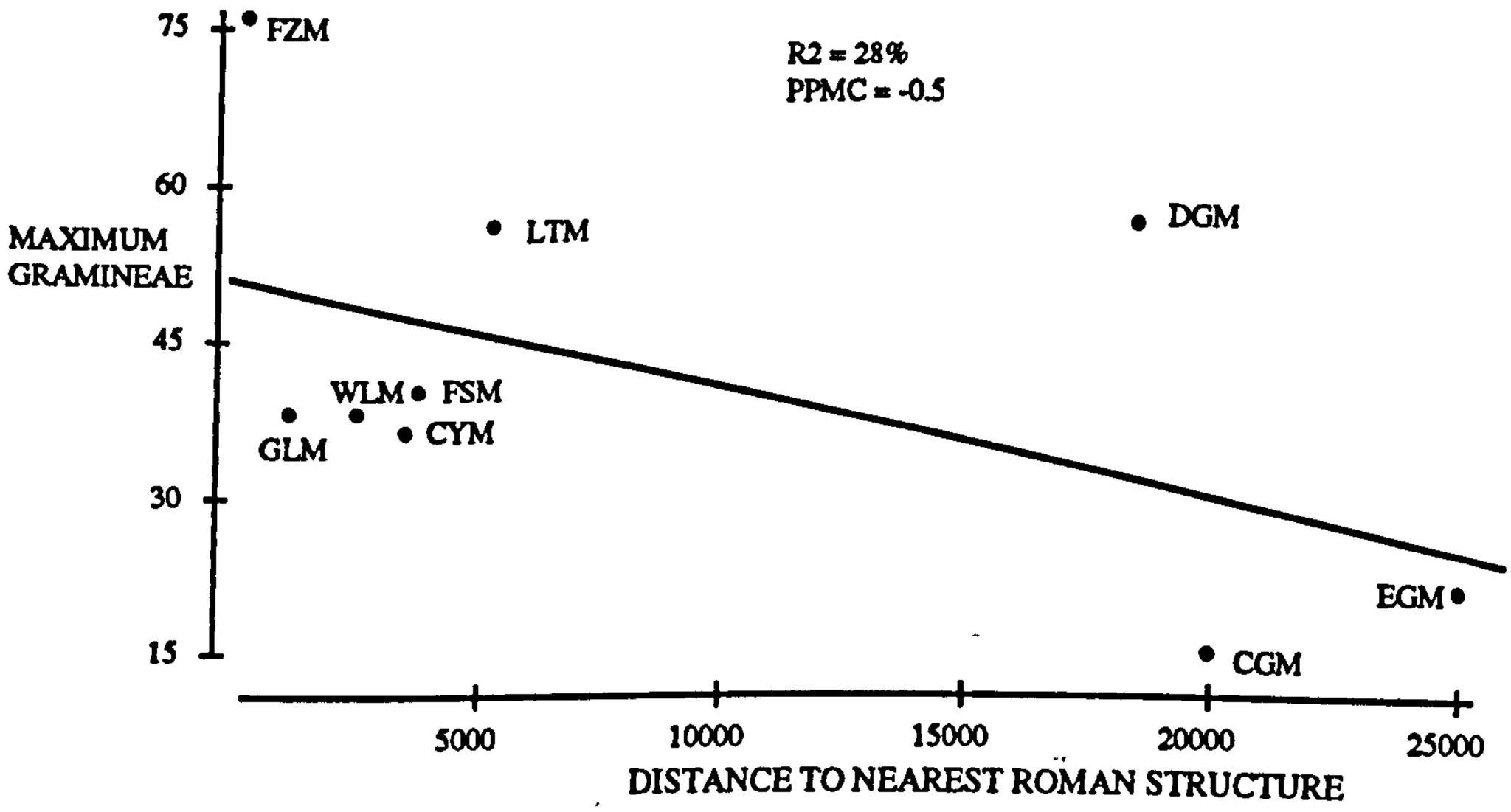


FIGURE 5.41 REGRESSION OF AVERAGE GRAMINEAE AND DISTANCE TO NEAREST WALL

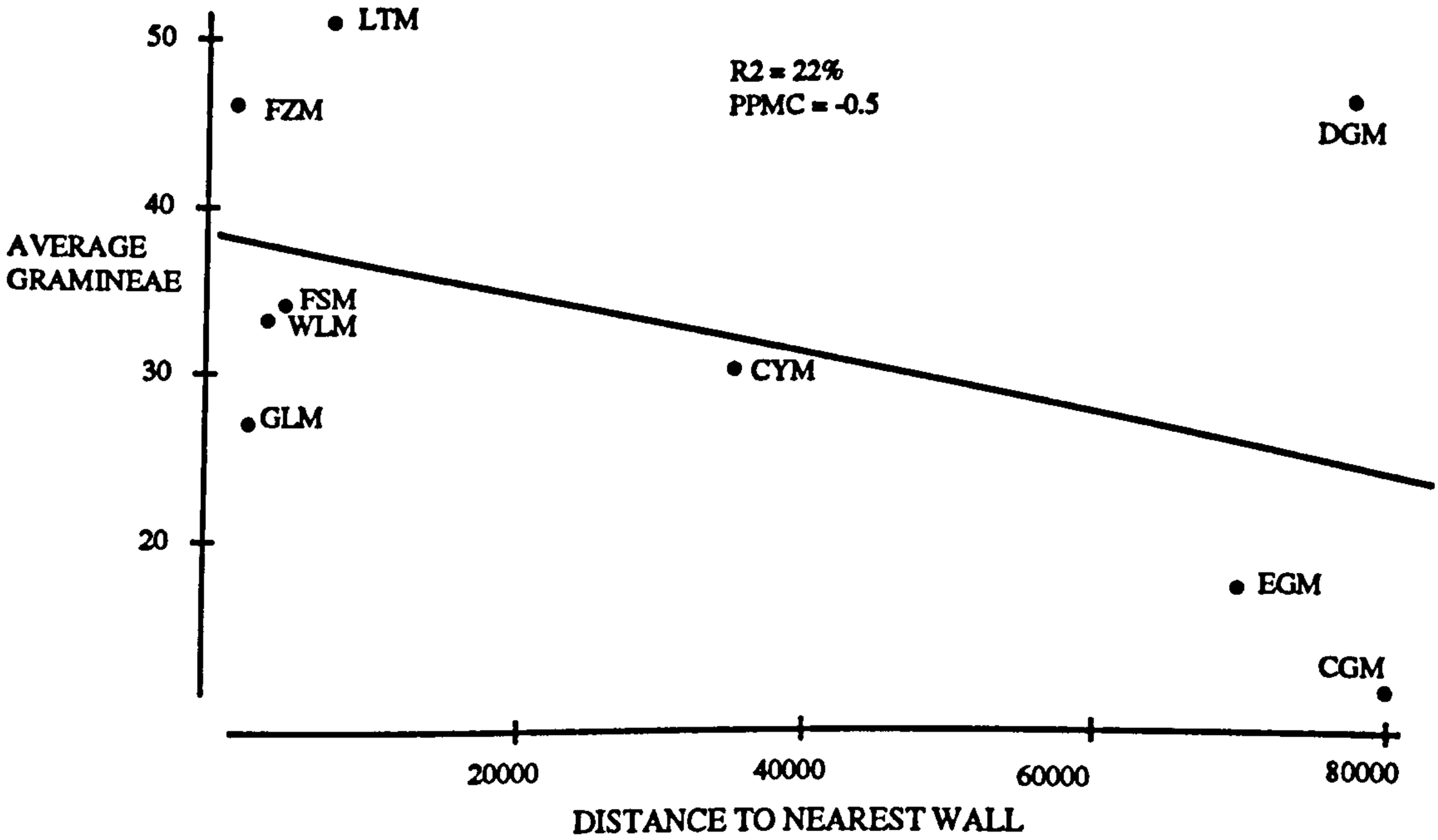
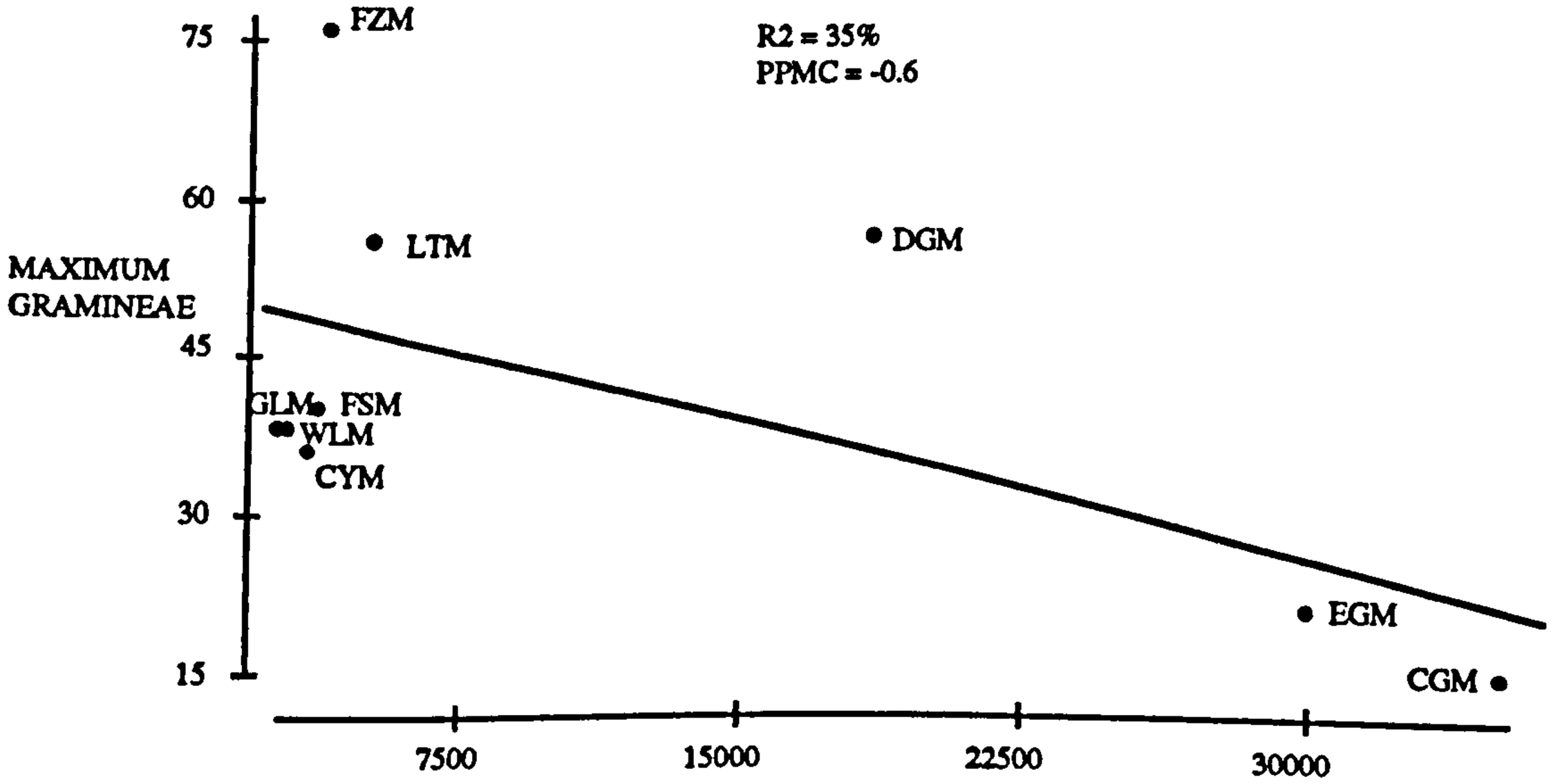


FIGURE 5.42 REGRESSION OF MAXIMUM GRAMINEAE AND DISTANCE TO NEAREST FORT



precise measure of past soil conditions the Land Capability Survey of Scotland (Soil Survey of Scotland, 1983), Agricultural Land Classification of England and Wales (Ordnance Survey, 1965), the Land Classification of the British Isles (Stamp, 1945), and the Assessment of Climatic Factors In The Land Capability For Agriculture (Ordnance Survey, 1982), can be consulted to attempt to gain an idea of soil fertility. However, present day soil fertility is not directly related to past fertility due to land improvement practises which were undertaken in the Eighteenth Century and Nineteenth Century. Soil fertility around the sites is reflected in Table 5.6. To some extent Roman clearance can be related to soil quality. Greater clearance at Letham Moss and, to a lesser extent, at Dogden Moss, is related to better soil fertility and low clearance at Ellergower Moss to poor soils. However, at Fozy Moss massive clearance occurs on poor soils and therefore clearance here must be related to military factors.

For a fair assessment of Roman clearance a combination of three factors have to be considered - the proximity of the site to archaeological structures, prehistoric factors and environmental factors. The relative importance of these varies between sites. For example, at Fozy Moss massive clearance occurs on soils of poor quality in an area of high relief, with low prehistoric settlement density, whilst the proximity of the site to Hadrian's Wall and the date of clearance suggest that military factors had a major role to play in deforestation. At Letham Moss 6 km. from the Antonine Wall, large-scale clearance is related to high native population densities and better soils. At Dogden Moss, a greater distance from the Antonine Wall, large-scale clearance is related to high native population and settlement and relatively good agricultural land.

The situation which has been inferred from the pollen diagrams in northern Britain can now be compared with those further afield. In Derbyshire (Hicks, 1971), the north Yorkshire Moors (Atherden, 1976 a, b; Simmons and Cundill, 1974) and at Thorpe Bulmer, county Durham, (Bartley *et al.*, 1976) the landscape was predominantly open during the Roman period, often to a greater extent than that in the frontier zone. Variations exist, for example, in the Shropshire lowlands the landscape was open, but at Birchgrove Pool and Berth Pool regeneration was underway (Barber and Twigger, 1987; Twigger, 1988; Twigger and Haslam, 1991). However, in contrast, there was no clearance in some areas. This is evident in the pollen diagrams from Flanders Moss, Forth Valley and Bloak Moss, Ayrshire, where clearance does not begin until A.D. 450 (Turner, 1965). However, the validity of the extrapolated dates used in Turner's diagrams have been questioned by Barber (1982). A forested landscape also occurred at Pow Hill and Cranberry Bog, Durham (Turner and Hodgson, 1981; Turner and Kershaw, 1973).

5.7.11 The Effect Of The Roman Withdrawal On Vegetation In Northern Britain.

At the end of the Roman occupation of the north two outcomes are possible. Either Roman civilisation collapsed on the removal of Roman administration or there was continuity into the Anglo-Saxon period (Finberg, 1972, 251). At all sites except Walton Moss, regeneration of the forest occurs at the time during which Roman troops were being withdrawn from Britain. Massive regeneration occurs at Fozy Moss and is associated with the abandonment of Hadrian's Wall and its structures. At Fannyside Muir, Glasson, Dogden, and Cranley Mosses gradual regeneration is probably associated with native population remaining in the area and sustained clearance, with the partial regeneration being linked to the Roman abandonment. At Letham

Table 5.6 Land Classifications For Area Around Each Site.

SITE	LAND CAPABILITY 1965/1982	AGRICULTURAL LAND CLASSIFICATION 1945	CLIMATIC FACTORS
Walton Moss	Grade 3/4	-	-
Glasson Moss	Grade 3	-	-
Fozy Moss	Grade 4/5	-	-
Letham Moss	Grade 3	Ist class level or undulating land. Deep fertile soils. Arable/grassland.	Minor climatic constraints.
Fannyside Muir	Grade 5	Good general purpose land some arable.	Moderate climatic constraints.
Dogden Moss	Grade 4	Medium quality farmland. Crops and grass	Moderate climatic constraints.
Cranley Moss	Grade 3	Good general purpose land. Fertile and ploughed	Moderate climatic constraints.
Carsegowan Moss	Grade 4	Good general purpose land. Well drained soils of good depth	Moderate climatic constraints.
Ellergower Moss	Grade 6	Poor quality mountain land. Poor soils and rough pasture	Very severe climatic constraints.

Grade 3 - Average production of barley, oats, grass and potatoes. Good yield of narrow range of crops.
Grade 4 - Grassland and short arable rotations, ley and forage crops with grassland.
Grade 5 - Restricted to grassland.
Grade 6 - Rough grazing only with severe limitations.

Moss less regeneration occurs due to high native settlement densities. At Carsegowan and Ellergower Mosses some regeneration occurs in an area where arboreal pollen was already high and where low native population densities and few Roman structures were built.

This evidence of regeneration does not seem to be in accord with other published pollen diagrams from northern Britain. In contrast Turner (1979) identifies a period during which the landscape remained open and associates this with economic and political stability lasting until Sixth Century. Regeneration seems to occur well after the Roman withdrawal. At Fellend Moss the landscape retains an open aspect until A.D. 620 ± 40 (cal. A.D. 685); at Steng Moss until A.D. 460 ± 60 (cal. 580) (Davies and Turner, 1979); at Stewart Shield Meadow until A.D. 1100 ± 100 (Roberts *et al.* 1973) and at Hallowell Moss A.D. 595 ± 65 (Donaldson and Turner, 1977). Similarly clearance also continues at Bolton Fell Moss (Barber, 1981, 114), which is in accord with the record at Walton Moss. Such stability after the Roman withdrawal could be a result of the greater distance of these sites from the frontier.

Previous clearance at those sites where regeneration occurs was probably sustained by the Roman presence, military requirements, occupation of settlements, and the practice of agriculture. The level of native population density and intensity at which the Romans occupied the area determines the extent to which regeneration occurs. Regeneration is coincident with the Roman withdrawal and this indicates that a period of economic and social instability occurred after the troops withdrew and Roman administration ceased. Once the troops were removed the artificial economy created by their presence collapsed and settlement in the frontier areas was abandoned (Clack, 1982). Their artificial foundations based on trade and administration were removed leading to social and economic reorganisation and population dispersal (Bennett, 1983). Only at Walton Moss does clearance continue during and after the Roman withdrawal indicating a period of continued stability. This might be due to the fact that natives maintained this clearance throughout and were little disrupted by the withdrawal or that the civilian population occupying the area remained.

5.7.12 The Nature Of The Rural Economy In Northern Britain During The Roman Occupation.

The traditional view of the agricultural economy on the eve of the Roman invasion is one of:

> "Celtic cowboys and shepherds, footloose and unpredictable, moving with their animals over rough pasture and moorland" (Piggott, 1958).

However, the presence of ard marks, querns, granaries and charred seed remains (Clack, 1982; Frere, 1987, 270; van der Veen, 1985; 1991) suggest arable production was more common than originally supposed and may have made a significant contribution to the economy. Corn was the staple food of the army (Breeze, 1981) and the total amount of grain required to feed troops in the north has been calculated at 9855 tonnes/year in the second century A.D. and half that in the fourth century A.D. (Gates, 1981). Archaeological and other botanical evidence suggest that oats and barley, with some rye were most common, and new crops became available including bean, turnips, grapes, nuts and fruit (Finberg, 1972, 108; Frere, 1987, 270). Botanical evidence shows that the basic diet also included bacon, cheese, pulses and vegetables with other meats and fish (Dickson and Dickson, 1988, Dickson,1989). The agricultural economy was mixed, though pastoralism, evidence of which is associated with most excavated rural sites, rather than arable practises, probably predominated. Pastoralism involved a greater area of land and meat was a normal part of the Roman diet. Bone evidence suggests that cattle, sheep and pig, goats and deer were eaten (Davies, 1971; Maltby, 1981; Clack, 1982).

The nature of the Roman agricultural economy can also be assessed using the pollen diagrams. At Walton Moss there is a substantial increase in Gramineae and *Plantago* spp. between *c.* A.D. 125 and A.D. 390. Along with the renewed presence of Compositae lig., Compositae tub., *Filipendula*, and Ranunculaceae this suggests that pastoral agriculture was practised throughout the Roman period. Arable agriculture is indicated by the presence of *Triticum* type, Chenopodiaceae, Labiatae, and *Rumex* spp.. The predominance of pastoral indicators suggests that pastoralism was the dominant element of the economy. At Glasson Moss, after a slight decline in agriculture during the invasion period,*Plantago* spp. and Gramineae begin to rise between *c.* A.D. 125 and A.D. 245, whilst Compositae lig., Compositae tub., and *Filipendula* also reoccur. However, cereals do not reoccur during the Roman period suggesting that they were not grown, but the presence of *Artemisia*, *Rumex* spp., and Umbelliferae suggest some arable agriculture was practised.

During the Iron Age at Fozy Moss there is relatively little in the way of agriculture. However, during the Roman period a massive increase in herbs indicating open ground and agriculture occurred. Gramineae increases along with *Plantago* spp., which reaches a peak slightly before that of Gramineae. This indicates that clearance for military reasons continued after the period of maximum agriculture or that grazing became so intense that *Plantago* spp. were reduced. Pastoralism is also indicated by the presence of Caryophyllaceae, Compositae lig., Compositae tub., *Filipendula*, Papilionaceae, Rubiaceae, Rosaceae, and Ranunculaceae. The presence of *Triticum* type, *Secale cereale*, *Artemisia*, Chenopodiaceae, and Umbelliferae indicate that arable agriculture began in earnest for the first time.

At Fannyside Muir *Triticum* type, *Artemisia*, Chenopodiaceae, *Rumex* spp., *Thalictrum* and Umbelliferae are present and this indicates that both pastoral and arable agriculture was practised at higher levels than during the Iron Age. At Letham Moss there is a scattered presence of *Triticum* type, *Artemisia*, *Rumex* spp., and Umbelliferae, whilst Chenopodiaceae ceases to occur. This indicates that arable agriculture continued but at a much reduced level. *Plantago* spp. remain stable until *c.* A.D. 265, whilst Compositae lig., Compositae tub., Cruciferae, Ranunculaceae, and *Urtica* cease indicating that pastoralism also continued at a lower level. Cereals are virtually absent during the Roman period at Dogden Moss, whilst *Rumex* spp. decrease significantly and Chenopodiaceae ceases. Caryophyllaceae, Compositae lig., Compositae tub., Cruciferae and *Filipendula* disappear, whilst Ranunculaceae, Rosaceae, and Rubiaceae become sporadic. After an obvious increase, *Plantago* spp. then decrease. Therefore, arable agriculture decreased during the Roman occupation and after an initial increase, pastoralism also declines. Again at Cranley Moss cereals do not reoccur after the decline during the invasion period, but *Artemisia* continues to occur until around A.D. 150 and then disappears, whilst *Rumex* spp. are significantly reduced. *Filipendula* and *Plantago* spp. continue to decline, ceasing around A.D. 320. No Caryophyllaceae, Compositae lig., Compositae tub., Ranunculaceae or Rosaceae occur and all types of agriculture were reduced during the Roman period. At Carsegowan Moss all herb types decline or disappear, with only scattered occurrences of Caryophyllaceae, Compositae lig. and tub., *Filipendula*, and Ranunculaceae. At Ellergower Moss herbs are more or less extinct except for scattered occurrences of Rosaceae, *Plantago* spp., and *Rumex* spp.. At both sites the agriculture declined drastically.

It appears, therefore, that distinct differences in agriculture occur between sites and between the Roman period and the Iron Age. Differences in the proportions of pastoral and arable agriculture between sites can be demonstrated by the use of the pastoral/arable indices displayed in Figures 5.43 to 5.48. These demonstrate that a range in the proportions of pastoral and arable agriculture occurs, the exact nature of this depending on the index used.

In general, a distinction can be made between the predominance of pastoral agriculture in the western region of the Antonine Wall and more arable agriculture in the eastern areas of the Antonine wall, where arable

FIGURE 5.43 PASTORAL/ARABLE INDICES FOR THE ROMAN PERIOD AFTER TURNER.

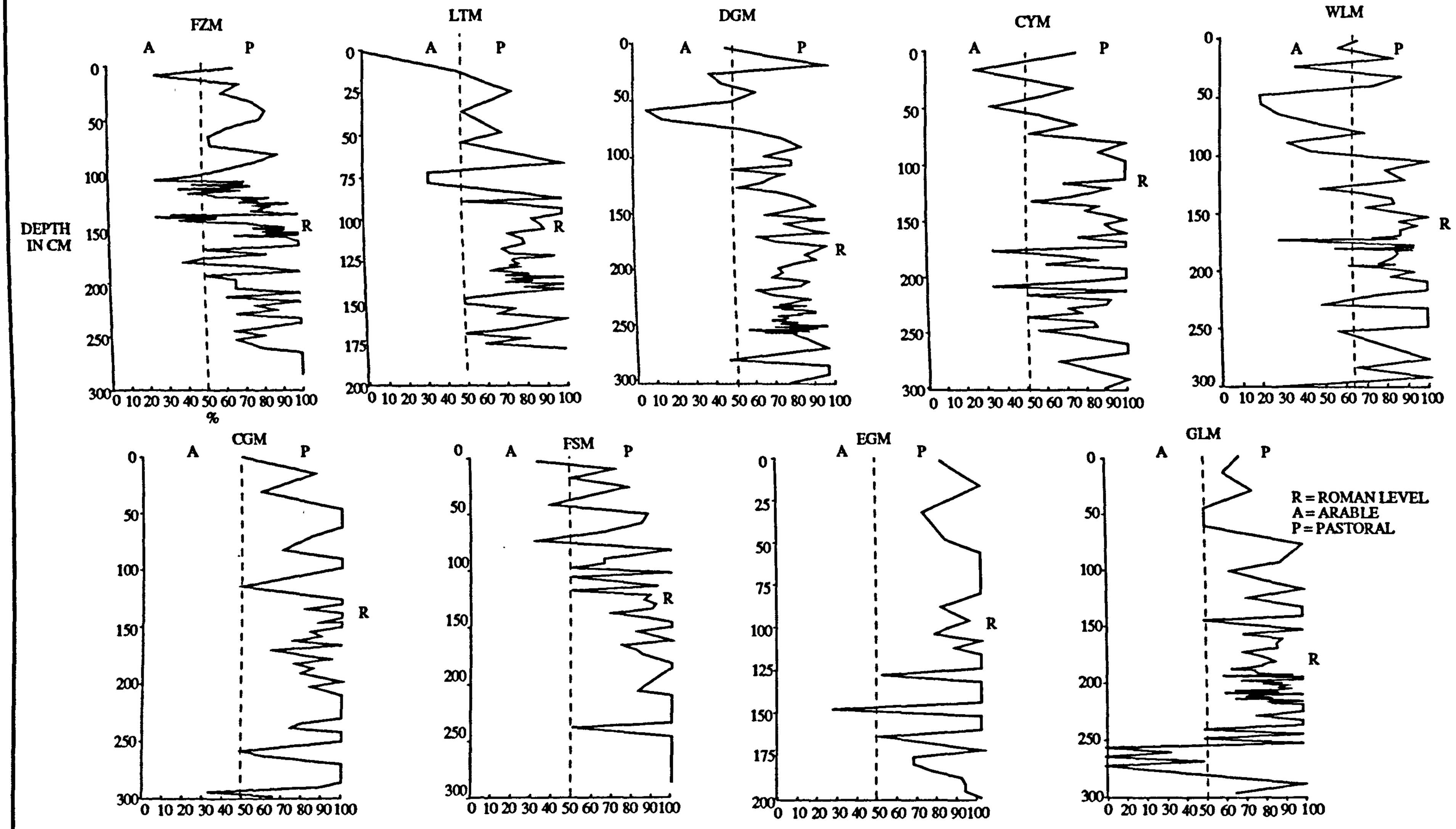


FIGURE 5.44 ARABLE INDICES FOR THE ROMAN PERIOD AFTER RIEZEBOS AND SLOTBOOM, 1978.

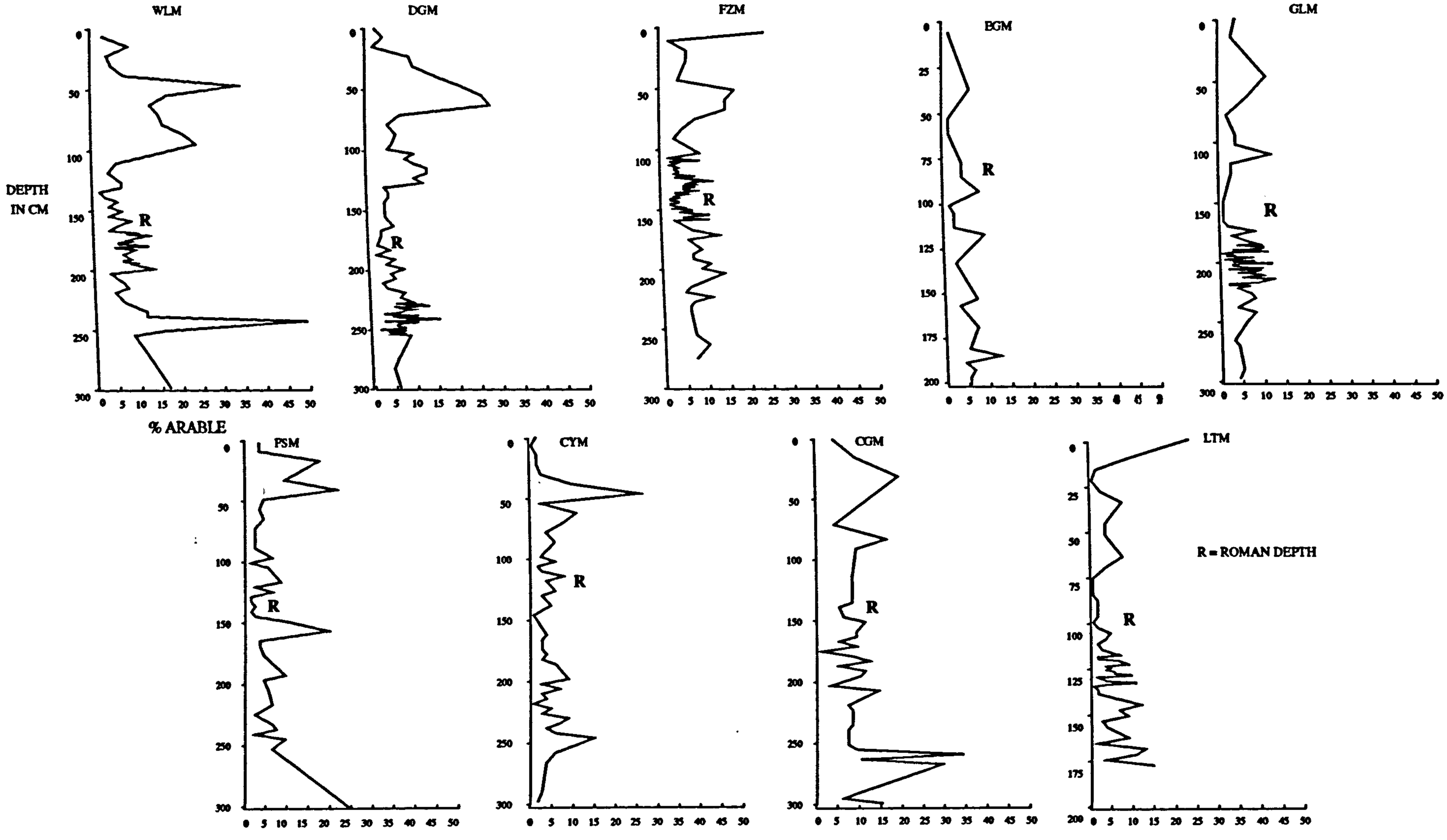


FIGURE 5.45 PASTORAL/ARABLE INDICES FOR THE LEVEL OF MAXIMUM ROMAN CLEARANCE AFTER TURNER.

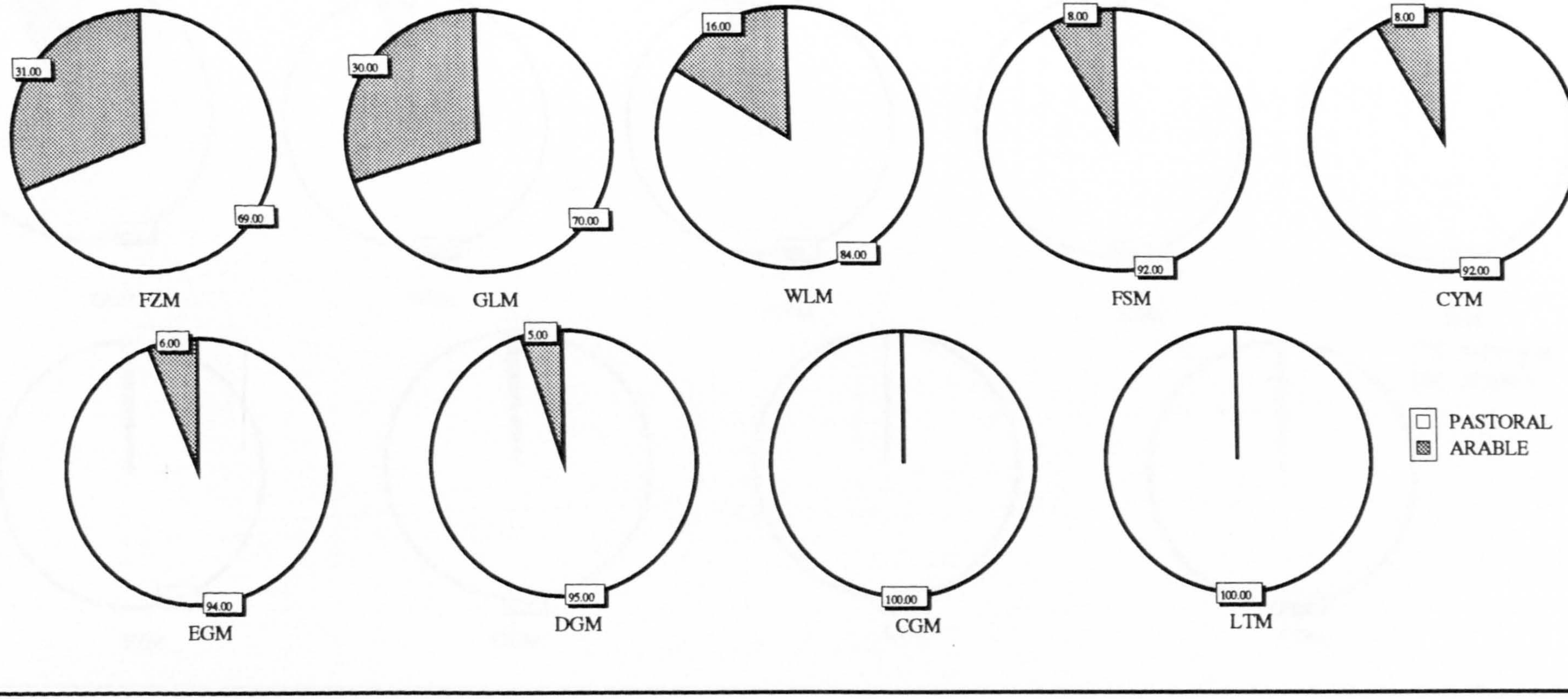


FIGURE 5.46 PASTORAL/ARABLE INDICES FOR THE LEVEL OF MAXIMUM ROMAN CLEARANCE AFTER RIEZEBOS AND SLOTBOOM, 1978.

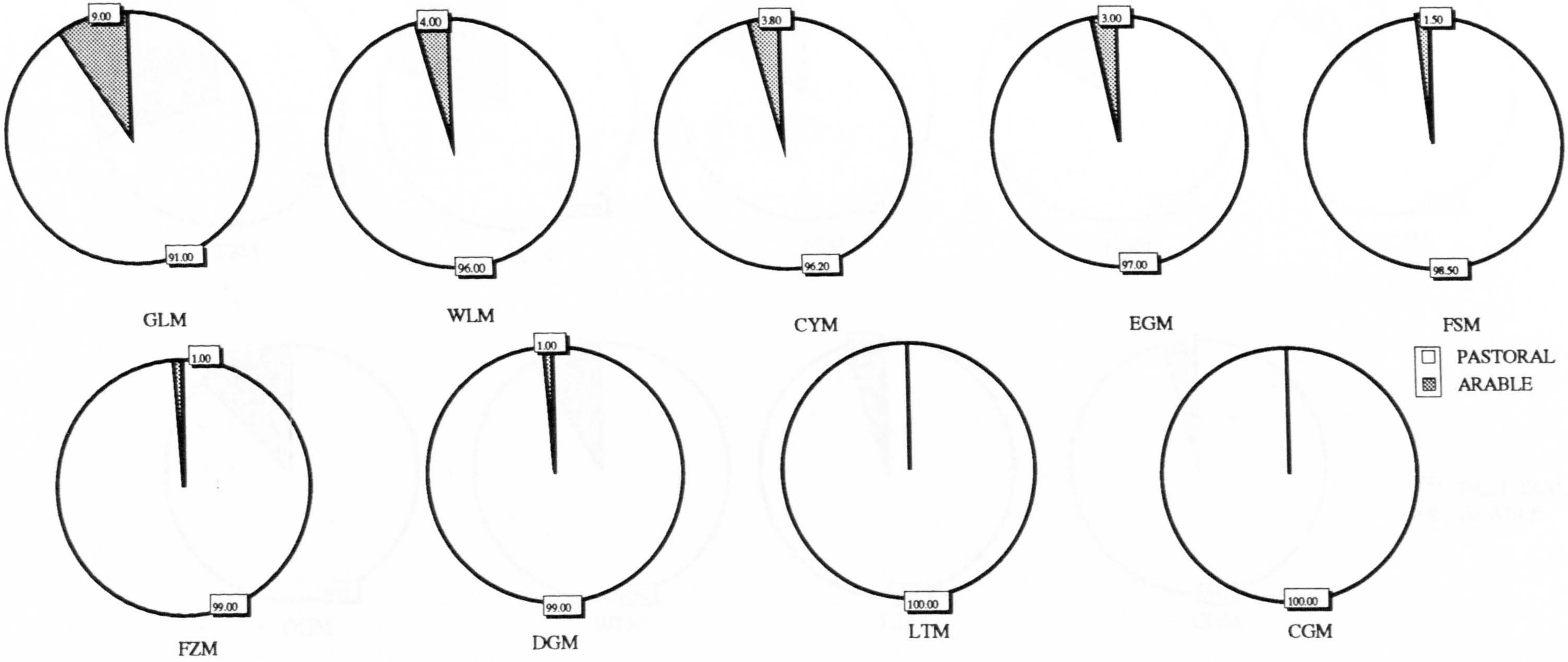


FIGURE 5.47 AVERAGE PASTORAL/ARABLE INDICES FOR THE ROMAN PERIOD AFTER TUNER.

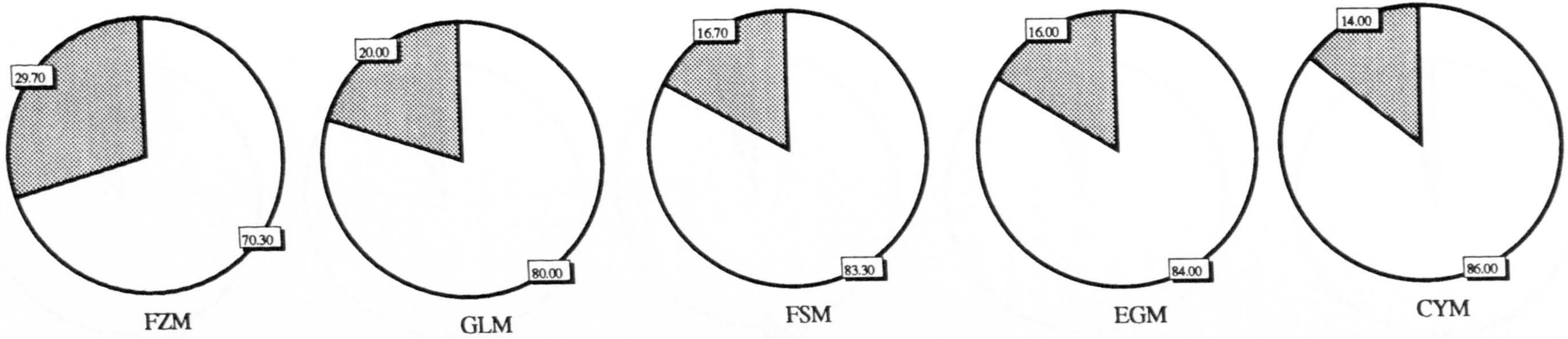
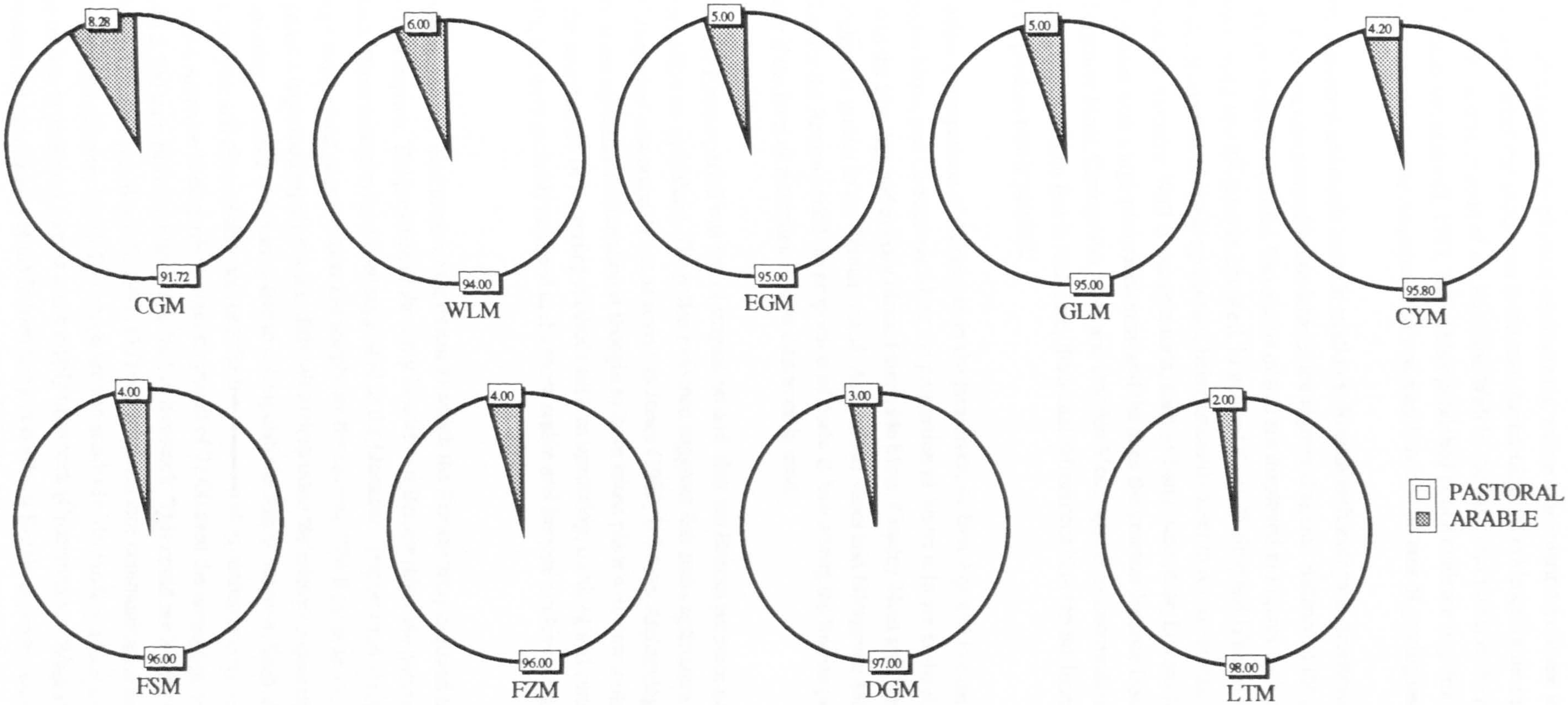


FIGURE 5.48 AVERAGE PASTORAL/ARABLE INDICES FOR THE ROMAN PERIOD AFTER RIEZEBOS AND SLOTBOOM, 1978.



agriculture predominates both in the Iron Age and to a lesser extent during the Roman period. This would be expected considering the differences in the physical environment, with a more maritime climate in the west and a drier climate with lower relief and better soils in the east. Archaeological evidence for the use of materials other than turf for the construction of the Antonine Wall in the east, also points to the prevalence of arable agriculture (Hanson and Maxwell, 1983, 164). Other published pollen evidence (e.g. from Bearsden fort (Breeze, 1979)) also suggests that the Antonine Wall was established in an area of grazing land.

The relative proportion of pastoral and arable herbs in relation to Roman archaeological structures can be examined more closely if the various pastoral/arable indicies are regressed against distance of the pollen site from various Roman archaeological structures. The results of this are displayed in Figures 5.49 to 5.52. A weak positive correlation and a low R^2 value is obtained. In general Fozy, Walton and Glasson Mosses appear as having a greater proportion of arable agriculture, being situated closer to Roman archaeological structures. Sites close to the Antonine Wall or out-post forts, such as Fannyside Muir, Letham Moss and Cranley Moss appear as those with a high pastoral element and the sites the greatest distance from Roman structures, such as, Ellergower Moss, Carsegowan Moss and Dogden Moss, appear as intermediate between the two extremes. It is important to note that in each case, the actual differences between the index value is not great and all sites are predominantly pastoral.

Figures 5.53 to 5.55 allow a comparison of differences in the proportion of Iron Age and Roman agriculture. At Letham Moss, Dogden Moss, and Carsegowan Moss the proportion of herbs is lower in the Roman period when compared to the Iron Age and at Fozy Moss, Fannyside Muir, Cranley Moss and Walton Moss the proportion of agriculture is greater in the Roman period. At Glasson Moss and Ellergower Moss if average values are taken for the Roman period the proportion of herbs is less during the Roman period than the Iron Age and greater if the level of maximum Roman clearance is used.

Jones' (1982) view that the Roman period was one of stagnation and that the Roman presence had a stifling rather than a stimulatory effect on agriculture. The pollen evidence suggests that some agriculture continued and indicates that the 'stagnation' was probably not as severe as Jones (1982) believes. Archaeological evidence indicates that some agricultural innovation is thought to have taken place with new tools, spades, scythes, ploughs and the introduction of harvesting methods such as uprooting, combing and cutting (Jones, 1981; Frere, 1987, 270), but were probably confined to the more arable and intensely cultivated lands of southern Britain.

This palynological evidence can be used to assess the extent to which the Roman army acquired food from the local economy or from imports. The presence of the army in northern Britain raises the question of how the troops were supplied. Three strategies have been suggested in the literature - import from abroad; production by the troops themselves; or production and supply by the natives. The Roman army in northern Britain must have required a large food supply but it is difficult to determine the relative importance of the role of the natives in meeting the needs of the army and to distinguish the role of imports. Each soldier needed 1/3 ton of corn per year and this probably accounts for the presence of granaries at most military sites. On the assumption that the Antonine Wall garrison was composed of 7,000 men the amount of corn supplied yearly would have been 2,500 tons, plus that required to feed to livestock. This could not be met locally, but was imported from abroad (Hanson and Maxwell, 1983, 177) and long distance communication lines, especially by sea, were common (Cleere, 1978). The troops arrived suddenly, demanding a food supply, therefore requiring the natives to produce a surplus and a supply netwoork (Groenman van Waateringe, 1980; 1983; 1989). The provision and maintenance of the Roman army in northern Britain depended on sea-borne traffic to harbours on the Clyde and Forth and the forts at South Shields, Maryport and Carlisle (Higham,

FIGURE 5.49 REGRESSION OF TURNER'S PASTORAL/ARABLE INDEX FOR LEVEL OF MAXIMUM ARABLE AGRICULTURE AGAINST DISTANCE TO NEAREST ROMAN STRUCTURE

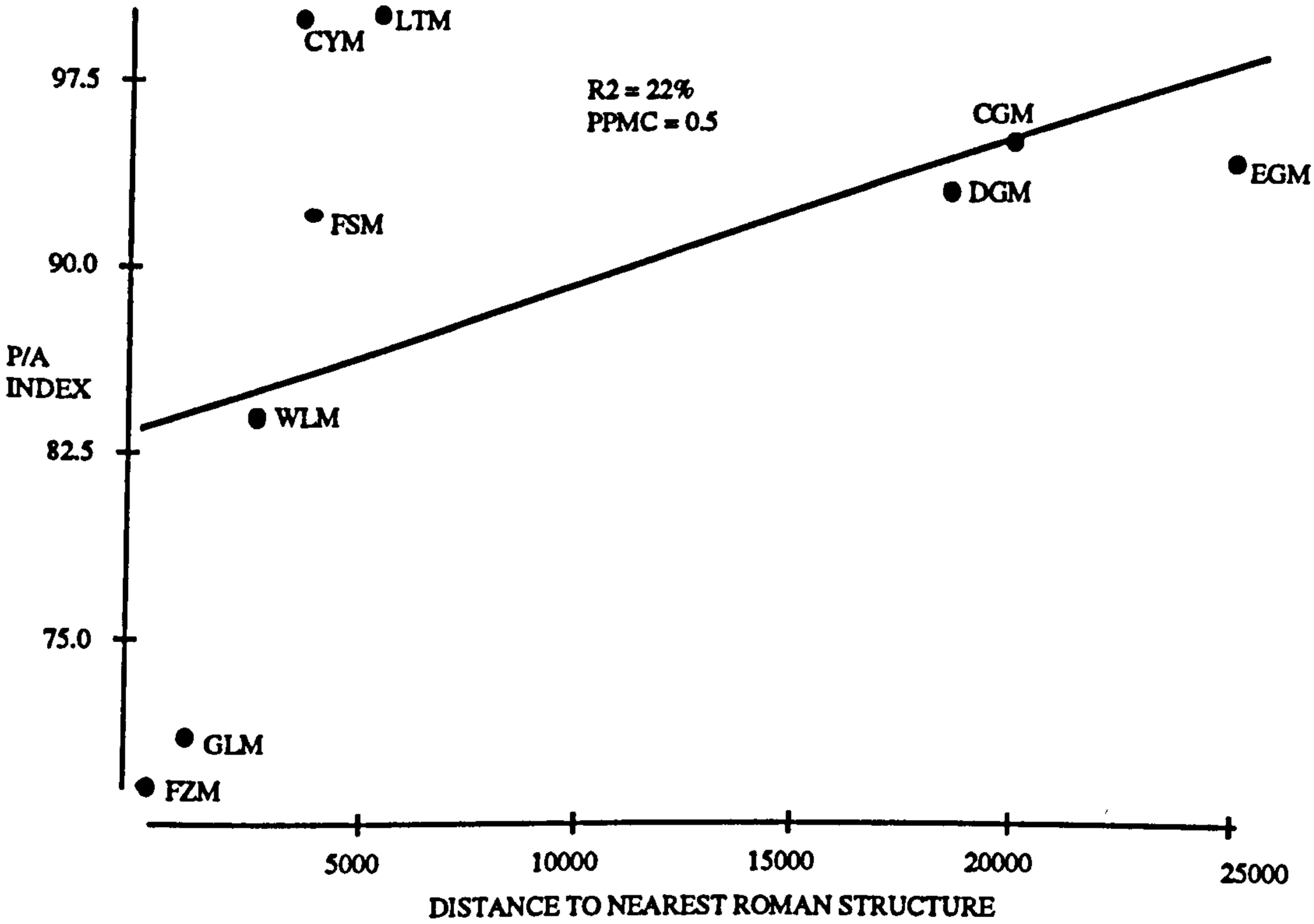


FIGURE 5.50 REGRESSION OF TURNER'S PASTORAL/ARABLE INDEX FOR LEVEL OF MAXIMUM ARABILE AGRICULTURE AGAINST DISTANCE TO NEAREST WALL

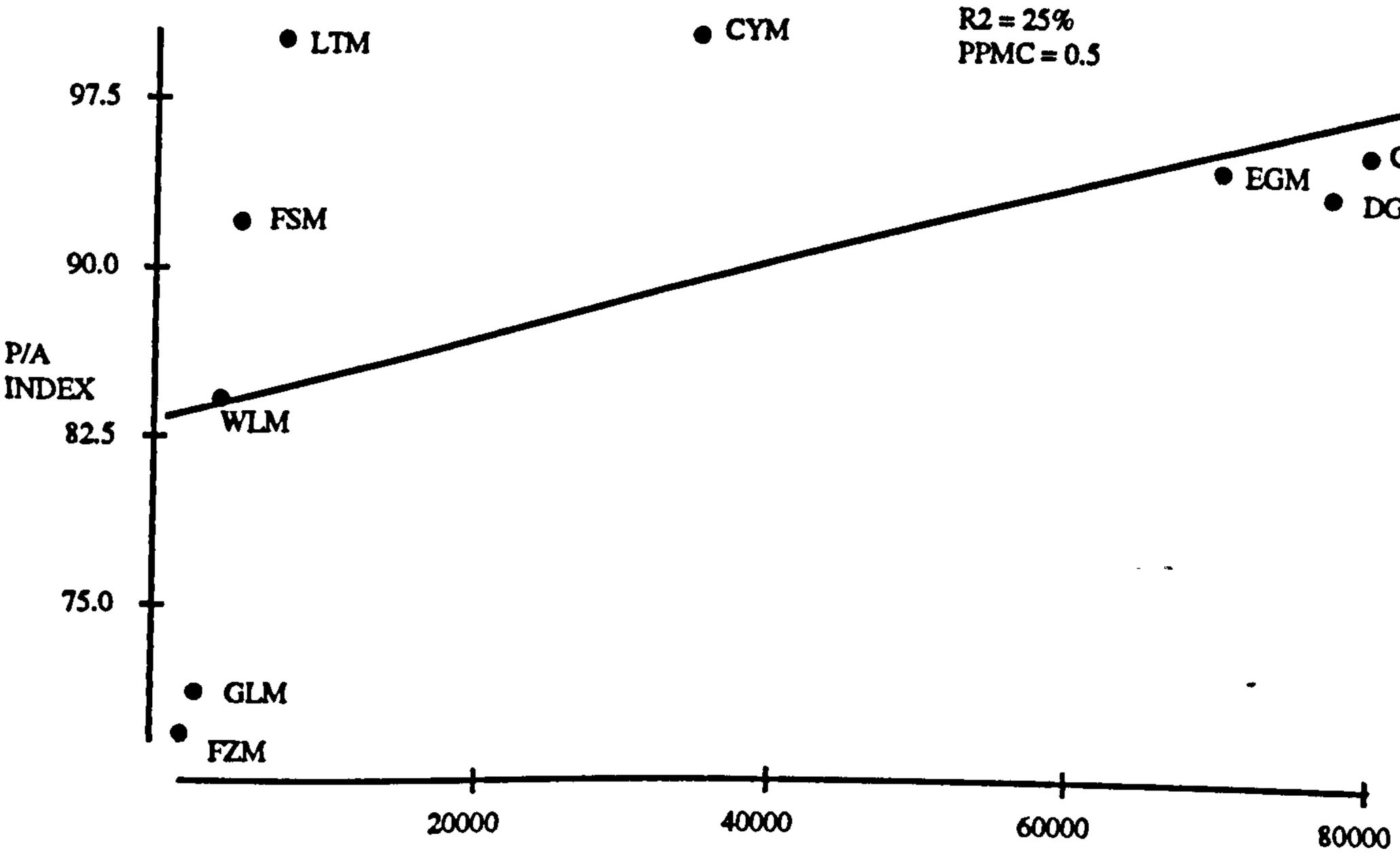


FIGURE 5.51 REGRESSION OF RIEZEBOS AND SLOTBOOM'S PASTORAL INDEX FOR LEVEL OF MAXIMUM ARALE AGRICULTURE AGAINST DISTANCE FROM NEAREST FORT

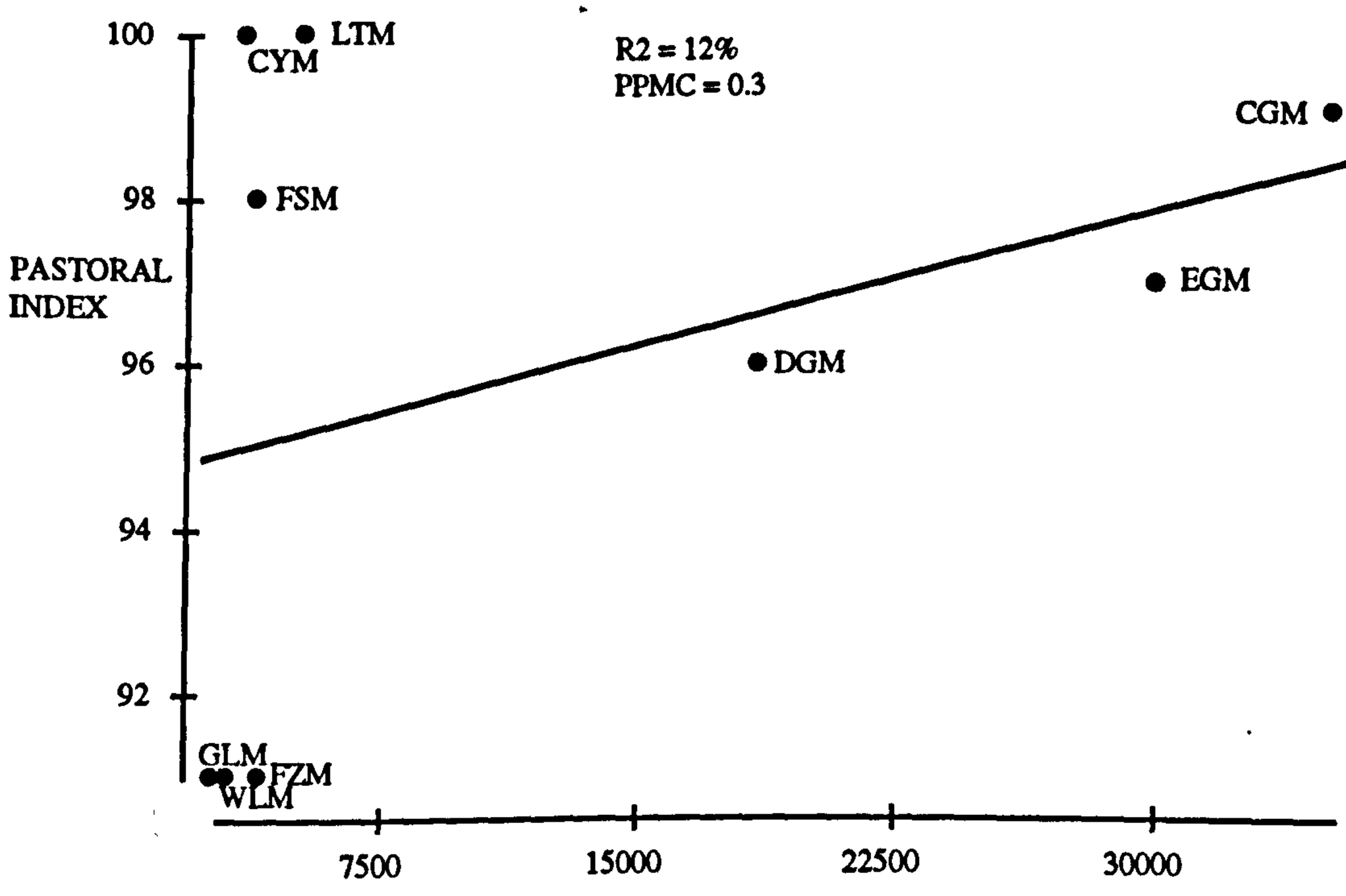


FIGURE 5.52 REGRESSION OF RIEZEBOS AND SLOTBOOM'S PASTORAL INDEX FOR LEVEL OF MAXIMUM ARABLE AGRICULTURE AGAINST DISTANCE FROM NEAREST ROMAN STRUCTURE

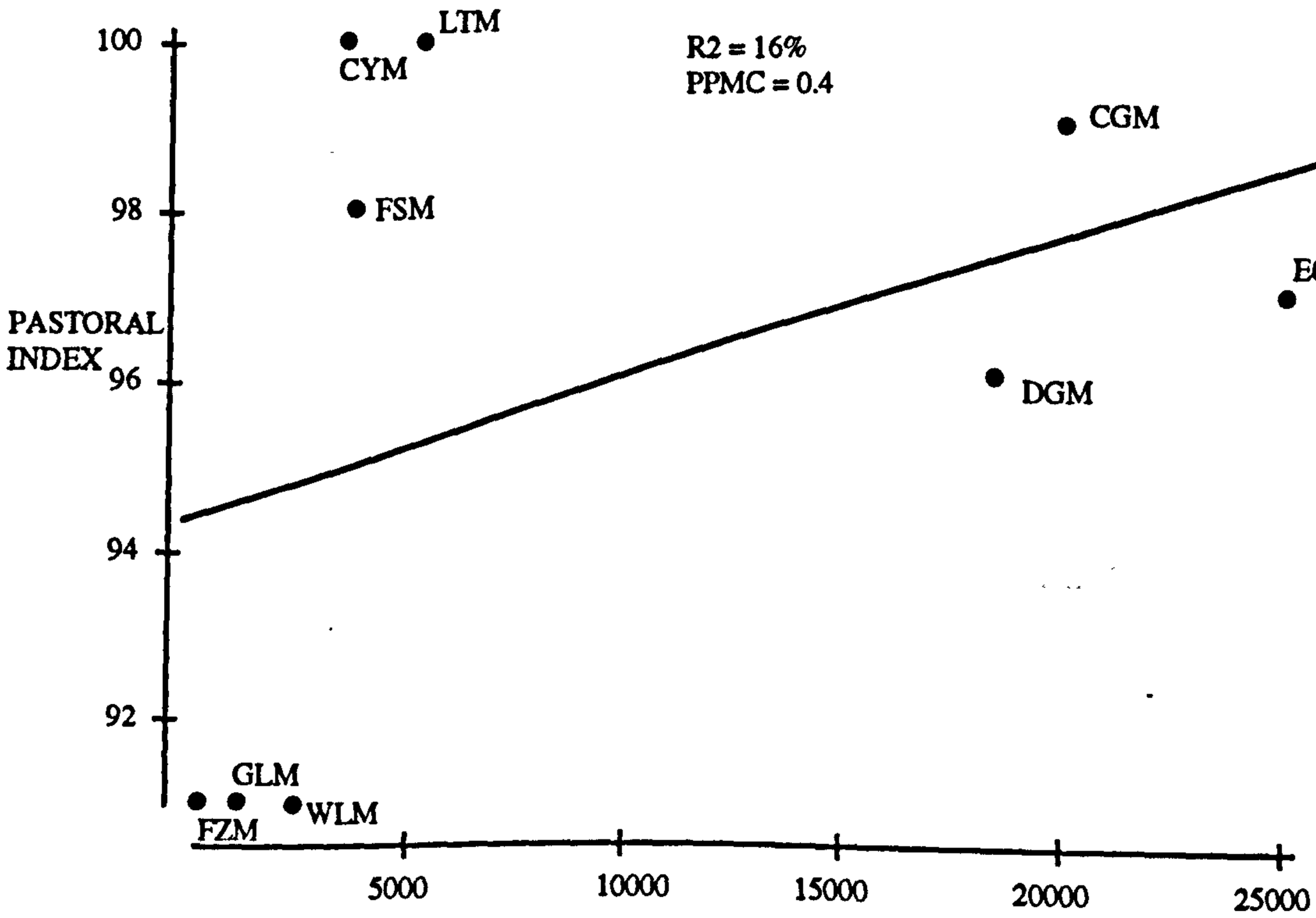
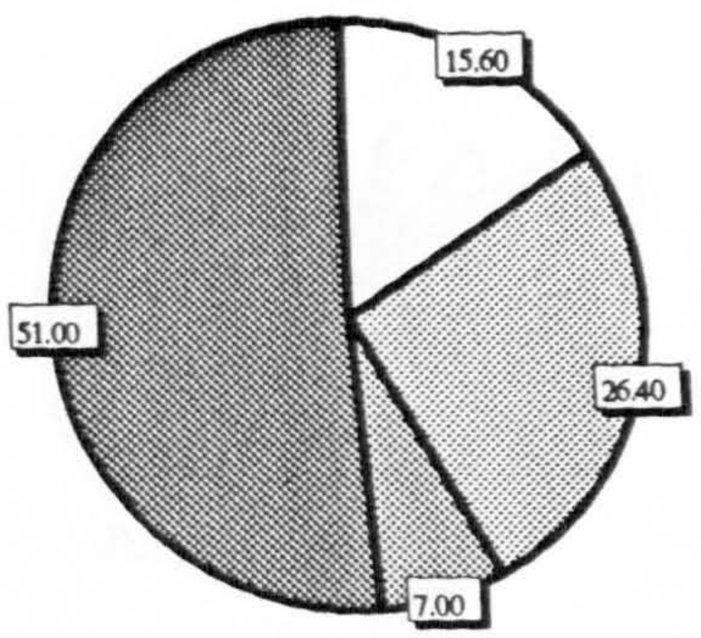
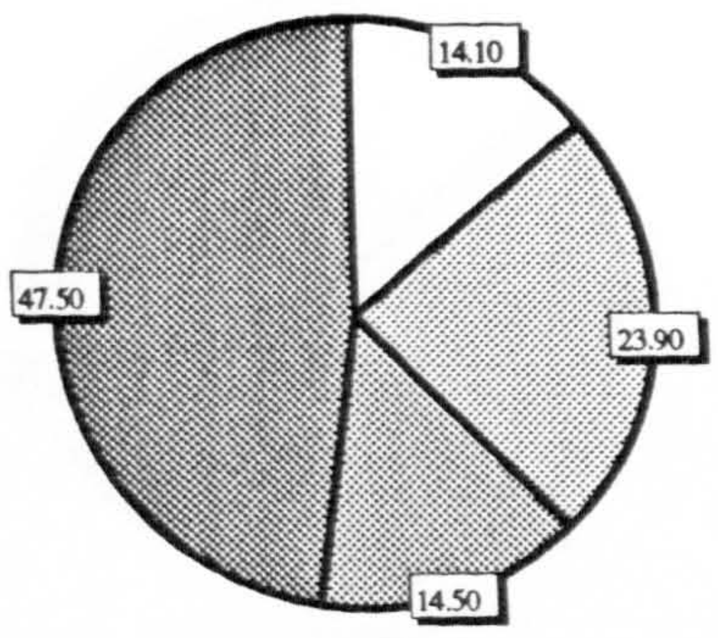


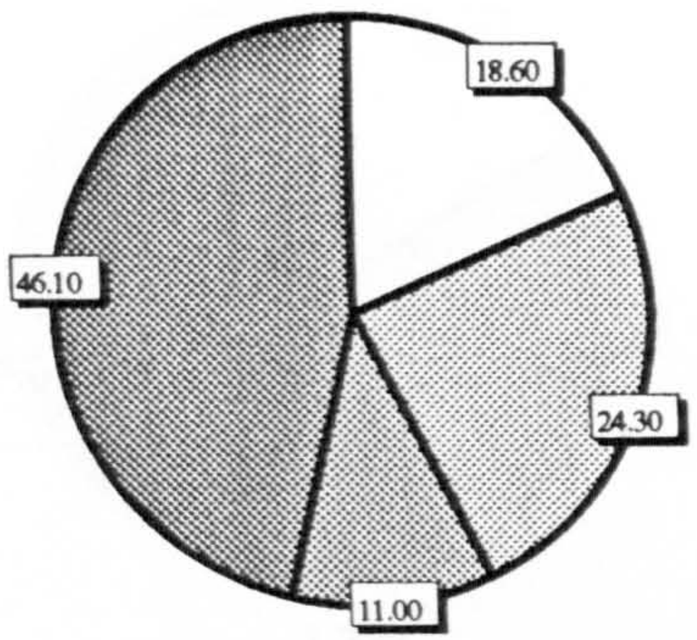
FIGURE 5.53 MEAN, TREE, SHRUB, HERB AMD GRAMINEAE PERCENTAGES FOR THE ROMAN PERIOD.



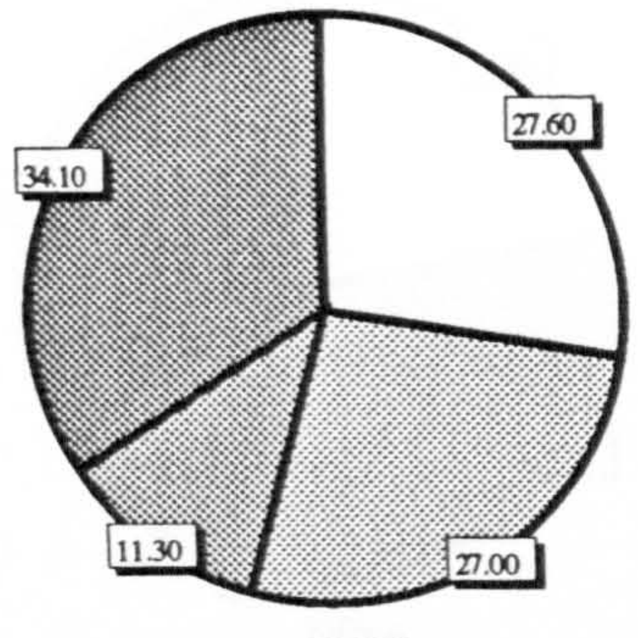
LTM



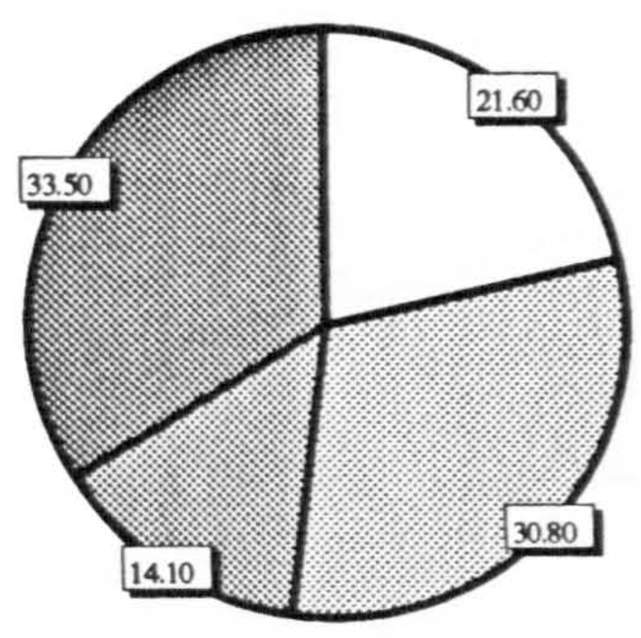
DGM



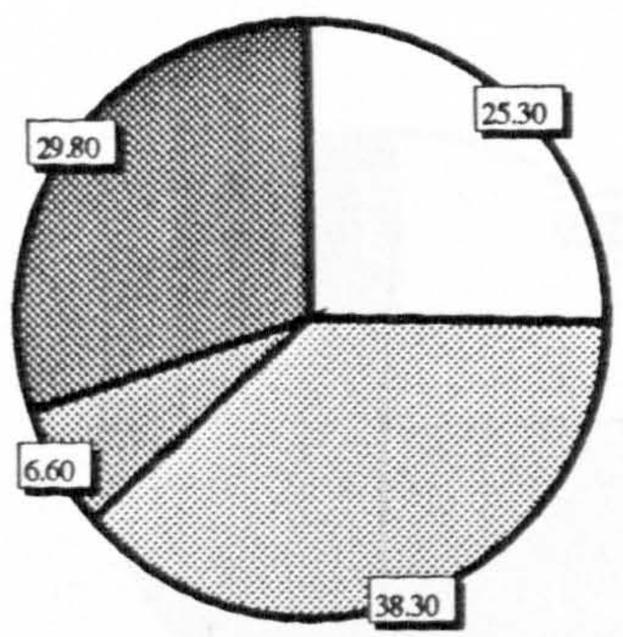
FZM



FSM



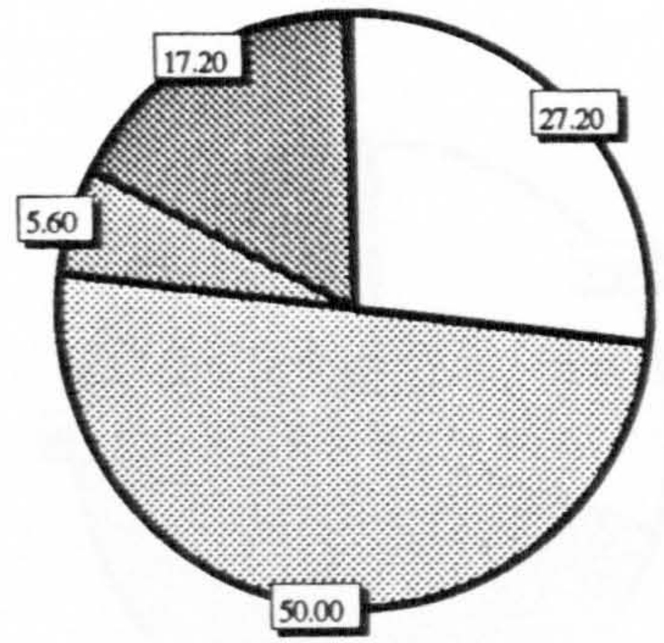
WLM



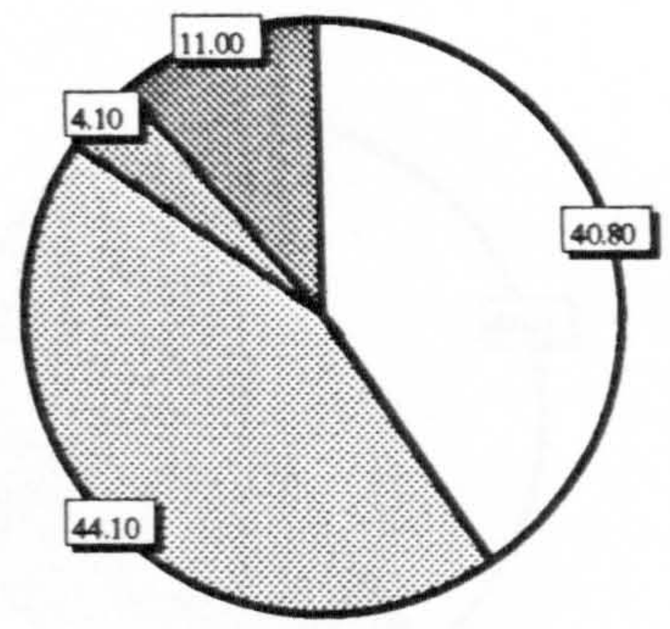
CYM



GLM



EGM



CGM

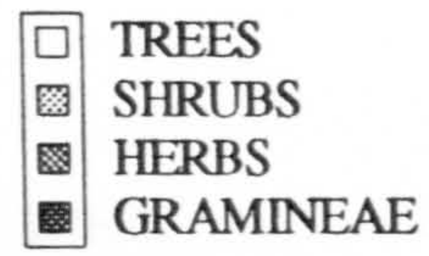
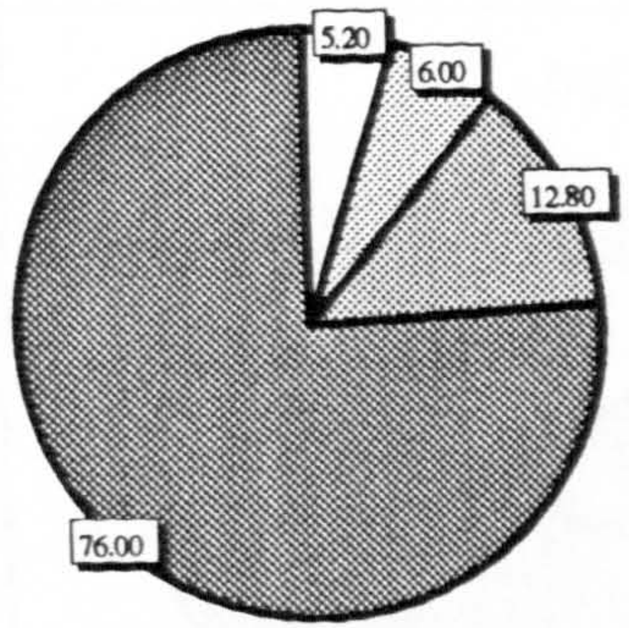
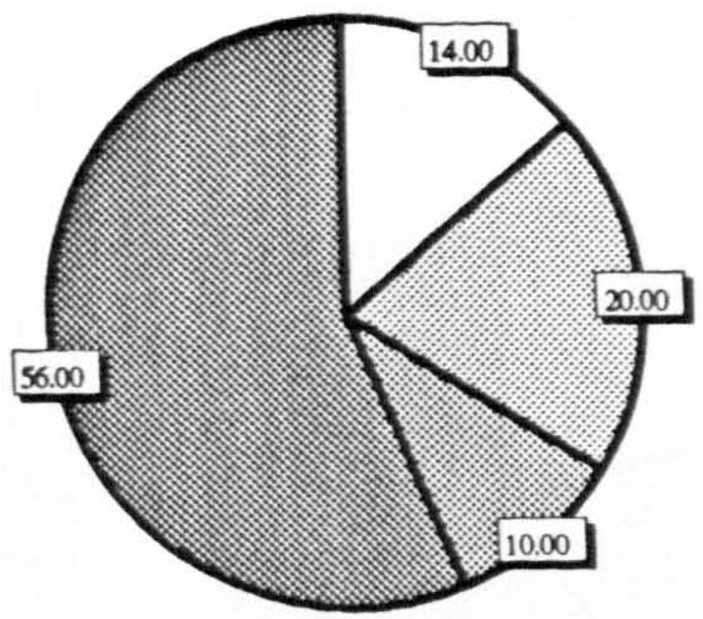


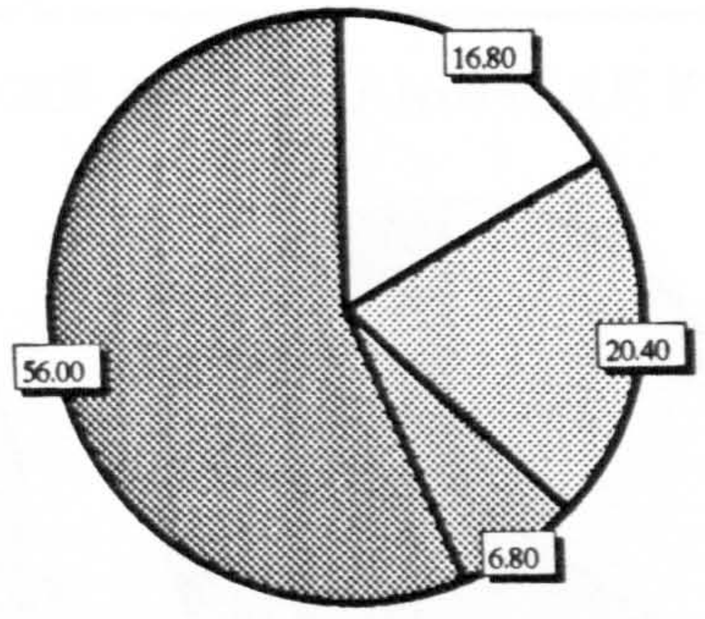
FIGURE 5.54TREE, SHRUB, HERB AND GRAMINEAE PERCENTAGES FOR LEVEL OF MAXIMUM ROMAN CLEARANCE



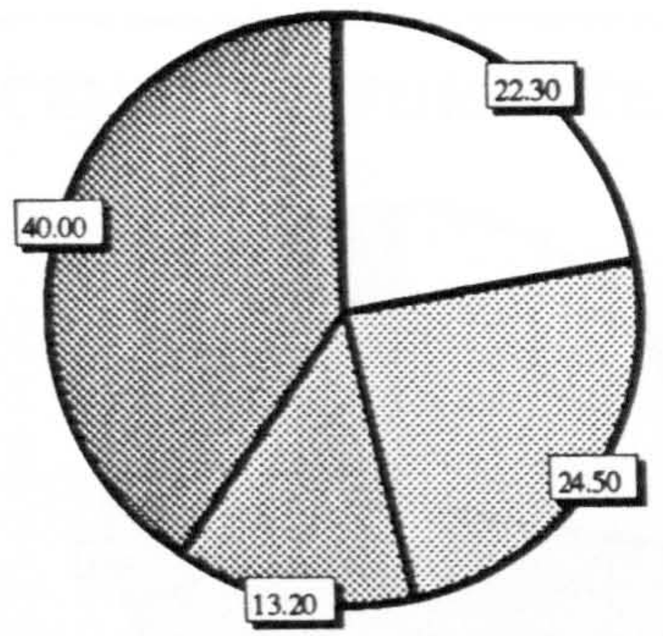
FZM
143 CM = 365 AD



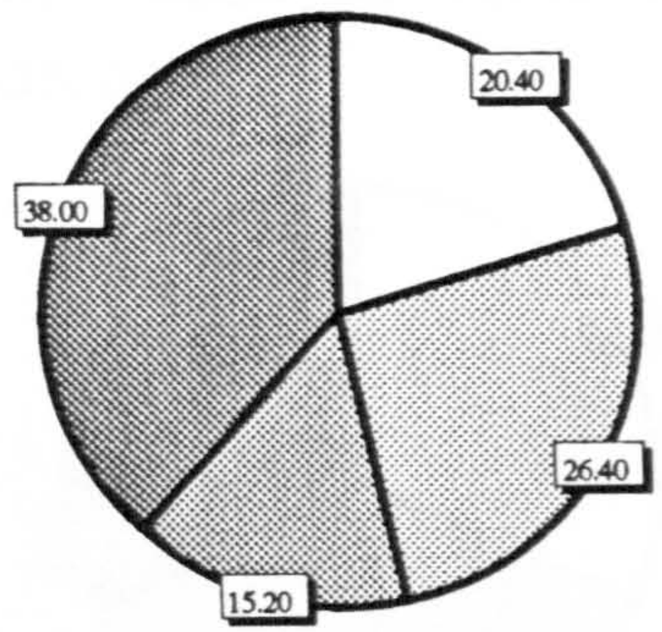
DGM
188 CM = 158 AD



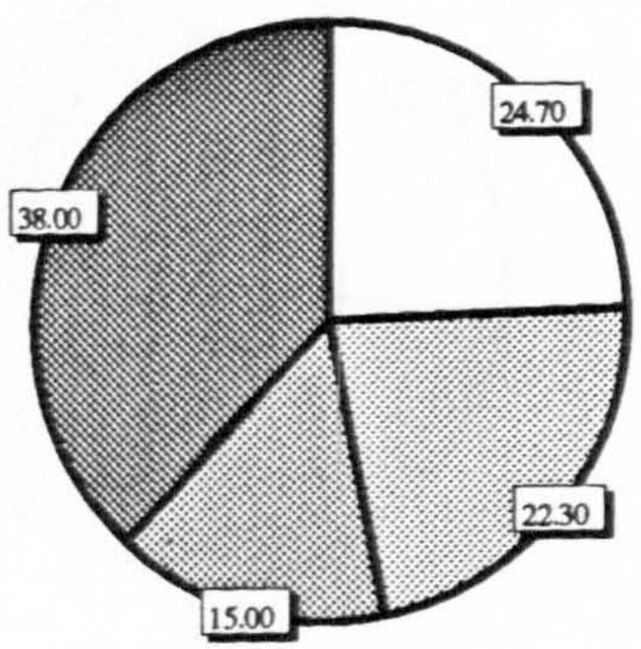
LTM
96 CM = 208 AD



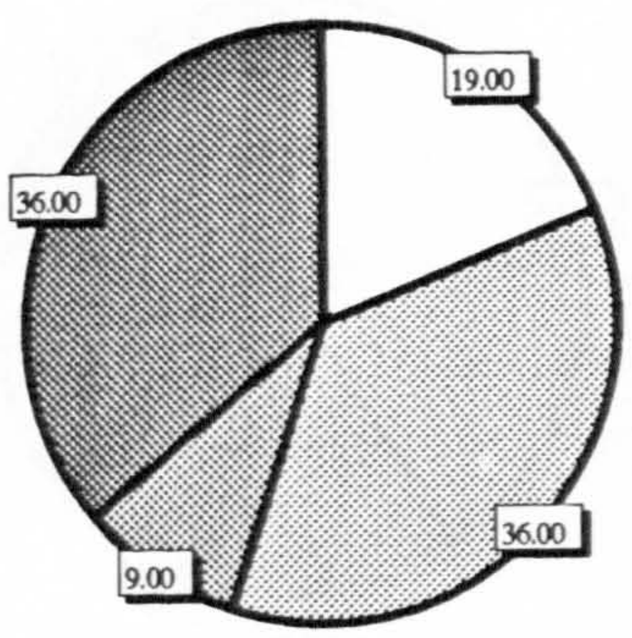
FSM
128 CM = 205 AD



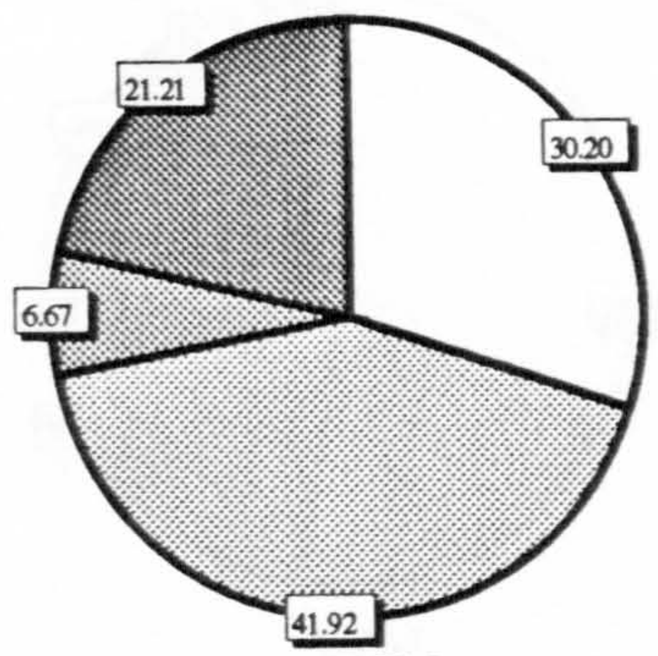
WLM
148 CM = 342 AD



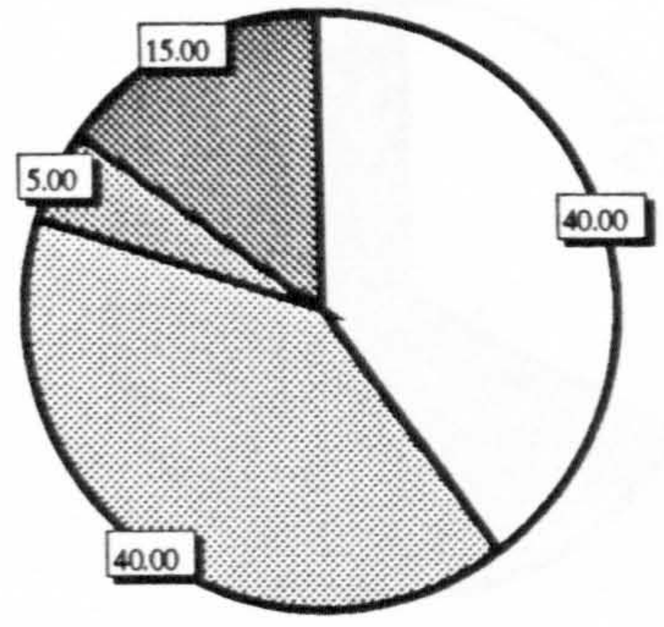
GLM
176 CM = 204 AD



CYM
120 CM = 120 AD



EGM
96 CM = 139 AD



CGM
144 CM = 199 AD

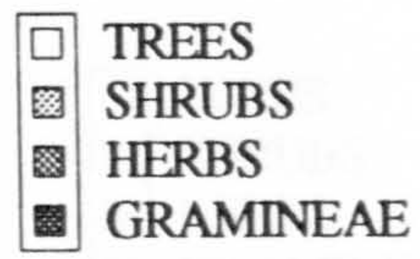
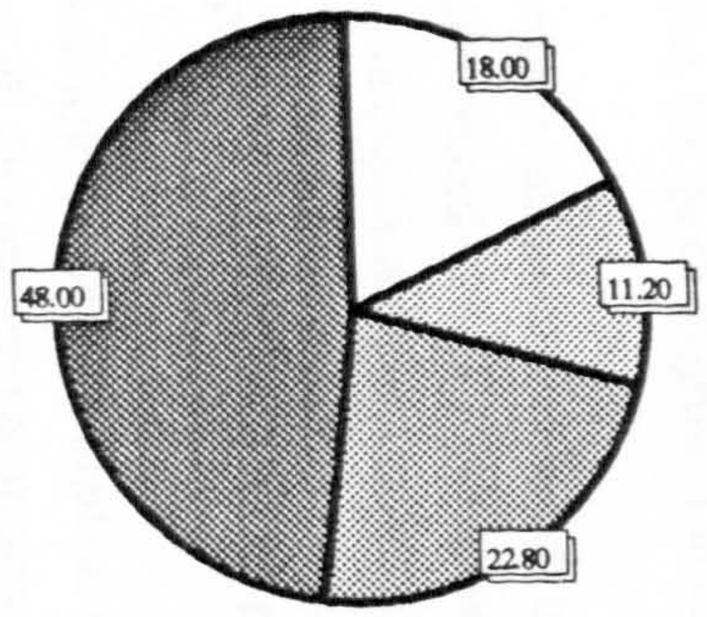
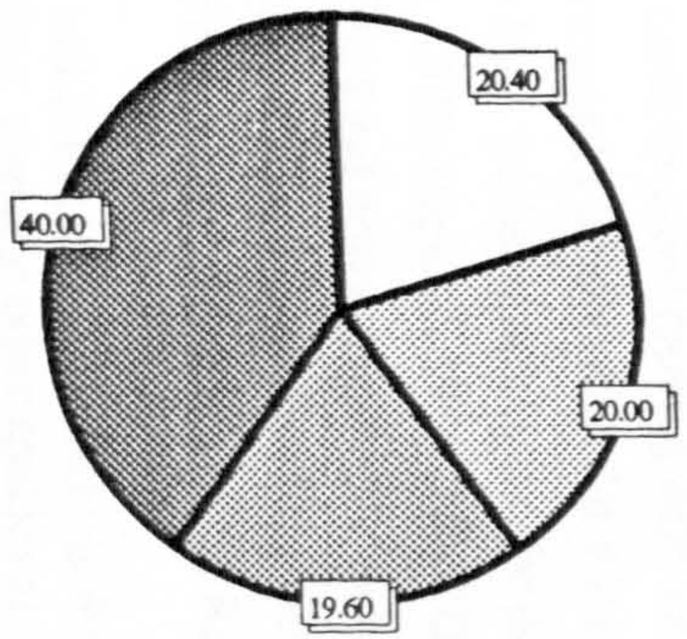


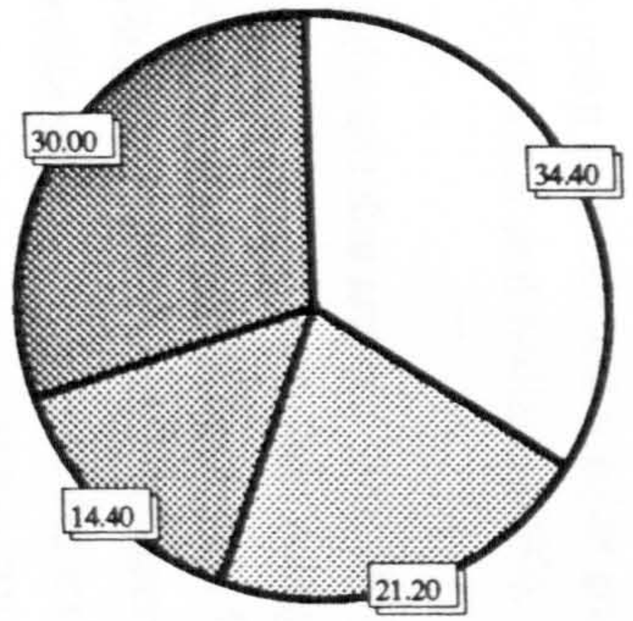
FIGURE 5.55 TREE, SHRUB, HERB AND GRAMINEAE PERCENTAGES FOR LATE IRON AGE



LTM



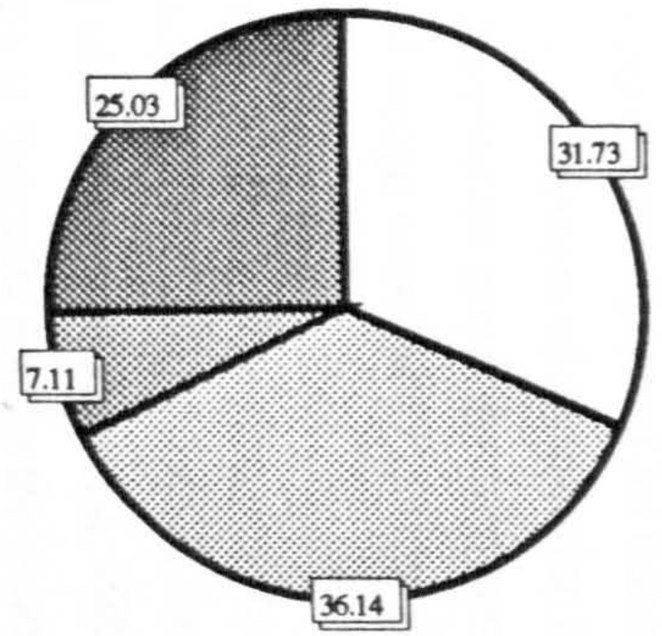
DGM



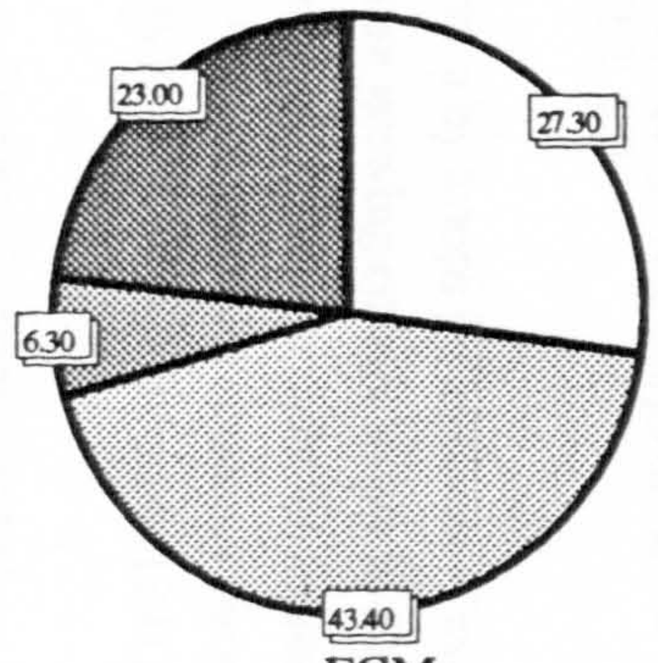
GLM



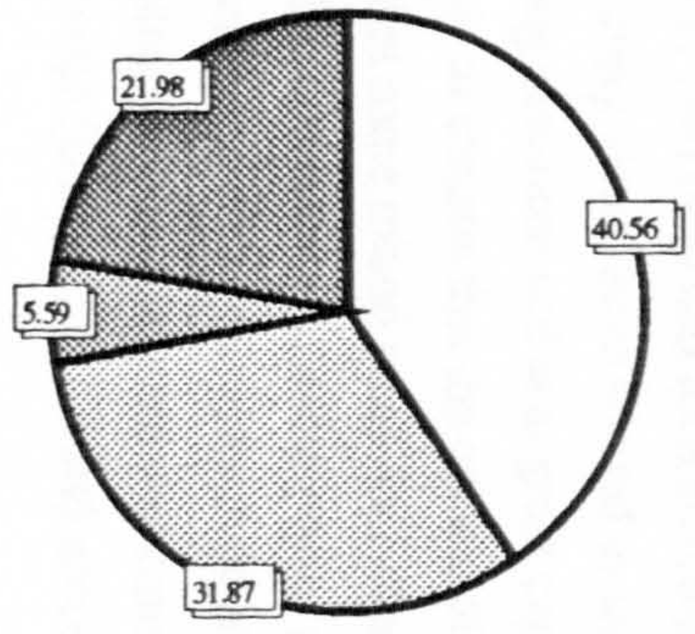
CYM



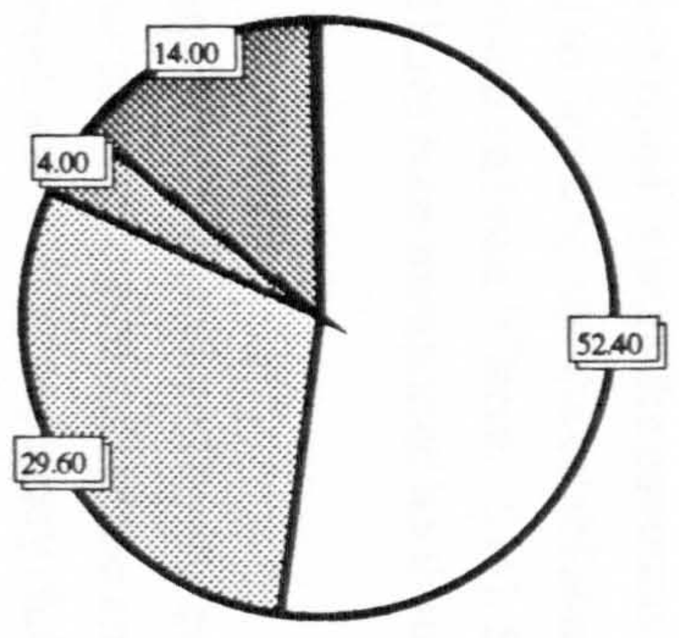
CGM



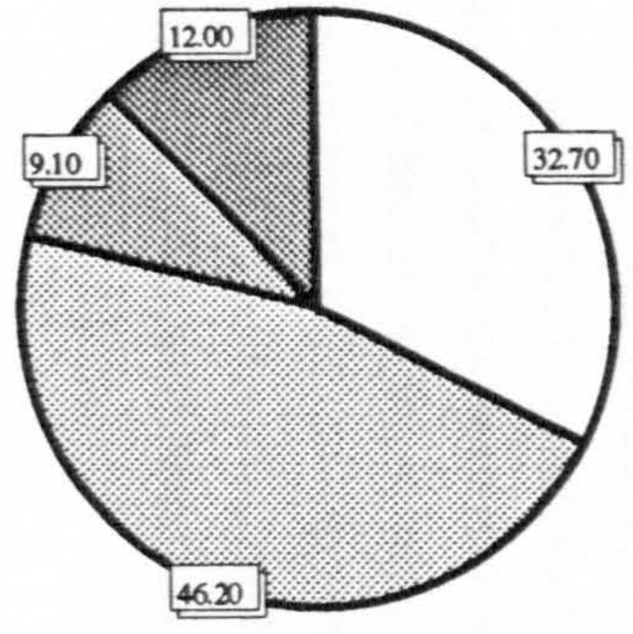
EGM



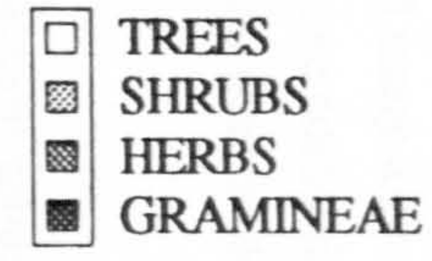
FSM



FZM



WLM



1986, 220). Rivers and coasts were important for transport of supplies and many legionary bases were located close to estuaries. An efficient system of distribution by land, although more costly than sea-borne transport, must have been used to disseminate goods from the ports. The roads, which were initially designed to facilitate the movement of troops were used (Hodder and Millett, 1990).

Local acquisition from a small group of native people would not be a long-term solution (Groenman van Waateringe, 1980) and botanical remains of exotic foodstuffs also indicate that not all food was obtained locally (Breeze, 1982, 114; Dickson and Dickson, 1988; van der Veen, 1988). The analysis of food remains from a sewage-filled ditch at Bearsden fort on the Antonine Wall confirmed that cereals and pulses eaten by the Roman army were similar to those from Germany and the rest of Britain, which in turn suggests that many plant foods were generally distributed, transported over long distances and even imported from the Mediterranean region (Dickson 1989; Dickson and Dickson 1988; Boyd 1985). Botanical evidence indicates that olives, grapes, dates, nuts, figs, mulberry, pulses, beans, peas and millet were imported (Greene, 1986, 72; Dickson and Dickson, 1988, 1989).

Food supplies could also have been imported from southern Britain. Grain for military garrisons was supplied from the closest available source and long distance movement of supplies from the continent was generally avoided (Manning, 1975). Most grain must have been shipped to Scotland and the establishment of coastal bases would have enabled supplies to be brought in from the south and east (Cleere, 1978). Southern Britain had the capacity to be a grain exporter and surplus grain could have been transported north to supply the troops (Frere, 1987, 257; Hodder and Millett, 1990).

Inscriptional evidence indicates that another possible food source was that produced by the troops on the military land which extended around each fort. A large number of men in each unit of the army was concerned with the collection or distribution of food for the troops and making necessary charges, payments or records (Higham, 1986, 216). It may not be chance that the route of Hadrian's Wall has a tendency to maximise the land of arable potential south of the wall (Higham, 1981) and that forts are concentrated in areas of good agricultural potential (Jones, 1984). The Roman army would have wanted to use good agricultural land in the north to avoid moving supplies over long distances and at at great expense. Grain is bulky and expensive to move by land and whilst it is reasonable to assume that the coastal districts were provisioned by imports from further south it may be possible that some inland areas depended on local provisioning (Manning, 1975; Higham, 1986, 221/222). The demand and purchasing power of the soldiers would have stimulated the local population to produce goods, encouraged by the growth of *vici* and good communications (Higham, 1981). The traditional Romano-centric view is that there was considerable expansion of local farming to meet the needs of the Romans troops (Garlick, 1970) and according to Tacitus:

> "the soil (of northern Britain) is fertile and can bear all produce, except the olive, vine and other species native to warmer climes. Crops are slow to ripen, but quick to grow" (in Breeze, 1982, 35).

Native production is a viable alternative to import or production by troops themselves. Two types of native farming strategy probably existed - firstly small-scale agriculture growing emmer wheat and barley and secondly, a more extensive regime representing intensification of agriculture to meet the increased demand (van der Veen, 1991). Tacitus indicates that grain was extracted from the local economy through taxation or in return for cash and prestige goods (Jones, 1984; Finberg, 1972, 108; Allason-Jones, 1991).

Pollen evidence allows an assessment to be made as to whether food was imported or derived from the local area and indicates that at all sites analysed no massive increase in agricultural production occurred during the

Roman period and that in some instances agricultural indicators actually cease or decline. This suggests that no large-scale increase in agricultural production occurred to meet the requirements of the Roman troops and grain must have been imported from the continent or southern Britain. This along with the botanical evidence for exotic goods, foreign beetles and foreign seed remains, provides evidence for import. Despite the fact that no significant overall increase in agriculture occurred in northern Britain agricultural indicators in the pollen diagrams do continue throughout the Roman period. At some sites (e.g. Dogden Moss and Letham Moss) agricultural indicators do increase. This provides evidence for some local agricultural production, though whether production was undertaken by natives or civilians around the *vici* cannot be determined. It seems that a combination of both imports, native and civilian supplies were used to provision the troops and it could be envisaged that the relative proportion of these differed over time. The pollen evidence for a decrease in agriculture during the invasion period might suggest that imports were more important during the invasion period, as a secure local source could not be guaranteed. As the native tribes were conquered and subjected to Roman rule and administration, taxation in kind might have supplemented the imports as implied by a slight increase in agriculture at Letham and Dogden Mosses. During the peaceful conditions of the Third Century A.D. and as the *vici* grew, food might have been derived from this source. It is also the case that the palynological results might not reflect agricultural production accurately. The poor pollen dispersal abilities of herbs, the relatively large size of the mires and the fact that the mires studied are not immediately adjacent to *vici* or forts would lead to under-representation of the agricultural record in the pollen diagram.

5.7.13 The Effect Of The Roman Withdrawal From Northern Britain On Agriculture.

At all sites except for Walton Moss a break in agricultural production occurs during the time when the Roman troops were withdrawn from northern Britain. This is shown by a decline in Gramineae and a reduction or the disappearance of agricultural indicators. In contrast at Walton Moss Gramineae and *Plantago* spp. continue to increase and agricultural indicators remain at relatively high levels until A.D. 570. This indicates that throughout the period of troop withdrawal, pastoral and arable agriculture continued undisturbed. This could be because agricultural production in this area was dominated by the native or civilian population, who were not affected by the Roman withdrawal.

The break in agriculture at the time of the Roman withdrawal at all sites except for Walton Moss suggests that the agricultural economy and production depended on and was sustained by the presence of the Roman troops. This evidence for agricultural decline might suggest that the Roman were supplied from the local area and that production fell with the reduction in military demand. Alternatively some destruction of field systems and settlements could have been undertaken as the Romans withdrew. The archaeological evidence for this is tenuous and the pollen evidence indicates a gradual decline, consequent with the gradual withdrawal of troops.

5.7.14 Conclusion.

At the time of the Roman invasion of northern Britain the palynological evidence demonstrates that forest regeneration occurred at all sites except for Dogden and Letham Mosses and the archaeological literature suggests that this was probably a result of land abandonment by natives as the Romans raided and plundered their settlements and agricultural systems in an attempt to gain control of tribal territories.

At all sites except for Fozy Moss an Iron Age clearance predates the Roman clearance and at all sites palynological evidence of renewed clearance occurs during the time of the Roman occupation. The radiocarbon dates and archaeological evidence suggests that clearance was probably initiated by the military demand for

timber especially for the construction of the walls and forts. After this initial military clearance, an open landscape was probably maintained and sustained by settlement and agriculture practised by both the Roman civilians and native populations. Clearance can generally be related to distance of the site from Roman archaeological structures though prehistoric and environmental factors are important in determining the size and nature of clearance.

5.8 Vegetation Change During Celtic, Anglo-Saxon And Scandinavian Times *c.* A.D. 410 - A.D. 1070.

This phase encompasses the post-Roman, Celtic, Anglo-Saxon and Scandinavian times and archaeological evidence for this period is sparse. Little artefactual evidence exists and knowledge of the area has been derived from documentary sources such as the writings of Bede and Gildas, place name evidence, monastic settlement and burial evidence (Clack and Gosling, 1976; Darby, 1976 a; Higham, 1986, 242). The counting interval of the pollen diagrams between the end of the Roman period and the present day has been increased to 8 cm. or 16 cm. and therefore the resolution of the pollen record much reduced.

5.8.1 Fozy Moss - Regeneration.

A phase of rapid forest regeneration occurs between *c.* A.D. 375 and A.D. 580 at Fozy Moss ($FZMd_2$). Arboreal pollen increases rapidly whilst Gramineae and other herbs decline, though indicators of both pastoral and arable land uses occur and *Triticum* type and *Cannabis* type are present. *Cannabis* type indicates that retting of hemp to extract fibre could have been undertaken in the area (Godwin, 1967; Bradshaw and Coxon, 1981; Whittington and Edwards, 1989). Regeneration was probably initiated by the Roman withdrawal and the following period of political instability in which the Britons formed themselves into new political groups ruled by kings (Cramp, 1983). The British kingdom of Bernicia emerged in Northumbria as a result of the union of Northumbria, Durham and Tyne and Wear, and this created a strong dynasty and powerful resource base (Higham, 1986, 253).

This regeneration is followed by a period of virtually stable forest cover between approximately A.D. 580 and A.D. 800 though there are some signs of renewed clearance (FZMe) and renewed agriculture is suggested by the presence of *Secale cereale* and *Triticum* type. Substantial rises in *Plantago* spp. and Rosaceae suggest that pastoralism was the dominant land use in the area. This palynological evidence can be explained by the fact that this was a particularly turbulent time in Northumbrian history and during the reign of Aethelfrith (A.D. 593-617), the two Anglian kingdoms of Bernicia and Deira were welded together to form the powerful kingdom of Northumbria (Rollinson, 1978, 30; Arnold, 1988). Edwin seized the throne from Aethelfrith in A.D. 617 and dynastic conflicts led to war. Crises between A.D. 603 to A.D. 685 led to the wasting of much of Northumbria and around A.D. 634 a series of battles took place at Hexham, only 12 km. from Fozy Moss. However, from A.D. 685 a period of political stability occurred (Higham, 1986, 261) followed by renewed conflict from A.D. 698 when the Picts, Scots and Britons seized their independence from the English. In the Eight Century A.D. Northumbria emerged as a weak kingdom, devoid of the flow of patronage and booty available, it was forced back onto the indigenous resource base (Higham, 1986, 286).

The renewed clearance and agriculture towards the end of the phase was probably a result of the establishment of the church and foundation of monastic communities associated with the spread of Christianity. St. Wilfred founded a monastery in Hexham and such monasteries became recipients of considerable tracts of land as the Northumbrian crown disposed of estates. Such land was used for agriculture especially pastoralism (Higham, 1986, 286).

Renewed clearance occurs at Fozy Moss between *c.* A.D. 800 and A.D. 1085 and despite increased clearance *Plantago* spp. and Rosaceae decline, perhaps indicating over-grazing or an increase in the proportion of arable land. Clearance can be attributed to the extension of the agricultural activities of the monasteries and although secular power survived into the Ninth and Tenth Centuries., by A.D. 900 the church had accumulated vast estates which were intensively farmed. Outside of the church, officials also became successors to Royal resources and became responsible for royal burghs (Higham, 1986, 291). By the mid Ninth Century A.D. Northumbrian society was organised via a hierarchical structure with a small elite until A.D. 793 when Viking invasions initiated a period of widespread raiding, joined by Danish fleets in A.D. 830. The first kingdom to collapse was Northumbria in A.D. 869 but this had little effect on the vegetation in the Fozy Moss area as raiding was concentrated around the coast (Higham, 1986, 294). The Scandinavians controlled Northumbria becoming the major land holders and ploughing much land. Settlement became nucleated (Higham, 1986, 306; Jones, 1990) resulting in increased clearance. The area then faced further disruption at the hands of the Scandinavian armies in the Tenth Century A.D., but between A.D. 921 and A.D. 954 the influence of the Saxon monarchy grew dramatically, ousted the Norse influence and established their own tenure on the Northumbrian throne until the Norman conquest of the area around A.D. 1070 (Higham, 1986, 307).

5.8.2 Walton Moss And Glasson Moss - Clearance And Regeneration.

At Walton Moss clearance continued from *c.* A.D. 420 to A.D. 570 (latter part of $WLMe_2$). Woodland cover declined as Gramineae and other herbs increased, suggesting continued arable and pastoral land uses. This is followed by regeneration beginning *c.* A.D. 570 (first part of WLMf). Meanwhile, at Glasson Moss between approximately A.D. 405 and A.D. 635 (latter part of GLMd) a period of relatively stable forest occurs though there are some fluctuations in forest cover and a slight regeneration towards the end of this period. Few herbs and no cereals are present.

Clearance at Walton Moss was probably due to continuity of settlement in the area after the Roman withdrawal as discussed in Sections 5.7.1 and 5.7.11 and accords well with the results from Bolton Fell Moss (Barber, 1981, 114). However, regeneration at Glasson Moss and later regeneration at Walton Moss may be attributable to the fact that after the break down in Roman control, the area was subject to famine and frequent raids for cattle and slaves by the Picts and Scots until the mid Fifth Century A.D. (Higham, 1986, 245; Jones, 1990). Political circumstances made it a matter of great urgency that leadership should evolve to deal with the raiders and consequently tyrant leaders and kings emerged (Higham, 1986, 250). Sometime in the Fifth Century A.D. a British kingdom called Rheged became established in the north-west, encompassing the Eden valley and Solway plain, but following the death of king Urien at the end of the fifth century it became subservient to the kingdom of Strathclyde (Rollinson, 1978, 28). Civil war was endemic and raiding of neighbouring territories was the only way of obtaining access to resources. No break in this pattern occurred until the late Sixth Century when a new political geography began to emerge (Higham, 1986, 253).

Forest regeneration followed by a period of stability occurred until *c.* A.D. 955 at Walton Moss (WLMf), although the presence of *Triticum* type and *Secale cereale* along with other indicators of arable agriculture suggest that tillage was practised and Compositae lig. and tub. and *Filipendula* provide evidence for pastoralism. Retting of hemp could be indicated by the occurrence of *Cannabis* type (Bradshaw and Coxon, 1981). At Glasson Moss clearance occurred between around A.D. 635 and A.D. 675 and then regeneration until *c.* A.D. 890 (GLMe and f) and this seems to be a period of subdued agricultural activity.

Documentary sources point to outbreaks of plagues between the mid Sixth and the Eighth Centuries

(Higham, 1986, 245) and a drop in population is associated with the extension of Northumbrian control into the area, perhaps explaining the regeneration. By the Seventh Century A.D., most of Cumbria was in the hands of the kingdom of Northumbria, the Anglians entered the area and settled in the fertile areas on the Cumbrian plain (Rollinson, 1978, 30). After the collapse of the Northumbrian estate in A.D. 876, the area was exposed to attack by its neighbours and numerous church dedications to St. Mungo reflect the extension of ecclesiastical jurisdiction from Glasgow (Higham and Jones, 1985, 132), though evidence for monastic sites is scarce and probably only two monasteries were founded - Bewcastle and Carlisle - both associated with St. Ninian (Cramp, 1983; Higham and Jones, 1985, 127).

Regeneration between *c.* A.D. 955 and A.D. 1220 at Walton Moss and renewed clearance at Glasson Moss between *c.* A.D. 890 and A.D. 1235 (GLMg) can be related to the historical evidence. After the demise of the Cumbrian Royal house in the Eleventh Century A.D., the Solway basin was incorporated into the Scottish kingdom and Cumbrian culture declined as the cultural orbit of the Irish Sea Scandinavians expanded. Viking raids from Ireland are not documented until A.D. 900 and these raids could account for the regeneration at Walton Moss. Continued clearance at Glasson Moss may be due to the fact that Scandinavians settled around the coasts, from which they pushed into underutilised and marginal lands (Darby, 1976 a, 20). The Scandinavians controlled grazing land, but throughout the era of immigration, the English villagers continued to occupy their settlements. By the Tenth Century A.D., immigration into Cumbria had ceased though the increased population led to pressure on resources and as a result, friction between communities occurred (Rollinson, 1978, 30; Higham, 1986, 306). In 1092 the Scots were in a position to extend their territory into Cumbria but this being recognised by the Norman rulers, William II came to Carlisle fixing his kingdom's northern boundary along the Solway shore (Clack and Gosling, 1976).

5.8.3 Dogden Moss - Gradual Forest Clearance.

At Dogden Moss a period of very gradual forest clearance occurred between around A.D. 450 and A.D. 690 ($DGMf_1$) and those herbs which are present suggest that both pastoral and arable agriculture took place. There is little literature pertaining to this area but after the withdrawal of the Romans it is thought that that the Votadini re-emerged as the kingdom of Gododdin (Duncan, 1978; Higham, 1986, 253) and although the area was occasionally raided by the Picts, the raids were perhaps not as frequent or intense. Settlement was less disrupted and this probably explains the clearance (Small, 1983). After A.D. 600 Gododdin was subject to Northumbrian control and was totally assimilated into Northumbria in A.D. 683 (Higham, 1986, 267).

At Dogden Moss, clearance continued and intensified between *c.* A.D. 690 and A.D. 1060 ($DGMf_2$) and *Alnus*, *Betula* and Coryloid decline to levels similar to those attained in the early Iron Age. Gramineae, *Plantago* spp. and *Rumex* spp. and other open ground indicators increase slowly with the presence of *Triticum* type and *Secale cereale*, *Cannabis* type, *Artemisia*, Campanulaceae, Caryophyllaceae, Chenopodiaceae, Compositae lig. and tub., *Succisa* and Rosaceae indicating that both arable and pastoral agriculture was practised. Clearance and increased agriculture was probably attributable to Monastic settlement and during the Eight Century A.D. when Christianity spread into the area, St. Cuthbert obtained land in the Leader-Whiteadder area near Dogden Moss (Higham, 1986, 286). The Vikings campaigned in the area between A.D. 873 and A.D. 875, but very little colonisation occurred and the St. Cuthbert community still retained their land (Higham, 1986, 306). In the late Eleventh Century. the area was controlled by the Normans under Malcom III, but on his death the natives drove out the English, Malcom III's sons turned to the English kings for assistance and an army was sent north by Rufus the result being that Edgar, son of Malcom, gained the crown. Under Edgar and his successors Norman and English settlers flocked to Scotland to gain land and property (Donaldson, 1974, 14) resulting in increased clearance.

5.8.4 Letham Moss - Gradual Forest Regeneration.

Very gradual forest regeneration occurs at Letham Moss between approximately A.D. 320 and A.D. 600 (LTMe) and this was a period of subdued agricultural activity and few herbs occur, there are no cereals although *Cannabis* type is present. Continued regeneration occurs between *c.* A.D. 600 and A.D. 825. (LTMf) and total arboreal pollen reaches levels similar to those attained in the early Iron Age. A massive decline in agricultural activity is suggested by Gramineae sinking to very low levels and the fact that virtually no other herbs occur.

The territory of Gododdin probably extended into this area and had a stronghold at Stirling (Clack and Gosling, 1976) and therefore the events outlined for Dogden Moss probably apply to this area. Though situated on the border of the Pictish kingdom of Dalradia (Kirk, 1983; Small, 1983), this area was one in which frequent conflicts took place. The Northumbrians invaded the area, culminating in the battle of Nechtan's Mere in A.D. 685 with the Picts defeating the Northumbrians and the frontier being established on the Firth of Forth (Kirk, 1983), regeneration possibly being related to these events.

Renewed clearance begins to occur at Letham Moss between *c.* A.D. 825 and A.D. 1160 (LTMg) and renewed pastoral and arable activity occurs indicated by the presence of *Secale cereale*, *Triticum* type, *Artemisia*, Caryophyllaceae, Compositae tub., Rubiaceae, *Rumex* spp., Saxifragaceae and Umbelliferae. This is perhaps related to the fact that in A.D. 844 the Irish and Picts joined forces and formed the kingdom of Alba north of the Forth and Clyde. Acquisition by Alba of English territory in south eastern Scotland was a result of aggression and the acquisition was consolidated in A.D. 1018 (Donaldson, 1974, 14).

5.8.5 Fannyside Muir - Regeneration And Clearance.

At Fannyside Muir regeneration is followed by a period of forest stability between around A.D. 475 and A.D. 860 (FSMh) and this can be related to the historical evidence. After the departure of the Romans, the area was frequently invaded by the Picts and a period of local trouble and strife occurred (Millar, 1968). The area was then incorporated into the tribal lands of the Damnii and frequent conflicts with other tribes occurred, explaining the subdued forest clearance and agricultural activity (Ogilvie, 1950, 38).

Between *c.* A.D. 860 and A.D. 1160 (FSMi) a small sudden clearance occurs, followed by a period of forest regeneration and the presence of *Triticum* type, *Secale cereale*, Chenopodiaceae, Labiatae, Compositae lig. and tub., *Rumex* spp., Ranunculaceae and Umbelliferae suggests that both pastoral and arable agriculture was practised. The clearance is probably a result of Norman settlement on estates in areas which had previously been trouble spots and this resulted in the establishment of feudalism, increased clearance and agriculture (Millar, 1968).

5.8.6 Cranley Moss - Forest Clearance.

A period of gradual but increasing forest clearance occurred between approximately A.D. 555 and A.D. 950 (CYMh), mainly attributable to a decrease in *Betula* and *Quercus* and a small rise in Gramineae. There is some increase in *Plantago* spp. and scattered occurrences of *Triticum* type, Chenopodiaceae, Cruciferae, *Filipendula*, Papilionaceae, *Rumex* spp. and Rosaceae suggesting that both pastoral and arable agriculture continued at low levels. A marked clearance follows between *c.* A.D. 950 and A.D. 1160 (CYMi).

The greater part of central Scotland was absorbed into the Kingdom of Strathclyde which was governed by a

long-lived successful dynasty from a strong-hold on Dumbarton Rock (Stevenson, 1985, 13) and therefore this stability resulted in increased clearance. From A.D. 600, Strathclyde was subject to a period of Northumbrian rule under Aethelfrith (Higham, 1986, 261) but Northumbrian influence was withdrawn in the Eigth Century. Between A.D. 873 and A.D. 875, Scandinavians campaigned in the area although very little settlement occurred (Higham, 1986, 306). Increasing tension led to an expedition from the south against the Scots between A.D. 934 and A.D. 937 resulting in the Battle of Brunanburh. The British kings in Strathclyde allied themselves with the Norse and were harried by English kings in A.D. 945 and A.D. 1000 (Higham, 1986, 306). According to the pollen evidence, such disruption obviously did not lead to land abandonment or regeneration.

5.8.7 Carsegowan Moss And Ellergower Moss - Gradual Regeneration.

At Carsegowan Moss, between *c.* A.D. 480 and A.D. 785 (CGMf) there is a very gradual trend towards increased forest cover. There are few herbs present except for sporadic occurrences of *Artemisia*, Labiatae, Papilionaceae, *Plantago* spp. and Ranunculaceae which suggests a decline in agriculture. Between *c.* A.D. 410 and A.D. 620, forest regeneration occurs at Ellergower Moss (EGMd) and attains a level similar to that of the early Bronze Age, followed by a period in which forest remains stable. The only other herbs which occur include Chenopodiaceae, *Filipendula*, Papilionaceae, Rosaceae and *Rumex* spp. suggesting that agriculture was limited. The kingdom of Rheged extended north of the Solway (Rollinson, 1978; Higham, 1986, 253) but Millman (1975) and Small (1983) suggest that the area was at times under the control of the kingdom of Strathclyde. The period was obviously politically unstable as indicated by strongly defended settlements (Small, 1983) and the pollen evidence for regeneration. During the A.D. 600s the area came under Northumbrian control and a pastoral economy dominated (Higham, 1986, 267; Ritchie and Breeze, 1991, 29).

A period of renewed forest clearance occurs at Carsegowan Moss between *c.* A.D. 785 and A.D. 1365 (CGMg) and at Ellergower Moss a period of sustained forest clearance begins around A.D. 620, ending approximately A.D. 1105 (EGMe), and being larger than that which occurs at Carsegowan Moss. Clearance is related to increased settlement in the area and a series of early Christian settlements extend from the Rhinns of Galloway to Whithorn where St. Ninian was based (Ritchie and Ritchie, 1981, 147; Higham and Jones, 1985, 128). Scandinavian raids began in A.D. 790s (Donaldson, 1974, 14; Darby, 1976 a, 19) and during the Scandinavian period south-west Scotland filled up with Irish speaking immigrants, Norwegian settlers and British immigrants from Strathclyde. Settlement is indicated by Norse place names which are distributed throughout Wigtonshire, Kirkcudbrightshire and Dumfriesshire (Piggott, 1962; Kirk, 1983; Scott, 1983).

5.8.8 Conclusion.

The period under discussion is obviously one during which varied and contrasting patterns of vegetation change occurred both in space and time. This may reflect the politically unstable conditions and events as the area was subject to a mixture of settlement by Anglo-Saxons, Scots, Picts, Scandinavians and Normans.

5.9 Vegetation Change In Northern Britain During Medieval Times - *c.* 1070-1600s.

Clack and Gosling (1976) define the Medieval period in northern Britain on the basis of agricultural change. The period therefore begins around the time of the Norman conquest (*c.* 1070) but continues later than in southern England because of the slower uptake of agricultural improvements which did not take place until

Seventeenth and Eighteen Centuries A.D.. For much of the Medieval period in this area historical events have to be considered within a framework of complex political interaction between England and Scotland (Clack and Gosling, 1976).

5.9.1 Walton Moss And Glasson Moss - Regeneration.

As discussed in Section 5.8.2, regeneration at Walton Moss continued until around A.D. 1220 (WLMg) as Cumbria was subject to conflicting claims of sovereignty by English and Scottish kings until *c.* 1242. Then a settlement was agreed whereby the Scottish king (Alexander II) relinquished the claim to sovereignty in return for the liberty of Tynedale. Between A.D. 1060 and A.D. 1093 Malcom III invaded the area five times, the Eden valley being held by the Scots for most of this period. In 1069 William I marched north to Carlisle, removed peasants from the land and took Carlisle castle (Millman, 1975, 66; Winchester, 1987, 5). Between A.D. 1139 and A.D. 1142 the area was again in Scottish hands until A.D. 1157 when it was reannexed to England, but this was short lived and in A.D. 1173 William II invaded northern England causing widespread devastation, repeated in later invasions by Alexander II in 1215, Wallace in 1296/7 and 1315. The route taken by the Scots into northern England was along the Carlisle gap to the west of Walton Moss (Millman, 1975, 65) and beside the major invasions the period was also characterised by incessant raiding by small armed groups throughout the Fourteenth Century. Truces separated the invasions in A.D. 1317, 1347-1355, 1357-1377, 1384 and 1390-1399 but these were all short lived. Turmoil continued until A.D. 1502 when a period of peace was initiated by the marriage of Henry VII's daughter, Margaret, to James IV of Scotland but this ended in A.D. 1513 when James led the Scots into northern England. Border troubles continued until 1569 and began again after the Union of the Crowns in A.D. 1603 (Clack and Gosling, 1976). These border troubles led to settlement abandonment and the wasting of much of the area around Walton Moss and forest regeneration. This pollen evidence is not in accord with that from Bolton Fell Moss where regeneration occurred between A.D. 1190 and A.D. 1380 (Barber, 1981), thus continuing later than at Walton Moss.

At Walton Moss regeneration is followed by renewed clearance between *c.* A.D. 1220 and A.D. 1580 (WLMh) and clearance was perhaps due to the periods of truce during the A.D. 1300s and the 1500s or because the population had learnt to adjust to the insecurity. This period was that of the hey day of the Border reivers or moss troopers, thought to have been constantly raiding and feuding. However, Barber (1981) attempts to reconcile the palynological evidence for clearance and the unsettled events outlined in the historical record. Firstly, there was a definite raiding season of autumn to spring when the cattle and their owners were back from their summer sheilings in the Border hills. The most favoured time was after the cereal harvest and although there were raids at other times, the needs of producing a crop for food affected both sides of the Border. Secondly, despite the raiding, the emergence of strong clans gave some degree of permanence to agricultural settlement in the area (Barber, 1981). According to Donkin (1976) and Postan (1972) there was a doubling of population in most parts of England at this time, although the famines of A.D. 1315 and 1321 and the typhoid epidemics of A.D. 1288 and 1329 put some check on this growth. Early agricultural expansion and improvements began and the open-field or ridge and furrow system became increasingly common, where each individual farmer owned a small strip of land within a field and rough grazings extended away from the arable holdings (Winchester, 1987, 133). These were organised on an infield-outfield basis where a tract of land near the hamlet (infield) was cropped every year, the fertility maintained by the application of manure. The outfield was cultivated spasmodically and the land allowed to lie fallow for several years (Evans *et al*, 1975, 172; Taylor, 1975, 78; Cantor, 1982 b). Agricultural holdings extended onto marginal land and some soil improvement using marling and dung was introduced (Donkin, 1976; Postan, 1972, 24). Although Cumbria was a predominantly pastoral area (Emery, 1976; Hughes and Huntley, 1988) wheat was also grown (Cantor, 1982 a), technological advance took place and improvements

in tools, husbandry, fertilising, marling, manuring and liming were made (Clapperton, 1983).

The A.D. 1500s were a period during which there was a final spate of Monastic building before the dissolution which resulted in the redistribution of land into secular ownership. Manorial estates also grew and arable and pastoral farming took place in most areas on a subsistence level. Wood became the dominant material for building and field boundaries (Moorhouse, 1986). A period of expansion had begun during which woodland destruction and farm expansion became common, explaining the pollen evidence for clearance (Winchester, 1987, 51/100; Campbell, 1990). This can to some extent be related to the pollen record at Bolton Fell Moss where clearance took place between A.D. 1380 and A.D. 1640.

Clearance at Glasson Moss continued until around A.D. 1230 (GLMg) and extended between *c.* A.D. 1220 and A.D. 1445 (GLMh), probably due to the fact that the Solway plain initially escaped the troubles associated with the border raids. Scandinavian settlement continued undisrupted and clearance intensified, but despite this, defences such as pele towers were built to protect cattle and population (Clack and Gosling, 1976). Population grew and assarting (whereby land was reclaimed and brought into cultivation) began, leading to the extension of peasant agriculture (Donkin, 1976; Baker, 1976; Postan, 1972, 18). Holm Cultram monastery in Melrose possessed scattered landholdings on the Solway Plain and huge sheep walks were created (Campbell, 1990). Woodland was also destroyed as there was an increase in demand for charcoal to be used in the smelting of iron ore and for domestic uses. However, the plagues of 1348, 1360, 1362, 1369 and 1375 (Campbell, 1990) must have led to massive population decline in the north, but this is probably not recorded in the pollen diagram because of the poor counting resolution at this point.

Whilst clearance continues at Walton Moss regeneration begins at Glasson Moss continuing between approximately A.D. 1445 and A.D. 1630 (GLMi) (16 cm. counting interval), but despite the regeneration, agricultural indicators continue to occur and by this time border troubles had extended into the Solway area. Troubles associated with feuds between Scottish and English families occurred between A.D. 1569 and 1596, but resumed after the Union of the Crowns in 1603. This was settled in A.D. 1606 when large areas were laid waste by Scott of Buccleuch to break up raiding clans (Clack and Gosling, 1976). Assarting which ceased in the Fourteenth Century A.D.; population decline due to the Black Death in A.D. 1348; and bad harvests in A.D. 1315-1317, 1360s and 1380s (Postan, 1972, 35) were factors which probably contributed to clearance.

5.9.2 Fozy Moss - Regeneration.

A short period of forest regeneration indicated by an increase in arboreal pollen occurred between *c.* A.D. 1080 and A.D. 1200 at Fozy Moss (FZMg) (8 cm. counting interval), probably associated with the border troubles of this time when Northumbria was subject to similar raids as those in Cumbria. Between A.D. 1060 and A.D. 1093, when Malcom III of Scotland invaded the area, the Earl of Northumbria led a counter rebellion which failed and the Scots took a number of castles in Tynedale (Clack and Gosling, 1976). Regeneration could also possibly be due to beginning of the climatic deterioration (Parry, 1987; Winchester, 1987, 50).

Between about A.D. 1200 and A.D. 1290 a small short lived clearance occurred at Fozy Moss ($FZMh_1$). Forest clearance is indicated by a decline in *Alnus*, Coryloid and *Quercus* whilst *Betula* actually increases perhaps because the area around the mire was not affected by clearance activities. Clearance is possibly related to the fact that at this time Tynedale was in the hands of the Scots until A.D. 1291 and although some raiding did occur, this was possibly a more settled time for Northumbria (Clack and Gosling, 1976).

Meanwhile, assarting and land improvement began, manorial estates were expanded, population grew and monastic communities extended their sheep pastures (Postan, 1972, 18; Moorhouse, 1986; Campbell, 1990).

A period of forest regeneration immediately followed by a renewed clearance took place between about A.D. 1290 and A.D. 1555 ($FZMh_2$) and despite the fluctuations in arboreal pollen and Gramineae other non-arboreal species increase constantly. There are significant increases in *Triticum* type, Compositae tub., *Filipendula*, *Rumex* spp. and Saxifragaceae, but *Secale cereale*, *Artemisia*, Caryophyllaceae, Compositae lig., Cruciferae, Labiatae, Ranunculaceae and Rosaceae are also present. The initial regeneration was probably attributable to further Scottish invasions which caused widespread damage, devastation and village desertion between A.D. 1296 and A.D. 1315 and again between A.D. 1380 and 1387 (Baker, 1976; White, 1973). Regeneration could be due to Black Death in A.D. 1348 and 1361, cattle and sheep plagues in A.D. 1325-21, and harvest failures in A.D. 1315 (Cantor, 1982; Winchester, 1987, 50). The A.D. 1330 - 1500s was a time during which the area was thinly populated (Ward-Davis, 1972; Newton, 1972; MacDonald, 1976 a; Wright, 1989).The following clearance can be related to a series of truces which continued into Fifteenth and Sixteenth Centuries. Population growth and the extension of peasant open-field farming and monastic settlement also promoted clearance (Donkin, 1976; Clack and Gosling, 1976). During the Twelfth Century, motte and bailey castles were commonly built out of timber as a response to invasions and one such construction is situated on the eastern side of Fozy Moss (Clack and Gosling, 1976).

5.9.3 Dogden Moss - Regeneration.

Between *c.* A.D. 1060 and A.D. 1270 forest cover becomes almost stable at Dogden Moss (DGMg), but regeneration intensifies around A.D. 1270 and A.D. 1390 (DGMh). This is probably attributable to the border raids (Millman, 1975), the English frequently raiding this area of Scotland, advancing along the eastern valleys. In A.D. 1215 King John of England came north, laying waste and destroying land until A.D. 1217 (Clack and Gosling, 1976). Settlements were deserted and land abandoned in the Lammermuir Hills, explaining the palynological evidence for regeneration (Coull, 1983).

A prolonged phase of clearance extends between *c.* 1390 to 1675 (DGMi) and *Triticum* type, Compositae lig. and tub., *Plantago* spp. and *Rumex* spp. all increase to between 5% and 8%. *Cannabis* type occurs for the last time and other pastoral and arable indicators are frequent. *Juglans* is present, possibly introduced by the Normans. This clearance was probably a result of a period of peace initiated by the marriage of Margaret to James IV of Scotland. Although the east coast was subject to a series of raids by the English between A.D. 1542 and A.D. 1546, these did not extend inland to Dogden Moss which is situated some distance from the border line. With the Union of the Crowns in A.D 1603 a period of lasting peace and stability came to the borders. Agriculture, especially pastoralism, expanded (Donaldson, 1951; Millman, 1975, 66) and a powerful class of landowners emerged who, because of their obligation of military service, enjoyed rights and privileges. Norman lords began to penetrate Scotland and established castles and estates (Tuck, 1979). This led to increased prosperity and arable farming with assarting frequently being practised (White, 1973; Parry and Slater, 1980). A variation of ridge and furrow agriculture occurred in Scotland - run-rig. The infield near the farmstead was under perpetual cultivation but the outfield was divided into two, one part being cultivated for several years and then grassed whilst the other half was uncultivated (Cantor, 1982).

5.9.4 Letham Moss - Clearance.

As discussed in Section 5.8.4 clearance at Letham Moss was underway before A.D. 1160 and this was accelerated between approximately A.D. 1160 and A.D. 1385 (LTMh) and is attributable to Norman lords

beginning to penetrate the Forth and establishing castles and estates (Tuck, 1979). By this time much of Scotland had become a feudal state, and the Thirteenth Century was a period of peace, expansion and prosperity (Stevenson, 1985, 14). Waste was colonised and new settlements founded as population increased (Parry and Slater, 1980; Dodgshon 1980; Campbell, 1990). Medieval society in Scotland was feudal with the majority of the population legally subordinated to a dominant lordly class made up of laymen and clerics who ensured their position by controlling land. The greater barons held major fiefs which were subdivided into a number of small tenancies and tenants, who also owed tithes to the church and taxes to the crown, were exploited through serfdom rent which was often paid in kind (Campbell, 1990).

This clearance phase is followed by forest regeneration between *c.* 1385 and A.D. 1720 (LTMi) and there are few herbs, though the presence of a limited number of open ground indicators and cereals imply subdued agriculture was undertaken. There is little historical evidence pertaining to this area and the Fourteenth and Fifteenth Centuries was a period in which there were famines, poor harvests and outbreaks of the Black Death (Parry and Slater, 1980). For some parts of Scotland a period of economic adjustment followed the Union of the Crowns in 1603 and this period of regeneration could be due to economic stagnation in the area (Donaldson, 1951).

5.9.5 Fannyside Muir - Regeneration.

At Fannyside Muir regeneration, followed by a period of forest stability, occurred between around A.D. 1160 and A.D. 1410 (FSMj), the increase in Plantago spp. and Rumex spp. with the presence of *Secale cereale*, *Triticum* type, *Cannabis* type, *Artemisia*, Chenopodiaceae, Compositae tub. and lig., *Filipendula* and Labiatae indicating that practise of pastoral and arable agriculture continued. This is followed by a short clearance superseded by a period of marked regeneration between around A.D. 1410 and A.D. 1740 (FSMk) when agricultural indicators continue to occur, though more sporadically. The period was one characterised by instability (Watson, 1865) and the area was invaded by Edward III between A.D. 1329 and A.D. 1333. Throughout the Fifteenth Century family feuds between the Livingstones and Flemmings resulted in devastation of much land. Troubles continued into the 1600s as nobles became divided after the death of James V, and into the early 1700s when civil war broke out (Millar, 1968, 14-17).

5.9.6 Cranley Moss - Regeneration.

Following the period of forest clearance which continued until *c.* 1160 (CYMi) (Section 5.8.6), forest regeneration occurred at Cranley Moss between A.D. 1160 and 1300 (CYMj) and although regeneration was underway, somewhat limited agriculture continued indicated by the presence of *Triticum* type, *Artemisia*, Compositae lig., Papilionaceae, Labiatae, Rosaceae and *Rumex* spp.. There is little historical evidence relating to this area but it can be assumed that it was also affected by disturbances, border raids and the other events outlined above, causing regeneration.

A prolonged period of forest clearance occurs between approximately A.D. 1300 and A.D. 1700 (CYMk) as Gramineae rapidly increases to levels greater than those recorded in the Iron Age and other open ground indicators increase especially *Triticum* type, Compositae tub., *Plantago* spp. and *Rumex* spp.. *Secale cereale*, *Artemisia*, Compositae lig., Cruciferae, *Filipendula*, Papilionaceae and Umbelliferae occur, representing increased tillage and pastoralism. This is probably attributable to the fact that agricultural land and settlement expanded during this period and Clydesdale was intensely settled (Donaldson, 1974; Millman, 1975, 76). The Sixteenth Century A.D. was a period of settlement expansion and assarting (Parry and Slater, 1980; Dodgshon, 1980; Coull, 1983) resulting in clearance.

5.9.7 Carsegowan Moss And Ellergower Moss- Forest Clearance And Regeneration.

Forest clearance at Ellergower Moss intensifies between about A.D. 1105 and A.D. 1770 (EGMf) whilst at Carsegowan Moss, following the period of clearance which continues until *c.* A.D. 1365 (Section 5.8.7), a period of forest regeneration occurred between *c.* A.D. 1365 and A.D. 1585 (CGMh).

South-west Scotland was to some extent cut off and retained a degree of isolation from the developments elsewhere (Millman, 1975, 66), but clearance at Ellergower Moss could be due to the fact that motte and bailey castles were widely established and the monasteries expanded the extent of their sheep pastures especially at Glenluce and Dundrennan. However, parts of Galloway became troublesome areas and revolts occurred, perhaps explaining the regeneration at Carsegowan Moss (Donaldson, 1974, 20).

5.9.8 Conclusion.

This period was one in which a complex series of events occurred which were often very localised and extended over different time periods. Although many events such as the border raids and Black Death occurred over most of the north, local circumstances tended to differ. The pattern of vegetation change at the sites studied is complex, varying over space and time, and this is probably a function of more localised events.

5.10 Agricultural Improvement In Northern Britain - *c.* 1600 - 1800s.

Agricultural improvement began relatively late in northern Britain, and it was not until the Union of Parliament in A.D. 1707 that improvement diffused into Scotland and Medieval practices ceased (Blake, 1956; Millman, 1975). Numerous sources of detailed documentary evidence are available for this period but because the counting interval of the pollen diagrams was increased to 8 cm. or 16 cm., only a coarse assessment of vegetation change can be made.

5.10.1 Walton Moss And Glasson Moss - Regeneration And Clearance.

A period of forest regeneration occurs at Walton Moss between *c.* A.D. 1580 and A.D. 1840 (SRR-4529) (WLMi). Arboreal pollen increases and Gramineae, *Plantago* spp. and *Pteridium* decline. After a slight decrease, *Triticum* type rises again and *Secale cereale*, *Artemisia*, Caryophyllaceae, Compositae lig., Compositae tub., Ranunculaceae, Rosaceae, Saxifragaceae and *Cannabis* type occur suggesting that agriculture continued. At Glasson Moss regeneration also continues until *c.* A.D.1630 (GLMi). This compares to a shorter revertence followed by clearance at Bolton Fell Moss (Barber, 1981, 114).

Before A.D. 1750 there was very little agricultural change or improvement and Medieval open-field systems continued to exist. Crop rotations remained unchanged and it was impossible to improve stock through breeding because of the general run of impoverished beasts and disease (Rowe, 1972). At this time the mountainous districts were open, with cultivable areas existing as a mixture of enclosure and commons (Bailey and Culley, 1794). Enclosure was slowly introduced and in A.D. 1742 an Enclosure Award for Walton Parish (Carlisle Public Records Office) led the beginning of enclosure, though regeneration at Walton Moss does not seem to have ceased. Regeneration was also stimulated by poor harvests and agricultural depression between A.D. 1820 - 1830s. Between A.D. 1763 and 1800 approximately 40,000 acres of common in Cumbria were enclosed and improved, and following the passing of the General Enclosure Act of 1801 the process was further stimulated. Under this Act common rights were extinguished and the land reapportioned among the promoters of legislation and the holders of rights on the old commons. However,

despite this, by A.D. 1800 much land still waited enclosure, wasteland in Cumbria was great and most of these areas were in a state of common. In the less elevated parts of the county there were many commons with large tracts of soil capable of being improved and although the new ideas of improvers such as Arthur Young, Cockburn, Barclay, Middleton and Silver had some impact, there were no agricultural societies which could induce and accelerate improvement (Bailey and Culley, 1794).

A phase of marked and prolonged clearance begins around A.D. 1840 (WLMk) and there is a significant increase in Gramineae and *Plantago* spp. whilst *Rumex* spp. and *Triticum* type begin to decline. Other herbs indicating arable and pastoral agriculture continue to occur. At Glasson Moss (GLMj) a period of renewed forest clearance begins *c.* 1630, somewhat earlier than at Walton Moss. Coryloid, *Alnus* and *Quercus* decline though *Betula* remains stable perhaps reflecting the rand vegetation around the mire. *Pinus*, *Fraxinus* and *Ulmus* increase; Gramineae rises rapidly and *Triticum* type continues to occur. *Plantago* spp. reach a peak around A.D. 1650 but then decline and at the same time *Cannabis* type disappears. A similar change is seen at Bolton Fell Moss (Barber, 1981, 114).

Such clearance was due to the acceleration of agricultural improvement and enclosure was stimulated by the government acts of A.D. 1836 and 1845 (Harris, 1976; Yelling, 1990). Land in Glasson parish was enclosed in 1816 (Glasson Enclosure Award, Carlisle Public Record Office) and the enclosure of such fields gave obvious advantages, allowing the improvement of stock and preventing over-grazing. Rotation also became feasible, and where the land was initially ploughed from grass a rotation of oats-oats-barley-oats was undertaken. If the land was already fallow, the rotation consisted of wheat-oats-barley-oats or turnips-barley-clover-clover-oats-oats (Bailey and Culley, 1794; Fox, 1895; Hanley *et al.*, 1936). The type of wheat grown at this time was a modern introduction into Cumbria and oats and barley were also produced. Turnips were first cultivated in A.D. 1755 and were later taken up widely (Rollinson, 1978). The increase in Gramineae and *Plantago* spp. at Walton and Glasson Mosses occurs at a time when improved grasslands were first established. These were initially confined to a small area where red clover, white clover, common hay seed, little ribbed-grass and ray-grass were planted (Fussell, 1964 a, b).

The rise in *Triticum* type, other agricultural indicators and Gramineae at Walton Moss could also be a result of the Napoleonic Wars (A.D. 1793-1815). The wars brought rising agricultural prices which along with the fear of imports being cut off and the fear of famine, meant that farmers were encouraged to produce more. The amount of wheat grown at this time increased considerably. The 'Golden Age' of British farming followed between the late A.D. 1840s and 1870s and prosperity grew (Walton, 1990; Lawton and Pooley, 1992). After the Napoleonic Wars a good deal of inferior land which had been ploughed up was left to 'tumble down' to grass and therefore pasture increased (Fox, 1895). From A.D. 1870s the price of wheat declined as cheaper grain from America was imported, resulting in a decline of arable agriculture and increased pastoralism (Lawton and Pooley, 1992, 147). This accounts for the decrease in *Triticum* type and increase in Gramineae at Walton Moss.

In 1893, the Tithe Rent charge for Walton Parish under the Acts of A.D. 1839 - 1840, were in part redeemed (Tithe Return and Award for Walton Parish, Carlisle Public Records Office; Walton, 1990) and the removal of the Tithe charges at Walton Moss and change in rotation in A.D. 1893 should have led to increased input of profit back into the land, resulting in increased output. However this did not happen because the agricultural depression, which was first felt in A.D. 1881, had deepened and reached its most acute stage in A.D. 1883. Agricultural land was abandoned and between A.D. 1874 and 1894 there was a decrease of 9.3% in the area under crops in Cumbria amounting to a 79.4% decrease in the acreage of wheat and 65.3% in the acreage of barley. The acreage of permanent pasture increased by 9.5%, green crops by 3.2% and grass and

clover by 18.8% (Fox, 1895). During the depression, the laying down of land to permanent grassland was widespread and land was allowed to either tumble down to grass or was sown with grass seed (Harris, 1976; Hall, 1976). This may explain the rise in Gramineae at Walton Moss. Signs of more favourable times were apparent from 1894-1895 (Fox, 1895) and evidence for the revival in arable agriculture found at Walton Moss from *c.* A.D. 1890-1920 is shown by an increase in *Triticum* type and herbs indicative of cultivation whilst Gramineae, *Plantago* spp. and *Rumex* spp. decrease.

By A.D. 1794 Cumbria was far from being wooded with the Irthing and Eden valleys being the only areas where any natural woodland was growing (Bailey and Culley, 1794). The Eighteenth Century A.D. was a period during which the landscape was designed on a large-scale, the landed gentry with their country seats being the main centres for design with considerable sums being spent on extending gardens and parks, woodland design and management. Avenues, belts and screens were lined with trees and income was gained from the sale of timber for pit props and ship building (Daniels and Seymour, 1990). The rise in *Pinus* and *Fagus* in the pollen diagram reflect this activity.

Thus improvements in crop husbandry included an increased range of crops available, new strains of cereals, roots, clover, grass and the introduction of market gardening. Fertilisers included manure, peat, soot, lime and sea-weed were introduced along with new implements such as seed drills, ploughs and threshers. New improved breeds and fodder crops led to advances in pastoralism. Drainage and field enlargement proceeded (Dickinson, 1850; Darby, 1976 b, 18; Harris, 1976). These improvements led to an increase in agriculture which, despite the poor resolution of the pollen diagrams, is reflected by increased clearance at Walton and Glasson Mosses.

5.10.2 Fozy Moss - Continued Clearance.

Between approximately A.D. 1550 and A.D. 1770 continued clearance occurs at Fozy Moss (FZMi) as total arboreal pollen falls to levels similar to those which occurred during the Roman period, though *Pinus* and *Ulmus* increase. Gramineae and *Plantago* spp. continue to rise and many other herbs continue to occur. *Triticum* type declines and the pollen evidence suggests a predominance of grazing. Rapid forest regeneration then follows between *c.* A.D. 1770 and 1880 (FZMk) as arboreal pollen increases. *Pinus*, *Fagus* and *Ulmus* increase *c.* 1780, somewhat earlier than at Walton Moss. Gramineae and other herbs decline suggesting that agriculture continued but at a lower intensity.

In Northumberland the parts of the county which were capable of cultivation were already well enclosed by A.D. 1800. For example, around Greenlee Lough, 5 km. west of Fozy Moss, enclosure occurred between A.D. 1749 and A.D. 1750 when stone walls were built to divide fields (Welfare, pers. comm.). Various systems of husbandry had been tried, and the boasted one of turnips, barley, clover and wheat had been pursued until soil fertility and output had declined. Land was restored by the adoption of a system made up of 3 years arable and 3 years grass with sheep, turnips and manure. The most common rotation became fallow-wheat-oats and fallow but on clayey soils fallow-wheat-clover and beans was practised (Mackenzie, 1825; Hinds, 1896; Hepple, 1976). Rye was formerly the principal grain grown, but since the use of lime, the introduction of turnips and artificial grasses, it was rarely cultivated and by A.D. 1794 wheat dominated. The proportions of arable and grass varied according to the quality of the soil but in most situations it was usual to:

> "keep a certain portion of the best and richest old grazing lands constantly in grass, as a *corps de reserve*, in case artificial grasses fail" (Bailey and Culley, 1794).

Areas of high relief were devoted solely to pastoralism (Hinds, 1896).

Clearance associated with agricultural improvement led to the demise of woodlands and Bailey and Culley (1794) record that by 1794 woods growing in a natural state were rare. Oak was felled for use in ship building and the demand by colliers and lead mines had induced the proprietors of woods to cut them at an early age (Prince 1976). Oak, elm, ash, birch, willow, alder and hazel were all felled and the general practice was to cut the wood away all together. This also explains the demise of arboreal pollen at Fozy Moss. The significant rise in *Pinus* is due to extensive coniferous plantations (Bailey and Culley, 1794; Hinds, 1896).

5.10.3 Letham Moss And Dogden Moss - Clearance.

At Letham Moss clearance begins around A.D. 1725 (LTMj) and all arboreal species decrease except for *Pinus*, *Fagus*, *Ulmus* and *Fraxinus*. Gramineae increases to levels similar to those which occurred in the Roman and Iron Age periods whilst *Triticum* typė, *Artemisia*, Chenopodiaceae, *Plantago* spp., Ranunculaceae, *Rumex* spp. and Saxifragaceae increase slightly. At Dogden Moss clearance begun before *c.* 1675 (DGMi) continued between *c.* A.D. 1675 and A.D. 1845 (DGMj). Arboreal pollen falls further and Gramineae increases. *Triticum* type, *Plantago* spp., *Rumex* spp., Caryophyllaceae, Chenopodiaceae, Compositae lig., Compositae tub., Saxifragaceae and Umbelliferae continue to occur suggesting pastoral and arable agriculture. *Pinus* begins to increase *c.*1675.

Clearance at Dogden and Letham Mosses can be related to similar advances which took place in Scottish agriculture (Edgar, 1865; Hope, 1895; Whyte, 1979, 1980; Parry, 1980) and Nimmo (1880) describes the improvements in drainage and agricultural implements that took place. Enclosure and stock improvement increased in the 1760s, 1770s and A.D. 1810, which allowed an increase in agricultural production and the extension of fields into marginal areas (Geddes, 1951). At the time of Roy's military survey of Scotland (1747-1755) the limit of cultivation was at high altitudes and extended into the head-waters of the Whiteadder river.

Between A.D. 1740s and A.D. 1830s, new crops such as legumes and turnips allowed the introduction of fallow and continuous cultivation became possible. The rotation of barley, barley, oats and peas was common in Berwickshire (Meiklejohn, 1951; Whyte, 1979). Barley dominated, though oats were more common in the uplands because of a wetter climate. The plough-up of the Napoleonic Wars led to increased amounts of land under arable cultivation suggested by increased cereals in the pollen diagrams (Stevenson, 1985; Lawton and Pooley, 1992, 39/44) and Berwickshire and Stirlingshire emerged as arable areas (Donaldson, 1966; MacGrail, 1979).

Following the end of the Napoleonic Wars in A.D. 1815 agricultural prosperity declined, rents increased, prices fell and yields were poor (Lawton and Pooley, 1992, 38), but the depression was felt less in Scotland because less land had been committed to wheat cultivation which was the principal crop affected by the depression. The price of wheat fell lower than that of oats, which was Scotland's main crop. For this reason, because Scotland's agriculture was more mixed and because Scottish farmers had been more ready to invest war time profits in land improvement, the depression was felt less in Scotland, explaining the pollen evidence for continued clearance. The English farmer was also compelled to bear the burden of high poor rates whilst in Scotland the poor were supported by the church. Scottish agriculture also recovered more quickly from the post-war depression due to the adherence to the practice of temporary leys. On the relatively poor soils of Scotland the laying down of grass for 2-3 years had become necessary to maintain the fertility of the soil (Symons, 1959, 158).

The land-owning classes dominated agriculture in the Eighteenth Century (Timperley, 1980) and legislation between A.D. 1661 and A.D. 1695 allowed landlords to sweep away open run-rig systems and to enclose land (Millman, 1975, 94; 1, Whyte, 1979, 20). By A.D. 1770 all run-rig systems had been removed in Berwickshire (Kerr, 1809; Turnock, 1982), long leases were introduced giving farmers greater security and incentive to invest in improving their land. The size of land-holdings increased and on estates, land was placed into the hands of a single tenant as land-holdings became vacant (Millman, 1975, 105).

The rise in *Pinus*, *Fagus* and *Ulmus* is a result of a series of government acts passed in Scotland to encourage tree planting. From A.D. 1457 the Scottish parliament passed acts to encourage tree planting and in A.D. 1504 an act promoting the establishment of deer parks was passed, but such planting was not taken up. Initially hardwood species were planted and conifers were introduced in A.D. 1685 (Edlin, 1969, 6; Darby, 1976 b, 27). Natural woodlands had been diminished (Lowe, 1794; Home, 1865; Jamieson, 1865), but oak, birch, elm, ash and beech were planted in the Dogden Moss area between A.D. 1503 - 1567, and in the Letham Moss area between A.D. 1792 and A.D. 1820 (Ure, 1762; Macgachen, 1865; MacGrail, 1979). Trees were planted in hedges, shelter belts or large plantations; mansions were built and gardens laid out (Geddes, 1951; Caird, 1983).

5.10.4 Fannyside Muir - Clearance.

Renewed clearance occurs from around A.D. 1740 at Fannyside Muir (FSMI) as Gramineae rises and reaches its highest level. *Plantago* spp. decline although other herbs, including cereals, increase indicating pastoral and arable agriculture and this palynological evidence for clearance can be explained by the agricultural improvements which occurred all over Scotland at this time (Section 5.10.3). A rotation of oats, turnips, potatoes, wheat, hay and pasture was commonly practised and lime was added to the soil to improve its quality (Stuart, 1793; Watson, 1865; MacPhail, 1962, 60). Land was enclosed and improved right up to the margins of the high moors (Geddes, 1951) and agricultural societies were particularly active in this part of Scotland which accelerated the dissemination of knowledge and improved agricultural methods (Ogilvie, 1950). Forest clearance was also a result of the industrial revolution during which timber was required for pit props in coal mines, ship building and glass making. Deforestation in this area was probably accelerated by its proximity to the rapidly growing industrial centre of Glasgow and to the Crammond and Carron iron works and communication was eased with the establishment of the Forth-Clyde canal (MacPhail, 1962, 69). The increase in *Pinus* and *Fraxinus* is a result of planting of hedgerows and the establishment of private plantations from 1700 onwards (Geddes, 1951; MacPhail, 1962, 59).

5.10.5 Cranley Moss - Forest Regeneration.

Clearance which began at Cranley Moss prior to *c.* 1700 (CYMk) is followed by a period of regeneration beginning around this date (CYMl) explained by the fact that in some areas of Scotland, the uncertainty associated with the Union of Parliament in A.D. 1707 restricted improvement so that the landscape was dominated by unenclosed patches of infield and outfield (Caird, 1983). Agricultural change was also interrupted by civil wars and famines (Whyte, 1980) and Roy's Military Map (1745-1755) shows that run-rig, rather than enclosure, predominated in the area (Smart, 1965).

In A.D. 1794 there was little woodland in Lanarkshire, but planting accelerated during the Nineteenth Century (Millman, 1975, 145). The rise in *Pinus* and *Ulmus* is probably due to the planting of trees on the Carstairs estate (Munro, 1865; Finlayson, 1973).

5.10.6 Carsegowan And Ellergower Mosses - Forest Clearance.

At Carsegowan Moss renewed clearance occurred between approximately A.D. 1585 and A.D. 1770 (CGMi) as arboreal pollen sinks to its lowest level and an associated increase in Gramineae and *Plantago* spp. occurs. *Triticum* type and *Rumex* spp. also increase and other pastoral and arable indicators including *Cannabis* type are common. At Ellergower Moss the clearance begun prior to *c.* A.D 1770 (EGMf) is followed by a period of forest regeneration (EGMg) dominated by a rise in *Pinus* which reaches 60%, whilst *Betula*, *Quercus*, *Alnus* and Coryloid decline. Few other herbs occur and Gramineae continues to rise before falling to level similar to that at Carsegowan Moss.

Clearance is again probably due to agricultural improvement which began late in south-west Scotland, but gradually the system of agriculture changed (Duncan, 1795). In Wigtonshire, Galloway and Dumfriesshire improved breeds, turnip cultivation and soil improvements were introduced, and farmers were under obligation to adhere to some modification of the 4-course rotations. Often special injunctions were added so that the land remained four years in pasture after the first or second years' clover or hay crop had been taken (Symons, 1959, 136). Oats, barley and wheat were commonly planted (Duncan, 1795; McLelland, 1875; Laird *et al*, 1965; Arnott, 1965) and it became relatively easy to pursue a progressive livestock improvement policy as farms were consolidated, fields enclosed and new breeds of sheep and cattle were introduced (Young, 1845; MacCreath, 1917; Gilchrist and Rowat, 1954; Laird *et al*, 1965; Blackwood and Melrose, 1977). The marked progress in Scottish agriculture continued into the 1800s and south-west Scotland evolved as a dairying area supplying the market in Glasgow (Caird, 1983; Whittington, 1983). The Levellers revolt of A.D. 1724 - a protest movement against enclosure - obviously did not lead to regeneration at either site (Charlesworth, 1983, 23).

The later regeneration at Ellergower Moss might be a result of the fact that Galloway received new ideas more slowly, of the poor harvests between A.D. 1770-1779 and of a fatal epidemic of small pox (Maitland, 1793). Roy's military map of Scotland shows the area was dominated by unimproved moor (Parry, 1980) and sizeable tracts of natural woodland still existed (Johnstone, 1865; Home, 1931; Gladstone, 1961; Millman, 1975, 105). *Pinus* plantations were established (Charlesworth, 1983, 23) and the *Pinus* rise has been radiocarbon dated at Ellergower Moss to A.D. 1835 (Clymo *et al*.. 1990).

5.10.7 Conclusion.

This period was one in which improvements in agricultural practises led to the extension of agriculture and increased clearance in most areas. These changes are well documented in the historical record, but the poor pollen counting resolution prevents a detailed reconstruction of vegetation change.

5.11 Modern *c.* 1800s -1992.

The modern period is a time during which abundant evidence for land use is available but because the pollen has not been analysed in detail only a broad assessment of vegetation change is possible. There is also the added complication that the surface layers of Letham Moss, Carsegowan Moss and Glasson Moss have been burnt in the recent past and therefore some of the pollen record must be missing.

5.11.1 Walton Moss - Regeneration.

At Walton Moss between *c.* A.D. 1930 and the present day (WLMk) forest regeneration continues due to

increased *Pinus*, *Fagus*, *Ulmus* and *Fraxinus*. Gramineae and *Plantago* spp. decline and after a small peak, *Triticum* type and *Rumex* spp. fall. Regeneration is attributable to the fact that agriculture went through a period of profound depression, and after A.D. 1920 production of food had overtaken demand and prices dropped catastrophically (Symons, 1959). Between A.D. 1914 and 1939 the area of crops and grass in Britain fell by 2.7 million acres - much of the land previously classified as permanent pasture deteriorating to rough grazing and large areas that were arable, to permanent pasture (Coppock, 1976). Estate plans and sale papers have been consulted to obtain a general view of the agriculture of the area at this time. In Walton and Lanercost parishes estate papers for A.D. 1919 and 1920 indicate the proportion of land devoted to particular uses at the time of sale and show both pastoral and arable land use (Dalton, 1914) . Similar trends are noted in Barber's (1981, 144) study of Bolton Fell Moss.

Plantations have taken over as a viable use for marginal land around Walton Moss and only 1 km. to the south of the mire a coniferous plantation has been established, explaining the continued rise in *Pinus*. The value of timber as a crop on poor land and the necessity to replenish stocks after the War was recognised, the Forestry Commission was established in A.D. 1919 and systematic planting and management of woodland began (Lawton and Pooley, 1992, 255). The further increase in *Fagus*, *Ulmus* and *Fraxinus* is due to continued hedgerow planting.

5.11.2 Glasson Moss - Clearance.

The forest clearance which began around A.D. 1630 (GLMj) continues until the present day at Glasson Moss, but the surface of the moss has been burnt several times (1952, 1956, 1976) (N.C.C., unpublished report) and part of the pollen record must be missing. Arboreal species continue to decline and there is only a slight increase in *Pinus*, *Fraxinus* and *Ulmus*. Gramineae continues to rise and *Triticum* type along with a variety of other herbs continues to occur.

The proportion of arable land relative to pasture and waste increased between A.D. 1893 and A.D. 1918 and when the First World War was declared in A.D. 1914, more land was brought into cultivation. The policy of free trade, unrestricted food imports and the rise in prices of farm produce during the war were sufficient incentives for farmers to produce all the home-grown food required (Symons, 1959, 210). The world scarcity of food and the shortage of shipping at the close of the War were so great that the need for home production continued. High production was the objective through increasing the intensity of farming or the amount of land under production.

During World War II the three-fold task of agriculture was to produce more wheat and potatoes to ease the burden on shipping; to maintain the fertility of the land; to produce sufficient health-promoting foods so that the year of maximum effort in food production might be synchronised with the time when shipping deficiencies were at the greatest (Symons, 1959, 240). Thus the area around Glasson Moss has evolved as a predominantly pastoral area (Jarvis *et al.*, 1984, 42). The increase in *Pinus* is not as large as that at Walton Moss as the area has not been afforested.

5.11.3 Fozy Moss - Regeneration.

At Fozy Moss forest regeneration occurs between *c.* A.D. 1885 and the present day, mainly being attributable to the continued rise in *Pinus* whilst Gramineae falls *c.* 1920 and then increases. The initial regeneration is probably due to the fact that the forty years before World War I were a period of agricultural depression, and poor weather and cheaper food imports contributed to the decline in agriculture (Clark 1983). The following

clearance is perhaps a result of increased production during the wars as wheat, oats and pasture came to dominate agriculture in the area (Northern Economic Planning Council, 1967; Pawson, 1961; MacDonald, 1976 c; Lawton and Pooley, 1992, 254). *Pinus* continues to increase as more plantations were established following the war-time shortage, especially after the establishment of the Forestry Commission (MacDonald, 1976 b; Hewitt, 1977).

5.11.4 Letham Moss - Clearance.

Clearance which began around A.D. 1725 (LTMj) continues until the present day, although again there is evidence that the surface peat at this site have been subject to burning and the pollen record is incomplete. All arboreal species decline except for *Pinus*, *Ulmus*, *Fagus* and *Fraxinus*, while Gramineae and other herbs increase. Clearance occurred possibly because agricultural improvements progressed in this area and agricultural incomes continued to rise - the area subsequently evolving as one of Scotland's major arable regions (Rennie, 1966; Lawton and Pooley, 1992, 254). Planting of coniferous woodlands accelerated after A.D. 1948 explaining the increase in *Pinus*, and hedgerow planting explains the increase in *Ulmus*, *Fagus* and *Fraxinus* (Rennie, 1966).

5.11.5 Fannyside Muir - Clearance.

Clearance which began in A.D. 1740 (FSMl) at Fannyside Muir continues until the present day although some regeneration occurs at the top of the pollen profile as agricultural improvement progressed in the area and land has more recently been improved by drainage (Clark, 1959). Today agriculture in the area is dominated by dairying and rough pasture. *Pinus* continues to rise and is probably a result of planting on the margins of the mire by the Forestry Commission (Clark, 1959; Edlin, 1969, 27).

5.11.6 Dogden Moss - Regeneration And Clearance.

Between *c.* 1845 and 1950 forest regeneration occurs at Dogden Moss followed by a period of clearance which extends to the present day and regeneration is possibly attributable to a decline in agriculture in some areas of Scotland at this time. Since A.D. 1918 Scotland's cropped area has shrunk from 2,099,000 acres to 1,480,000 acres and regeneration is also probably due to the pre-war and the inter-war depressions (Robson, 1990). The following clearance could be due to government policies to assist agriculture with the introduction of subsidies after World War II. Other improvements were made in machinery and capital input (Lawton and Pooley, 1992, 254). *Pinus* and hedgerow planting continued (Ragg, 1960).

5.11.7 Cranley Moss - Regeneration.

At Cranley Moss regeneration beginning in *c.* 1700 (CYMk) continues to the present day (CYMl). *Alnus*, *Quercus*, *Betula*, Coryloid and *Pinus* increase significantly, whilst there are slight rises in *Fagus* and *Ulmus*. Gramineae and other herbs decline, though are still present, suggesting that a reduced amount of pastoral and arable agriculture continued. Before World War I and during the inter-war years, depression led to a decline in agriculture. The harvest of A.D. 1916 was bad, and despite the larger acreage of oats, total production grain declined.

5.11.8 Carsegowan Moss And Ellergower Moss - Regeneration.

At Carsegowan Moss woodland regeneration occurs between *c.* A.D. 1915 and the present day, although

burning of the mire has probably resulted in part of the pollen record being lost. The increase in arboreal pollen is due to a rise in *Pinus*, whilst Gramineae declines slightly, and other herbs sink to low levels. Meanwhile, at Ellergower Moss regeneration occurs between around A.D. 1770 and the present day due to a rise in *Pinus*. Regeneration at both sites is probably attributable to the fact that agricultural improvements did not bring overwhelming financial rewards to the farmers in this area, the economic position of the industry was becoming increasingly poor, with the inter-war depression affecting the area badly (Ross, 1979; Arnott, 1965). Although some cereals have been planted, livestock raising dominates agriculture (Ross, 1979; Mather, 1983). Regeneration is also attributable to afforestation, and around Ellergower Moss this is the main industry, having accelerated since A.D. 1948 (Laird *et al*, 1965; Brooke, 1965).

5.11.9 Conclusion.

The evolution of the modern landscape at each site has been determined by a series of historical events which have either led to further development or decline of agriculture, and increased afforestation. Although detailed knowledge of such events is available, the correlation of the historical and palynological evidence is restricted by the lack of high resolution pollen counts.

5.12 Results Of Statistical Analysis.

Principal components analysis was performed for each site on all land pollen types. The results from Walton Moss, Glasson Moss, Dogden Moss, Letham Moss and Fozy Moss are displayed in Figures 5.56 to 5.60. Although 27 principal components analyses were undertaken, only a selection of the results are displayed. In each case, most variation in the scores is explained by axis one. On axis one, trees and shrubs with lower eigenvalues, are to some extent separated from the herbs which have higher eigenvalues. The spread of taxa are almost identical for each site and axis one probably represents clearance, with a gradation occurring from a tree covered landscape to one which is becoming increasingly cleared. In order to assess whether any distinct groupings of herbs could be identified within the data, principal components analysis was undertaken on non-arboreal pollen types as the plots showing arboreal pollen as well as non-arboreal pollen were too cluttered to identify any trends. The results for Fozy, Walton, Letham and Glasson Mosses are shown in Figures 5.61 to 5.64 Gramineae always appears as an outlier on axis one and this is probably because principal components analysis 'pushes' the most abundant taxa towards the edges of the plot (Ter Braak, 1988). For each site, the non-arboreal taxa show most spread along axis 2. Although *Plantago* spp., *Triticum* type and *Rumex* spp. do seem to occur at one end of the distribution with other herbs clustered towards the centre, there does not seem to be any distinct pattern identifiable within each distribution or between sites.

Principal components analysis was undertaken on non-arboreal species, excluding Gramineae, in an attempt to improve the representation of the species on the axes. The results from Walton, Fozy, Glasson and Letham Mosses are shown in Figures 5.65 to 5.68. In each case, *Plantago* spp. occupy the same position as Gramineae in the previous plots and therefore, it seems that the most abundant species are pushed towards the edge of the plot. Axis 2 seems to show some grouping of herbs. For Walton Moss and Letham Moss *Rumex* spp., followed by *Triticum* type have high eigenvalues. As the eigenvalue decreases a mixture of herbs cluster around the centre of the plot and *Plantago* spp. occur with the lowest eigenvalues. Although poorly defined, this might reflect a trend from arable herbs through to species indicating pastoralism. Such a trend might also be reflected along axis 2 for Fozy Moss and Glasson Moss, but again this is poorly defined.

As the results of principal components did not allow any clear trends to be identified and because those species which were most abundant were always pushed towards the edges of the plots, a weighted principal

components analysis was performed on all species from Walton Moss. The species were weighted equally and the results obtained were identical to those from the previous unweighted plot. Correspondence analysis was also undertaken on the herb data, excluding Gramineae, for Walton Moss to investigate how the data responded to a unimodal model (Figure 5.69). The data is spread most widely along axis one. Crop plants, *Triticum*, *Cannabis* type and *Secale cereale*, are clustered in one area whilst a grouping of Chenopodiaceae, *Artemisia*, *Centuria*, and *Urtica* indicate abandoned agricultural land. However, no really distinct grouping of herb types can be identified on either axis. It seems that no distinct ecological groupings or trends in the herb data can be identified, this restricting their value as indicators of different land uses. However, this does not restrict the value of herbs as indicators of land use. A clearer grouping of herb types might have been displayed if principal components analysis had been undertaken on smaller sections of the pollen profiles, rather than the whole profile. The ecological niches of herbs can also to some extent be established from botanical evidence (Clapham *et al.*, 1989).

FIGURE 5.56 WALTON MOSS - PCA AXIS 1 V AXIS 2 FOR ALL SPECIES.

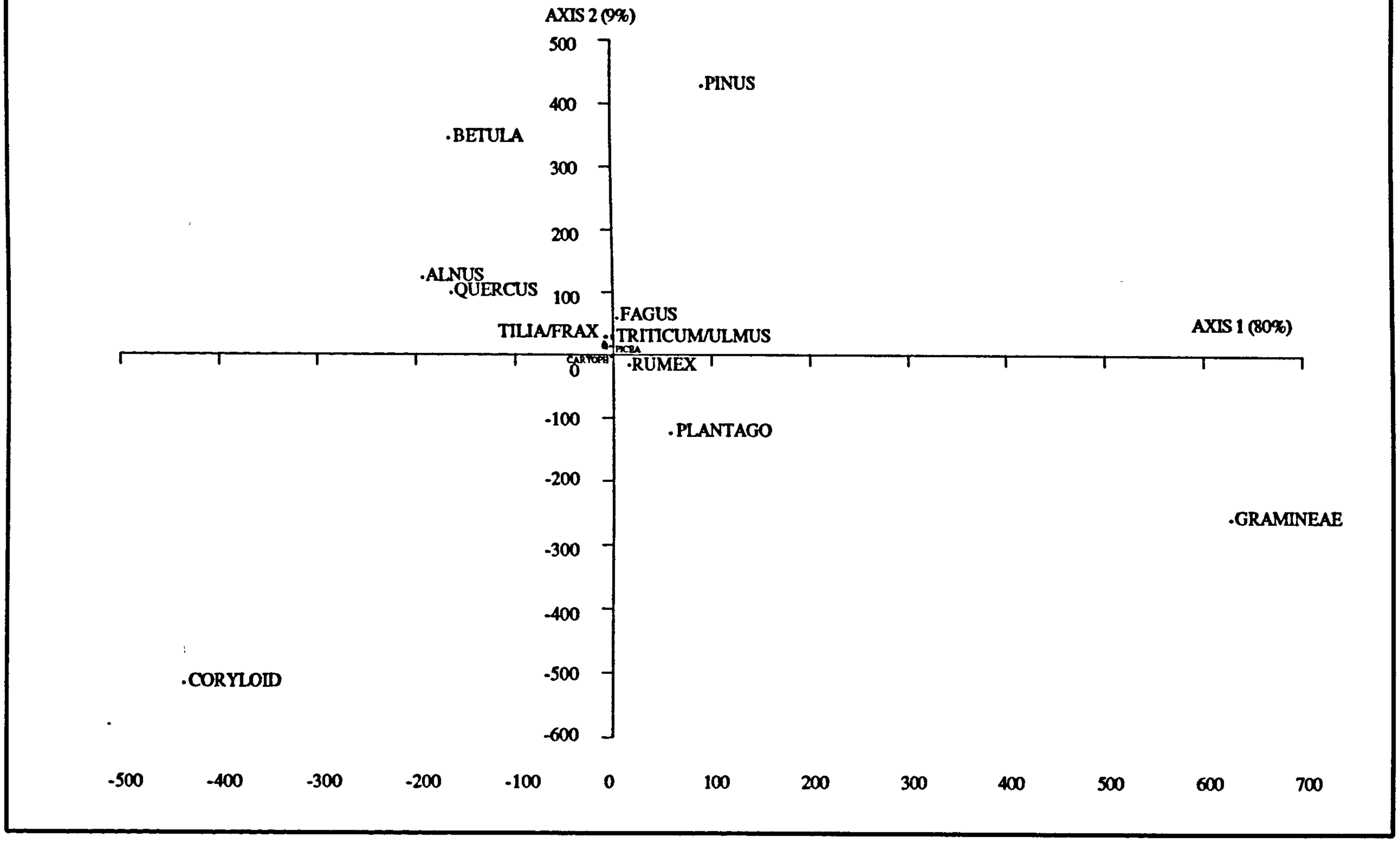


FIGURE 5.57 GLASSON MOSS - PCA SCORES FOR AXIS 1 'V' AXIS 2 FOR ALL TAXA

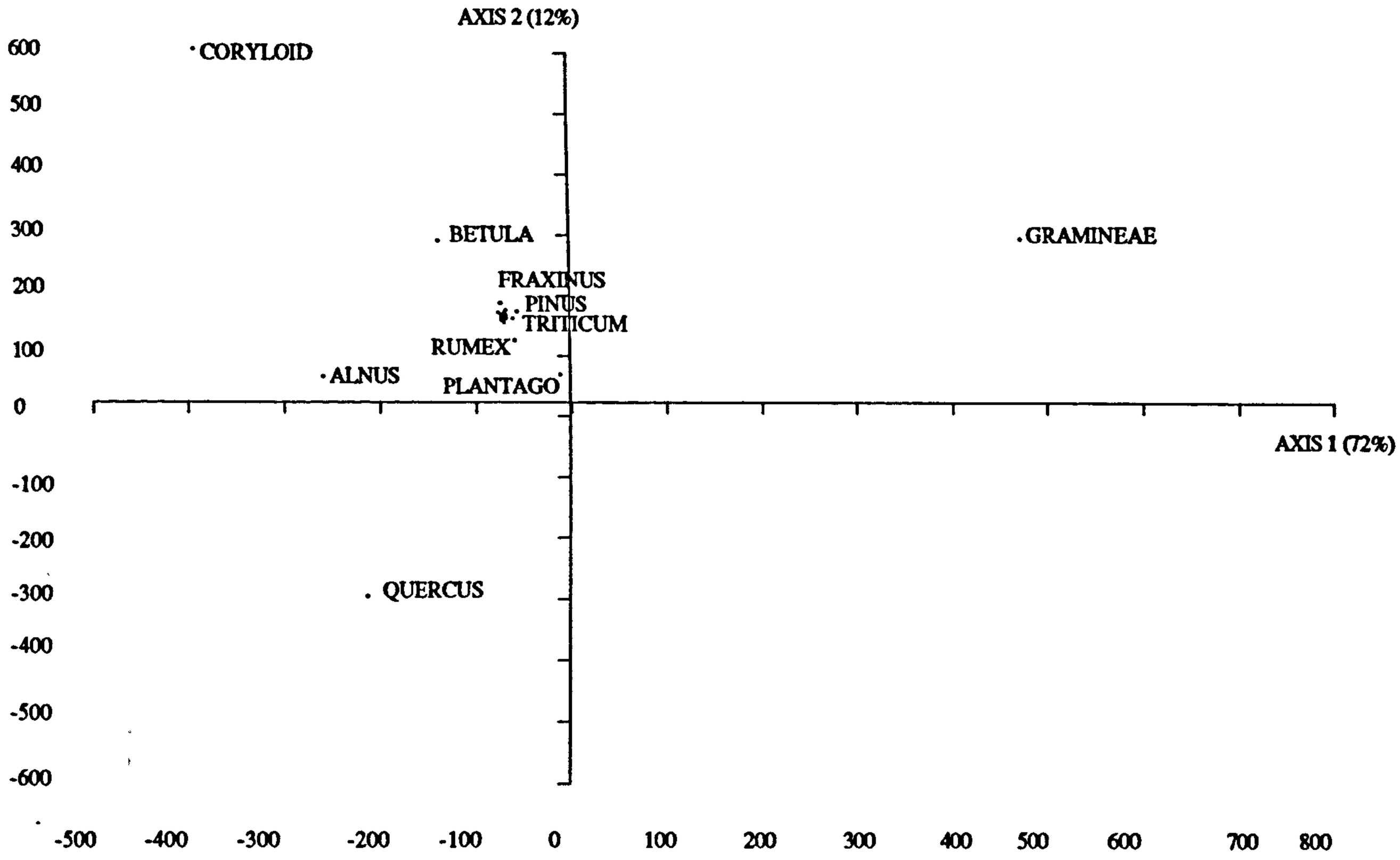


FIGURE 5.58 FOZY MOSS - PCA AXIS 1 V AXIS 2 FOR ALL SPECIES

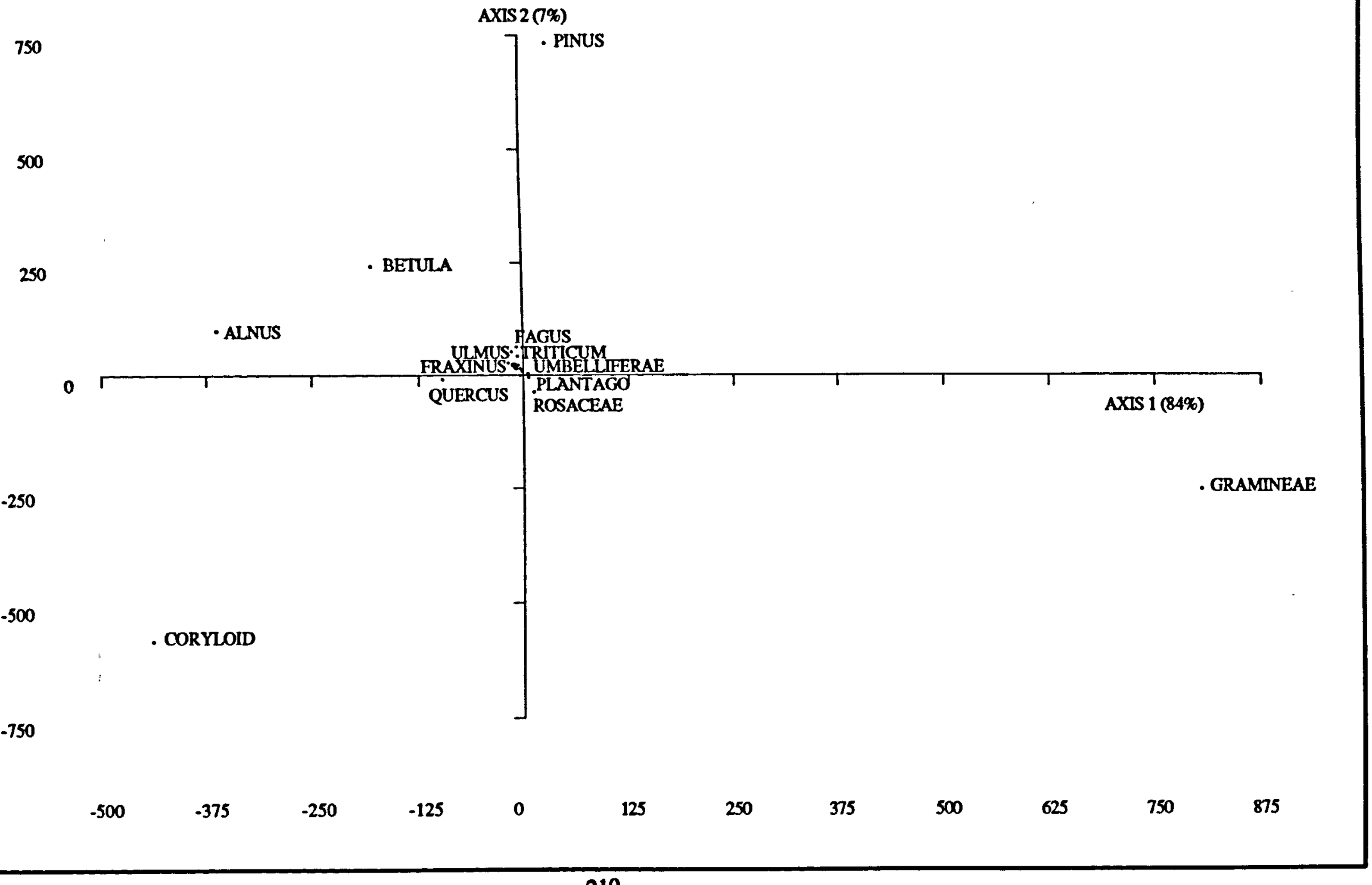


FIGURE 5.59 LETHAM MOSS - PCA SCORES AXIS 1 'V' AXIS 2 FOR ALL TAXA

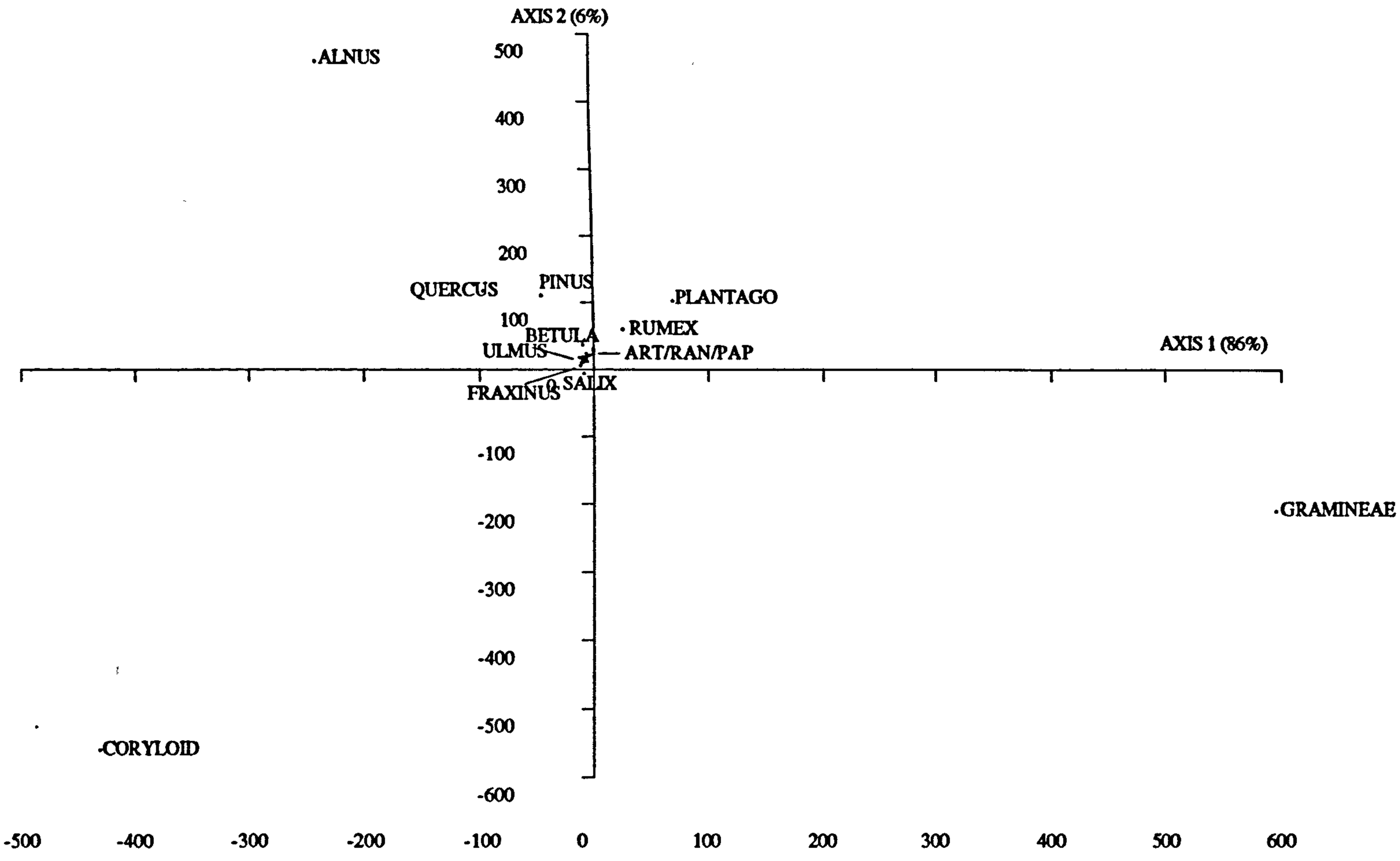


FIGURE 5.60 DOGDEN MOSS - PCA SCORES AXIS 1 'V' AXIS 2 FOR ALL TAXA

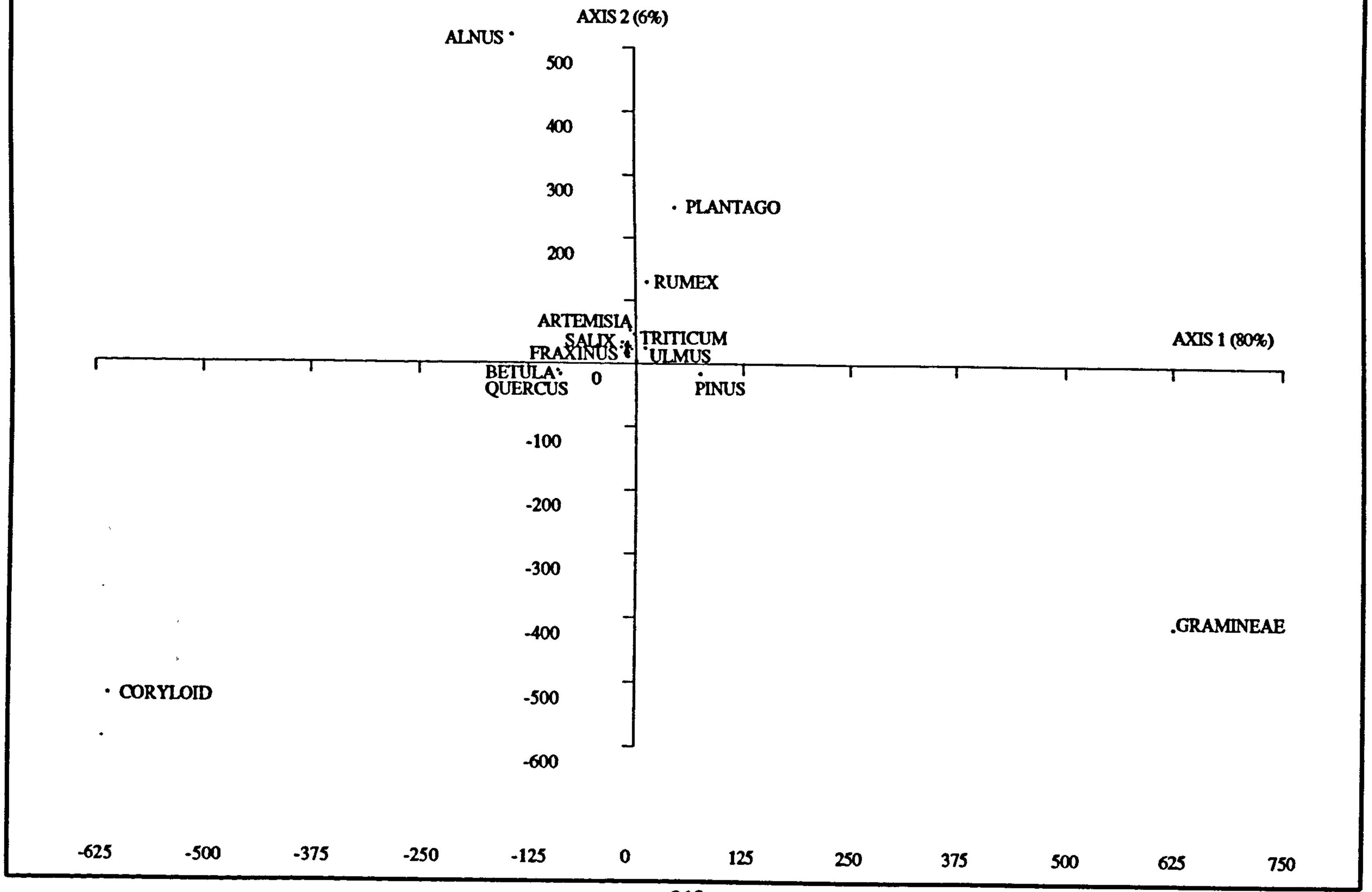


FIGURE 5.61 WALTON MOSS - PCA SCORES FOR AXIS 1 VERSUS AXIS 2 FOR HERBS INCLUDING GRAMINEAE.

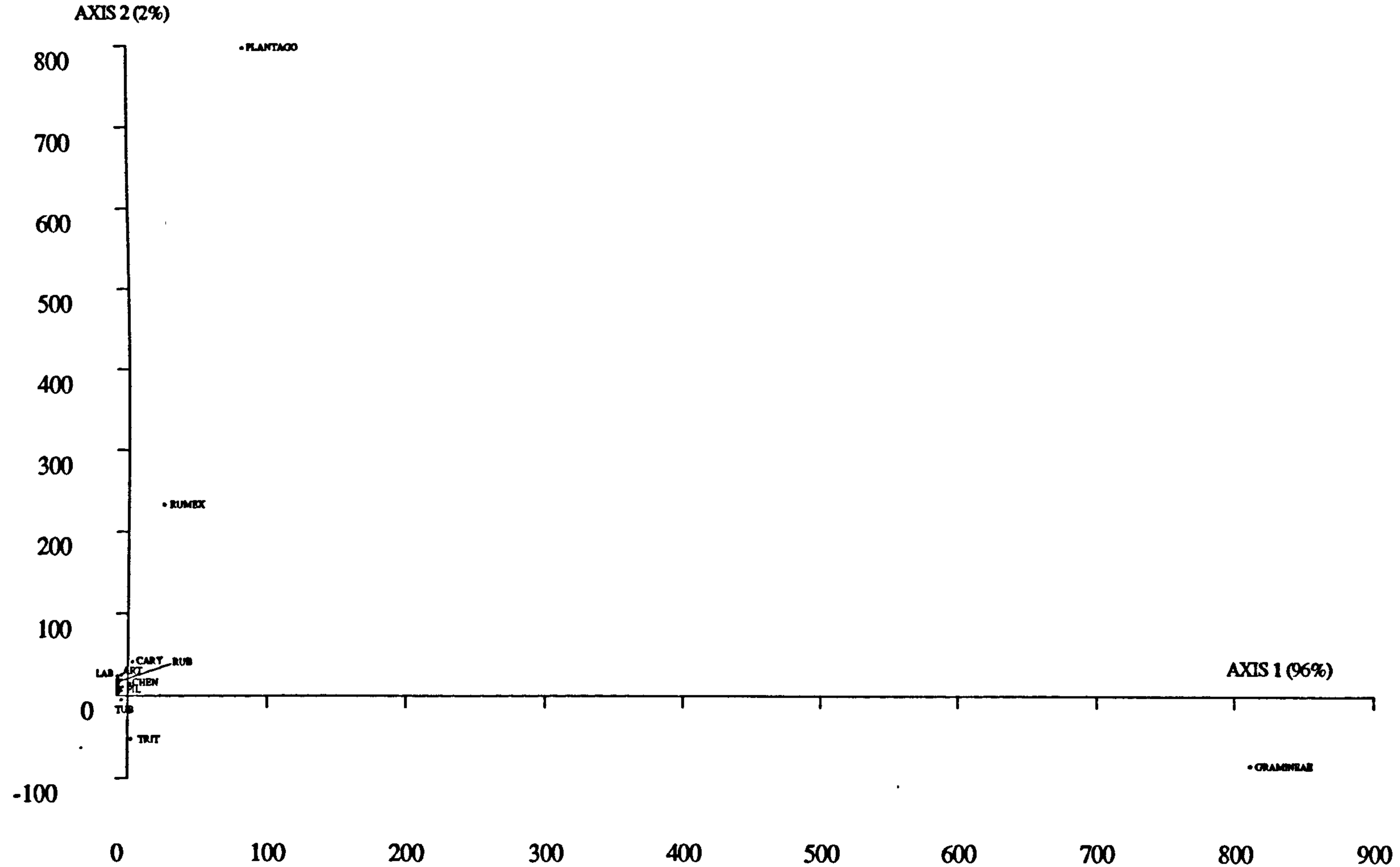


FIGURE 5.62 GLASSON MOSS - PCA SCORES AXIS 1 'V' AXIS 2 FOR HERBS INCLUDING GRAMINEAE

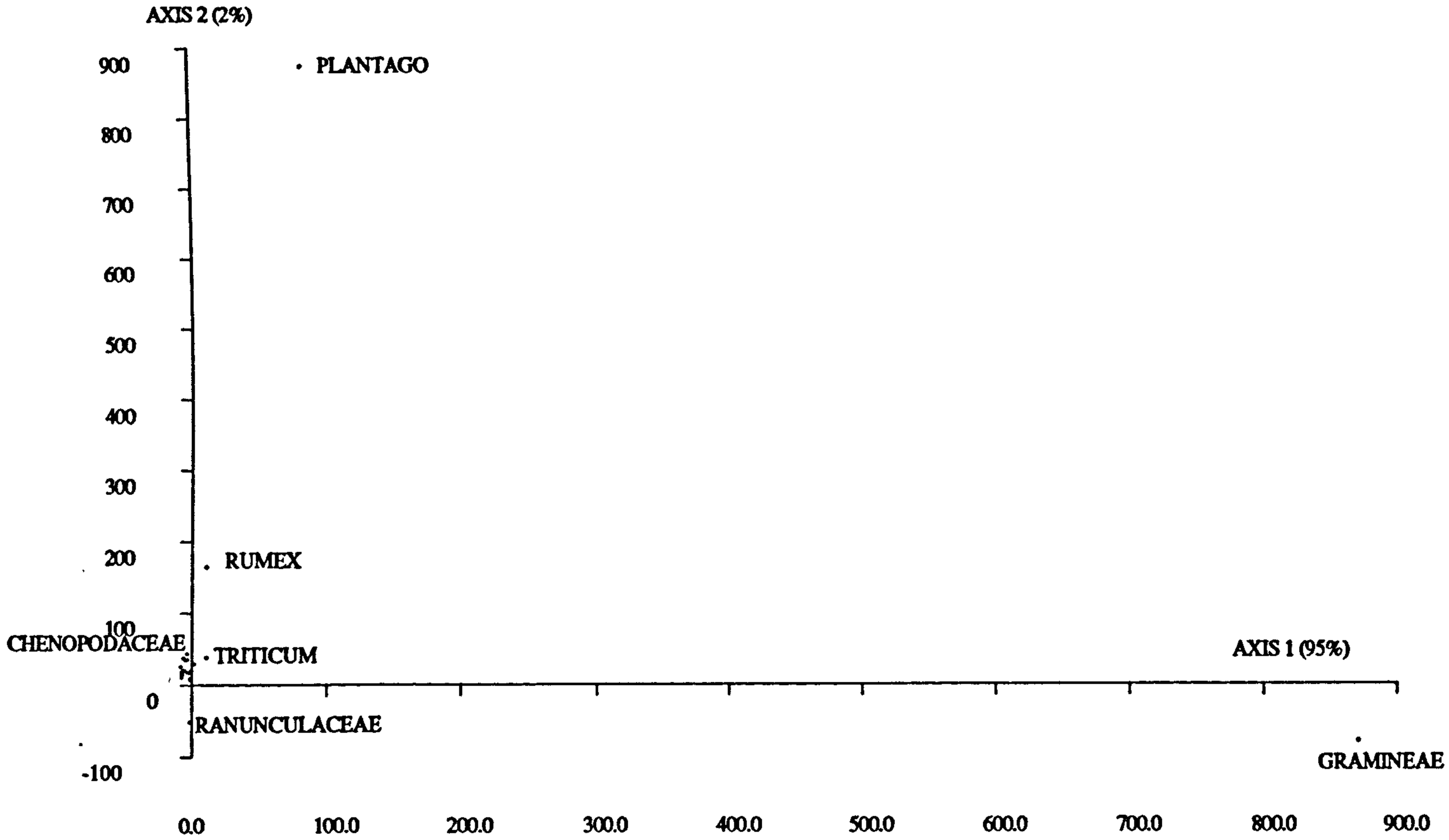


FIGURE 5.63 FOZY MOSS - PCA SCORES AXIS 1 V AXIS 2 FOR HERBS INCLUDING GRAMINEAE

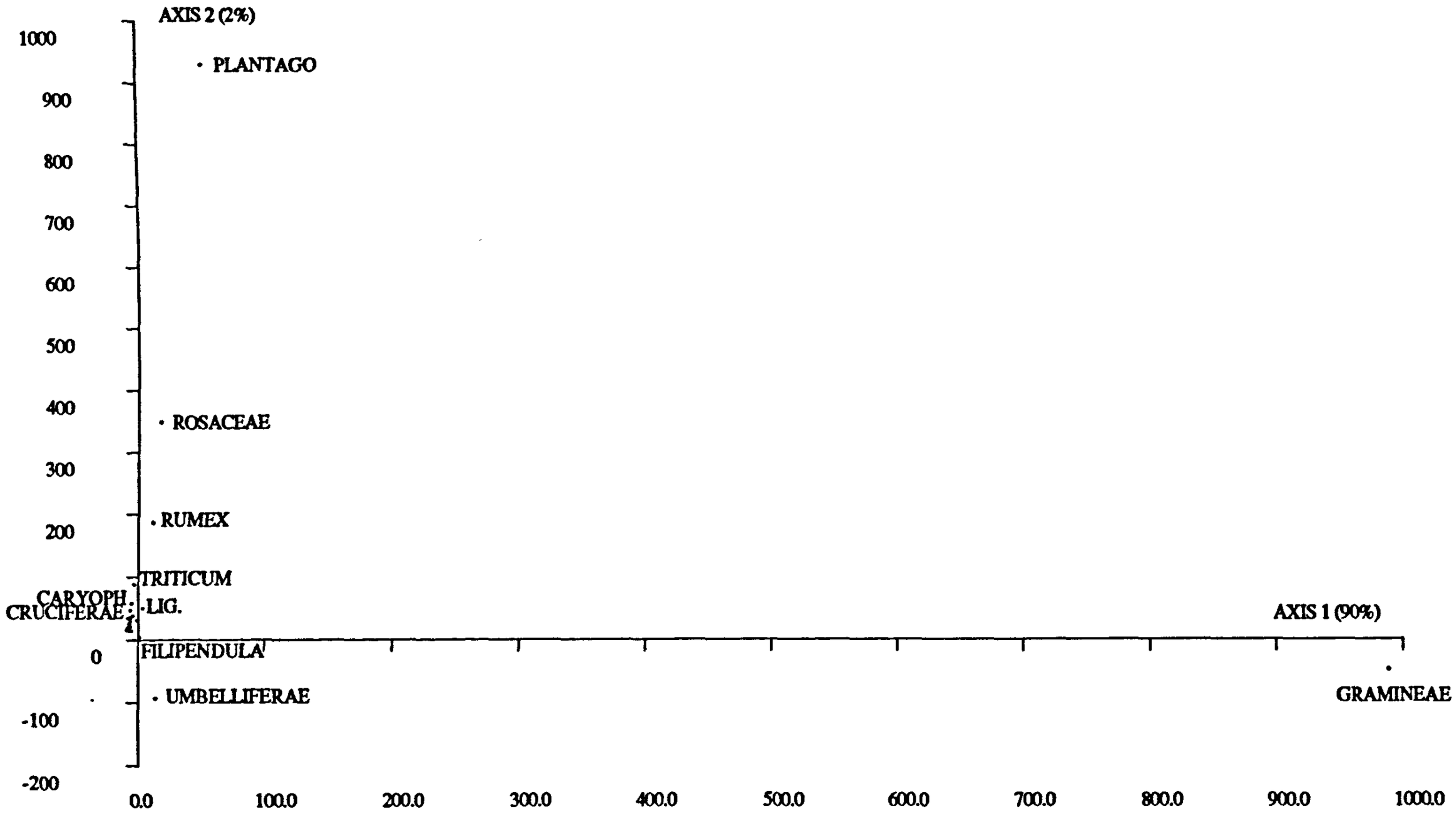


FIGURE 5.64 LETHAM MOSS - PCA SCORES FOR AXIS 1 'V' AXIS 2 FOR HERBS INCLUDING GRAMINEAE

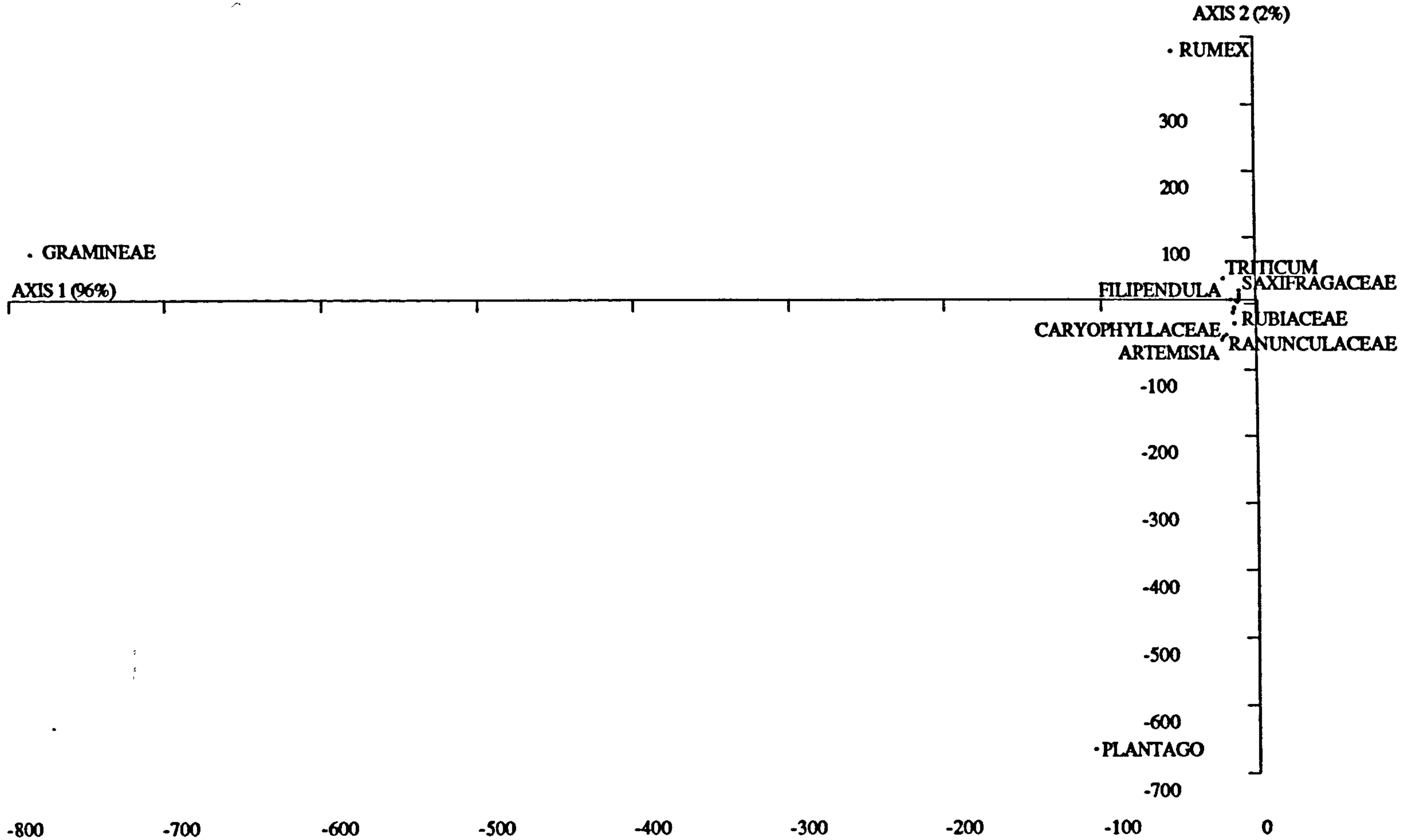


FIGURE 5.65 WALTON MOSS - PCA AXIS 1 'V' AXIS 2 FOR HERBS EXCLUDING GRAMINEAE

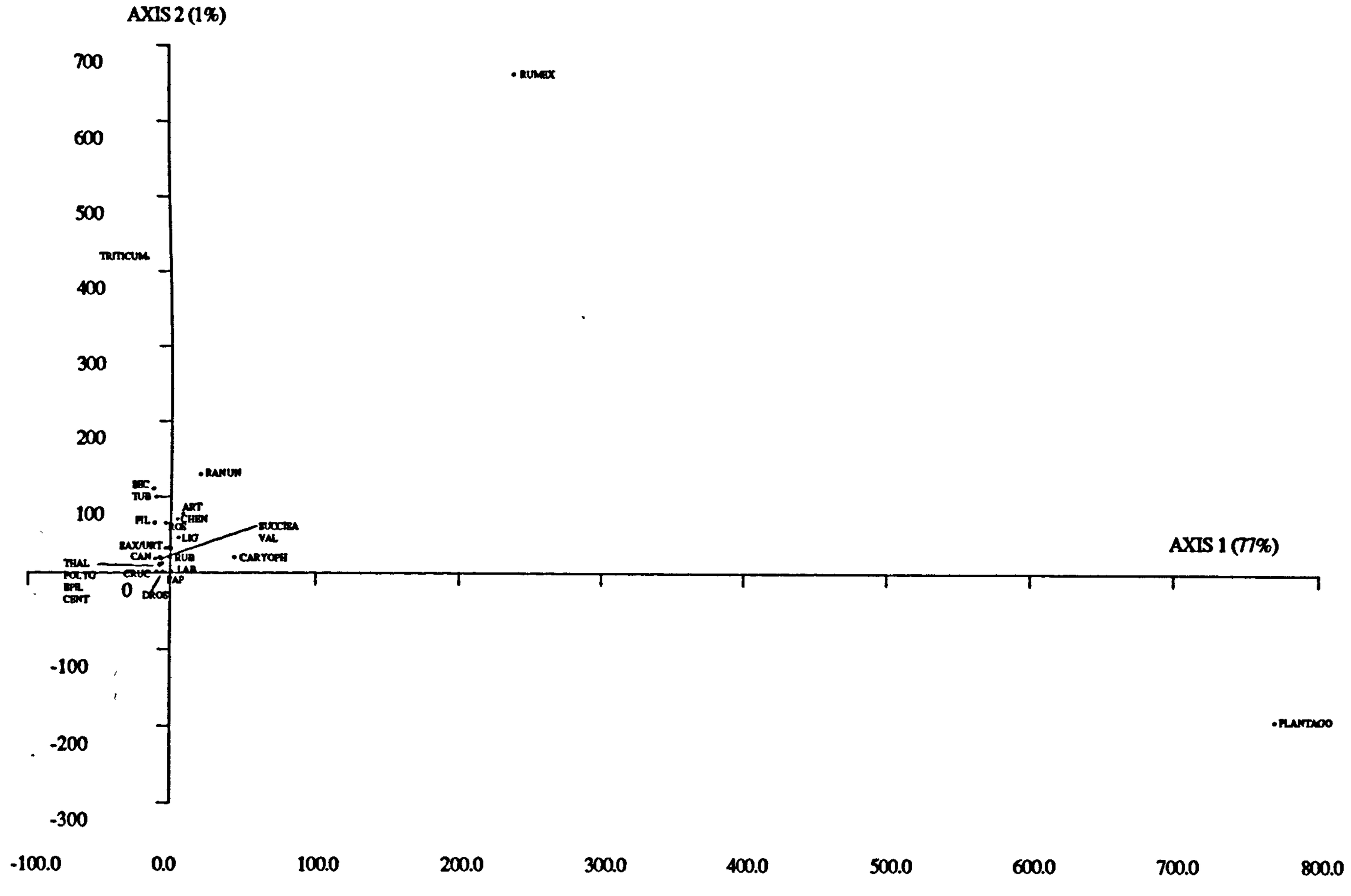


FIGURE 5.66GLASSON MOSS - PCA SCORES AXIS 1 'V' AXIS 2 FOR HERBS EXCLUDING GRAMINEAE

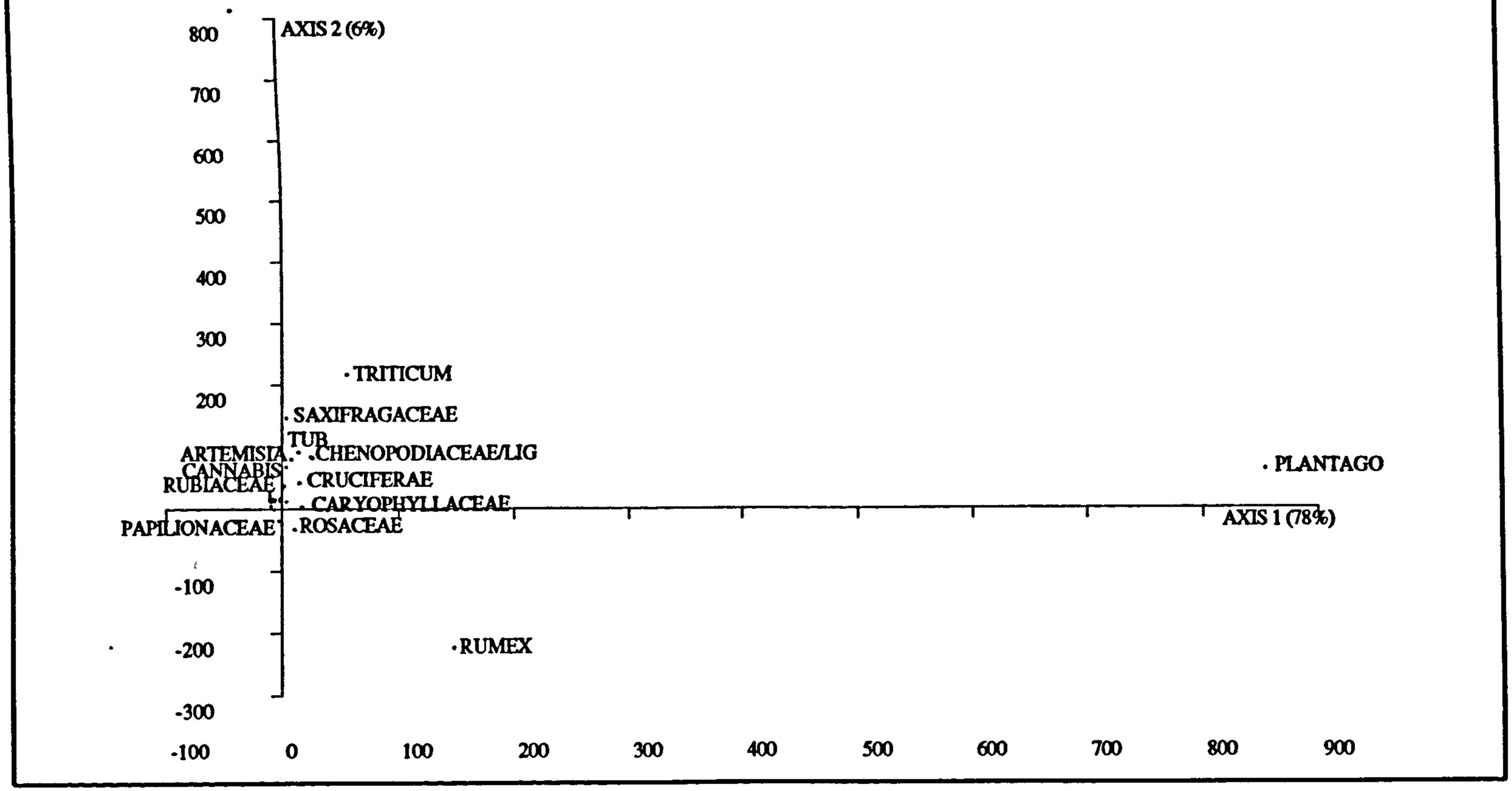


FIGURE 5.67 FOZY MOSS - PCA SCORES - AXIS 1 V AXIS 2 FOR HERBS EXCLUDING GRAMINEAE

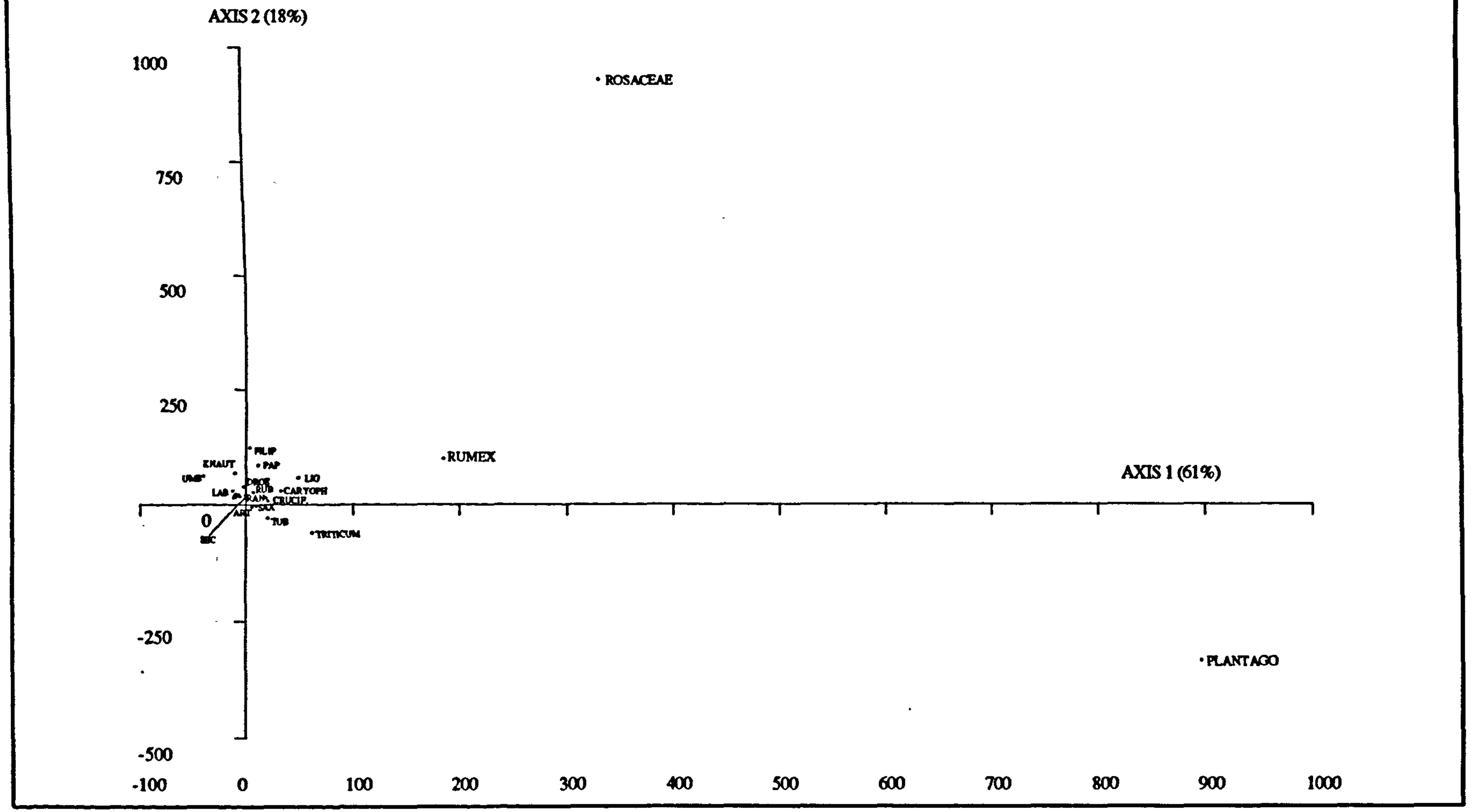


FIGURE 5.68 LETHAM MOSS - PCA SCORES FOR HERBS EXCLUDING GRAMINEAE AXIS 1 'V' AXIS 2

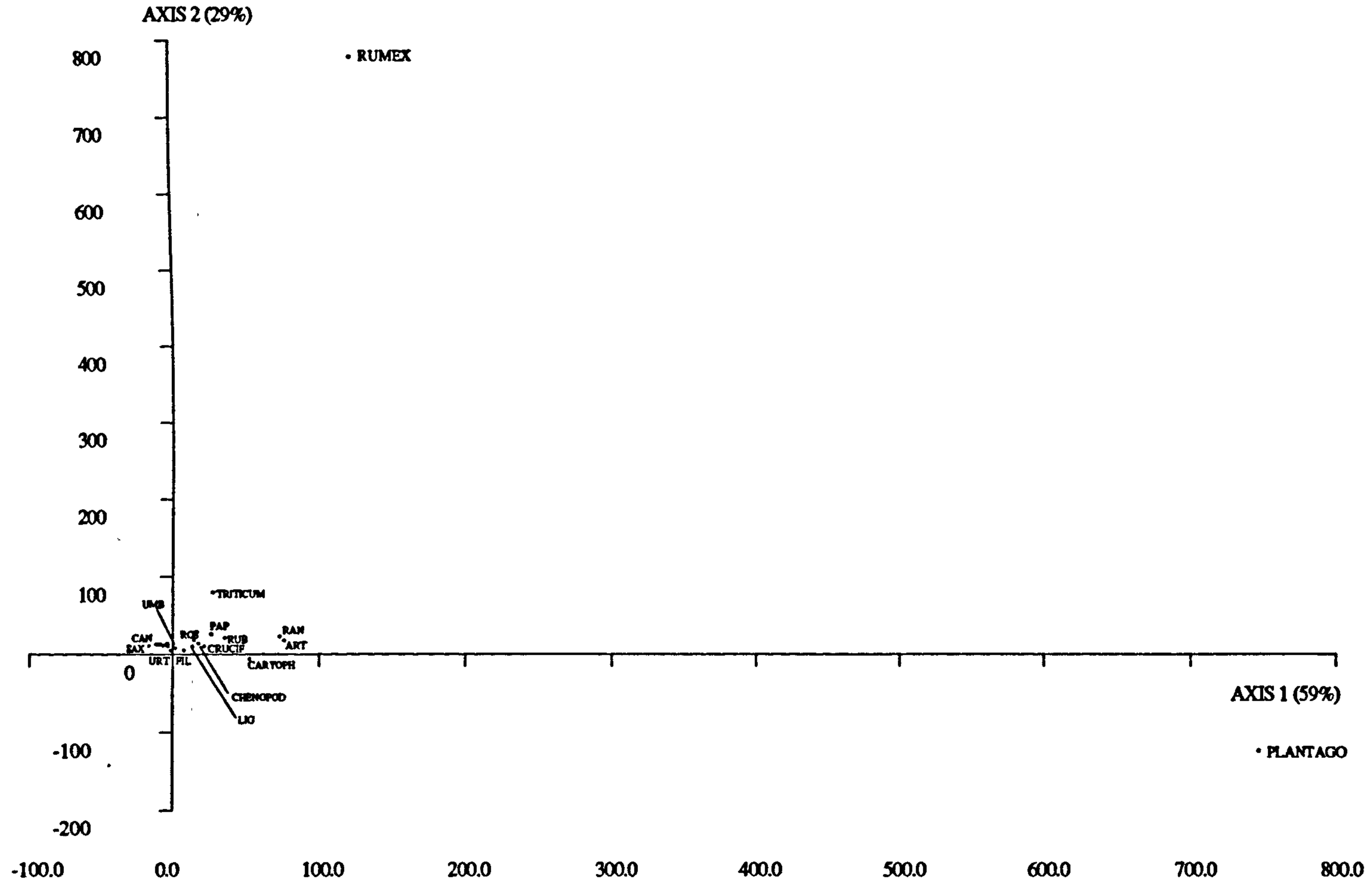
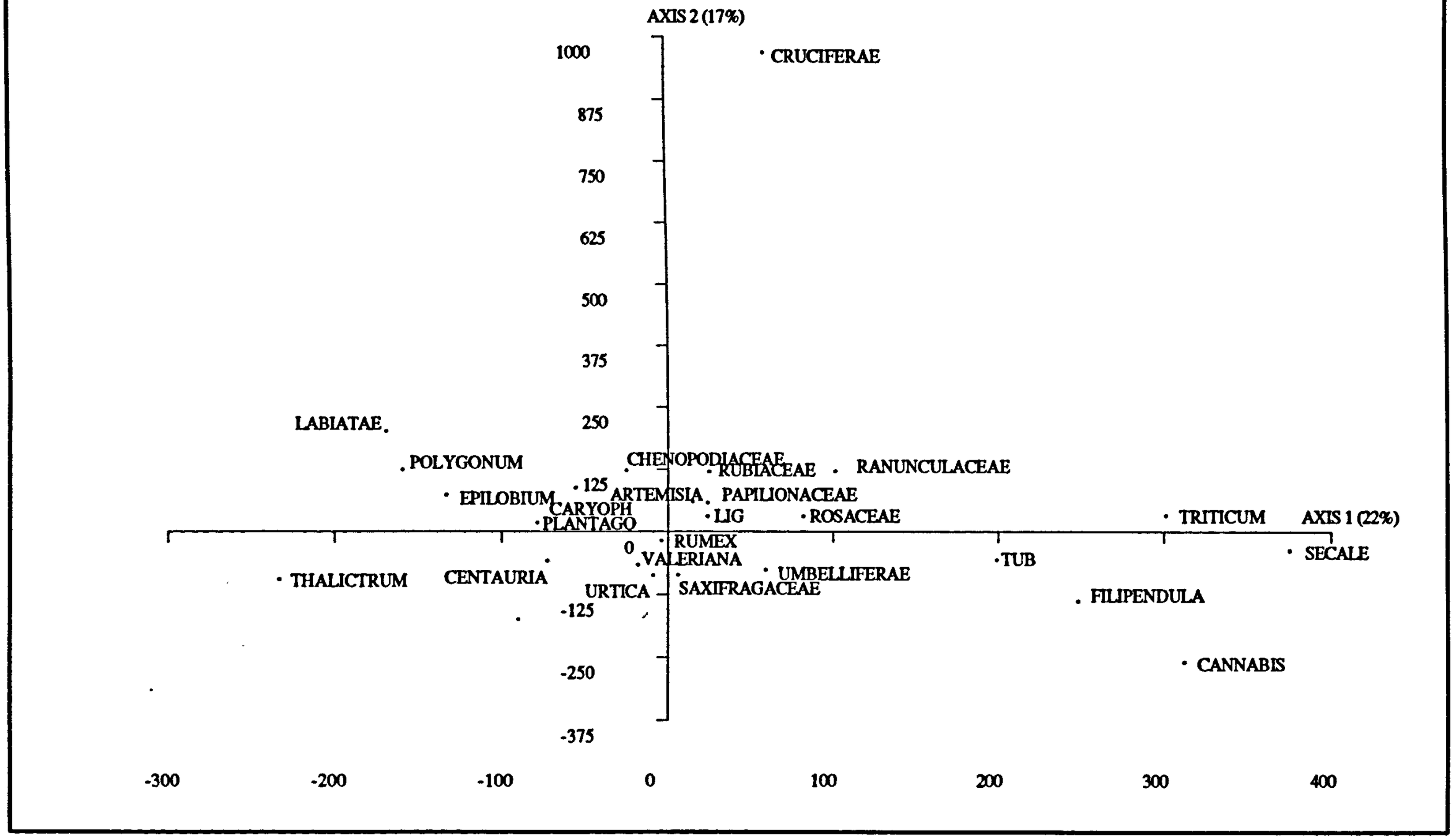


FIGURE 5.69 WALTON MOSS CA AXIS 1 V AXIS 2 FOR HERBS EXCLUDING GRAMINEAE



CHAPTER 6.

DISCUSSION.

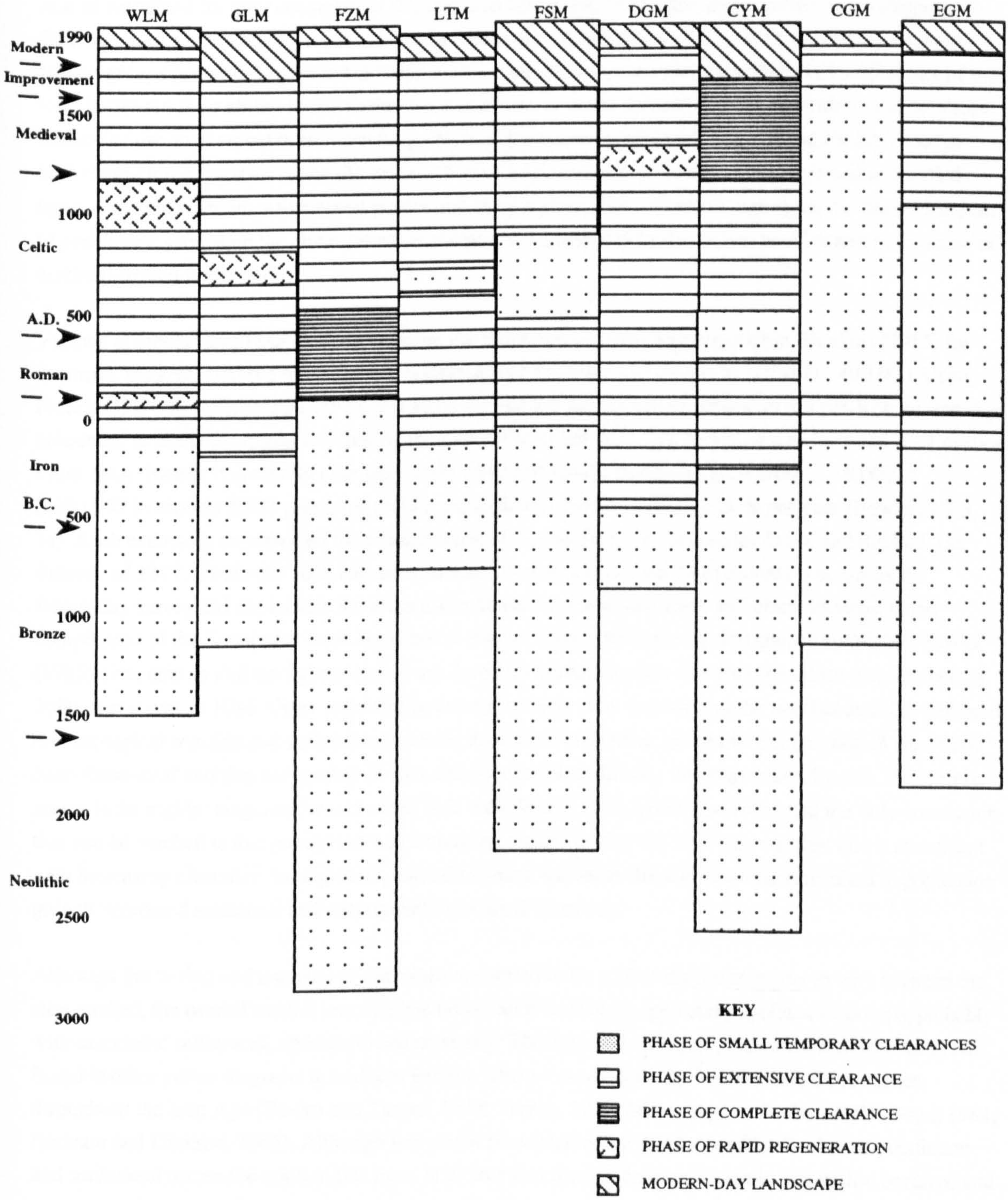
The main aspects of human impact on vegetation have been discussed in depth in Chapter 5. The following chapter will focus on some more general issues which arise from the results of this study.

6.1 Summary Of Vegetation Change In Northern Britain During the Last 3,000 Years.

Figure 6.1 attempts to summarise the palynological evidence for vegetation change at the sites presented here during the last 3,000 years. The definition of small temporary clearances, extensive clearance and complete clearance follow the criteria set by Turner (1965). Small temporary clearances are defined as those where non-arboreal pollen reaches 15%, after which trees soon regenerate and the woodland becomes as it had been before. This level has been used to define small temporary clearances as, in this study, values of non-arboreal pollen above 15% are usually associated with further, accelerating clearance. Turner (1965) describes an extensive clearance as any clearance where, using a tree pollen sum, grass pollen frequencies rise above 100%. For the purposes of the present study where a non-mire pollen sum has been used, extensive clearance is defined as any clearance where grass pollen frequencies rise above 30%. This is based on the fact that the present-day grass pollen frequencies vary between 60 and 70%, representing an almost completely cleared landscape. The value of 30% must therefore represent something like half the area from which the pollen is being derived today, but a significantly larger area than that of a small temporary clearance. Based on present-day pollen frequencies, complete clearance is defined as any clearance where grass pollen frequencies rise above 60%. A fourth and a fifth category have also been added - rapid regeneration and modern day landscape. Rapid regeneration is defined as a period in which woodland quickly regenerates and forest cover remains high for at least 100 years. The modern day landscape is defined as that in which *Pinus* rises, other arboreal pollen types are relatively low, whilst Gramineae rises to around 60%.

Figure 6.1 demonstrates that at all sites studied, small temporary clearances and limited human impact on vegetation occur during the Neolithic and Bronze Age. Neolithic and Bronze Age culture in the north seems to have been characterised by shifting agriculture within a forested setting, with each clearance being succeeded by forest regeneration and this is coincident with low population levels and settlement evidence at this time. Not only is the pattern of Neolithic and Bronze Age small temporary clearance shown by the sites under study in accord with the archaeological evidence, it also corresponds with similar evidence for clearance in other pollen diagrams across northern Britain (Chapman, 1964; Newey, 1976; Mannion, 1978a, b; Davies and Turner, 1979; Turner, 1979; Barber, 1981; Innes, unpub., Whittington *et al.*, 1990; 1991) The results from the sites under study are also in accord with those from other areas of Britain such as west Wales (Turner, 1970), Cheshire and Lancashire (Simmons and Tooley, 1981) and Derbyshire (Hicks, 1971). Although small forest openings may be inferred from the pollen profiles presented here, none of these sites show any large-scale clearance such as that recorded at Bishop Middleham, Durham (Bartley *et al.*, 1976) or at Callaly Moor, Northumberland (Macklin *et al.*, 1991). The results are also in contrast to extensive clearances in Southern England (Godwin, 1967; Waton and Barber, 1987), Shropshire (Barber and Twigger, 1987), Dartmoor (Simmons and Cundill, 1974) and parts of the Lake District (Pennington, 1970).

FIGURE 6.1 SUMMARY OF VEGETATION CHANGE IN NORTHERN BRITAIN DURING THE LAST 3, 000 YEARS.



Such small temporary clearances extend into the Iron Age at all sites except Dogden Moss where extensive clearance begins around A.D. 500. Large-scale clearance is similarly found at other sites in this area of south eastern Scotland (Tipping, forthcoming, 1992) and this might suggest that large areas of south east Scotland were extensively cleared during the early Iron Age, consequent with the early evolution of settlement in the area. At all the sites studied, except Fozy Moss, extensive clearance occurs sometime during the late Iron Age, which is coincident with archaeological evidence for increased population (either as a result of natural increase or immigration) and settlement. Large numbers of homesteads, hillforts, palisaded enclosures and finds of metal work associated with Iron Age populations provide evidence for extensive settlement across the north at this time (Cunliffe, 1991). Although it is thought that each Iron Age hillfort required only one acre of woodland for their construction (Hanson and Macinnes, 1981), the large number and widespread distribution of forts probably means that clearance was well underway. Along with population increase, human groups possessed enhanced abilities to alter their environment and the widespread availability of iron tools increased their ability to fell timber for settlement, to create cleared land for agriculture and to obtain timber for use as charcoal in iron smelting. With an increasing population, the demand for land used in settled agriculture increased, and the introduction of implements such as the iron plough enabled settled agriculture and more intensive cereal production to take place. This clearance represents the heaviest impact of prehistoric groups on the environment in the period represented by the pollen profiles and in the areas of northern Britain under study.

Various attempts have been made to estimate the magnitude of Iron Age population. Hoskins (1955) for example, suggests that the late Iron Age population of Scotland had grown to 300,000 - 400,000. Using Frere's (1967) figures, Fowler (1983, 33) suggests that the population of Britain in the pre-Roman Iron Age amounted to about 2 million and that by the first millennium A.D. this had grown to between 2 - 4 million. From these figures it seems that the later prehistoric population of Britain grew from *c.* 10,000 to 2,000,000 in around 2,500 years, suggesting a population growth rate of 0.21 % per year (Fowler, 1983, 34). Such estimates are based on the extrapolation of figures from the Domesday Book and the Poll Tax Returns of 1377. Obviously such calculations and interpretations must be extremely tenuous as the Domesday survey did not include the areas under consideration in this study and errors inherent in the compilation of the Domesday Book itself and in extrapolation, make the figures quoted unreliable. Fowler (1983) even admits that the figures quoted are based on the assumption that the population was less before 1086 than it was in 1086. Other estimates have been arrived at by considering the number and distribution of archaeological remains and such estimates must have been erroneous, given the fact that not all sites have been discovered and that the number of sites does not translate directly into population figures. It therefore seems to be highly dangerous to attempt to link such figures to the pollen evidence and the only conclusion that can be reached is that population was increasing rapidly during the Iron Age and that this is coincident with increasing clearance. Immigration, natural increase and technological innovation resulted in population growth, increased settlement and consequently increased clearance.

Although the timing and intensity of clearance registered in the pollen diagrams seems to vary between the sites studied, the overall trend is nevertheless one of an increasingly open and populated landscape, probably with associated settlement, agriculture and economy. This trend of increasing clearance is dissimilar to that found in other pollen diagrams in northern Britain, where a predominantly forested landscape existed throughout the Iron Age (Davies and Turner, 1979; Turner, 1979; Innes, unpub.; Barber, 1981; Boyd, 1984; Dickson and Dickson, 1988). Although this might be explained by the uneven distribution of population and settlement across the north at this time, it is clear that distinct local variation in vegetation occurred and that a mosaic of cleared and wooded areas occurred, changing both spatially and temporally. The changes in vegetation and clearance revealed by the pollen diagrams in this study are more akin to the pollen records

obtained from other areas of Britain at this time. During the Iron Age extensive clearance seems to have been widespread in most areas, including southern England, the Pennines, Derbyshire and the Lake District (Simmons, 1964; Pennington, 1970; Hicks, 1971; Merryfield and Moor, 1974; Tinsley, 1975; Turner, 1981; Waton and Barber, 1987) and also in Fife (Whittington *et al.*, 1990; 1991) and the Loch Lomond area (Stewart *et al.*, 1984).

During the Roman invasion of the north, forest regeneration occurs at Glasson Moss, Walton Moss, Ellergower Moss and Carsegowan Moss, whilst clearance is sustained at Fozy Moss, Letham Moss, Cranley Moss, Dogden Moss and Fannyside Muir. These contrasting situations raise the question of to what extent the activities of the invading army affected the vegetation. The Roman invasion of the north proper occurred over a limited time (i.e. *c.* A.D. 70 - A.D. 120). Brigantia was conquered within the seven years between A.D. 71 and A.D. 78, Dumfriesshire and Galloway between A.D. 81 and 82 and much of southern Scotland between A.D. 80 and 82 (Keppie, 1986, 67; Cunliffe, 1991, 207). It might be difficult to assess the influence of the invasion on the vegetation over such a short time, but it is clear that between A.D. 70 and A.D. 120 significant changes do occur in the pollen diagrams. Despite the fact that the landscape in some areas of the north was already relatively open, the invading army would have required timber for the construction of marching camps and the initial forts, the forest must have been cleared to build roads and the native population must also have been removed from some areas. A campaigning army must have relied on local resources for such needs and it seems very unlikely that the timber required to build marching camps would have been imported - timber would have been required quickly, the infrastructure in northern Britain would have been poor, thus restricting the movement of imported timber, and troops required in such a task would have been better deployed elsewhere (Hanson and Macinnes, 1981). The military timber requirement may account for the clearance at Fozy Moss, Letham Moss, Cranley Moss, Dogden Moss and Fannyside Muir. However, vegetation change may have been influenced by the relationship between the invading army and the native tribes. The sites where clearance occurred are situated in areas where the tribes offered little resistance to the Roman invasion and therefore there was little disturbance of their way of life, settlement and agriculture (Higham, 1986). Regeneration and a break in agriculture occurred around Walton Moss, Glasson Moss, Ellergower Moss and Carsegowan Moss which are situated in areas where the tribes resisted Roman presence and the invasion may therefore have led to land abandonment, plundering of settlements and fields by the Romans and widespread rebellion (Higham, 1986).

The hypotheses which this study set out to test - that the first large-scale clearance of vegetation in northern Britain was related to the Roman occupation and that the intensity of clearance is related to the distance of the pollen site from Roman military structures such as the walls, forts, milecastles and turrets - can now be assessed. As discussed above it is clear that at all sites, except Fozy Moss, the forest had been affected by human activity prior to the Roman invasion and occupation of the north, and only at Fozy Moss was the first large-scale vegetation clearance related to the Roman occupation of the area. At all sites renewed clearance occurred during the Roman period and woodland was probably cleared to meet the demand for timber which was required for use in building military structures. Woodland was also removed to create a military clear zone around the walls and forts, to create land for agriculture, to obtain timber to be used in the slaking of lime, pottery furnaces, in the hypocaust furnaces used to heat the bath-houses (Birley, 1973a), and cooking. Timber would also have been removed and used by natives to construct settlements.

It is argued here that the primary reason for clearance was military, rather than agricultural. At all sites clearance can be related to military events (Table 5.3) and clearance is greater than the former Iron Age clearances at sites closest to Hadrian's Wall and the Antonine Wall (i.e Walton, Glasson, Fozy and Letham Mosses), which suggests that timber was removed for military requirements. The pollen evidence also

indicates that at all sites there was no rise in agricultural indicators and therefore, it is probable that no significant increase in agricultural production occurred during the Roman occupation and at Letham Moss, Dogden Moss, Carsegowan Moss, Ellergower Moss and Glasson Moss agriculture actually ceases or declines. Agricultural land must have been one element of the landscape, but it seems unlikely to have covered a large area or have been associated with many sites (Higham, 1986, 182). Except for Walton Moss, forest regeneration occurs at the time when the Roman troops were being withdrawn from northern Britain and this suggests that their presence must have been sustaining clearance.

If a significant amount of land had been cleared prior to the Roman occupation, the origin of the timber used by the Romans for military structures has to be considered. In view of the cost entailed and labour required in moving timber from the south, it seems unlikely that timber was imported. Presumably an army wishing to establish its presence in an area and speedily complete its conquest would require rapid construction of military structures. As indicated by the pollen evidence, local supplies of timber were probably sufficient for such construction. Some attempt has been made at calculating the total area of woodland which was cleared for the construction of each fort. Oak was the preferred wood used in construction (Hanson and Macinnes, 1981) and James (1981,147) calculates that an oak tree of 2 tons contains 80 cubic feet of timber. Therefore, 2,000 of such trees would contain 160,000 cubic feet of timber. The distance between trees in a managed woodland with an understory is 30 feet upwards and therefore each acre would contain *c.* forty trees. Keppie (1986) estimates that a Roman fort 4 acres in size would require 22,000 cubic feet of timber for its construction and combining both Keppie's and James' figures this would represent 275 oak trees which would entail 7 acres of oak-rich forest being removed to construct each fort. There were 20 forts on both the Antonine Wall and Hadrian's Wall and therefore only 280 acres of woodland would need to be removed to construct the wall forts. However, these calculations do not take account of the fact that timber would also have been used in construction of the walls, marching camps, turrets, milecastles, inter-wall forts and that woodland would have been removed to create a military clear zone around the walls and forts; for charcoal and firewood and to clear land for agriculture. Also as the walls were abandoned and reoccupied when the position of the frontier fluctuated during the third and fourth centuries and as natives plundered the military structures, forts were destroyed and then rebuilt thus entailing the use of additional timber. The figures quoted by James (1981) are based on managed woodland and it is probable that the density and quality of oak-woodland in the north was lower because of the harsher environment and poor soil fertility. The calculated figures represent a minimum estimate of the amount of land cleared and the actual figure was probably much higher, in fact Hanson and Macinnes (1981) suggest that the forts in Scotland alone would have required at least 770 - 1430 acres of woodland to have been cleared for their construction.

The sites studied show extensive, if not complete clearance of forest during the Roman occupation and this can be seen to be the case across most of the frontier zone. Indeed similar changes have been found at Bolton Fell Moss (Barber, 1981), Midgeholme Moss (Innes, unpub.), Muckle Moss (Pearson, 1960), Fellend Moss (Davies and Turner, 1979; Turner, 1979), at other sites in central Northumberland (Davies and Turner, 1979), and in south east Scotland (Tipping, forthcoming, 1992). Clearance similar to that in the pollen diagrams presented in this research occurred further afield at Weardale (Roberts *et al.*, 1973) and in the Durham area (Bartley *et al.*, 1976; Donaldson and Turner, 1977). The landscape was also predominantly open in Derbyshire (Hicks, 1971) the North Yorkshire Moors (Atherden, 1976), often to a greater extent than in the frontier area. Conversely regeneration has not been found during the Roman period in the nine sites studied, but did occur around the Antonine Wall (Boyd, 1984 a, b; Dickson and Dickson, 1988), in Aberdeenshire and Fifeshire (Edwards, 1978; Whittington, *et al.*, 1990, 1991) and in Shropshire (Barber and Twigger, 1987; Twigger, 1988). Thus it seems that in a number of pollen diagrams across northern Britain a larger proportion of woodland was being replaced by cleared areas during the time of the Roman occupation.

The second hypothesis - that the degree of clearance is related to the distance from Roman military structures - is not upheld by the palynological results. Although the pollen diagrams from sites situated close to the walls such as Fozy Moss and Fannyside Muir do seem to display greater clearance, there are anomalies to the pattern. For example, at Dogden Moss which is situated at some distance form either wall, clearance is relatively high with Gramineae pollen reaching 60%. Factors such as the levels of native population, soil fertility and other environmental factors combine with the intensity of the Roman occupation to determine the level of clearance. The relative importance of such factors must also vary between sites.

The agricultural economy in northern Britain during the Roman occupation has been assessed using the palynological results (Section 5.7.12). The pollen evidence suggests that there was a break in agricultural production during the Roman invasion coincident with the native populations abandoning land and the Roman army plundering their fields and crops. At most sites agriculture recommences during the Roman occupation but does not attain Iron Age levels. There is certainly no massive increase in agricultural production in the north to support the needs and demands of a large number of Roman troops (*c.* 17,000 men on Hadrian's Wall alone (Breeze and Dobson, 1987)). Despite the fact that wheat, rye and oats were the staple foods in the Roman military diet; that each fort had a sizeable granary for storing grain; and that the climate in the north during the Roman period was similar to or warmer than today (Barber, 1981), the pollen diagrams indicate that there was no increase in cereal production in the area. Rather than being grown locally, corn must have been imported into the north from southern Britain or the continent. This is surprising considering the cost, time and manpower entailed in transporting and securing an adequate supply of grain, and this perhaps supports the view that the Roman occupation of the north was essentially military with the provision of food locally being a minor concern - especially in view of the risk of natives attacking such resources. Botanical evidence shows that exotic foodstuffs such as figs, fruit, nuts, lentils and spices were imported from the continent and were also part of the Roman military diet (Dickson and Dickson, 1988; Dickson, 1989). Botanical evidence also suggests that grain beetles and plant foods in Roman granaries were similar in northern Britain, South Wales and Germany (Dickson and Dickson, 1988) and this implies that standard supplies came from a central source. This is in accord with the palynological evidence for limited production. It is also possible that the Romans exploited other local resources to ensure a food supply, especially whilst on campaign or in the early stages of occupation. Local resources such as hazel nuts and fruits might have been exploited and other perishable foodstuffs would have been obtained from the local area. Some food might also have been obtained from taxation of natives or grown around the *vici*.

Except for a small period of regeneration following the Roman withdrawal, extensive clearance continued until the present day at Fozy Moss, Walton Moss, Glasson Moss and Dogden Moss. Extensive clearance, with some small temporary clearances, continued up to the present day at Letham Moss, Fannyside Muir and Cranley Moss. At Ellergower Moss and Carsegowan Moss small temporary clearances continue until Medieval times, following which extensive clearance occurs. The present day landscape could be described as completely cleared at Fannyside Muir and Dogden Moss. Although the period covering post-Roman times to the present day has been studied in less detail, it is still possible to identify broad changes in the pollen diagrams, and vegetation changes at each site can be related to a series of events which took place across the north at this time (Sections 5.8 and 5.9). It is because these events were often local in character that variations in the magnitude and timing of changes in the pollen spectra vary so widely. However, certain common trends can be seen in the pollen diagrams, notably increased clearance with agricultural improvement, and increased *Pinus*, *Fraxinus* and *Fagus* associated with the establishment of plantations and hedgerows.

The archaeological and palynological evidence point to a dynamic pattern of vegetation and social change in

the frontier zone during the last 3,000 years. Population, settlement and clearance increased as human groups exploited their environment against a background of climatic change and successive invasions such as that by peoples from the Rhine into eastern Scotland during the Bronze Age and the Romans. The pollen and archaeological evidence provides no reason to believe that there was a major crisis such as social collapse or economic stagnation at any time during prehistory. Instead, evolution, long term development and technological advances of what has traditionally been considered as a backward society and economy, is suggested. Thus it seems that after a Late Iron Age clearance, the Roman occupation of the north and initial period of military building resulted in renewed woodland clearance, which was sustained by further military timber requirements, agriculture and the need for timber for native settlements, charcoal and fuel. Vegetation clearance ceased as the Romans withdrew from northern Britain and forest regeneration with a further decline in agriculture followed.

6.2 Problems of Interpretation - Pollen Source Areas, Representativity and Variability In Northern Britain.

The results of this present study highlight the problem of characterising the pollen source area of a site, particularly in relation to the distribution of archaeological remains and the use of these in interpreting the vegetation changes shown in a pollen diagram. As outlined in Chapter 1, this has been subject to much discussion in the literature and the significance of this for the present study will now be considered.

When comparing the pollen diagrams in this study, it was recognised that each pollen diagram reflects the vegetation of its own pollen source area, this varying between sites and over time at each particular site. As discussed in Chapter 3, the pollen diagrams in this study should be dominated by regional pollen rain and if Bradshaw's (1991) suggestion that for a site 1 km. in diameter, pollen originates within 30 km. of the site, then the pollen deposited at Walton, Letham, Dogden and Cranley Mosses and Fannyside Muir would be derived from a large area and at Glasson, Fozy, Ellergower and Carsegowan Mosses from a smaller area. If such a pollen source area is plotted around each site, then the nature of the area from which the pollen is derived (i.e. in terms of relief, soil fertility), and the archaeological distributions within that radius, can be considered. If the pollen source area of the site is determined and the Roman fortifications and Iron Age settlement in the area plotted, clearance shown in the pollen diagrams can be related to such information. For example, Roman clearance at Fozy Moss should be related to the fact that large numbers of Roman fortifications were situated within the supposed pollen source area. Iron Age clearance at Dogden Moss and Letham Moss should be related to the large numbers of Iron Age hillforts and homesteads, as well as soil fertility and relief in the pollen source area. Indeed there are marked similarities between a number of the sites whose pollen source areas would have overlapped. The pollen diagrams from Walton and Glasson Mosses show broadly similar changes in the pollen spectra between the Bronze Age and Roman periods. Although the magnitude of the changes might be different, the broad trends within the pollen diagrams are similar. The diagrams from Glasson, Fozy and Walton Mosses display similar small clearances during the Bronze Age. However, differences in Iron Age clearance occur, with extensive clearance only occurring at Walton and Glasson Mosses. At Fozy Moss more extensive Roman clearance occurs, whilst the magnitude and timing of Roman clearance at Walton and Glasson Moss is similar. Likewise, the diagrams from Ellergower and Carsegowan Mosses are similar in many respects. These sites are situated away from the immediate frontier zone, where prehistoric populations densities were low. Consequently there are few significant changes in the pollen profiles. The vegetation changes which occurred at Cranley Moss and Fannyside Muir are also alike, though change is not as dramatic or pronounced as at Dogden and Letham Mosses. Significant similarities exist between Dogden and Letham Moss in the Iron Age and Roman periods and although Iron Age clearance occurred earlier at Dogden Moss than at Letham Moss (420 B.C. and 150

B.C. respectively), the pattern of extensive Iron Age clearance extending into the Roman period is similar. Similar trends are also seen throughout Monastic times, the period of agricultural improvement and modern times.

Similarities do exist within the suites of sites identified above and if Bradshaw's (1991) definition of pollen source area is applied to the sites, the pollen source areas overlap. This perhaps explains the similarities in the pollen records. Although inter-site variability exists, regional trends can also be identified, particularly in Roman and Iron Age times. However, this application of the concept of the pollen source area is somewhat undermined by the fact that the results from Walton Moss and Bolton Fell Moss (Barber, 1981) indicate that inter-site variability in the pollen record is greater than the published models suggest (Jacobson and Bradshaw, 1981; Bradshaw, 1991). These results suggest that localised elements in the pollen rain are more important than envisaged. Bolton Fell Moss and Walton Moss are adjacent sites of a similar size and should both be receiving a predominantly regional pollen rain. The pollen cores are located within 1 km. of each other and according to the models, the pollen source areas of the two sites should overlap. Although the pollen diagrams do show some broadly similar changes, there are also some significant differences. This is especially apparent in the Iron Age (Section 5.5.1) where substantial deforestation is shown at Walton Moss, whilst at Bolton Fell Moss the forest cover remained more or less intact. In the Medieval period (Section 5.9.1) regeneration occurred at Walton Moss though the landscape around Bolton Fell Moss, as inferred from the pollen evidence, was becoming increasingly open. Although such differences could be a reflection of different pollen counting resolutions and peat accumulation rates, the differences might also be a result of different pollen source areas. If this was so then the Iron Age clearance at Walton Moss is a result of more localised changes in the pollen spectra and these changes are not recorded in the pollen rain falling 1 km. away. Extra-local pollen (defined by Jacobson and Bradshaw as that derived from between 20 m. to several 100 m. from the site) must be playing a significant part in the pollen rain at Walton Moss and the clearance must have been near the bog margins.

The results from Walton Moss and Bolton Fell Moss agree with other studies which have shown that inter-site variability can be relatively large over a small spatial area. Studies of a series of lake basins in Minnesota, U.S.A. allowed local pollen types to be separated from regional pollen and indicated that variability in pollen rain over the local area was relatively wide (Jacobson, 1979). Palynological study of 52 sites in the Northern Pennines showed that the composition of the forest varied over distances of only a few hundred metres (Turner and Hodgson, 1979). A palynological study of a series of sites in Shropshire shows that significant differences in the pollen rain occur between sites only 400 m. apart (Barber and Twigger, 1987; Twigger, 1988). Therefore, pollen data in this study and in the published literature supports the idea that local variations over small areas seem to be more important than the models imply. Whether such inter-site variability occurred around any of the other sites in this project would necessitate a study of a suite of sites in their immediate areas. Spatial variation in the intensity of human impact is evident in space and time, and the pollen source area at each site must vary. Differences between the Walton Moss and Bolton Fell Moss diagrams suggest that no one site can be used to construct chronologies of vegetation change, and these conclusions suggest that if possible, sampling and comparison of a number of sites should take place before a full assessment of vegetation change can be made.

6.3 Problems of Interpretation - Pollen and the Agricultural Record In Northern Britain.

In this study an assessment of the agricultural economy around each site has been attempted using the palynological and archaeological evidence, and has been discussed in Sections 5.3.6, 5.5.10, 5.6.10 and

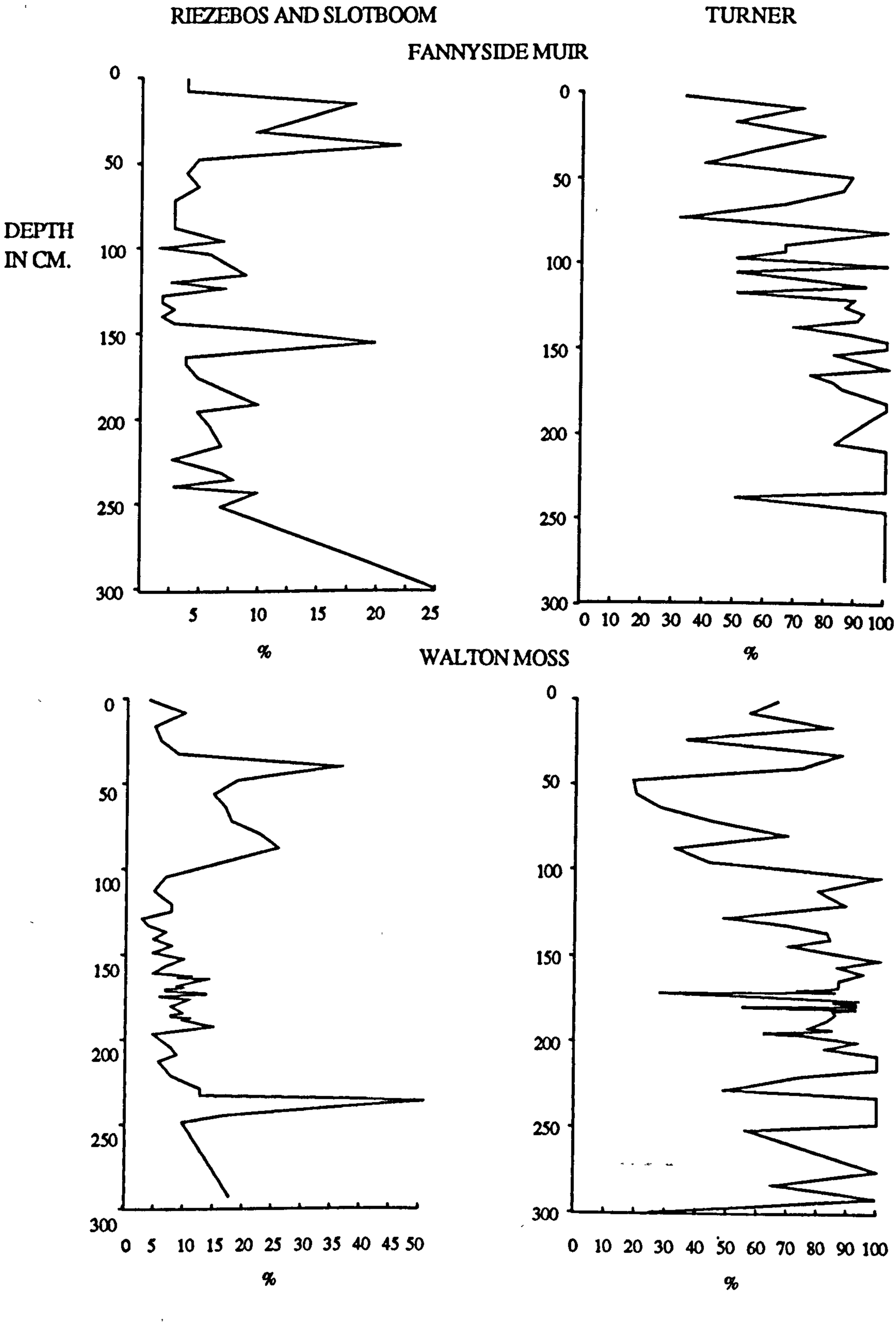
5.7.12. The palynological results have been helpful in elucidating the agricultural record in northern Britain, particularly in the Bronze, Iron and Roman periods. The pollen record has been used to highlight agricultural activity, particularly arable activity, in areas where archaeological evidence is limited, or to suggest that such practices did not occur. For example, the Bronze Age economy in northern Britain was traditionally considered to be pastoral, but the presence of cereal pollen in the profiles from Fozy Moss, Fannyside Muir Walton Moss and Ellergower Moss provide unequivocal evidence that cereal cultivation occurred. The presence of cereals or herbs indicating arable agriculture occur at all nine sites during the Iron Age and although pastoralism was a significant part of the economy, arable agriculture must also have been practised.

However, from the results of this study, it firstly seems necessary to question the value of the agricultural indicator approach and as discussed by Behre (1981, 1986) and Maguire (1983) it seems an oversimplification to assign one taxa to a particular agricultural environment. The interpretation of agricultural indicators in a pollen diagram requires precise knowledge of the ecological amplitude of the species, and interpretation of pollen diagrams and land use has to be undertaken with caution as the ecological niches of herbs are not sharply defined. In the pollen profiles from the sites under investigation, *Plantago lanceolata* occurs relatively abundantly throughout, but as discussed in Chapter 1, this herb can be associated with pastoral activities or abandoned arable fields (Behre, 1981; Groenman van Waateringe, 1986). Thus any interpretation of agricultural activity from a consideration of such herbs must be surrounded with caution. Varying productivity and dispersal abilities of species occurs which affects their representation in the pollen diagram. A wide range of non-arboreal pollen types are displayed in each of the pollen diagrams and this is seen to be an important problem when attempting to determine types of agricultural activity. In each diagram Gramineae, *Plantago* spp., *Rumex* spp., and in the case of Fozy Moss, Rosaceae, are those herbs which occur in greatest abundance, but it is unlikely that this truly reflects vegetation composition around each site. At every site the core analysed for pollen was obtained from the centre of a large mire and this is a problem as pollen dispersal abilities of herbs will restrict their deposition and therefore representation in such a pollen diagram. In this type of study the presence of just one pollen grain of a taxa such as *Triticum* type was considered sufficient to suggest that arable agriculture was undertaken.

Agricultural indices, as defined by Turner (1964) and Riezebos and Slotboom (1978), have been used in an attempt to define the proportions of arable and pastoral land use at each site through time. Figure 6.2 shows that the results of both indices are highly variable and 'peaky'. Values vary between 0% to 100% between just two levels and it is impossible to believe that this reflects an actual change in land use, and changes in the taxa in the diagrams do not reflect this. Comparison of the agricultural indices indicates that at times, one index suggests a more arable landscape whilst the other a pastoral land use. This sheds doubt on the validity of such methods. *Rumex* spp. are used by Turner as a pastoral herb and by Riezebos and Slotboom as an arable herb, and the ecological niches of other species used in the indices are not well defined. Comparison of the pastoral/arable indices with the cereal curves from each site indicate that although cereals increase towards the top of each core, especially at Walton, Dogden and Fozy Mosses, this does not necessarily correspond with an increasing arable index. Under well-defined environmental conditions it might be possible in a particular locality and within a specific time period to construct such an index, but the index cannot be taken out of its temporal and spatial context, and where different regions, crops, methods of husbandry and time periods are involved the pastoral/arable index becomes inappropriate. Thus the agricultural indicies are not useful for the geographical areas and time span studied in this project.

To overcome the problems of defining the ecological niches of herbs and pastoral/arable indices principal components analysis was undertaken in an attempt to define groups of herbs related to certain types of land use (Section 5.12). Except for the correspondence analysis undertaken on Walton Moss, the results show

FIGURE 6.2 COMPARISON OF AGRICULTURAL INDICIES.



that no well defined groups of herbs, and therefore land use, can be distinguished and therefore any interpretation of agricultural practice from pollen evidence must be made with caution. This however does not restrict the value of herbs as indicators of land use, and if the ecological niches of herbs is known then some interpretation of land use can be made, especially if such a niche is well defined. A comparative approach, which involves characterisation of pollen spectra from modern agricultural communities and their comparison with fossil spectra (Maguire, 1983), seems to over come the problems of statistical and indicator approaches. The evidence from the present study agrees with the conclusion of Edwards (1988) - only a series of broad categories of agricultural land use can be derived from pollen diagrams. These include mixed farming with the presence of cereals, Gramineae and other herbs; possible cereal cultivation as part of a mixed farming system where weed taxa are common but cereals are not present; and non-specific disturbances where weeds indicate pasture, husbandry, wind-throw and settlement clearance.

6.4 Problems of Interpretation - Pollen and Archaeology In Northern Britain.

Pollen analysis of the nine sites presented here has enabled human impact on vegetation and agricultural activity to be evaluated in the time period under consideration. However, the results have highlighted a series of limitations and problems with both the archaeological record and palynological evidence. The recognition of such problems in this study have wider implications for archaeological and palynological theory as a whole and are vitally important if results are to be interpreted accurately and if there is to be cooperation between the archaeologist and palynologist. It seems that archaeologists are rarely aware of the problems and potential of palynology and the dynamics of vegetation change, whilst the palynologist requires the support of the archaeologist if pollen diagrams are to be interpreted accurately in terms of the archaeological record.

Most of the pollen diagrams published from northern Britain were undertaken on sites which were not chosen in relation to archaeological problems. These are general Holocene diagrams where human impact is not analysed in detail and often the diagrams are not radiocarbon-dated (Pearson, 1960; Chapman, 1964; Walker, 1966; Birks, 1972; Newey, 1976; Mannion, 1979 a, b; Rowell and Turner, 1985). The results of this project make it clear that if human impact is to be fully assessed pollen sites must be chosen with reference to archaeological structures. The main focus of this investigation was to explore vegetation change related to the Roman occupation of northern Britain and therefore site selection was partly based upon the location of mires in relation to Roman archaeological structures. Whilst on-site pollen analysis (that taken from deposits from within the archaeological site itself e.g. turves, latrines) allows an assessment of vegetation change directly associated with a particular settlement at a particular time, their value is restricted because the spatial and temporal coverage provided by such analysis is limited. The regional pollen diagrams produced here are useful in constructing a chronology of human impact on vegetation and the use of such mires has several advantages. They have high accumulation rates allowing high resolution diagrams to be produced. For example the average peat accumulation rates for Walton Moss are 11.8 years/cm., Glasson Moss and Dogden Moss 9.9 years/cm.. This allows high resolution pollen diagrams to be produced, especially where the core has been counted at one centimetre intervals. At Walton Moss each pollen spectra reflects 14.8 years and at Dogden Moss 8.9 years in parts of the diagram counted at 1 cm. intervals. There is no indication of hiatuses in the pollen records and sedimentation is autochthonous. Pollen is generally well preserved and the corroded/unidentifiable curves in each of the diagrams are low. All pollen transport to mires is aerial and there is virtually no horizontal or vertical mixing of pollen.

It is recognised that differences in growth rates of peat will cause changes in pollen concentration which are not a result of vegetation change, whilst the resolution and counting interval of a pollen diagram is also

important if human impact is to be assessed (Edwards, 1979, 1982). Such difficulties have been experienced in this project despite the fact that the pollen profiles are radiocarbon dated. Iron Age clearance is evident in the Walton Moss diagram whilst only 1 km. away at Bolton Fell Moss (Barber, 1981) no such clearance occurred. Although this could be a true reflection of differences in the local vegetation record, clearance might not be registered in the Bolton Fell Moss diagram because of the wider pollen counting interval and the slower peat accumulation rate. Broadly-spaced sampling intervals may not have isolated different phases of agriculture sufficiently well and closely-spaced pollen counts help differentiate short-term clearance from an environment which is kept permanently open, especially if the sediment accumulation rate is slow. For example, the detection of Bronze and Iron Age small temporary clearances in the pollen diagrams from all sites in this project is aided by use of relatively closely-spaced pollen counts.

The mires cored in this project are likely to have been unattractive for human settlement and would probably have remained fringed. Where woodland is present between a clearance and the sampling site, registration of the pollen record will be restricted because of pollen filtering effects (Tauber, 1965). For example, during the Iron Age at Fozy Moss (Section 5.5.3) there is archaeological evidence for some settlement, but very little clearance is displayed in the pollen record. The registration of clearance could thus be restricted by filtering effects of woodland around the moss. It has also proved difficult to determine the size of clearance from pollen evidence and because of distance-decay effects in pollen transport, a small-scale clearance portrayed in a pollen diagram could be a larger clearance at a greater distance from the sampling site (Oldfield, 1970; Tinsley and Smith, 1974; Edwards, 1979). Clearance taking place at a distance from a site may not recognised or may be under-represented in the pollen diagram. This problem is apparent when attempting to determine the nature of Neolithic and Bronze Age small temporary clearances in the pollen diagrams presented here, especially at Cranley Moss, Fannyside Muir and Fozy Moss. Having defined a small temporary clearance as a clearance where non-arboreal pollen reaches 15% and after which trees soon regenerate, it is difficult to assess whether such a change in the pollen profile is attributable to a small clearance near the mire or whether it is the registration of a larger clearance at some distance from the mire. A small clearance lasting longer than a hundred years could also reflect aggregate clearance activity (e.g. Bronze Age clearance at Fozy Moss). These results make it clear that without a knowledge of pollen source areas, pollen transport ability, a high pollen counting resolution and a detailed knowledge of archaeological distributions, the exact nature of small temporary clearance in pollen diagrams and their spatial significance cannot be accurately assessed.

Radiocarbon dating of the nine pollen profiles has aided the correlation of the pollen diagrams and of the pollen and archaeological records. However, difficulties of correlation have arisen. Archaeological chronologies in the north are often incomplete, making correlation and interpretation of finds, events and documents difficult, especially if they are to be related to pollen evidence. This is particularly true of the Neolithic, Bronze Age and Iron Age in the area. The nature of the archaeological record, and human impact recorded in the pollen record, is very localised and correlation of such pollen diagrams can be dangerous, especially if not radiocarbon dated. This was evident, for example, in the Iron Age in northern Britain as the crystallisation of different tribal entities led to very different archaeological records in the area. The densely settled hillfort-dominated area of south east Scotland contrasts markedly with the areas of lower density curvilinear settlement around Glasson Moss. These differences are reflected in the pollen diagrams but, despite radiocarbon dates, it is difficult to correlate such records.

Some inaccuracies and problems with radiocarbon dating have been discussed in Section 3.5, but there are other potential problems that have been identified in the present study and which need to be considered when using radiocarbon dates in environmental archaeology. Very often a short archaeological event such as the

Roman occupation of northern Britain needs to be dated and often a dramatic vegetation change occurs over one or two pollen counts. This is the case at Letham Moss where a rapid clearance occurs in the late Iron Age (Section 5.5.5) over only two centimetres of peat and at Fozy Moss where rapid Roman clearance occurs over 3 cm. of peat. If such changes are to be dated with accuracy, the depth over which the sample for radiocarbon dating is taken needs to be as small as possible and in the case of Letham Moss, where the peat was sampled using a monolith tin, only 1.5 cm. of peat was required for radiocarbon dating. At all other sites, where cores were obtained using a Russian-pattern corer, approximately 8 cm. of peat was submitted for dating and therefore the precision with which a date can be assigned to a well defined event in a pollen diagram is limited because of the width of sediment dated. The problem of sample size (8 cm.) was evident with the samples submitted for dating from Walton Moss. Here the ranges of two radiocarbon dates overlapped - 10 B.C. (SRR-4530) and A.D. 65 (SRR- 4531) - and the problem might have been avoided if thinner sections of sediment were available for dating. Where only small samples are available for dating, or where a short time period needs to be dated, the use of accelerator (AMS) dating is particularly advantageous (Hedges, 1991) and ideally high-precision AMS dating would be used in a study such as this.

The dates obtained were calibrated and the importance of calibrating radiocarbon dates needs to be stressed, especially when other data is based on calendar dates. The historical record in the north and indeed elsewhere, is based upon the calendrical time-scale with some, but not all events, finds and artefacts being calendrically dated. In fact a whole series of finds in northern Britain are not calendrically dated and where evidence for settlement occurs, there are often no remains or structures (e.g. wooden posts) which are suitable for dating. This is apparent for Iron Age settlement in the north and there are consequently very few settlements whose dates are known. It is therefore difficult to interpret the settlement patterns in terms of a dated chronological sequence and this restricts the interpretation of the pollen record. A serious problem in the radiocarbon time-scale is that radiocarbon years diverge from calendar years and that short-term oscillations (Suess wiggles) can result in ambiguities of up to 200 years. The calibration relationship is not a smooth one and as a consequence a single radiocarbon date may represent several true ages or a band of ages. The calibration of the radiocarbon time-scale indicates that during the last 2, 000 years, the departure of radiocarbon years from calendar years was slight but the effect of calibration is more serious between *c.* 400 B.C. and 800 B.C. when all samples have virtually the same radiocarbon age (Tooley, 1981; Pearson *et al.*, 1986; Pilcher, 1991). This obviously causes many problems when dating material around the Iron Age/Bronze Age boundary and great ambiguities are introduced. Many dates in the literature have not been calibrated (Donaldson and Turner, 1977; Barber, 1981) and calibration data sets have only been widely used since the 1980s (e.g. Pearson *et al.*, 1986). This makes the comparison of diagrams and time-scales in northern Britain difficult.

The interpretation of archaeological evidence from northern Britain is also fraught with many problems and is subject to bias (Hanson and Breeze, 1991). Cunliffe (1991) discusses how, for most of prehistory, the north of England was backward in terms of technological development and material culture, and because of this the archaeological record is limited. The distribution of archaeological remains, including artefacts and settlements is also a result of their survival pattern and if archaeological evidence for human occupation and activity has not survived, then the record is immediately biased and in northern Britain evidence for prehistoric groups has been destroyed in some places by urbanisation, industrialisation (e.g. Central Valley of Scotland), agriculture (e.g. around Letham Moss) and peat growth (e.g. around Fannyside Muir). This may be demonstrated in the pollen evidence from Walton Moss where a large Iron Age clearance occurs (Section 5.5.1) but there is no archaeological evidence for Iron Age activity or settlement in the area (Clack and Gosling, 1976). Here palynological evidence is used to highlight areas in which human activity occurred, but where archaeological evidence is missing.

The archaeological record is also biased due to the fact that evidence may not yet have been discovered. The north of England is an area where archaeological survey has not been intense and only a few areas have been studied in depth. These include the Solway Plain (Higham and Jones, 1985) parts of Lancashire and Cumbria (Middleton, 1991) and Berwickshire (Jones, pers comm.). In the case of the Walton Moss area archaeological survey and field walking has not been undertaken, which perhaps explains the paucity of archaeological evidence. As archaeological methods and techniques improve more evidence comes to light and repeat survey becomes necessary. For example, with the advent of aerial photography sites have been discovered in areas where it was originally believed that none occurred, for example on the Solway Plain (Higham and Jones, 1985). Sometimes there is a problem of defining archaeological structures and placing them within an evolutionary scheme for settlement or the archaeological record. This is particularly difficult as the dating of many artefacts (e.g. isolated finds) is problematic whilst others can be difficult to interpret. For example, quern stones dated to the Roman period in northern Britain (van der Veen, 1988) are associated with grain processing but do not necessarily imply that cereals were grown in the immediate area. Although maps showing the distribution of archaeological remains are useful (e.g. Clack and Gosling, 1976) sites displayed on the maps were not necessarily occupied contemporaneously and this is especially problematic when transhumance and shifting agriculture was practised.

The archaeological record is a question of survival and discovery which limits the interpretation of pollen diagrams and this cannot easily be overcome. The problem of survival cannot be solved, whilst discovery is the task of the archaeologist. The palynologist can however, highlight areas where survey and discovery might be necessary. Thus problems with palynological and archaeological evidence and with the integration of the two are evident and must be considered when interpreting pollen profiles displaying evidence for human impact. To interpret individual pollen diagrams in the light of generalisations about prehistoric settlement and archaeology is not ideal . However, in the case of the area under study, such an approach is all that is possible.

The above discussion centres upon interpretation of the results obtained in the present study and stresses the problems and shortcomings of integrating pollen and archaeological evidence. If these problems are addressed and recognised when interpreting human impact on vegetation, then biased or erroneous interpretations can to some extent be avoided. Pollen analysis is a good and reliable technique for reconstructing the intensity and duration of human activity; it is only the finer details of the method which pose problems.

CHAPTER 7.

CONCLUSIONS.

Pollen analysis of the nine sites in this study has allowed human impact on vegetation in northern Britain over approximately the last 3,000 years to be reconstructed, the validity of the hypotheses set to be assessed, and the implications and problems of using both pollen analysis and archaeological evidence for assessing human influence on vegetation to be discussed. The results of this study have challenged the orthodox view of vegetation history in part of northern Britain, and in particular, human impact upon it.

The palynological and archaeological evidence along with the radiocarbon dates show minimal effects on the vegetation during the Bronze Age. This was a time of limited human impact on vegetation and during which small temporary clearances perhaps associated with human groups practising shifting agriculture occurred. During the Iron Age large-scale clearance occurred at all sites except for Fozy Moss. Such clearance is associated with increased population and settlement in northern Britain during this time, technological improvement, more settled agriculture and timber requirement for charcoal to be used in the smelting of iron.

During the Roman invasion of northern Britain forest regeneration occurred at Walton Moss, Glasson Moss, Carsegowan Moss and Ellergower Moss, associated with Roman troops plundering and raiding native settlements. Where natives were less resistant to the Roman invasion, such destruction did not occur and continued clearance is apparent at Dogden Moss, Letham Moss, Fannyside Muir and Cranley Moss. Renewed clearance occurred at all sites during the Roman occupation and the removal of forest is associated with the military need for timber supply used in the construction of the walls, forts, milecastles and turrets. Timber and cleared land was also required for agriculture, native settlement, fuel and for charcoal. The results suggest that the Roman occupation and initial period of military building resulted in renewed clearance and that this was sustained by the other requirements. Forest regeneration at all sites except Walton Moss is coincident with the withdrawal of Roman troops from the area. The pollen evidence indicates that little agriculture was practised in the area and the major part of the Roman military food supply was imported from southern Britain or from the continent. The pollen record accords well with the archaeological evidence for the Roman impact being one of woodland clearance for military purposes rather than for settled agriculture. There is spatial variation in the intensity of clearance and in general this is related to distance from Roman military installations, the level and distribution of Iron Age and native settlement and environmental factors such as relief and soil fertility. The Celtic, Scandinavian, Medieval, Improvement and Modern periods which followed determined the evolution of the modern-day landscape.

Although not a central focus of this project, the results might also suggest that the nature of pollen production, dispersal, transport and deposition have to be understood if pollen analysis is to be of use in understanding human impact on vegetation and in elucidating archaeological problems. Besides a consideration of the nature and reliability of pollen analysis, the quality of the archaeological record also needs to be critically assessed. Short-comings in the use of both palynological and archaeological evidence have been identified, especially in the use of agricultural indices. These constraints must be recognised if biased or incorrect interpretations are to be avoided.

Both extra-local and regional variation in the vegetation record across the Hadrianic-Antonine frontier zone

have been identified. Interpretation of human-induced vegetation change in the area would be strongly aided by greater spatial coverage within and beyond the frontier zone, for example, north of the Antonine Wall. A comparison of these results with those from another Roman frontier where palaeoecological investigations have been undertaken, such as the Rhine-Danube frontier, would also complement the present research.

There are numerous other ways in which the palaeoecological record obtained by the present research could be improved and expanded. The dissimilarities between the pollen records from Walton Moss and Bolton Fell Moss (Barber, 1981) requires in-depth study to assess the exact nature of inter-site variability. This could be attempted by high resolution counting of cores from both sites supported by a suite of radiocarbon dates and by multiple coring of both sites. The problem of pollen source area and inter-site variability discussed in Chapter 6 needs more attention. Numerous pollen profiles from sites of various sizes (therefore different pollen source areas) or multiple coring of individual sites in a relatively small geographical area, with detailed archaeological information, is required before firm conclusions about the nature of the regional pollen record can be made. Regional diagrams only provide a basis against which local diagrams from smaller sites can be compared. This approach to such a problem calls for greater cooperation between the palynologist and archaeologist.

In this study, the sediment horizon around the first massive increase in the Gramineae curve has been analysed using a one centimetre sampling interval. However, this high resolution analysis does not necessarily cover the Roman period and greater information and detail relating to the impact of the Roman occupation of northern Britain could be obtained if high resolution pollen analysis was undertaken across the Roman horizon. This would allow a closer comparison of the archaeological and palynological evidence, especially if supported by a suite of radiocarbon dates.

It is hoped that this study has answered some of the questions about the nature of human impact on the environment in northern Britain. Other questions remained unanswered and provide the background for further palaeoecological research. The abundance of mire sites of many sizes in the area provides an excellent opportunity for such research, but the rate in which sites are being destroyed by human activity highlights the need for the palaeoecologist to act quickly before palaeoecological records are lost permanently.

APPENDIX 1.
RADIOCARBON DATES AND CALIBRATIONS.

1.1 CALIBRATED RADIOCARBON DATES AT 68% CONFIDENCE LIMIT (YEARS B.P.).

CODE	SITE	DEPTH IN CM	RADIOCARBON AGE	CALIBRATED OLDER	CALIBRATED YOUNGER	CALIBRATED MID POINT	PROBABILITY	CALIBRATED TOTAL RANGE
SRR-4529	WLM	44-52	135±40	147	69	108	0.47	274-10
SRR-4530	WLM	164-172	1925±40	1902	1865	1883	0.43	1924-1823
SRR-4531	WLM	184-192	2000±40	1995	1865	1959	0.69	2039-1901
SRR-4532	GLM	80-88	960±40	861	825	843	0.36	948-797
SRR-4533	GLM	180-188	1860±40	1873	1775	1824	0.83	1873-1733
SRR-4534	GLM	216-225	2215±45	2254	2177	2216	0.61	2326-2158
SRR-4535	CGM	120-128	1680±45	1621	1537	1579	0.79	1689-1537
SRR-4536	CGM	164-172	2005±40	1996	1924	1960	0.70	2039-1903
SRR-4537	CGM	200-208	2095±45	2151	2040	2096	0.93	2285-2020
SRR-4538	FZM	100-108	925±45	917	817	867	0.85	917-794
SRR-4539	FZM	148-156	1820±45	1821	1704	1763	0.99	1821-1704
SRR-4540	FZM	234-242	3255±40	3550	3497	3524	0.51	3550-3444
SRR-4541	LTM	64-66.5	1465±40	1390	1312	1351	1.00	1390-1312
SRR-4542	LTM	87-89.5	1715±40	1694	1646	1670	0.44	1694-1565
SRR-4543	LTM	134-136.5	2125±40	2155	2057	2106	0.83	2294-2057
SRR-4544	CYM	24-33	340±40	393	317	355	0.64	464-317
SRR-4545	CYM	76-84	1310±40	1293	1236	1265	0.73	1293-1182
SRR-4546	CYM	188-196	2780±40	2924	2845	2885	0.71	2954-2972
SRR-4547	EGM	35-45	930±40	870	820	845	0.46	920-806
SRR-4548	EGM	164-172	2915±40	3082	3021	3052	0.40	3187-2972
SRR-4549	EGM	256-264	3915±40	4392	4298	4345	0.77	4423-4298
SRR-4550	DGM	25-33	250±40	317	281	299	0.43	422-5
SRR-4551	DGM	150-157	1540±40	1318	1433	1476	0.83	1518-1405
SRR-4552	DGM	250-257	2365±40	2393	2341	2367	0.50	2681-2341
SRR-4616	FSM	88-94	1550±40	1518	1431	1475	0.87	1518-1409
SRR-4617	FSM	125-132	1925±45	1927	1821	1874	0.94	1946-1821

1.2 CALIBRATED RADIOCARBON DATES AT 68% CONFIDENCE LIMIT (YEARS B.C./A.D.).

CODE	SITE	DEPTH IN CM	RADIOCARBON AGE B.P.	CALIBRATED OLDER	CALIBRATED YOUNGER	CALIBRATED MID POINT	PROBABILITY	CALIBRATED TOTAL RANGE
SRR-4529	WLM	44-52	135±40	1803	1881	1842	0.47	1676-1940
SRR-4530	WLM	164-172	1925±40	48	85	67	0.43	26-127
SRR-4531	WLM	184-192	2000±40	-46	28	-9	0.69	-90- +49
SRR-4532	GLM	80-88	960±40	1089	1125	1107	0.36	1002-1153
SRR-4533	GLM	180-188	1860±40	77	175	126	0.83	77-217
SRR-4534	GLM	216-225	2215±45	-305	-228	-226	0.61	-377- -209
SRR-4535	CGM	120-128	1680±45	329	413	371	0.79	261-413
SRR-4536	CGM	164-172	2005±40	-47	26	-10	0.70	-90- +47
SRR-4537	CGM	200-208	2095±45	-202	-91	-146	0.93	-336- -71
SRR-4538	FZM	100-108	925±45	1033	1133	1083	0.85	1033-1156
SRR-4539	FZM	148-156	1820±45	129	246	187	0.99	129-246
SRR-4540	FZM	234-242	3255±40	-1601	-1548	-1574	0.51	-1601- -1495
SRR-4541	LTM	64-66.5	1465±40	560	638	599	1.00	560-638
SRR-4542	LTM	87-89.5	1715±40	256	304	280	0.44	256-385
SRR-4543	LTM	134-136.5	2125±40	-206	-108	-156	0.83	-345- -108
SRR-4544	CYM	24-33	340±40	1557	1633	1595	0.64	1486-1633
SRR-4545	CYM	76-84	1310±40	657	714	685	0.73	657-768
SRR-4546	CYM	188-196	2780±40	-975	-896	-935	0.71	-1005- -844
SRR-4547	EGM	35-45	930±40	1080	1130	1105	0.46	1030-1155
SRR-4548	EGM	164-172	2915±40	-1133	-1072	-1102	0.40	-1238- -1023
SRR-4549	EGM	256-264	3915±40	-2443	-2349	-2396	0.77	-2474- -2349
SRR-4550	DGM	25-33	250±40	1633	1669	1651	0.43	1528-1955
SRR-4551	DGM	150-157	1540±40	432	517	474	0.83	432-545
SRR-4552	DGM	250-257	2365±40	-444	-392	-417	0.50	-732- -392
SRR-4616	FSM	88-94	1550±40	432	519	476	0.87	432-541
SRR-4617	FSM	125-132	1925±45	23	129	76	0.98	4-129

1.3 CALIBRATED RADIOCARBON DATES AT 95% CONFIDENCE LIMIT (YEARS B.P.).

CODE	SITE	DEPTH IN CM	RADIOCARBON AGE	CALIBRATED OLDER	CALIBRATED YOUNGER	CALIBRATED MID POINT	PROBABILITY	CALIBRATED TOTAL RANGE
SRR-4529	WLM	44-52	135±40	282	167	255	0.42	282-0
SRR-4530	WLM	164-172	1925±40	1951	1816	1884	0.86	2037-1737
SRR-4531	WLM	184-192	2000±40	2068	1872	1970	0.97	2116-1872
SRR-4532	GLM	80-88	960±40	958	788	873	0.98	958-788
SRR-4533	GLM	180-188	1860±40	1898	1702	1800	0.97	1920-1634
SRR-4534	GLM	216-225	2215±45	2341	2146	2244	0.95	2341-2122
SRR-4535	CGM	120-128	1680±45	1719	1517	1618	0.97	1719-1420
SRR-4536	CGM	164-172	2005±40	2061	1881	1971	0.97	2113-1881
SRR-4537	CGM	200-208	2095±45	2160	2035	2096	0.69	2300-1949
SRR-4538	FZM	100-108	925±45	632	741	837	0.98	947-741
SRR-4539	FZM	148-156	1820±45	1876	1691	1784	0.89	1876-1617
SRR-4540	FZM	234-242	3255±40	3586	3398	3492	0.97	3633-3398
SRR-4541	LTM	64-66.5	1465±40	1417	1296	1357	0.91	1516-1296
SRR-4542	LTM	87-89.5	1715±40	1724	1531	1628	0.98	1770-1531
SRR-4543	LTM	134-136.5	2125±40	2182	2039	2111	0.72	2304-2039
SRR-4544	CYM	24-33	340±40	496	311	404	1.00	496-311
SRR-4545	CYM	76-84	1310±40	1308	1172	1240	0.99	1308-1151
SRR-4546	CYM	188-196	2780±40	2972	2781	2877	0.95	3021-2781
SRR-4547	EGM	35-45	930±40	932	757	845	0.97	948-757
SRR-4548	EGM	164-172	2915±40	3212	2951	3082	0.96	3243-2924
SRR-4549	EGM	256-264	3915±40	4448	4247	4348	0.94	4514-4247
SRR-4550	DGM	25-33	250±40	334	271	303	0.36	437-0
SRR-4551	DGM	150-157	1540±40	1531	1348	1440	1.00	1331-1348
SRR-4552	DGM	250-257	2365±40	2492	2330	2411	0.75	2708-2330
SRR-4616	FSM	88-94	1550±40	1536	1366	1451	0.98	1536-1353
SRR-4617	FSM	125-132	1925±45	1952	1774	1863	0.87	1952-1732

1.4 CALIBRATED RADIOCARBON DATES AT 95% CONFIDENCE LIMIT (YEARS B.C./A.D.).

CODE	SITE	DEPTH IN CM	RADIOCARBON AGE B.P.	CALIBRATED OLDER	CALIBRATED YOUNGER	CALIBRATED MID POINT	PROBABILITY	CALIBRATED TOTAL RANGE
SRR-4529	WLM	44-52	135±40	1668	1783	1725	0.42	1668-1955
SRR-4530	WLM	164-172	1925±40	-2	134	66	0.86	-88- +213
SRR-4531	WLM	184-192	2000±40	-119	78	-21	0.97	-167- +78
SRR-4532	GLM	80-88	960±40	992	1162	1077	0.98	992-1187
SRR-4533	GLM	180-188	1860±40	52	248	150	0.97	30-316
SRR-4534	GLM	216-225	2215±45	-392	-197	-295	0.95	-392- -173
SRR-4535	CGM	120-128	1680±45	231	433	332	0.97	231-530
SRR-4536	CGM	164-172	2005±40	-112	69	-22	0.97	-164- +69
SRR-4537	CGM	200-208	2095±45	-211	-86	-149	0.69	-351- +1
SRR-4538	FZM	100-108	925±45	1018	1209	1114	0.98	1003-1209
SRR-4539	FZM	148-156	1820±45	74	259	167	0.89	74-333
SRR-4540	FZM	234-242	3255±40	-1637	-1449	-1543	0.97	-1684- -1449
SRR-4541	LTM	64-66.5	1465±40	533	654	594	0.91	434-654
SRR-4542	LTM	87-89.5	1715±40	226	419	323	0.98	180-419
SRR-4543	LTM	134-136.5	2125±40	-233	-90	-162	0.72	-355- -90
SRR-4544	CYM	24-33	340±40	1544	1639	1592	1.00	1454-1639
SRR-4545	CYM	76-84	1310±40	642	778	710	0.99	642-799
SRR-4546	CYM	188-196	2780±40	-1023	-832	-928	0.95	-1072- -832
SRR-4547	EGM	35-45	930±40	1018	1193	1106	0.97	1002-1193
SRR-4548	EGM	164-172	2915±40	-1263	-1002	-1133	0.96	-1294- -975
SRR-4549	EGM	256-264	3915±40	-2499	-2298	-2399	0.94	-2565 - -2298
SRR-4550	DGM	25-33	250±40	1616	1679	1648	0.36	1513-1955
SRR-4551	DGM	150-157	1540±40	419	602	511	1.00	419-602
SRR-4552	DGM	250-257	2365±40	-543	-381	-462	0.75	-459- -381
SRR-4616	FSM	88-94	1550±40	414	584	499	0.98	414-597
SRR-4617	FSM	125-132	1925±45	-3	+176	87	0.87	-3 - +218

1.5 CALIBRATED RADIOCARBON DATES AT 68% CONFIDENCE LIMIT (YEARS B.P.) FOR PUBLISHED SITES.

CODE	SITE	RADIOCARBON AGE B.P.	CALIBRATED OLDER	CALIBRATED YOUNGER	CALIBRATED MID POINT	PROBABILITY	CALIBRATED TOTAL RANGE
HV-3085	BOLTON FELL	505±35	544	516	530	1.00	544-516
HV-3084	BOLTON FELL	680±50	682	641	662	0.66	682-568
HV-3083	BOLTON FELL	920±70	922	782	852	1.00	922-782
HV-3082	BOLTON FELL	1185±60	1179	1052	1116	0.89	1179-1008
HV-3078	BOLTON FELL	1170±50	1165	1053	1109	0.89	1165-1009
HV-3081	BOLTON FELL	1860±60	1866	1731	1798	1.00	1866-1731
GAK-2072	BISHOP MIDDLEHAM	3660±80	4091	3885	3988	0.94	4131-3885
GAK-2073	BISHOP MIDDLEHAM	3360±80	3695	3540	3618	0.82	3695-3477
SRR-600	HUTTON HENRY	1842±80	1867	1709	1788	1.00	1867-1709
SRR-873	FELLEND	434±45	526	470	498	1.00	526-470
SRR-874	FELLEND	945±40	871	826	1697	0.46	926-794
SRR-875	FELLEND	1330±40	1298	1237	1267	0.92	1298-1196
SRR-876	FELLEND	1948±45	1949	1860	1905	0.93	1949-1840
SRR-877	FELLEND	3688±60	4094	3970	4032	0.77	4141-3937
SRR-101	NEASHAM FEN	3242±70	3496	3395	3446	0.64	3557-3395
SRR-97	NEASHAM FEN	2804±70	2996	2843	2920	0.90	2996-2799
SRR-98	NEASHAM FEN	2850±70	3050	2874	2962	1.00	3050-2874
SRR-99	NEASHAM FEN	2538±50	2749	2708	2729	0.33	2749-2499
SRR-100	NEASHAM FEN	2488±75	2679	2474	2577	0.81	2730-2474
SRR-96	NEASHAM FEN	1213±60	1190	1064	1127	0.87	1231-1064
HAR-1949	CAMP HILL	640±80	613	577	595	0.56	670-577
HAR-1947	CAMP HILL	2670±70	2850	2750	2800	1.00	2850-2750
SRR-89	VALLEY BOG	2212±50	2269	2154	2212	0.81	2319-2154
SRR-88	VALLEY BOG	2175±45	2308	2235	2272	0.52	2308-2132
SRR-411	HALLOWELL	907±55	910	783	846	1.00	910-783
SRR-412	HALLOWELL	1522±65	1456	1354	1401	0.74	1499-1354
SRR-413	HALLOWELL	1355±50	1321	1240	1281	1.00	1321-1240
SRR414	HALLOWELL	1782±60	1807	1689	1748	0.74	1807-1622
SRR-415	HALLOWELL	1956±70	1993	1832	1913	1.00	1933-1832
SRR-417	HALLOWELL	2432±60	2272	2152	2212	0.70	2339-2152

1.5 CONTINUED.

SRR-404	THORPE BULMER	2064±60	2116	1961	2039	1.00	2116-1961
GAK1713	THORPE BULMER	1730±120	1810	1530	1670	1.00	1810-1530
SRR-1041	STENG	1085±35	1007	961	984	0.66	1053-961
Q-1519	STENG	1490±60	1423	1313	1368	0.90	1489-1313
Q-1520	STENG	1970±60	2000	1862	1931	1.00	2000-1862
SRR-1042	STENG	2528±35	2745	2709	2727	0.37	2745-2508

1.6 CALIBRATED RADIOCARBON DATES AT 65% CONFIDENCE LIMIT (YEARS B.C./A.D.) FOR PUBLISHED SITES.

CODE	SITE	RADIOCARBON AGE B.P.	CALIBRATED OLDER	CALIBRATED YOUNGER	CALIBRATED MID POINT	PROBABILITY	CALIBRATED TOTAL RANGE
HV-3085	BOLTON FELL	505±35	1406	1434	1420	1.00	1406-1434
HV-3084	BOLTON FELL	680±50	1268	1309	1288	0.66	1268-1382
HV-3083	BOLTON FELL	920±70	1028	1168	1098	1.00	1028-1168
HV-3082	BOLTON FELL	1185±60	771	898	835	0.89	771-942
HV-3078	BOLTON FELL	1170±50	785	897	841	0.89	785-941
HV-3081	BOLTON FELL	1860±60	59	244	151	1.00	59-244
GAK-2072	BISHOP MIDDLEHAM	3660±80	-2142	-1936	-2039	0.94	-2182- -1936
GAK-2073	BISHOP MIDDLEHAM	3360±80	-1746	-1591	-1668	0.82	-1746- -1528
SRR-600	HUTTON HENRY	1842±80	83	241	162	1.00	83-241
SRR-873	FELLEND	434±45	1424	1480	1452	1.00	1424-1480
SRR-874	FELLEND	945±40	1079	1124	1101	0.46	1024-1124
SRR-875	FELLEND	1330±40	652	713	683	0.92	652-754
SRR-876	FELLEND	1948±45	1	90	45	0.93	1-110
SRR-877	FELLEND	3688±60	-2145	-2021	-2083	0.77	-2192- -2021
SRR-101	NEASHAM FEN	3242±70	-1547	-1446	-1496	0.64	-1608- -1446

1.6 CONTINUED.

SRR-97	NEASHAM FEN	2804±70	-1047	-894	-970	0.90	-1047- -850
SRR-98	NEASHAM FEN	2850±70	-1101	-925	-1013	1.00	-1101- -925
SRR-99	NEASHAM FEN	2538±50	-800	-759	-780	0.33	-800- -591
SRR-100	NEASHAM FEN	2488±75	-730	-525	-628	0.81	-781- -525
SRR-96	NEASHAM FEN	1213±60	760	866	833	0.87	719-866
HAR-1949	CAMP HILL	640±80	1337	1393	1365	0.56	1280-1393
HAR-1947	CAMP HILL	2670±70	-901	-801	-851	1.00	-901- -801
SRR-89	VALLEY BOG	2212±50	-320	-205	-262	0.81	-320- -205
SRR-88	VALLEY BOG	2175±45	-359	-285	-323	0.52	-359- -183
SRR-411	HALLOWELL	907±55	1040	1167	1103	1.00	1040-1167
SRR-412	HALLOWELL	1522±65	494	596	545	0.74	451-596
SRR-413	HALLOWELL	1355±50	629	710	669	0.99	629-710
SRR414	HALLOWELL	1782±60	143	261	202	0.74	143-328
SRR-415	HALLOWELL	1956±70	-323	-203	-263	0.70	-390- -203
SRR-417	HALLOWELL	2432±60	-548	-406	-477	0.62	-759- -406
SRR-404	THORPE BULMER	2064±60	-167	-12	-90	1.00	-167- -12
GAK1713	THORPE BULMER	1730±120	140	420	280	1.00	140-420
SRR-1041	STENG	1085±35	943	989	966	0.66	897-989
Q-1519	STENG	1490±60	527	637	582	0.90	461-637
Q-1520	STENG	1970±60	-51	+88	+37	1.00	-51 - +88
SRR-1042	STENG	2528±35	-796	-760	-778	0.37	-796- -559

1.7 CALIBRATED RADIOCARBON DATES AT 95% CONFIDENCE LIMIT (YEARS B.P.) FOR PUBLISHED SITES.

CODE	SITE	RADIOCARBON AGE B.P.	CALIBRATED OLDER	CALIBRATED YOUNGER	CALIBRATED MID POINT	PROBABILITY	CALIBRATED TOTAL RANGE
HV-3085	BOLTON FELL	505±35	559	501	530	0.94	628-501
HV-3084	BOLTON FELL	680±50	693	554	624	1.00	693-554
HV-3083	BOLTON FELL	920±70	952	704	828	1.00	952-704
HV-3082	BOLTON FELL	1185±60	1261	982	1122	1.00	1261-982
HV-3078	BOLTON FELL	1170±50	1193	970	1082	0.96	1234-970
HV-3081	BOLTON FELL	1860±60	1938	1691	1815	0.96	1938-1625
GAK-2072	BISHOP MIDDLEHAM	3660±80	4251	3823	4037	0.98	4251-3766

1.7 CONTINUED.

GAK-2073	BISHOP MIDDLEHAM	3360±80	3832	3454	3643	0.99	3832-3454
SRR-600	HUTTON HENRY	1842±80	1938	1606	1772	1.00	1938-1606
SRR-873	FELLEND	434±45	545	430	488	0.92	545-326
SRR-874	FELLEND	945±40	940	773	857	1.00	940-773
SRR-875	FELLEND	1330±40	1311	1176	1244	1.00	1311-1176
SRR-876	FELLEND	1948±45	2031	1816	1924	1.00	2031-1816
SRR-877	FELLEND	3688±60	4230	3875	4035	1.00	4230-3875
SRR-101	NEASHAM FEN	3242±70	3638	3351	3495	1.00	3638-3351
SRR-97	NEASHAM FEN	2804±70	3111	2796	2940	0.99	3150-2769
SRR-98	NEASHAM FEN	2850±70	3171	2844	3008	0.98	3205-2844
SRR-99	NEASHAM FEN	2538±50	2764	2460	2612	1.00	2764-2460
SRR-100	NEASHAM FEN	2488±70	2743	2401	2572	0.92	2743-2362
SRR-96	NEASHAM FEN	1213±60	1275	1051	1163	0.93	1275-1001
HAR-1949	CAMP HILL	640±80	705	519	612	1.00	705-519
HAR-1947	CAMP HILL	2670±70	2975	2711	2834	1.00	2957-2549
SRR-89	VALLEY BOG	2212±50	2343	2111	2227	0.99	2343-2076
SRR-88	VALLEY BOG	2175±45	2322	2102	2212	0.94	2322-2068
SRR-411	HALLOWELL	907±55	932	723	828	1.00	932-723
SRR-412	HALLOWELL	1522±65	1538	1306	1422	1.00	1538-1306
SRR-413	HALLOWELL	1355±50	1349	1175	1262	1.00	1349-1175
SRR414	HALLOWELL	1782±60	1839	1559	1699	0.99	1839-1559
SRR-415	HALLOWELL	1956±70	2066	1730	1898	1.00	2066-1730
SRR-417	HALLOWELL	2432±60	2558	2351	2455	0.60	2714-2351
SRR-404	THORPE BULMER	2064±60	2159	1878	2019	0.96	2301-1878
GAK1713	THORPE BULMER	1730±120	1920	1390	1655	1.00	1920-1390
SRR-1041	STENG	1085±35	1060	941	1001	1.00	1060-941
Q-1519	STENG	1490±60	1515	1299	1407	1.00	1515-1299
SRR-1042	STENG	2528±35	2661	2480	2571	0.70	2751-2480

1.8 CALIBRATED RADIOCARBON DATES AT 95% CONFIDENCE LIMIT (YEARS B.C./A.D.) FOR PUBLISHED SITES.

CODE	SITE	RADIOCARBON AGE B.P.	CALIBRATED OLDER	CALIBRATED YOUNGER	CALIBRATED MID POINT	PROBABILITY	CALIBRATED TOTAL RANGE
HV-3085	BOLTON FELL	505±35	1391	1449	1420	0.94	1322-1449
HV-3084	BOLTON FELL	680±50	693	554	624	1.00	693-554
HV-3083	BOLTON FELL	920±70	998	1246	1122	1.00	998-1246
HV-3082	BOLTON FELL	1185±60	689	968	829	1.00	689-968
HV-3078	BOLTON FELL	1170±50	757	980	869	0.96	716-980
HV-3081	BOLTON FELL	1860±60	12	259	135	0.96	12-325
GAK-2072	BISHOP MIDDLEHAM	3660±80	-2302	-1874	-2088	0.98	-2302- -1817
GAK-2073	BISHOP MIDDLEHAM	3360±80	-1883	-1505	-1694	0.99	-1883- -1505
SRR-600	HUTTON HENRY	1842±80	12	344	178	1.00	12-344
SRR-873	FELLEND	434±45	1405	1520	1463	0.92	1405-1624
SRR-874	FELLEND	945±40	1010	1177	1094	1.00	1010-1177
SRR-875	FELLEND	1330±40	639	774	707	1.00	639-774
SRR-876	FELLEND	1948±45	-82	+134	+52	1.00	-82- +134
SRR-877	FELLEND	3688±60	-2281	-1976	-2139	1.00	-2281- -1996
SRR-101	NEASHAM FEN	3242±70	-1689	-1402	-1546	1.00	-1689- -1402
SRR-97	NEASHAM FEN	2804±70	-1162	-820	-991	0.99	-1201- -820
SRR-98	NEASHAM FEN	2850±70	-1222	-895	-1059	0.98	-1256- -895
SRR-99	NEASHAM FEN	2538±50	-815	-511	-663	1.00	-815- -511
SRR-100	NEASHAM FEN	2488±70	-794	-452	-623	0.92	-794- -423
SRR-96	NEASHAM FEN	1213±60	675	899	787	0.93	675-949
HAR-1949	CAMP HILL	640±80	1245	1431	1338	1.00	1245-1431
HAR-1947	CAMP HILL	2670±70	-627	-600	-613	0.98	-1008- -600
SRR-89	VALLEY BOG	2212±50	-3702	-3494	-3598	0.90	-3702- -3378
SRR-88	VALLEY BOG	2175±45	-373	-153	-263	0.94	-373- -119
SRR-411	HALLOWELL	907±55	1018	1227	1123	1.00	1018-1227
SRR-412	HALLOWELL	1522±65	412	644	528	1.00	412-644
SRR-413	HALLOWELL	1355±50	601	755	678	1.00	601-775
SRR414	HALLOWELL	1782±60	111	391	251	0.99	111-391
SRR-415	HALLOWELL	1956±70	-425	-89	-257	0.98	-486- -89

1.8 CONTINUED.

SRR-417	HALLOWELL	2432±60	-609	-402	-506	0.60	-765- -402
SRR-404	THORPE BULMER	2064±60	-210	+72	-138	0.96	-352- +72
GAK1713	THORPE BULMER	1730±120	30	560	295	1.00	30-560
SRR-1041	STENG	1085±35	890	1009	780	1.00	890-1009
Q-1519	STENG	1490±60	435	651	543	1.00	435-651
SRR-1042	STENG	2528±35	-712	-531	-622	0.70	-802- -531

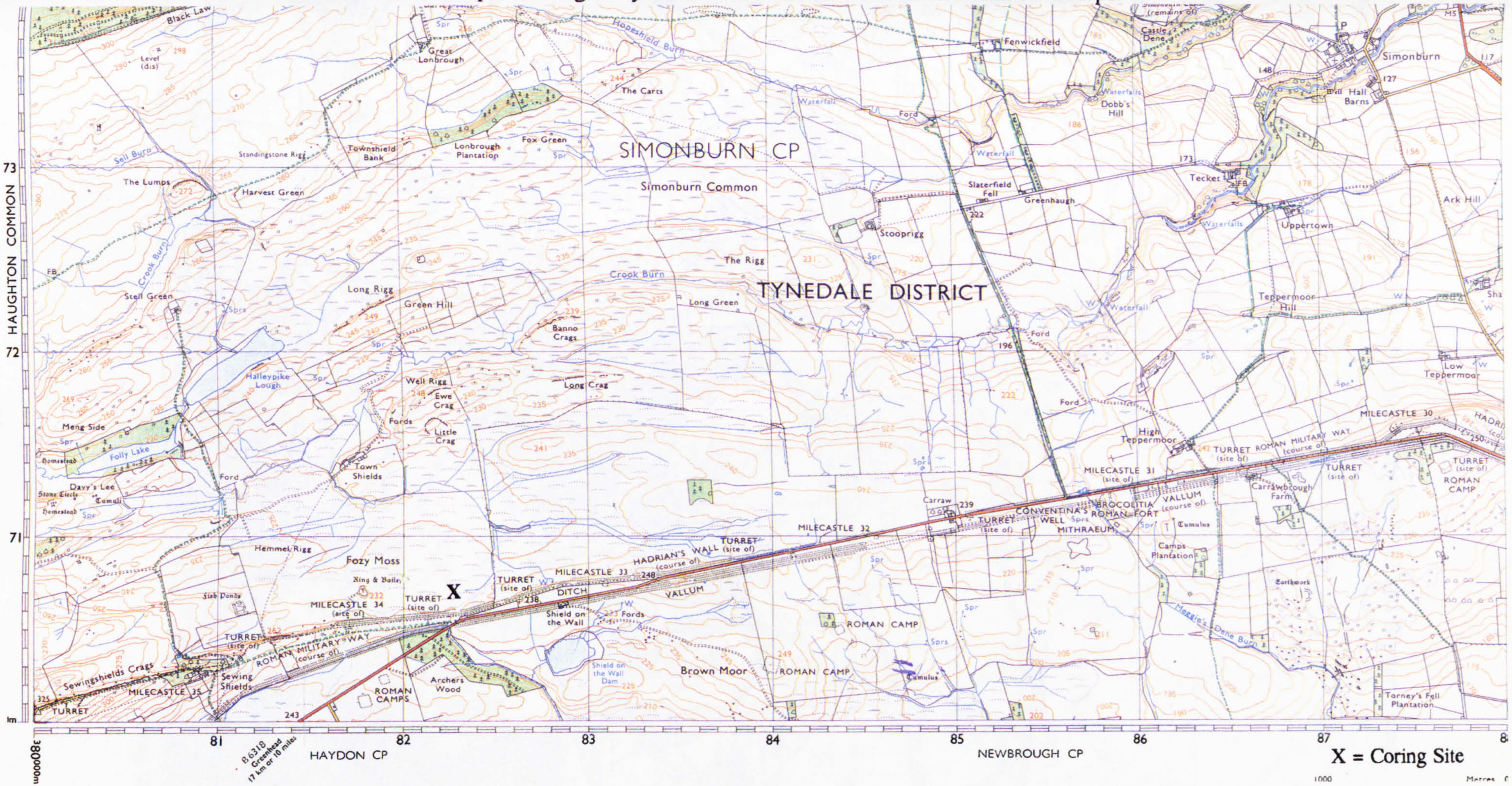
Map Showing Walton Moss With Hadrian's Wall and Bolton Fell Moss.

Map Showing Glasson Moss With Hadrian's Wall.



X = Coring Site

Map Showing Fozy Moss With Hadrian's Wall and Roman Camps.

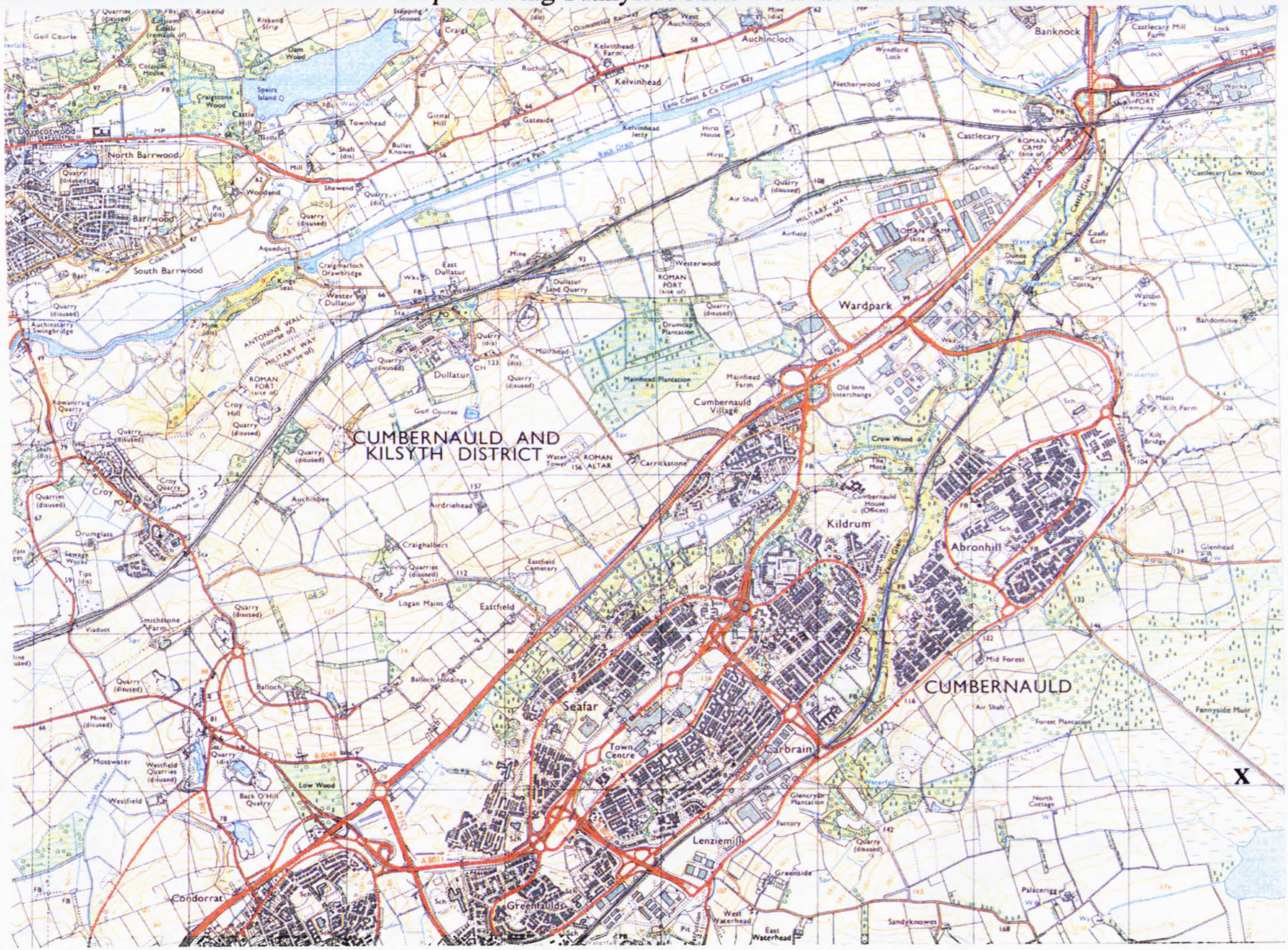


Map Showing Letham Moss With the Antonine Wall and Roman Camps.



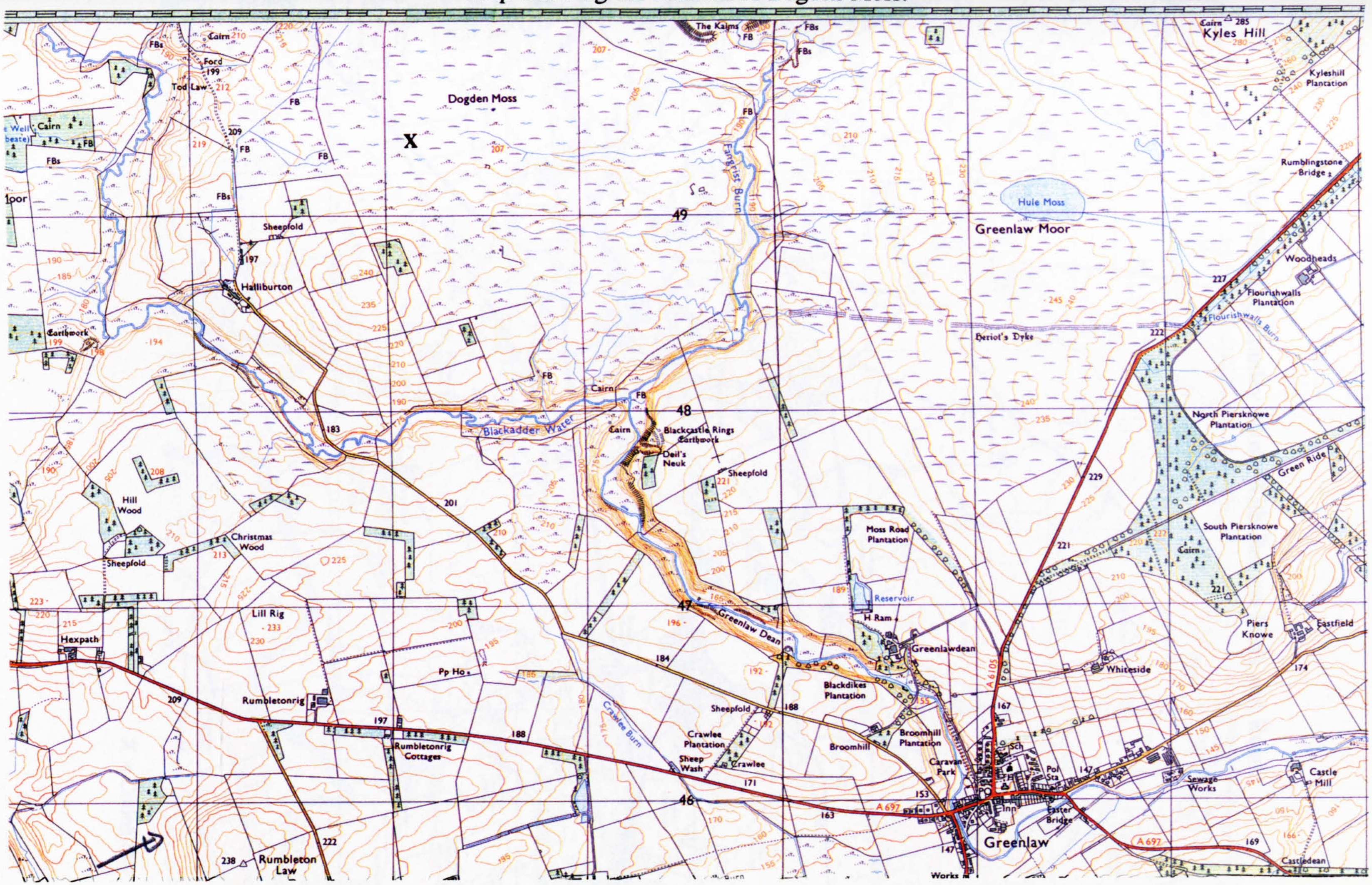
X = Coring Site

Map Showing Fannyside Muir With the Antonine Wall.



X = Coring Site

Map Showing the Position of Dogden Moss.



X = Coring Site

Map Showing Cranley Moss With Roman Forts and Road.



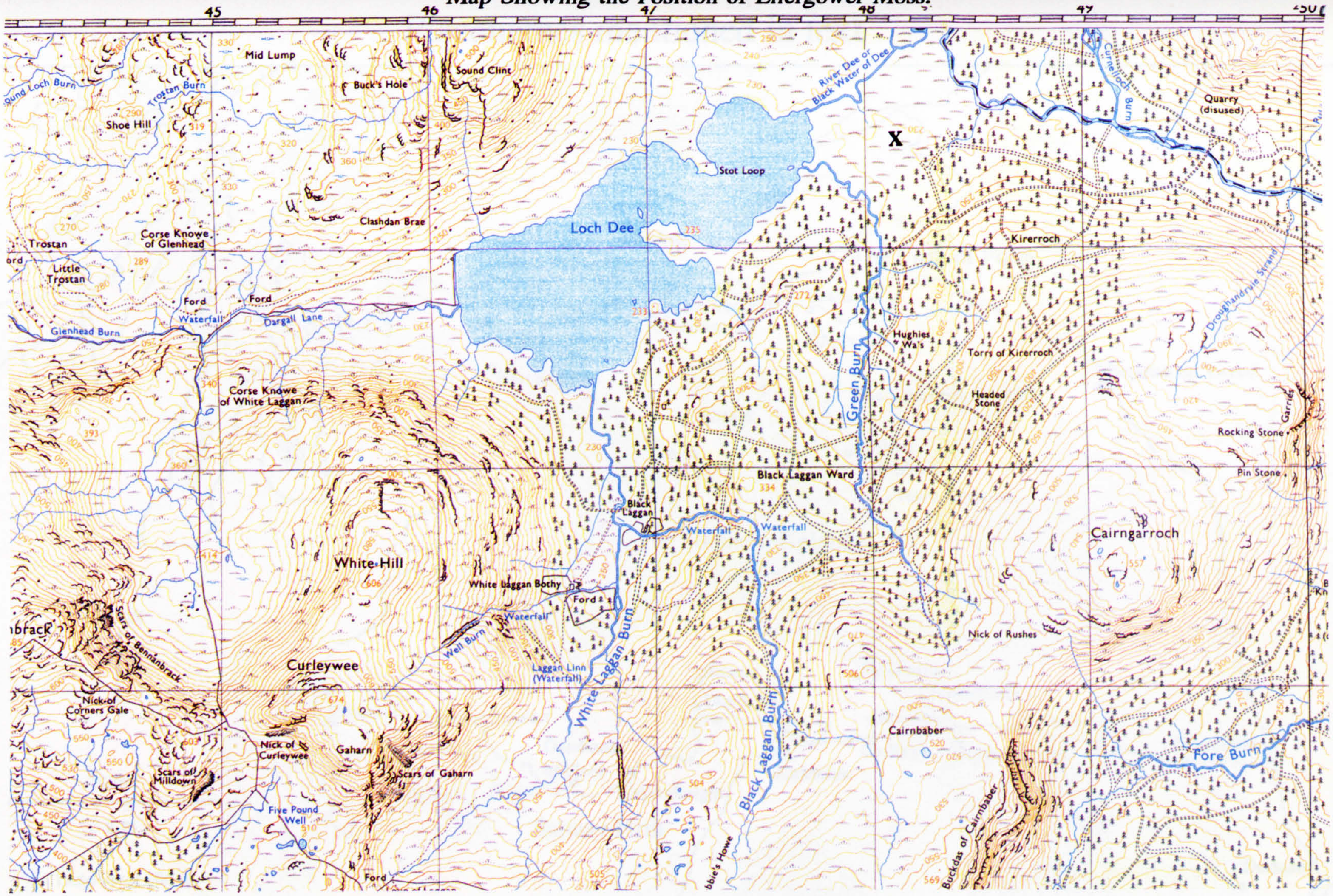
X = Coring Site

Map Showing the Position of Carsegowan Moss.



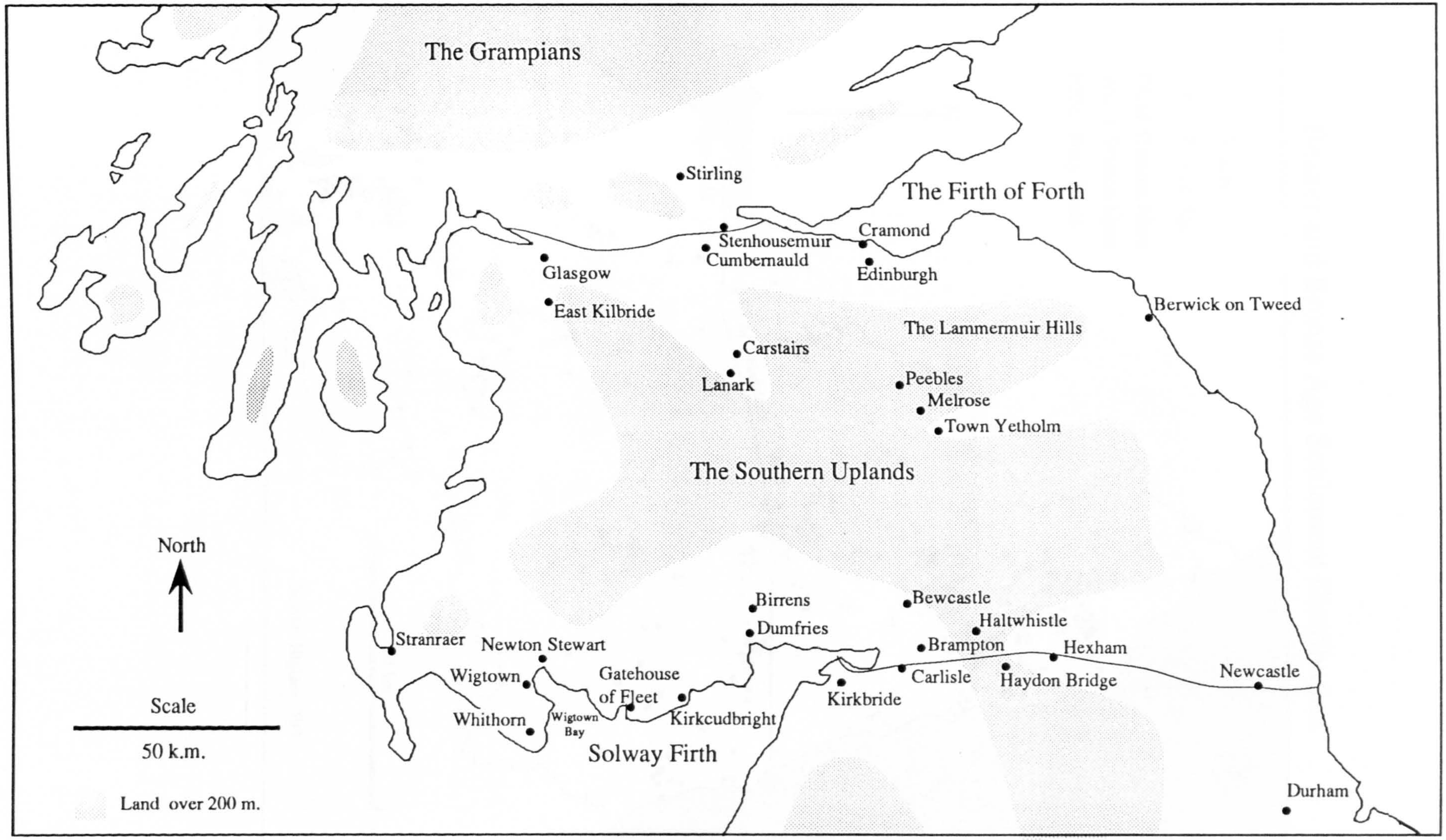
X = Coring Site

Map Showing the Position of Ellergower Moss.

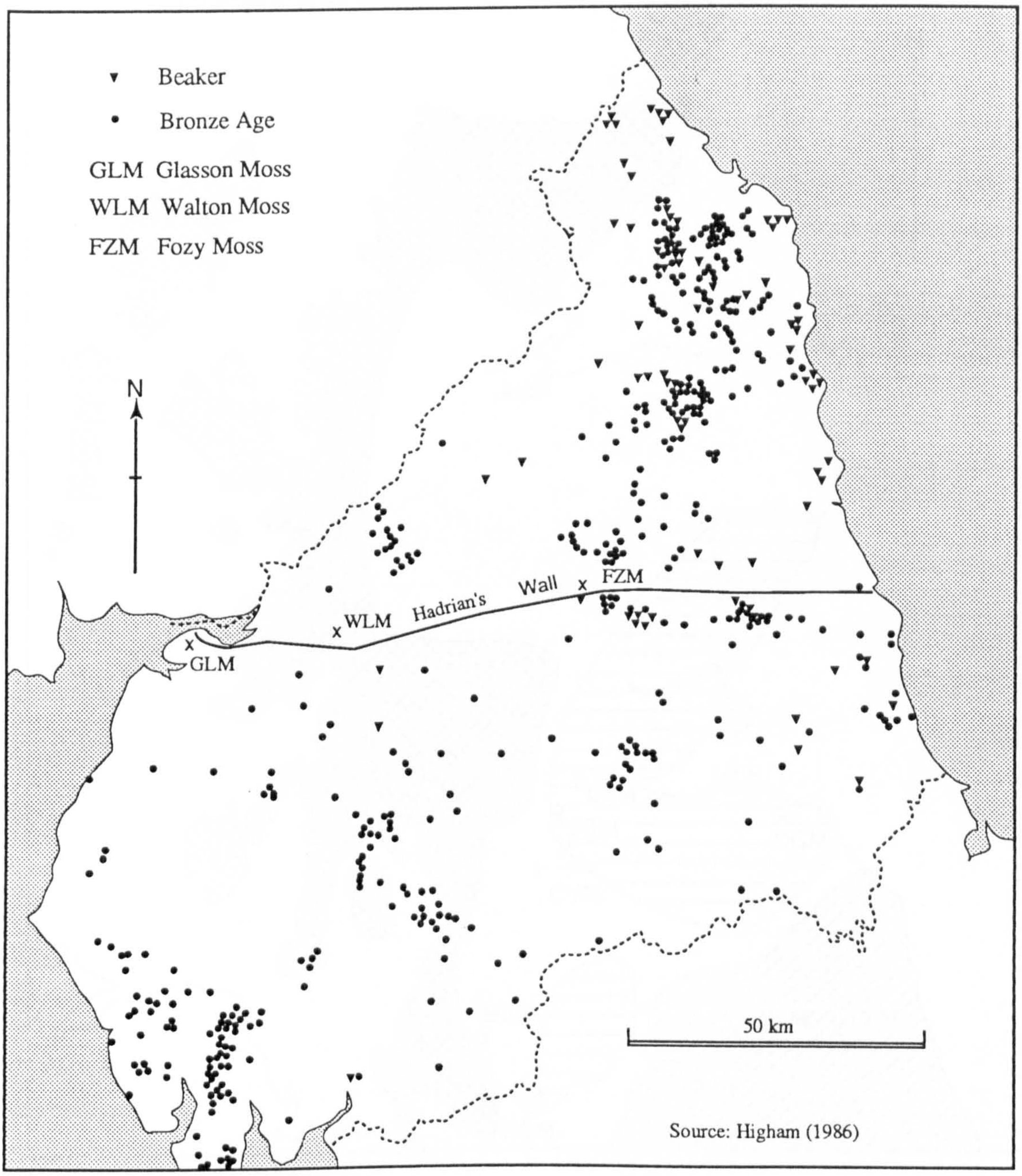


X = Coring Site

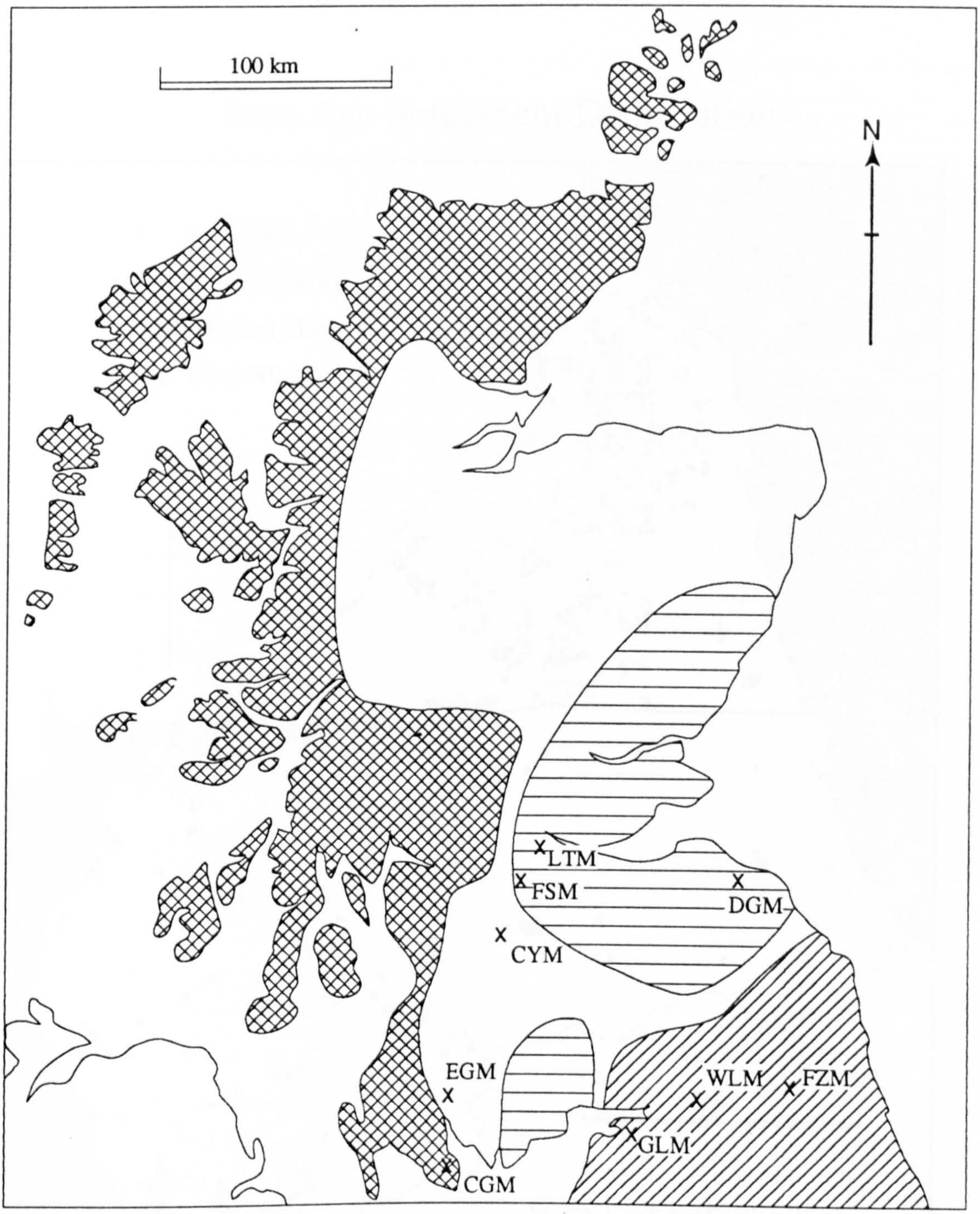
Placenames mentioned in text



Beaker and Bronze Age Settlement Distribution



Iron Age Settlement Distribution



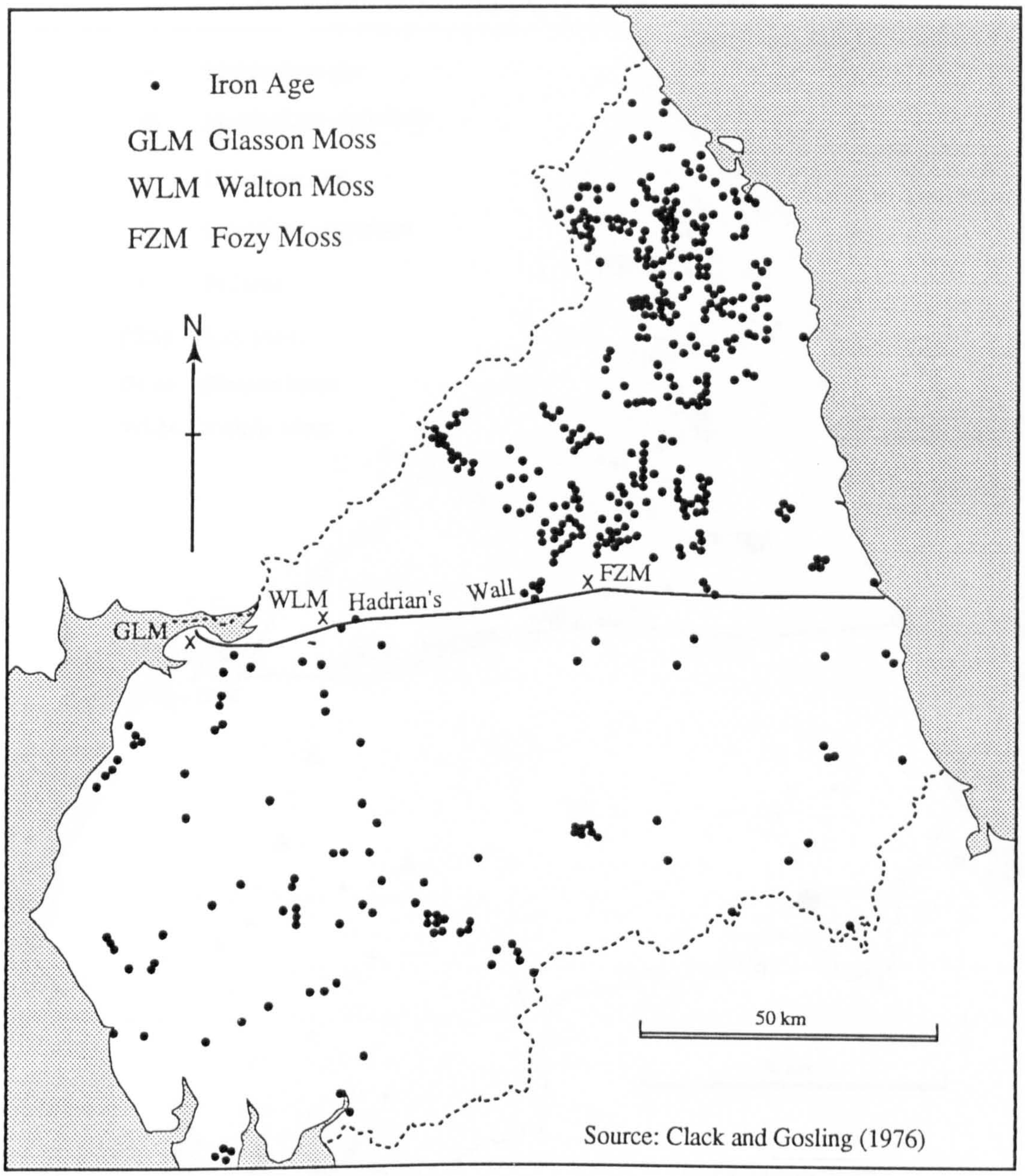
Strongly defended homesteads

Enclosed homesteads

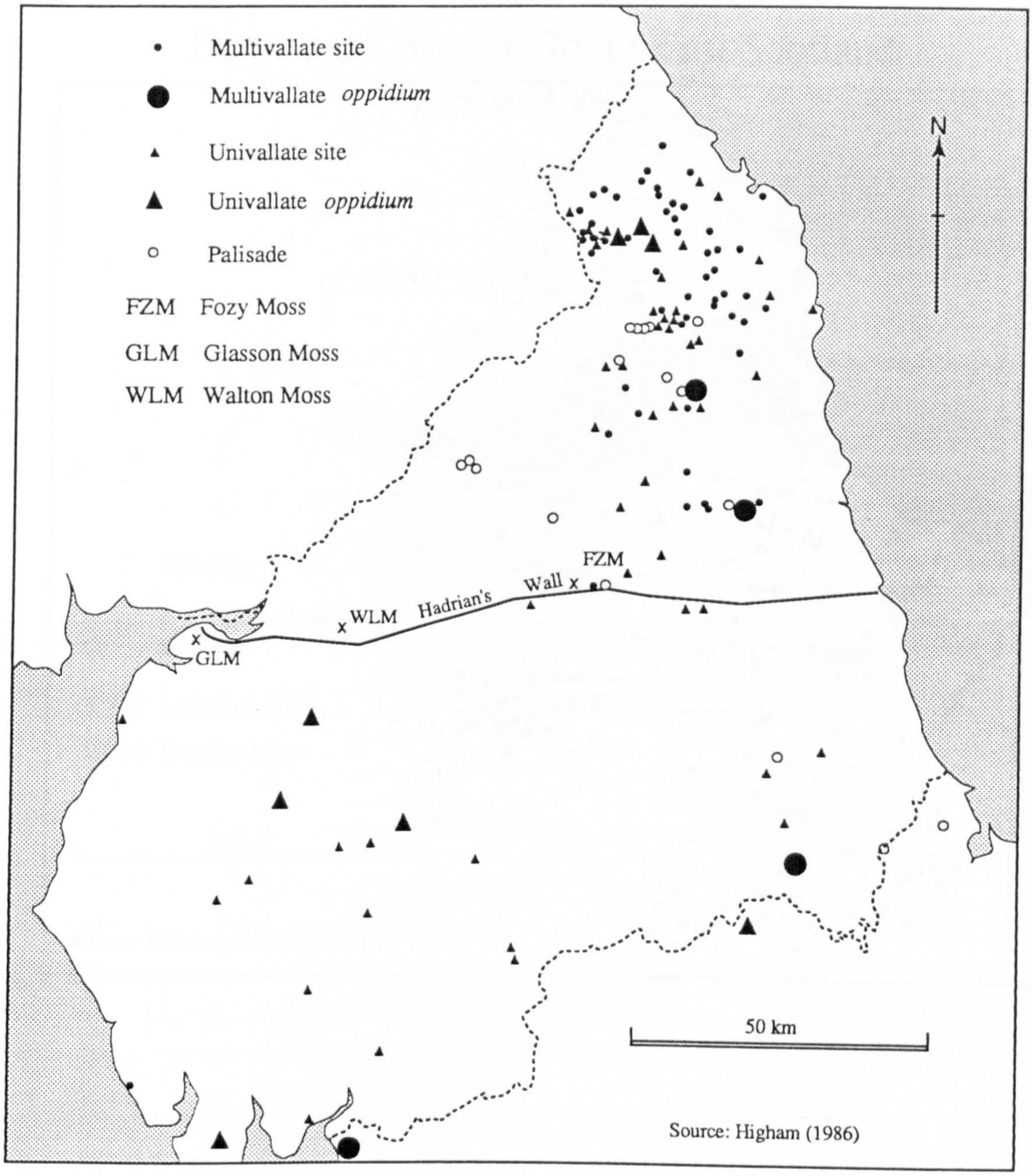
Hillfort dominated zone

Source: Cunliffe (1991)

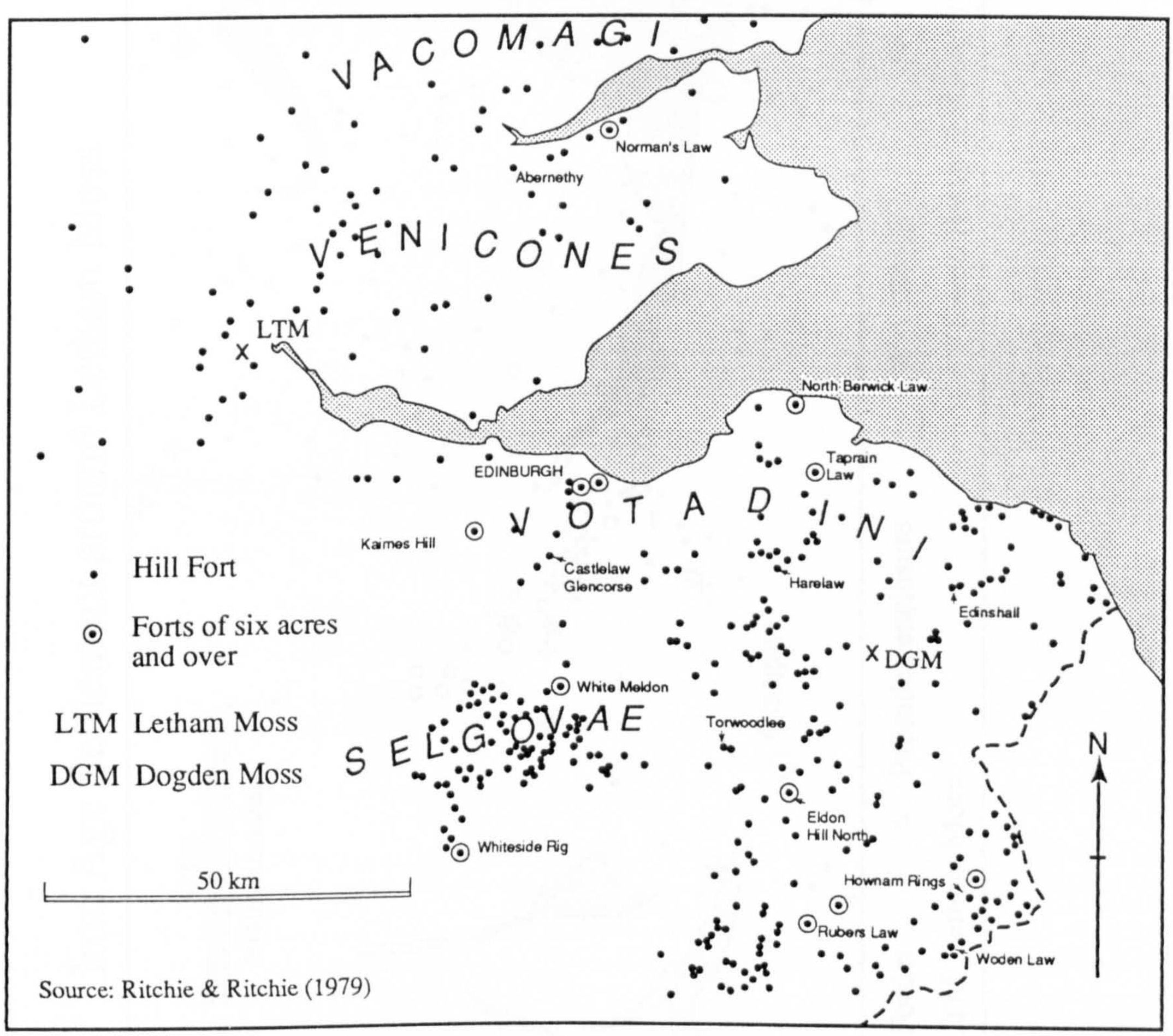
Iron Age Settlement Distribution



Palisade and Hillfort Distribution

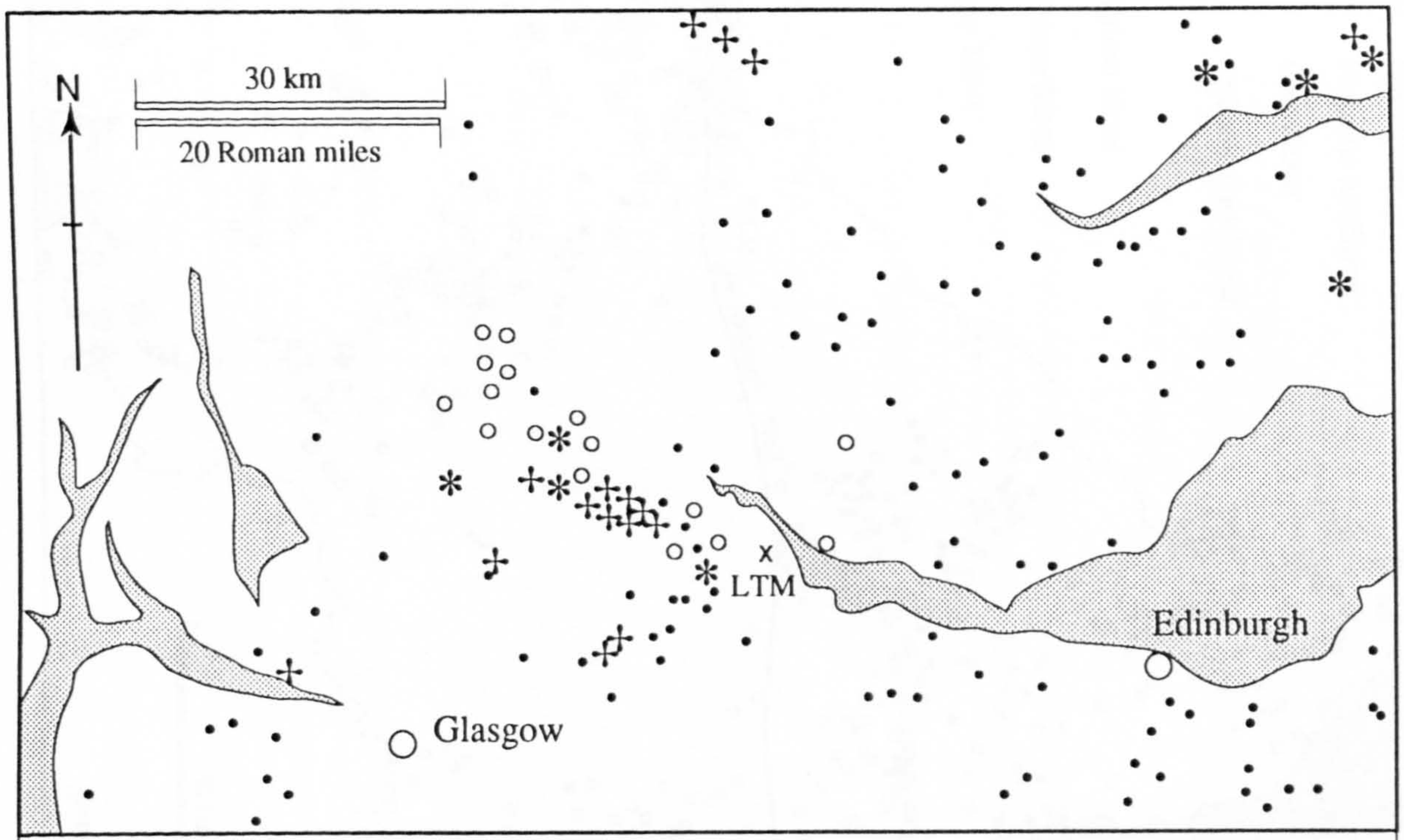


Forts and Tribes in South-East Scotland



Source: Ritchie & Ritchie (1979)

Iron Age Settlement around Letham Moss

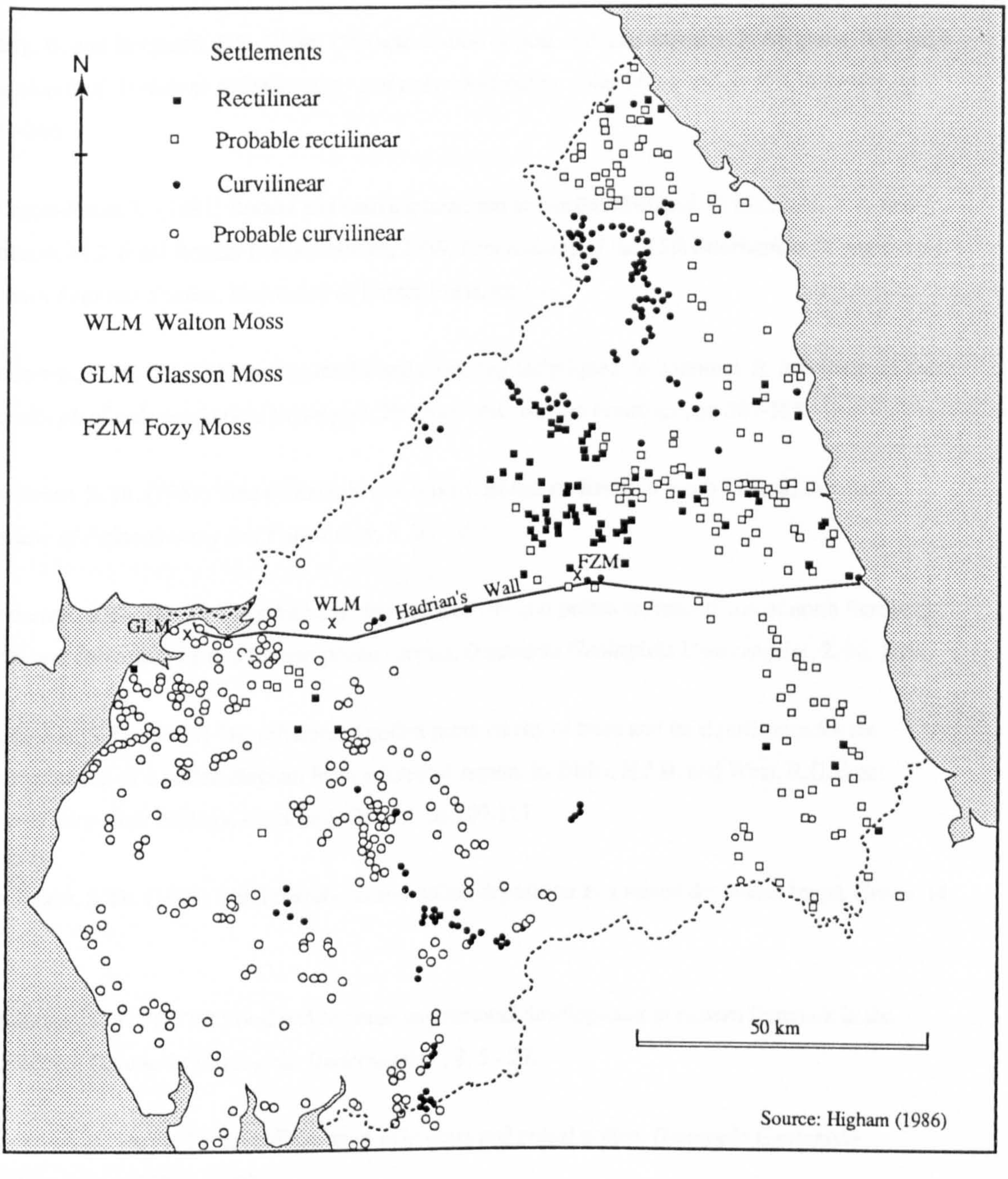


• Fortlet o Palisaded enclosure * Broch + Dun

LTM Letham Moss

Source: Hanson & Maxwell (1983)

Rural Settlement Distribution during the Roman Occupation



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FIGURE 3.14 GLASSON MOSS, CUMBRIA

