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Palynological, stratigraphic and chemical analyses of sediments in the Lothians with particular reference to the Lateglacial.

Alan J. Alexander

Ph.D.

University of Edinburgh

1985

Palynological and stratigraphic investigations have been conducted on sediment cores for three sites in Lothian Region, Scotland: Balgone House, Broxmouth and Corstorphine.

All phases of the Lateglacial period, as far as they are manifested in the Lothians at the sites studied, have been investigated with particular reference to the Younger Dryas, the main Interstadial, or Allerød, and also the evidence for the colder conditions that preceded it which are presumed to represent Older Dryas-type vegetation. Further light has been cast on the development of the Postglacial broad - leaved forests.

The Cambridge computer program POLLDATA MKV was used to perform the necessary calculations and controlled a graph plotter to generate pollen diagrams. A series of subroutines is described that translated the calls to the Cambridge graphics subroutine library. This may serve as a model for other installations.

Objective numerical zonation methods are applied to the pollen data. These methods are used not only to zone the pollen series but also to aid in the generation of hypotheses regarding vegetation changes.

Chemical analyses of the sediments from Balgone House were undertaken. The results obtained are at variance with those from published work and it is proposed that the reason is that the chemical pre - treatment of samples employed locally may be less efficient in leaching the cations from the mineral fraction.

ACKNOWLEDGEMENTS:

I gratefully acknowledge the encouragement and guidance of my research supervisors, Dr. W. W. Newey and Dr. J. B. Sissons, and also of the head of department, Dr. A. J. Crosbie who maintained a continuing interest in the progress of the work and provided much-needed sources of employment in teaching and in research work.

I am deeply indebted for the financial assistance, without which the thesis would not have been completed, given by the following scholarships and funds:

Vans Dunlop Scholarship 1979/80; 1980/81

Cowan House Residential Scholarship 1980/81

The Wardlaw Fund

The Lamb Fund

The Meiklejohn (John) Prize Fund

It was Dr. Peter Beckett and Dr. John Matthews who first opened my eyes to the fascination of ecological and palaeoecological studies of arctic - alpine vegetation during two University of Edinburgh Expeditions to Norway in the summers of 1976 and 1977. I am therefore grateful to both these individuals for nurturing my interest in the field and for allowing me to participate in the expeditions in the first place.

I should like to record my thanks to Sir Philip Grant-Suttie for granting consent to core the lake site near Balgone House that lies on his estate in East Lothian.

Dr. Marie Robinson and her husband Peter, Dr. Guruprasad Chattopadhyay, Dr. Roger Cornish, the late Dr. David Hodgson, and Dr. Timothy Lawson, as well as both of my supervisors, supplied muscular power and help on coring expeditions that were often frustrating and invariably muddy and exhausting.

Professor R. G. West FRS., gave permission for a short stay as a visitor of the Sub-Department of Quaternary Research, Cambridge University. This proved to be most rewarding and I am obliged to him for this opportunity. Dr. H. J. B. Birks generously made available listings of the source code for the POLLDATA, ZONATION and SLOTSEQ programs and their associated subroutines.

I have had stimulating and fruitful discussions about various aspects of the work with the following individuals: Dr. H. J. B. Birks; Dr. R. Bradshaw; Dr. P. Cundill; Dr. B. Huntley; Dr. D. Mann; Dr. S. Peglar; Dr. M. J. C. Walker and Dr. Whittington. I am indebted to Dr. Ian Morrison who read and commented upon parts of the first draft of the thesis.

The late Mr. A. Small gave much appreciated technical backup by making a calibrated brass sampler for taking exact volumes of sediment from cores and by competently repairing mangled coring equipment. Mr. David Agnew, laboratory technician, gave instruction

in the use of the apparatus for chemical analyses.

Mr. Malcolm Brown, manager of the ERCC advisory service, and the Cambridge University Computing Service gave assistance with modifications to graphics software and with the provision of special routines for data handling. I am also grateful to the ERCC machine operators for their forebearance in coping with my occasional embarassing blunders and for maintaining the high standard of graph plotter output.

Finally, Dr. Marie Robinson deserves a special mention as an enthusiastic and cheerful colleague in the laboratory whilst she was employed as an NERC post-doctoral research fellow and latterly as an authoritative correspondent.

To all of the above, and to anyone whom I have inadvertently left out, I owe a debt of gratitude. Any errors or omissions in this work are though, it should be stressed, entirely of my own making.

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* Diagram in separate pocket.

CHAPTER1

INTRODUCTION

The main objective of the research was to examine sediments of Late Quaternary age in the eastern portion of the plain of the Lothians of Scotland. The basic technique employed was pollen analysis; by identifying and counting the pollen grains extracted from the deposits it is possible to produce a picture of the former vegetation and of its changes during the Lateglacial and the following Postglacial periods. From the changes in the relative abundance of pollen and spores of particular plant species palaeoclimatic inferences are presented.

Hitherto few modern investigations have been applied to the biological and climatic development of the lowland areas of south-east Scotland, apart from those of Coope (1968) and Newey (1970), both of which concentrated on deposits of Lateglacial age at one site, namely those of the former Corstorphine Loch, Edinburgh and the studies of the Postglacial sediments at several locations by Newey (1965,1966,1968). By contrast, the palaeoecology of Northern Scotland has attracted much more attention and this work is reviewed in a later chapter. However, it is apparent from previous work that lowland sites in South-East Scotland offer a greater depth of biogenic deposits than those of the Highlands resulting in part from their greater organic productivity. These much thicker deposits have allowed, in the present work, the application of a closer sampling interval with a correspondingly more detailed analysis of vegetational changes than is apparent from earlier work. Previous work has concentrated largely on the elucidation of large-scale

changes in vegetation composition through time, in regional differentiation and also in using pollen analysis as a relative dating tool. Moreover the use of superior coring equipment, namely the Dachnowski, helped to eliminate the sampling errors that have been assumed to occur in previous investigations when a Hiller borer with its well-known disadvantages was used.

Three additional objectives are incorporated in the thesis:

First, the critical examination of the laboratory techniques employed by pollen analysts. In particular, an evaluation of the methods for preparing and adding exotic pollen to samples to enable 'absolute' counts to be made was undertaken as a part of the study.

Second, the uses of a computer to perform the necessary calculations and also to produce the pollen diagrams were investigated.

Third, the various multivariate statistical techniques which have been employed by palynologists to zone pollen diagrams objectively were applied and their relative merits and weaknesses assessed. From the results of the statistical analyses it was possible to judge the efficacy and performance of each technique in summarising the structure of individual datasets. Further the datasets were also compared using a range of statistical techniques to indicate how the sequence of vegetation at each site varied from each other.

In summary, although the main emphasis of the research described in this thesis is essentially a pollen analytical one it also covers a range of secondary topics. The work is geographical in context for in achieving the prime aim as outlined above, it includes the spatial and temporal prerequisites of all geographic research.

To conclude this introduction the terminology and nomenclature employed in the thesis are described below.

TERMINOLOGY and NOMENCLATURE

The climostratigraphic units that are used are basically the same as those which were provisionally defined by Gray and Lowe (1980), but with some minor alterations as set out below:

Lateglacial: The sediments formed between the start of the Lateglacial Interstadial and the start of the Younger Dryas Stadial.

Lateglacial Interstadial: The sediments formed between the thermal improvement around 13,000 BP and the thermal decline at around 11,000 BP.

Younger Dryas Stadial: The sediments formed between the thermal decline around 11,000 BP and the thermal improvement between about 10,500 and 10,000 BP.

The term 'Postglacial' is used in preference to the terms

'Flandrian' and 'Holocene' which have several different definitions (West, 1967; Suggate and West, 1967; Shotton and West, 1969; Mitchell et al 1973; Mangerud et al, 1974). The Postglacial is defined by the author after the definitions for the Lateglacial given by Gray and Lowe (1980) as:

Postglacial: The sediments formed during the thermal improvement that took place between about 10,500 and 10,000 BP and in the following time interval to the present day.

The boundary between the Lateglacial and the Postglacial periods is defined on lithostratigraphic and biostratigraphic grounds in the field area but, in the absence of radiocarbon dates, no absolute date is placed on it. In discussing the pollen stratigraphic evidence biostratigraphic units of the pollen assemblage zone type (Chapter 4; Cushing, 1967b;H. J.B. Birks, 1973) which are defined on the basis of the observed pollen and spore content of the sediments examined are employed in order separate the observed changes in the pollen stratigraphy from inferred changes in climate and vegetation.

In the absence of evidence for the absolute ages of the biostratigraphic units, following H. J. B. Birks (1973a) terms such as 'Rumex - Cyperaceae time' are used to refer to the time interval during which sediments containing that particular assemblage were deposited at the site under discussion.

The botanical nomenclature employed in the thesis follows that of Clapham, Tutin and Warburg (1962).

CHAPTER 2.

THE PHYSICAL BACKGROUND OF THE AREA STUDIED

2.1 INTRODUCTION.

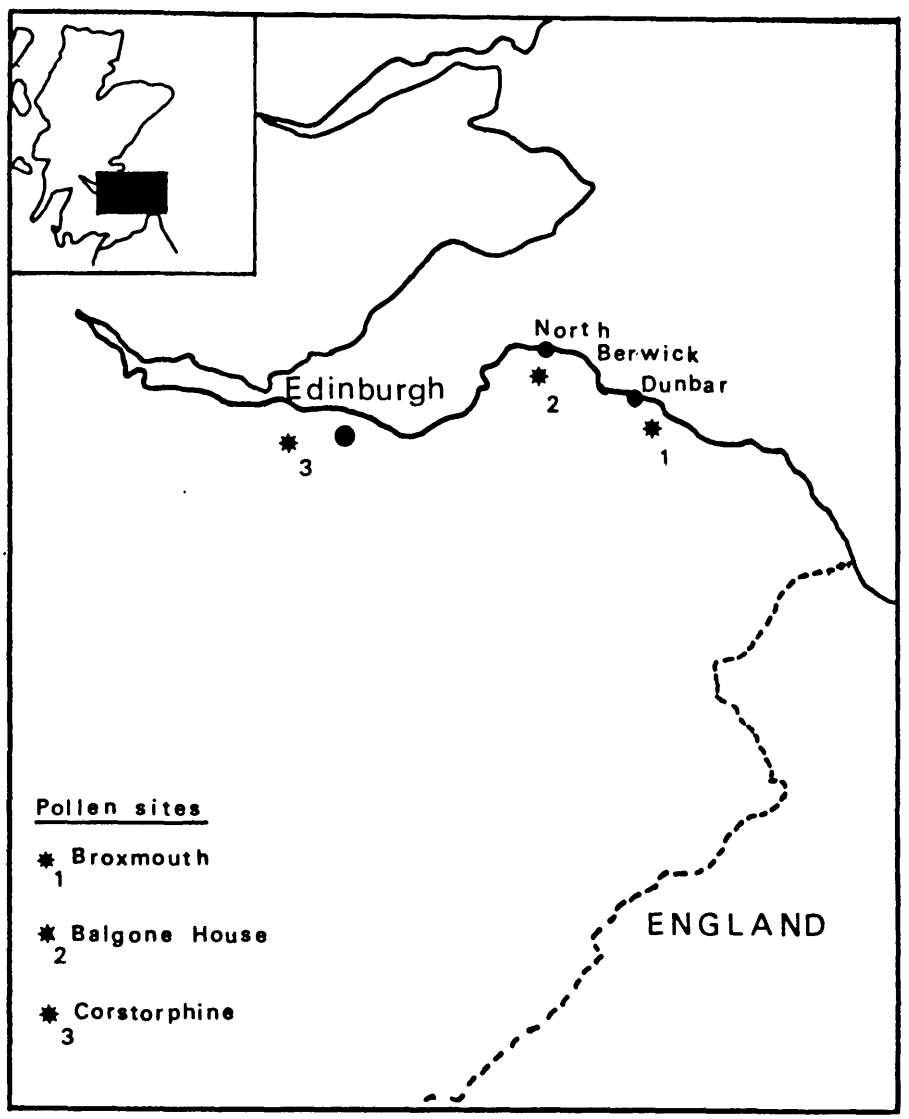
The sites from which cores were taken for palynological, stratigraphic and chemical analyses are all located in the Lothians, in particular in Midlothian and East Lothian, of South-east Scotland. The location of each of the sites is shown on map 2.1.

In the following sections various characteristics of the region are described to provide a background to the detailed descriptions of the sites which follow in later chapters.

2.2 Some general features of the physical geography of the area of research.

The Lothians lie to the south of the Firth of Forth in the Midland Valley of Scotland. The Midland Valley is a broad, lowland region approximately 80 kilometres from North to South and 200 kilometres from West to East that trends Northeast to Southwest across Scotland from the Firths of Forth and Tay in the East to the Clyde in the West.

The Highland Boundary fault, which runs from Stonehaven to Helensburgh, and the Southern Uplands fault, that extends from Dunbar to near Girvan, mark the northern and southern limits of the Midland Valley respectively and separate it from the metamorphic rocks of the Grampian Highlands and also from the folded Ordovician and Silurian



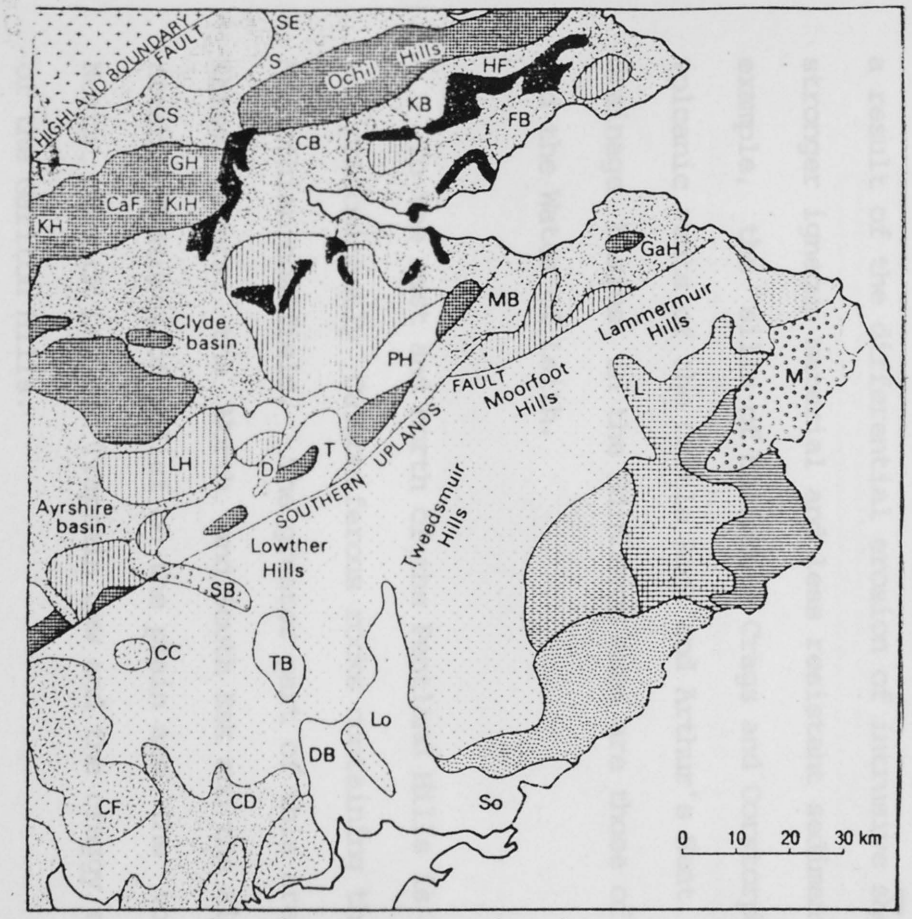
Map 2.1 Map showing locations of pollen sites.

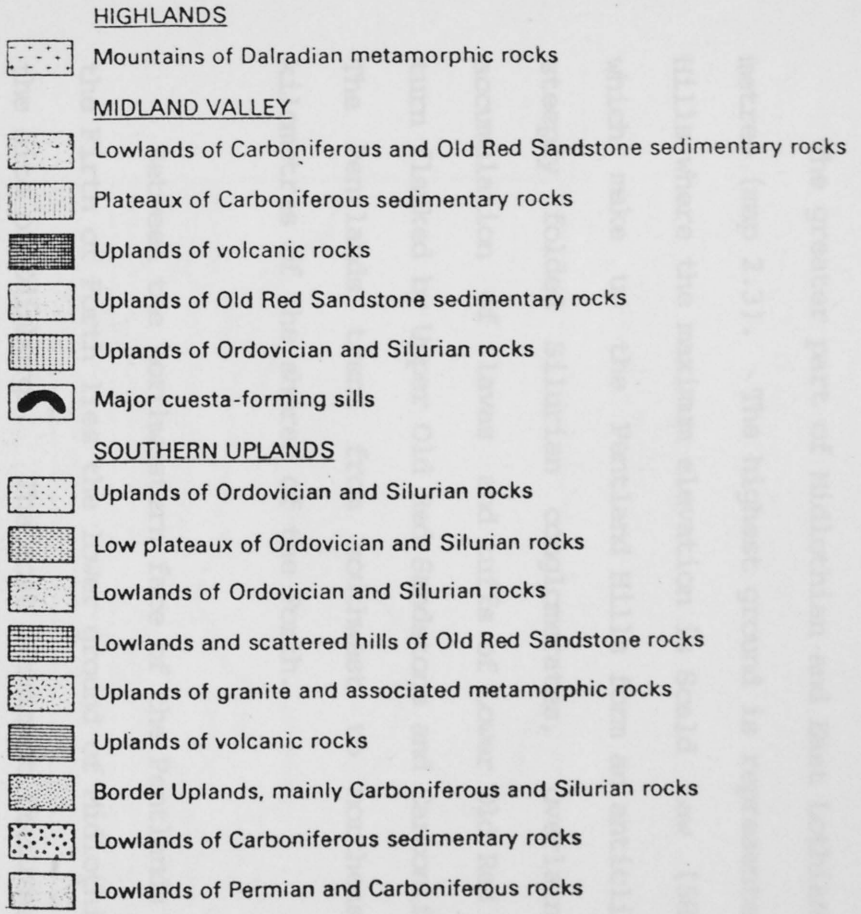
rocks of the Southern Uplands (map 2.2).

The principal rock formations are mainly Palaeozoic of Lower Old Red Sandstone and Carboniferous age. In general, the Carboniferous rocks form a wide complex syncline lying above and bordered by rocks of Old Red Sandstone age. The main axes of folding are parallel to the boundary faults mentioned above, and largely accounts for the S.W. to N.E. trend of many of the physical features.

In both the Carboniferous and Old Red Sandstone age strata there are locally great thicknesses of contemporaneous extrusive rocks and also many intrusive features such as vents, plugs, sills, and dykes. The differential erosion of these harder igneous rocks and of the relatively softer surrounding sediments of the Carboniferous and Old Red Sandstone has given rise to the large degree of correspondence of igneous rocks with the higher ground and sedimentary strata with the lower. Thus volcanic rocks mainly form the plateaus and ridges of the upland areas and also the majority of the smaller hills and crags are intrusive features, for example, sills or volcanic vents.

Folding and faulting have played an important part in the determination of relief in the region, while many of the minor topographic features are the result of the effects of Pleistocene glaciation both in erosion and deposition. The most widespread deposit associated with the glaciation is till, commonly called boulder clay, but there are also extensive deposits of fluvioglacial sands and gravels, raised beach deposits of both Late and Postglacial age, and alluvium.





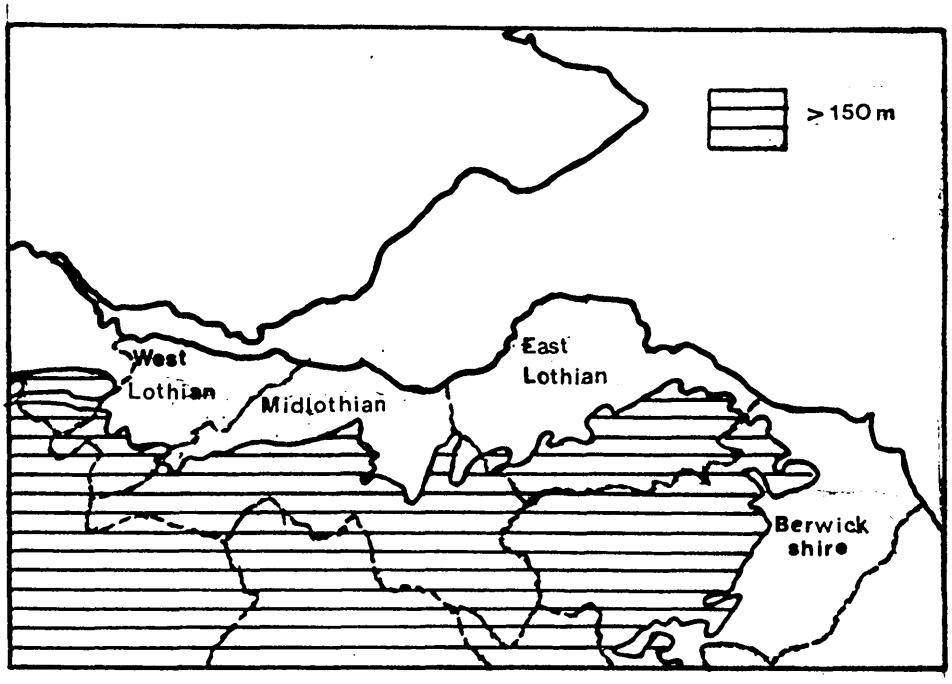
CB Clackmannan basin
CC Cairnsmore of Carsphairn
CD Castle Douglas basin
CF Cairnsmore of Fleet
CaF Campsie Fells
CS Carse of Stirling
D Douglas basin
DB Dumfries basin
FB Fife basin
GH Gargunnock Hills
GaH Garleton Hills
HF Howe of Fife
KB Kinross basin
KH Kilpatrick Hills
KiH Kilsyth Hills
L Lauderdale
LH Lesmahagow Hills
Lo Lochmaben basin
M Merse of Berwick
MB Midlothian basin
PH Pentland Hills
S Strathallan
SB Sanquhar basin
SE Strathearn
So Solway plain
T Tinto Hills
TB Thornhill basin

Map 2.2 Physiographic regions of South-East Scotland (after Sissons, 1976).

The greater part of Midlothian and East Lothian lies below 150 metres (map 2.3). The highest ground is represented by the Pentland Hills where the maximum elevation is Scald Law (580m). The rocks which make up the Pentland Hills form an anticline with a core of steeply folded Silurian conglomerates, overlain by a thick accumulation of lavas and tuffs of Lower Old Red Sandstone age, in turn flanked by Upper Old Red Sandstone and Carboniferous sediments. The Pentlands trend from southwest to northeast to within 10 kilometres of the shores of the Forth.

Between the northwestern face of the Pentlands and the coast of the Firth of Forth lies the lower ground of Midlothian which includes the site of Edinburgh. The most prominent features of this area are a result of the differential erosion of intrusive sheets or bosses of stronger igneous material and less resistant sedimentary rocks, for example, the sills of Salisbury Crags and Corstorphine Hill and the volcanic vents of the Castle Rock and Arthur's Seat. The two major drainage basins in the Edinburgh area are those of the River Almond and the Water of Leith.

To the east and north of the Pentland Hills is a lowland plain of predominantly Carboniferous rocks containing the syncline of the Midlothian coalfield. The greater part of this area is drained by three rivers: the North and South Esk and the River Tyne. Three notable features of relief on the plain are the volcanic necks of North Berwick Law and Traprain Law and the craggy extrusive outcrops of the Garlton Hills.



Map 2.3 Map showing ground over 150 metres in South-East Scotland.

To the south lie two ranges of hills, the Lammermuirs and the Moorfoots, which form a plateau of Ordovician and Silurian rocks rising abruptly from the lower ground to altitudes in excess of 500 metres.

During the Pleistocene a series of ice sheets several hundred metres thick at their maximum covered the area at different times. Ice which originated in the Highlands and in the Southern Uplands merged in the Midland valley and flowed eastwards to be diverted by the Pentland and Lammermuir Hills to a predominantly E.N.E. alignment. The ice sheets preferentially eroded the softer rocks, particularly the Carboniferous sediments, and moulded the underlying topography in the direction of its flow (Geikie, 1894; Sissons, 1967; Burke, 1969). The effect of the alignment on the drainage pattern is very clear, especially in the case of the River Tyne which flows from W.S.W. to E.N.E.

Sissons (1971) has inferred from a study of the depressions at the bases of crags in central Edinburgh that thicknesses of rock in excess of 100 metres may have been removed by the ice. He suggests figures of 105 metres of rock removed over the deepest part of the Castle Rock depression and at least 150 metres of erosion adjacent to the ice-moulded scarp of Salisbury Crags. As he states, however, such figures should be regarded as minimal since no trace of the pre-glacial relief exists.

A layer of till was deposited over the Lothian Plain and in the valleys of the upland region. The till is very variable in thickness

being thin or even absent on ridges and up to 15 metres or more thick in the hollows. Boreholes have revealed around 45 metres of drift in buried channels (Tulloch and Walton, 1958). Work by Kirby (1968, 1969a) in which he identifies three till sheets in Midlothian, (formerly only two were recognised), suggests that there may have been successive phases of ice advance from both the Highlands and the Southern Uplands.

The regional ice sheet first disappeared from the higher ranges of hills, although valley glaciers probably persisted locally on the Lammermuirs and the Pentlands, around 15,000 years B.P. as it downwasted. At this stage, however, it clearly still covered much of the lowland areas where its original thicknesses had been greatest. While ice was backed up against the northern slopes of the Lammermuir Hills and Garlton Hills, glacial meltwater from the decaying ice flowed along the margins and under the ice forming numerous large and small channels cut into rock and till, as described by Kendall and Bailey (1908), Bailey (1910) and Sissons (1958).

Deposition of fluvioglacial sands and gravels as kames, kame terraces and eskers also occurred. Kirby (1969a) mapped and obtained accurate altitudes for the terraces of the North Esk in Midlothian. He demonstrated that deposition of the terraces occurred because the flow of the Esk, which was carrying debris from the decaying Southern Uplands ice sheet, was blocked by ice retreating towards the Firth of Forth.

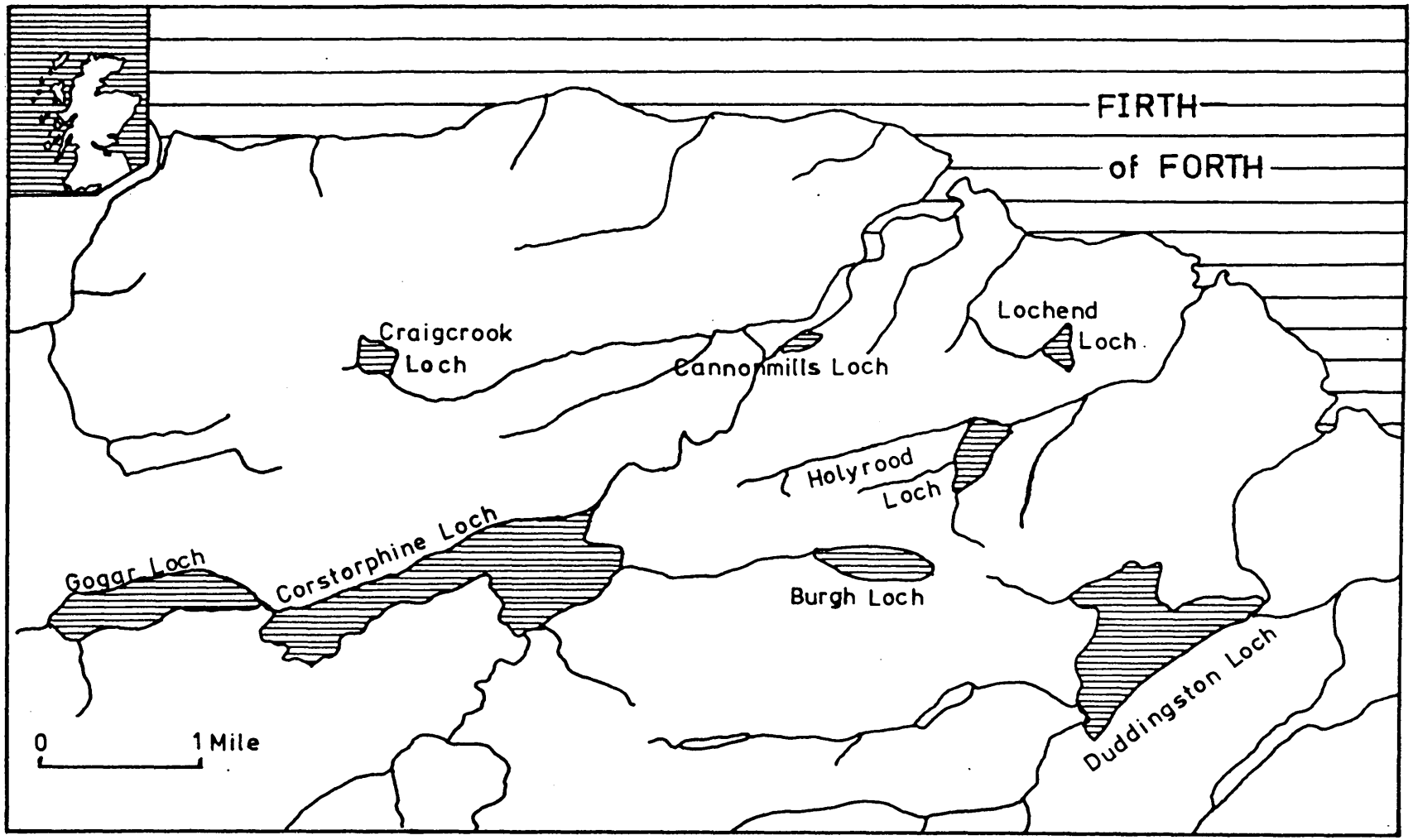
In and around the site of Edinburgh there are areas of

lacustrine deposits which clearly demonstrate the former existence of several lakes that probably formed in hollows that had either been eroded by the ice or had been formed by the irregular deposition of drift (map 2.4). Some of these are still represented by smaller lake basins, for example Duddingston Loch, whilst the one with perhaps the largest former surface area, Corstorphine Loch, was drained in stages between circa 1650 and 1840, (Cadell, 1913). Many of the lakes have disappeared as a result of the accumulation of silt, marl or peat, or have been drained and filled in by man, such as the Meadows and Holyrood Lochs.

Uplift, as a result of isostatic recovery on the melting of the ice sheet and eustatic changes in sea level, led to the formation of widespread beach deposits; some of these were subsequently buried by the estuarine sediments known as Carse clays ,(Sissons et al 1966). Pollen analysis and radiocarbon dating have been used to investigate the changes in vegetation during fluctuations in sea level and to determine their approximate dates, e.g. by Newey (1966) and Brooks(1972). The thick deposits of peat that accumulated on the carse lands of the Forth have been removed locally by man (Cadell, 1913; Dinham and Haldane, 1932). Dunes of wind-blown sand have covered in many places the raised beach deposits, for example, at Aberlady Bay.

2.3 CLIMATE.

Viewed at a European level the region has a maritime climate.



Map 2.4 Map showing extent of Edinburgh lochs in early Postglacial period.

The climate of the Lothian Plain, however, differs from that of other parts of Central and Eastern Scotland. First, the topography exerts a considerable influence. The prevailing westerlies are funnelled into the region via the Forth-Clyde Valley, but from the opposite direction east winds often penetrate the Lothians during the winter and spring months. The marked preponderance of winds from between west and southwest is a direct result of the funnelling effect of the central gap referred to above. The local topography has a great influence on observed wind speed and direction: winds are much lighter in strength in low-lying areas surrounded by hills and there is a tendency for wind direction to be aligned along valleys.

Second, in spite of the small longitudinal extent of the Central Lowlands, there is a distinct difference between the climates of the east and west coasts; the former being more frequently invaded by cold continental air masses in winter whereas the latter especially near the sea, the surface temperature of which is a degree or so warmer off western Britain than the North Sea, rarely experiences frosts. For example, Auchencruive in Strathclyde at a similar latitude on the west coast to Edinburgh has a recorded mean January temperature of 3.4 °C. This is 0.5°C higher than the comparable figure of 2.9 °C. The climatic summary diagram for the Royal Botanic Gardens, Edinburgh (fig 2.1) may be taken as representative of the coastal area of the Lothians.

Over the whole region the range of mean monthly temperatures is approximately 12.0 °C, with 2.5 °C being the average mean monthly temperature in the coldest month, January; 14.5 °C is the

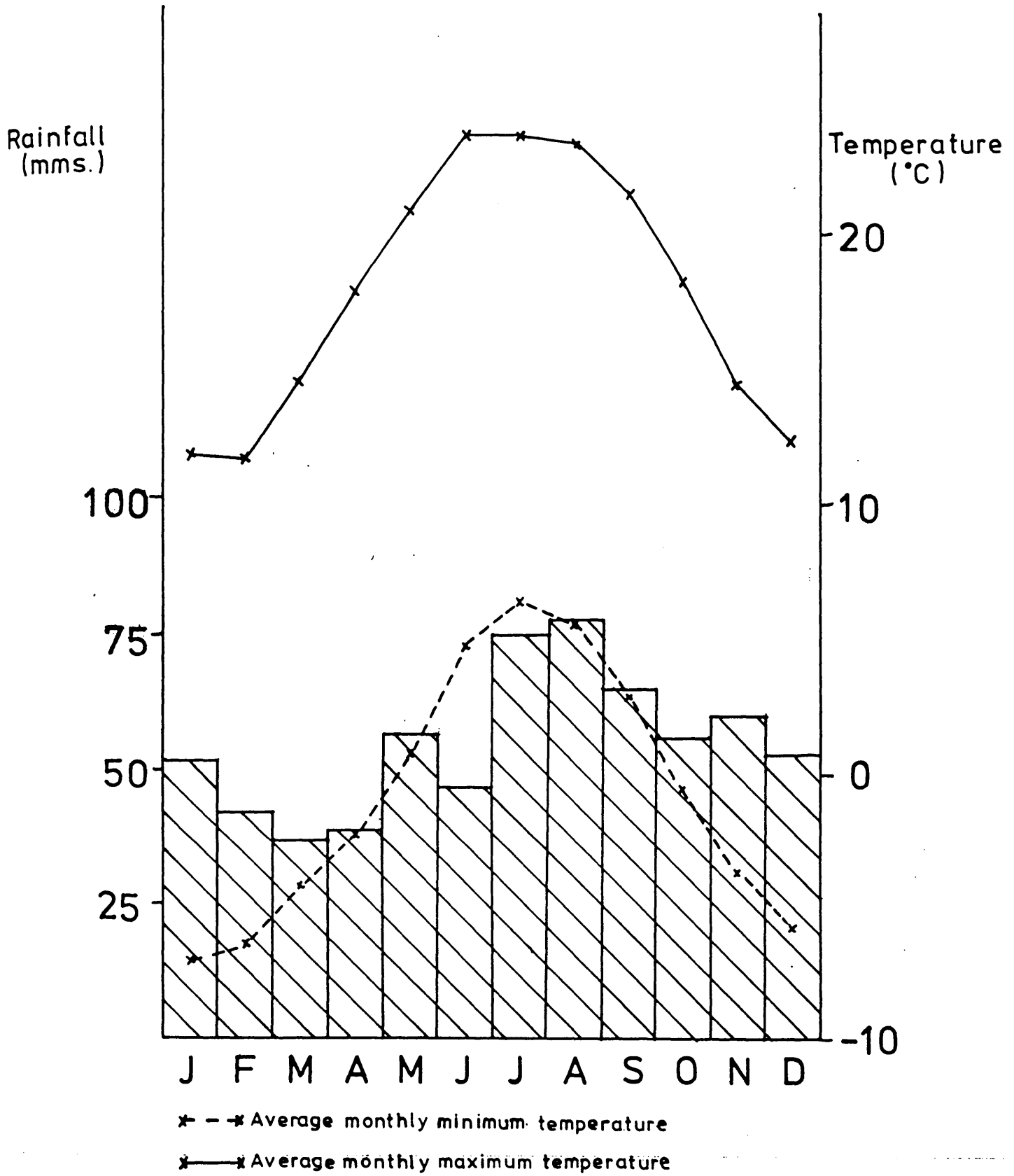


Fig 2.1 Climate graph for Edinburgh, Botanic Gardens.

corresponding figure for July. The coastal zone is rather warmer, especially in winter, but differences are slight. Rapid changes in temperature are common especially during winter but, excluding the uplands, rarely reach extremes. The cold North Sea and easterly winds, a combination which leads to 'haar' i.e. cold mists, slow down the rate at which temperatures rise in spring and early summer.

The prevalence of westerlies has some influence in reducing the number of ground frosts in coastal areas. Dunbar has around 60 nights of sub-zero temperatures per year, mostly between November and April. In sheltered areas and valleys ground frost is likely between September and May. The damage done by frosts when plants are at their most vulnerable is out of all proportion to the small extent to which they depress temperature means. Temperatures in winter resemble those of eastern England. The average January daily maximum temperature for Edinburgh is 5.9°C. This compares favourably with the corresponding figure of 5.7°C for Lowestoft in Suffolk. Summer temperatures, however, are appreciably lower. The daily July mean maximum temperature for Edinburgh is 18.6°C whereas for Lowestoft it is 20.1°C; a difference of 1.5°C. Relatively high insolation is recorded in the months April to June, the sunniest part of the year.

Rainfall is for the most part evenly spread throughout the year with a tendency to a minimum in April and a maximum for August. The amounts of rainfall are low to moderate with less than 650 mm per annum at Dunbar and less than 750 mm for most of the East Lothian plain below 150 metres. Rainfall is greatest, as might be expected, over the higher ground. More than 1,000 mm of rain per year is

recorded in the Eastern Lammermuirs. The variability of rainfall is high to moderate in the drier areas of East Lothian, receiving less than 750 mm. This should be contrasted with the western Highlands of Scotland, where the high average falls are associated with low variability (Gregory, 1968).

Snow almost invariably originates in air masses with polar maritime or continental sources brought by winds blowing from between north and south-east. The heaviest falls generally occur on the most exposed eastern part of the Lammermuirs. Along the coast itself, snow falls on average about 15 days per year, lying only on about 5 mornings. On the summits of the Lammermuirs there is snow lying on about 75 days per annum.

The growing season varies according to the altitude. At Dunbar it is around 240 days, in spite of cool spring temperatures, as a result of the fact that the season is prolonged in the autumn by the westerly winds which predominate at that time of year. At Penecuik, further inland, the season for vegetative growth is approximately 30 days shorter. Accumulated temperatures in day degrees over a certain threshold, usually taken as 6 °C, provide an index of climatic productivity potential. The 6 °C threshold is generally accepted as the point below which vegetative growth in most plants is insignificant, but it is not critical to life or death as is the 0 °C threshold. Gregory (1954) suggests figures for mean annual accumulated day degree temperatures over 6°C for the period 1881 - 1915 of 1111 - 1389 days for the coastal strip of the Lothians, 883 - 1111 days further inland decreasing to 556 - 883 days for the

Pentlands and the Lammermuirs. The conditions of temperature and rainfall described above are those of a natural forest climate.

2.4 SOILS.

The soils of the area vary in nutrient and drainage qualities and are affected also by climate, topography, vegetation and land use. They are mainly derived from the superficial deposits: glacial, fluvioglacial, alluvial, marine and aeolian. The character of the parent materials varies according to their origin.

This is especially true of the most important parent material - till. Till is usually red where it is derived from Old Red Sandstone strata or from most of the igneous rock types and is generally greyish when overlying or to the leeward of outcrops of Carboniferous rocks. The textures of soils derived from tills can vary widely even over small areas.

However, the textures of soils derived from the other deposits are more easily classified. Lighter, better-drained soils occur on the raised beaches on the Forth coast or on the outwash spreads of sands and gravels as in the Esk Valley to the east of Edinburgh. The soils on the carse (estuarine) clay are amongst the heaviest to be found.

In general the most widespread soils on the lowlands are moderately acid, podzolised grey-brown forest soils commonly affected

by gleying in their lower horizons where drainage is impeded. On the higher parts of the Lothians above 200m the colder wetter conditions are associated with peaty-gleyed soils and deep basin or blanket peat in depressions or on flattish summit areas. The soils of the upland areas are generally thin, acid and poor in phosphates. They can therefore support little more than heather, rough grassland pasture plants or peat - forming mosses and sedges. Many of the moorland and peat-bog areas have been drained and brought under cultivation.

2.5 VEGETATION

Upon the soils of the superficial materials described above the original cover of vegetation developed. As Newey(1965,1966,1968), demonstrates, the pollen evidence indicates that oak forest with birch was the natural vegetation of the area and would have covered a large part of the lower ground of the region thus confirming the view of McVean and Ratcliffe (1962) who proposed four potential vegetation regions for Scotland, (map 2.5), based on an examination of the existing forest fragments. Of their four regions the Lothians lie in the one where oak forest with birch would predominate. The remnants of old oak wood in the grounds of Dalkeith House and the oaks at Roslin Glen and in the surrounding area are, therefore, the modern representatives of a type of woodland that was formerly more extensive, Fenton (1951). These fragments of semi-natural woodland give some indication of the character of the former pre-historic natural forest vegetation, even though in the past they have been subjected to felling, grazing and often to replanting. The detailed

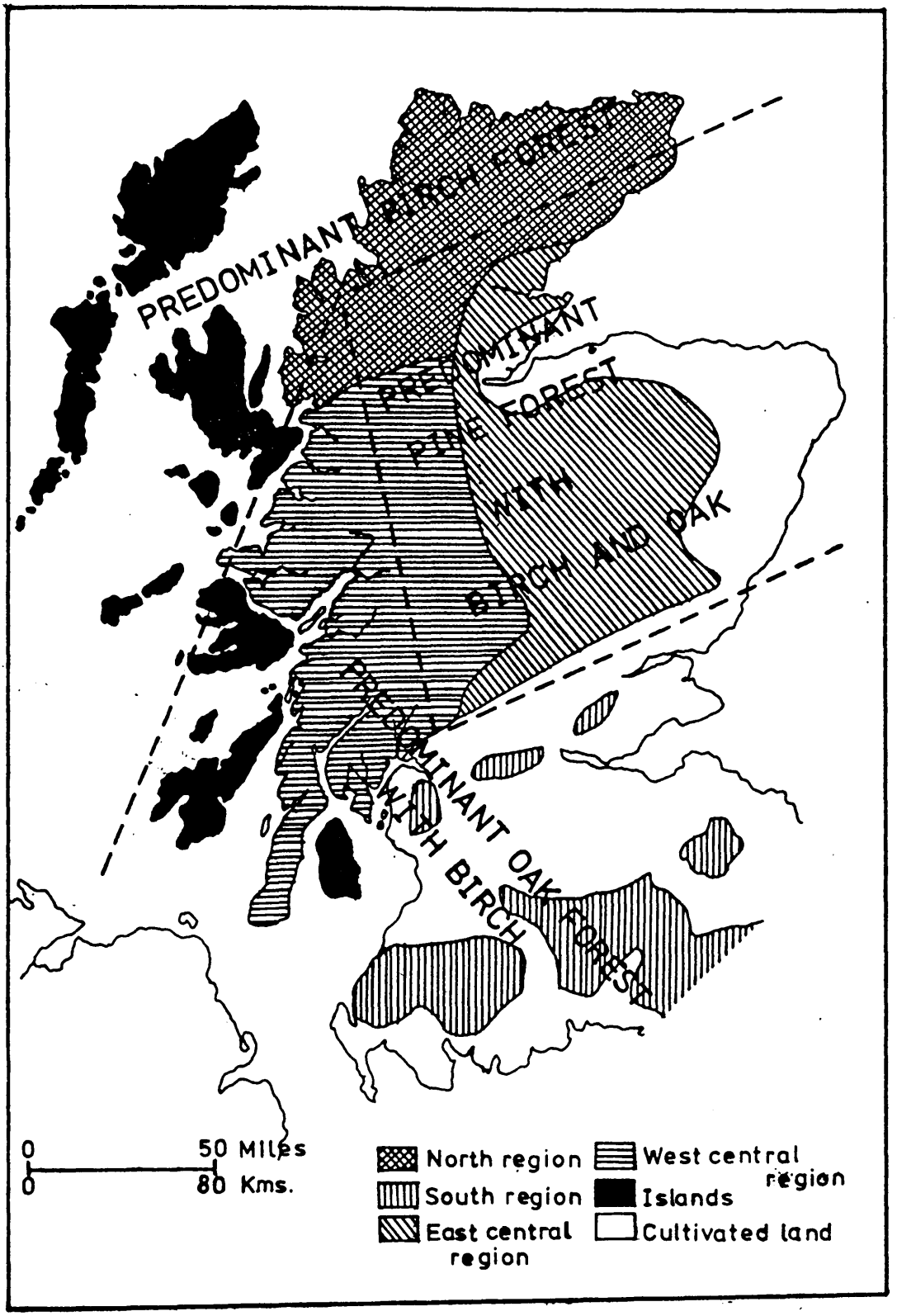


Fig 2.5 Vegetation regions of Scotland (after McVean and Ratcliffe, 1962).

ecological account of the oakwoods of the Loch Lomond area given by Tittensor and Steele (1971) and the the more general description by Smith (1900) are applicable to other oakwoods in Southern Scotland.

When man first colonised the area he began the progressive felling and clearance of trees. This process accelerated as the demand for fuel, building materials and agricultural land grew, so that by the eighteenth century perhaps no more than about 4% of the Lothians was woodland. During the eighteenth and nineteenth centuries, however, enlightened land improvers created a new woodland landscape by establishing plantations with several objectives: to renew timber resources; to improve agricultural production by planting shelter belts; by laying out parklands for their visual attraction. In these man-made woodlands, beech, sycamore and conifers took the place of lowland native tree species. In this century, the Forestry Commission has planted blocks of coniferous trees on the uplands. Around 10% of the Lothian's land surface now carries woodland. It is, however, a landscape dominated by overmature trees, often with little opportunity for natural regeneration.

The Lothians have been farmed for centuries. The vegetation of the area has been strongly influenced by the agriculture and silviculture so that few plant communities can be considered wholly natural. Within the pattern imposed by man's use of the land, the vegetation is related to the major soil groups and their subdivisions and, since the suitability of soils for the different types of agriculture and forestry largely determines the land use, biotic and

edaphic factors are clearly inter-related in determining the plant communities that occur. The local climate is also important, for example, intensive agriculture gives way to permanent pastures above 300 m, where temperatures and rainfall both influence land use (Meiklejohn, 1951). The use that has been made of the land has varied in the past and its history influences the present day vegetation.

2.6 CONCLUSION

In summary, the physical landscape as it appears today is the result of the influence of a variety of factors:

First, the geology has largely determined the relief with episodes of both folding / faulting and volcanism playing their part.

Second, many of the morphological features owe their origins to differential erosion of rocks of varying resistance through both sub-aerial erosion over millenia and successive phases of glaciation.

Third, it is largely upon the extensive deposits of glaciation that the present soil types have developed.

Finally, climatic changes, soil type and latterly the influence of man have been reflected in the vegetation and its development.

CHAPTER 3.

3.1 Introduction:

In this chapter the field and laboratory methods employed by the investigator are described. In pollen analytical investigations the selection of a site; care in the extraction of cores; avoidance of contamination of samples; suitable laboratory technique to concentrate pollen producing clear countable slides and careful identification and counting of fossil grains all have a great influence on the final counts of pollen types at each level. In the following paragraphs the field methods which were employed in this study are first described followed by an outline of the laboratory techniques adopted.

As stated in the introduction to this thesis, three sites were studied. Geological sections from each of the sites had been described in previous research (Bennie, 1891;Geol. Surv. Mem., 1910 ; Tait, 1934; Newey, 1970). The individual sections and sources are covered in later chapters. On the basis of the information from the sections, each of the sites was considered likely to yield suitable Lateglacial material for pollen analysis. In the case of Corstorphine, the third site to be examined, a published pollen diagram already existed (Newey, 1970). It was, however, felt to be worthwhile to re-examine the site in view of the gap of over ten years since the work was completed and the developments in sampling techniques and methodology in the intervening period.

The sediments at each of the sites studied were those of former lakes. A case can be made that lake deposits are preferable to peat. For example, it is easier to isolate the local aquatic and marginal hydroseral species; there is a definable source area for the catchment of the lake, (Oldfield, 1970) and grains are generally well-preserved in anaerobic bottom sediments. In addition as Pennington et al (1972,1975a,1977b) have shown lake sediments may be subjected to detailed chemical analysis that can provide useful supporting evidence for pollen data. However, in studying such sediments one has to allow for the possibility that erosional hiatuses caused by changes in lake level, slumping of sediment in steep-sided basins or those bounded by steep slopes which alters the stratigraphic sequence (Mackereth, 1965; Davis M.B, 1968; Davis R.B et al, 1969) and disturbance of sediment by animal burrowing and seasonal overturn of water in thermally stratified lakes occur frequently.

3.2 Site Investigation:

As the Hiller borer is likely to yield contaminated samples its use was confined to obtaining details of the stratigraphy of the deposits at each site; the actual pollen sampling was carried out by means of a piston sampler as described below. The core to be examined was then taken from the point where the deepest column of sediment was represented. This was done in the hope that the oldest sediments present would be sampled. in the deeper parts of the basin accumulation is also likely to have been more continuous.

In order to sample each site a modified Dachnowski piston sampler, was used. This corer is an end-filler as opposed to the Hiller. Modifications were made to the instrument by Walker and Lowe (1976) who renamed it the 'Abbey corer'. The sampler consists of a retractable piston attached to the end of a rod bearing a metal tube 60 cms in length by 5 cms in diameter.

To obtain the cores, the Abbey corer was used in association with a surveyor's level and a staff. The procedure adopted was as follows. The chamber was lowered to the depth at which sampling was to commence. The staff was then placed on top of the handle of the extension rods and the reading noted. The extension rods were then raised until the sampling chamber was fully opened and the whole corer pushed downwards again until the reading on the staff, resting on the handle, coincided with the first reading. At this point the chamber was full of sediment. The corer was then raised and the core extruded onto a length of semi-circular plastic guttering, which had been previously labelled with the sample number and site name. It was then sealed using polythene sheeting. Further readings on the staff ensured that, where possible, a 5 cms overlap was maintained between cores. Alternate cores were taken from adjacent holes a few cms apart so that the corer passed through a length of deposit, undisturbed by the corer, before each new core was taken.

The Abbey corer appeared to give satisfactory results in fine-grained stiff sediments, producing undistorted cores. The auger attachment proved useful for removing very coarse sands and gravels. These tended to block the corer chamber, and it was impossible to

force it through despite hammering on the specially strengthened handle. Two minor problems that were encountered, were that fine clays and fibrous peats tended to be compressed in the sampling chamber and small amounts of water leaked into the chamber through the top. Neither of these disadvantages was too serious since they could be overcome by assuming even compression throughout a core and, since a record of the depths of the top and bottom of each was kept, it was possible to adjust sampling intervals accordingly. By removing the few cms at each end of a core that were contaminated and also the smeared surface of the core, until the true sediment was revealed. The only other problem encountered using the Abbey corer was that it sometimes did not retain fluid loosely-consolidated deposits. This was generally solved by recoring to ensure that these were plugged into the chamber by firmer sediments.

The polythene-covered cores on their guttering were placed in the dark in a refrigerator at 2°C where they were stored until they could be analysed. Chemical changes, fungal growth and dessication were therefore kept to a minimum by the low temperatures, damp and light-free environment.

3.3 Sediment Description:

In the laboratory the core was first cleaned by cutting away the superficial material which was the most likely to be contaminated. To clean the cores a scalpel was used and all of the cuts were made perpendicular to the core axis to avoid contamination. The

stratigraphy of each core was then described with regard to (a) colour; (b) degree of humification; (c) presence of (d) macrofragments; (e) minerogenic content and (f) stratification. Samples for pollen and chemical analysis were then removed.

Initially a fairly wide interval, 8 or 16 cms was adopted and then the gaps where there were stratigraphic changes were filled in with additional samples. Thus a skeleton pollen diagram was prepared based on wide sampling intervals. This could be examined to detect parts of the core which merited further examination. The reason for initially spacing samples at 8 and 16 cms as opposed to a 10 and 20 cms spacing was that use of such intervals allows closer sampling at 4, 2 and even 1 cms if necessary whereas it is difficult to interpolate samples at intervals intermediate to 5 cms. At each level at least 3 cms^3 of sediment was removed which was then stored in a labelled glass vial sealed with wax until it could be prepared for analysis. At a late stage in the work, for absolute pollen analysis, a brass sampler was made which removed fixed volumes (0.5 and 1 cms) from the core.

3.4 The 'relative' and 'absolute' approaches to pollen analysis:

There are two ways of analysing pollen: first by use of relative counts and second by employing a method of measuring absolute pollen densities. The preparation technique for relative pollen is simpler and less time consuming than that for absolute. It is, however, more difficult to interpret the results since changes in the percentage of

one component of the pollen sum affect those of the other components at any particular level. It is also difficult with relative counts to assess the significance of between level variations, since changes in total input are not necessarily reflected on relative diagrams, especially if the proportions of different types remain unaltered.

Absolute pollen analysis requires either the introduction of a known quantity of exotic pollen or spores into a measured amount of sediment and fossil grains counted are related to the total count of the introduced type, or the sampling of a known proportion of the total population of pollen by taking a known weight or volume of sediment for counting (Peck, 1974). Although Maher (1972) and Colinvaux (1978) both point out that 'absolute pollen frequencies' is a misleading term, pollen analysts still refer to absolute as opposed to relative diagrams.

Exotic marker pollen grains were added to known volumes of each sample from the second and third sites analysed prior to extraction since it was felt that some estimate of the pollen concentration at each level would be potentially useful on the basis of experience in interpreting the data from the first site studied. Sims (1973) has demonstrated that absolute counts have advantages over percentage data, even where radiocarbon dates are not available, because each pollen curve on an absolute diagram can be considered as an independent variable rather than as an interdependent percentage. Also comparison of absolute and relative data allows evaluation of changes in pollen spectra through time, and of their relationship to the former vegetation. Additionally, absolute counts can be used to

resolve whether oscillations represent a real change in pollen deposition or only a small percentage fluctuation i.e. a 'statistical artifact' (Davis and Deevey, 1964).

The exotic pollen was added at the beginning of the preparation rather than at the end as was suggested by Bonny (1972) and Pennington (1973) so that any losses of pollen in the preparation process, through for example decanting after centrifuging or by pollen adhering to glass stirring rods, would affect both the exotic and fossil pollen, hopefully equally, and also to give the exotic pollen a better chance to become thorougly homogenised with the fossil than would be possible if it were added as the last step prior to mounting slides.

Two methods of exotic pollen addition were employed. The first was that described by Gunson and Edwards (1978) in which a Coulter counter was used for the determination of the concentrations of exotic additions of a suspension containing Ailanthus glandulosa. This method is essentially a modification of the method first described by Benninghof (1962) and which was later more fully described by Matthews (1969) and Bonny (1972). The second method entailed the use of 'pollen pills', (Stockmarr, 1972), which are assayed concentrations of exotic pollen or spore types in soluble carbonate tablets. Each tablet therefore contained a known number of, in this case, Lycopodium clavatum spores. These were distinguishable from native L. clavatum since they had been acetolysed prior to inclusion in the tablets. The second method was found more convenient to use in practice since it overcame the

problems of adding a known volume of more or less homogeneous exotic pollen suspension. Also the same difficulties were not encountered with contaminant exotic species using the second as opposed to the first method.

When the exotic suspension was used it was suspected that certain species identified on the slides had not originated from the sediment samples. In order to check whether this was the case type slides were made up from the 'pure' exotic pollen supplied. It was discovered, by the writer, after scanning around 750,000 grains that approximately 1 grain in a 1,000 was identified as being one of fourteen contaminant species found. Table 3.1 gives the counts and types identified. Therefore, the concentration of contaminants in the exotic pollen is low, amounting to just 0.1%, but if the exotic suspension is added to a sediment which is itself very low in fossil pollen, for example one of Younger Dryas age, the contaminant grains assume an importance, particularly if they are of thermophilous species, that is out of all proportion to their numbers. The list includes Ambrosia spp. and Tilia americana. Long distance transport might be invoked to explain the presence of grains of these species in European sediments , since these two are North American species, if the true origin were not known. In this connection the discussion by Cundill and Whittington (1983) of the origins of anomalous arboreal grains that they found in the Lateglacial and Postglacial deposits at Creich Castle in Fife and which they regard as having one of three possible origins: contamination, long - distance transport and reworking of interstadial material should be noted. They recommend that a re - examination of contaminated British Lateglacial

pollen records might be fruitful. However, it must be appreciated that only in rare instances is it likely to be possible to definitively locate the precise origin of any particular grains.

Correspondence with the laboratory which supplied the pollen has revealed that a record is kept of the contaminants found in sub-samples of each batch of pollen and that this information is available on request.

SLIDE	1	2	3	4	5	TOT	%
TYPES							
Ambrosia	13	15	6	6	11	51	4.98
Carya aquatica	1	-	-	-	-	1	.09
Ceanothes/Rhamnaceae	-	-	-	2	1	3	.29
Cerealia	1	2	-	2	-	5	.49
Chenopodiaceae	-	-	1	1	2	4	.39
Compositae - Taraxacum	-	-	1	-	-	1	.09
Compositae - undiff.	3	1	6	2	4	16	1.56
Gramineae	36	26	30	22	23	137	13.39
Juglans nigrans	2	1	2	-	1	6	.59
Picea	4	1	2	1	2	10	.98
Plantago lanceolata	-	-	1	-	-	1	.09
Tilia	7	8	13	8	12	48	4.69
cf. Umbelliferae	-	1	-	1	-	2	.19
cf. Viburnum lentago	134	172	146	126	160	738	72.14
Column totals	201	227	208	171	216	1023	

3.1 Table showing contamination levels for exotic suspension (Ailanthus glandulosa).

The ratio of fossil to exotic pollen aimed for on a slide was 1 : 1 (H. J. B. Birks, pers. comm.). The weight of suspension / number of tablets added to each sample was varied and then the counts were

standardised so that the exotic counts appeared to be based on the same weight of suspension / number of tablets per sample. Usually the standard volume of sediment, 1 cm^3, was sampled at each level for a site. The exotic grains are therefore counted along with all the other pollen and spores observed. Counting of the exotic pollen alongside the fossil enables the density of pollen in the samples to be calculated, once the counts have been standardised, as follows:

Since:

$$\frac{\text{Fossil pollen counted}}{\text{Exotic pollen counted}} = \frac{\text{Fossil pollen concentration in sample}}{\text{Exotic pollen concentration}}$$

Then the fossil pollen concentration is equivalent to:

$$\frac{\text{Fossil pollen counted}}{\text{Exotic pollen counted}} \times \frac{\text{Exotic pollen added}}{\text{Volume of sediment}}$$

The FORTRAN IV computer program POLLDATA that originated at Cambridge , and which will be fully described in chapter 4, was used to do all the necessary calculations and to plot, using a graph plotter, all of the pollen diagrams in the thesis.

Using concentration data pollen species curves, at any particular level, can be treated separately and changes in absolute numbers or total pollen input between levels quantified. The constraints of percentage counts are therefore removed (Faegri and Iversen, 1975).

To obtain the volumes of sediment required for analyses in absolute pollen work, again two methods were used. The first was to measure out the required volume of sediment either 0.5 or 1.0 cm^3 by displacement in water in a narrow bore, shortened to allow access with a spatula, 10 mls graduated measuring cylinder. The same cylinder was used for each sample and the meniscus change read between the same levels each time. The second method adopted was that of using a brass cylinder filled by pushing it into the sediment. The volume required was then extruded using a calibrated brass rod. The first method was preferred to the second since it was regarded that liquid displacement was a more accurate way of measuring exact volumes than using the brass sampler, in which variable compression of different sediment types could lead to error.

3.5 Preparation of pollen:

The aim of pollen preparation is to concentrate fossil pollen by removing as much as possible of the surrounding matrix of plant debris and mineral matter so that it is possible to prepare clear, countable slides.

The methods of chemical extraction adopted by the investigator broadly correspond to those described by Faegri and Iversen (1975) and are briefly outlined below. A laboratory notebook was kept in which details of sample numbers and depths, and notes about preparations and problems with particular samples were made. By

reviewing these notes it was found to be possible to judge the best preparation sequence when interpolating sediments in a core. Between 4 and 8 samples were generally prepared in a laboratory session. The number of samples that could be prepared at one time was limited by the capacity of the centrifuge head - 8 tube maximum. Centrifuging was carried out at 3,000 rpm in 15 ml tubes for 2 - 3 minutes. At each stage of centrifugation approximately 2 mls of ethanol was added to lower the specific gravity and to reduce possible losses of pollen in decanting.

The procedures employed are outlined below in the sequence in which they would be used if they were all to be applied to a single sample.

(A) Hydrochloric (HCl) acid treatment: to remove any carbonates present.

(B) Potassium Hydroxide (KOH) digestion: removes humic acids and deflocculates.

(1) The sample was put in a boiling tube and 10 mls of 10% KOH added. The tube was then placed in a boiling water bath for between 20 minutes and 1 hour and the contents stirred to break up clumps.

(2) The material was then sieved through a 100μm sieve into an

evaporating basin and the residue washed with distilled water. Pollen and microfossils and fine detritus came through leaving larger debris fragments on the sieve. These were retained by washing into a petrie dish and any identifiable macrofossils recorded.

(3) The contents of the evaporating basin were centrifuged and washed.

For many well-humified organic samples, i.e. non-minerogenic, the above procedures were sufficient and the material was mounted and stained as described in section - E.

Samples which contain large amounts of silica/plant debris were treated as in the following sections:

(C) Hydrofluoric Acid (HF) treatment : removes silicates. Silica is soluble in HF but the acid does not damage pollen and spores.

(1) Approximately 5 mls of 40% HF was added to the sample in a polythene centrifuge tube. Satisfactory results were obtained by leaving the samples in cold HF in the tubes overnight. Any 'grittiness' detected in the morning was removed by 10 - 15 minutes, in a boiling water bath. The grains after treatment in cold HF do not appear to shrink as is the case with prolonged treatment in hot HF and the silica is removed more efficiently. Caryophyllaceae and some Chenopodiaceae grains are especially vulnerable to treatment in

hot HF since they tend to implode.

(2) Once all the silica had been removed, the material was centrifuged and the waste HF poured into a plastic container for later disposal.

The sample was then resuspended in 10% HCl and warmed in a water bath, to remove silicofluorides which may have been produced during the HF treatment.

(4) The sample was washed several times and then either stained and mounted (section E) or the preparation continued with acetolysis.

(D) Erdtman's Acetolysis removes cellulose and was found to be most effective, disposing of much organic material that cannot otherwise be destroyed. The stages are as follows:

(1) To dehydrate the sample it was suspended in glacial acetic acid, then centrifuged and the supernatant discarded.

(2) 6 mls of freshly-prepared acetolysis mixture made by mixing acetic anhydride with concentrated sulphuric acid (H_2SO_4) in the ratio 9 : 1 was added to the sample in a polythene centrifuge tube. The best results were obtained using the mixture immediately. The tube was then placed in a boiling water bath for between 1 and 2.5 minutes.

(3) Centrifuge, having topped up the tube with glacial acetic acid and ethanol, then decant.

(4) It is suggested that the sample be re-suspended in glacial acetic acid and centrifuged, Erdtman (1960), but this was found to be unnecessary.

(5) Finally the sample was re-suspended in water and centrifuged. This step was repeated several times to wash the grains. To the final wash a few drops of dilute KOH were added since the safranin stain used takes better in an alkaline rather than in an acidic medium. Acetolysis is known to swell grians to varying extents depending on the duration of treatment (Reitsma, 1969) and acetolysed grains may be up to 25% larger than grains which have been treated only with KOH.

Once the preparation of the sample has been completed it may be stained and mounted as below:

(E) Staining and Mounting:

Both glycerine and silicon oil were used as mountants. The procedure for using silicon oil outlined by Andersen (1960) was adopted. The suspension to be mounted was spread evenly over the whole area to be covered by the coverslip to avoid the differential spread of grains of differing sizes (Brookes and Thomas, 1967) and

care was taken that the material on the slide was neither too thick nor too thin; between 15 - 25μm was ideal, to avoid problems caused by excessive compression and resulting changes in the sizes of the grains (Cushing, 1961) and also to allow examination by high power oil immersion lenses.

The chemical procedures, as outlined above, were found to cope with the majority of sediment types encountered.

The method of differential flotation as set out by Frey (1955), which uses a bromoform/acetone mixture, was tried but found to give unsatisfactory results in that it was inefficient, noxious and difficult to use. The use of sodium pyrophosphate ($Na_4P_2O_7$) as a deflocculent to remove clays from sediment samples, as described by Bates, Coxon and Gibbard (1978), was rather more successful but was time consuming in practice for even once the clay had been removed from the sample it still had to be treated with HF. This technique was reserved for only the most minerogenic and clay-rich sediments. Oxidation was used on some samples to remove lignin and other resistant organic material. The method described by Godwin (1956) which involved using a mixture of glacial acetic acid (CH_3COOH) 8 mls, sodium chlorate $NaClO_3$) 4.5 mls and concentrated sulphuric acid (H_2SO_4) 1 ml was adopted. Any oxidation process should come after acetolysis otherwise the size of pollen grains is greatly increased. Also Hafsten (1959) discovered that oxidation in combination with certain of the procedures described above could cause differential destruction of pollen so careful choice of techniques is necessary.

The only other chemical extraction treatment employed was the

use of hot 10% Nitric acid (HNO_3) for up to 10 minutes to remove pyrites and other sulphide compounds (Vallentyne, 1963). Nitric acid is a very effective oxidant which bleaches pollen grains and probably removes some less resistant types. Samples which contained only small amounts of pyrites were, therefore, diluted by adding more glycerine / silicon oil before mounting slides and the nitric acid treatment reserved for samples that had high concentrations of pyrites and in which the pollen densities were so low that dilution was not a practical alternative.

3.6 Pollen Identification:

Once the chemical preparation of the samples had been completed pollen identification was possible. In this study a Baker Patholette binocular microscope with Complan X 10 eyepieces and Baker X 10, X 40 and oil immersion X 100 objectives were used to examine the pollen. Much of the counting and identification was undertaken at a magnification of X 400 with critical identifications being made at X 1,000 under oil immersion.

The slides were traversed at regularly spaced intervals, these being sufficiently wide so as to avoid the possibility of pollen being counted twice, until the desired pollen total was reached, to reduce the chance of non-random distribution of either fossil or exotic grains on the slides, as discussed by Brookes and Thomas (1967) and Peck (1974).

Three aids were used in the identification of the grains: (1)

photomicrographs and line-drawings, (2) pollen keys and (3) pollen type material.

Useful detailed photomicrographs of individual pollen and spore types are to be found in the pollen atlases by Hyde and Adams 1958; Erdtman, Berglund and Praglowski (1961, 1963); Erdtman (1943, 1969); and Moore and Webb (1978). Two pollen taxonomic keys used in the course of the work were those in Faegri and Iversen (1975) and Moore and Webb (1978).

In view of the problems of size changes of pollen and spores mounted in glycerine jelly (Andersen, 1960; Cushing, 1961; Erdtman, and Praglowski, 1959) size statistical methods have not been used in this study to distinguish between pollen and spores of different species. A total of 500 pollen grains, excluding aquatic and spore types, were counted per sample in this study. Only in levels where pollen was sparse was it necessary to use a minimum total count of 300 grains.

Many taxa are relatively easy to identify being quite distinctive e.g. Helianthemum and Hippophae and the pollen keys for particular families proved useful, e.g. Reitsma, (1966), for the Rosaceae in making identifications to genus and sometimes to species level. These were confirmed, of course, by comparison with reliable type material and also with photomicrographs.

Qualifications to identification:

In the following sections the practical limitations encountered in pollen identifications by the writer are outlined; information that is lacking from much published material.

Betula: No measurements were made of grain size or pore depth so Betula nana pollen could not be separated from that of the tree birches, e.g. Betula pubescens, using the ratio of grain diameter to pore depth as a numerical index to pore protuberance (Birks, 1968). The presence of B. nana - like pollen was, however, noted

Salix: Pollen within this genus was not identified to species level.

Corylus / Myrica: No attempt was made to separate the Corylus and Myrica components.

Empetrum: As the specific distinction between tetrads of diploid Empetrum nigrum and those of tetraploid E. hermaphroditum requires the use of size statistics (Andersen, 1961) their separation was not attempted.

Ericaceae: Calluna vulgaris was the only taxon separately distinguished. Ericaceae undiff. therefore includes several taxa

within the Ericaceae.

Artemisia: Some of the grains identified as belonging to this genus were bigger than average with thicker exines and larger more prominent echinae which suggests that they may be A. norvegica Erdtman et al (1961).

Rumex: Grains of Rumex acetosa, R. acetosella and Oxyria digyna form this group. The investigator found it impossible to distinguish between the type material of species of the above using the morphological criteria proposed by Faegri and Iversen (1964) and Birks (1973a).

Pre-Quaternary Spores: A count was kept of the spores in this category which appeared green or yellow - green under the microscope and were morphologically distinct from sub-fossil or present day taxa.

Unidentified: The number of unidentified pollen grains in each sample was recorded to give some indication of the state of preservation of the pollen and of the success of the analyst at identification. There are three major categories of unidentified types: unknown, indeterminable: concealed and indeterminable: deteriorated (Birks 1973a p.242). Each unknown grain was classified as a distinct type

(e.g. type X) and sketched.

Indeterminable - concealed grains are those of which a clear view is obscured by organic / inorganic debris. Very few grains fell into this category since it was generally possible using a heated needle to produce a partial melting of the glycerine and move the grain to a different location for better examination.

Indeterminable - deteriorated. The four classes of pollen deterioration are (Cushing, 1964b, 1967b; Birks, 1973) (a) corrosion (b) degradation (c) breakage and (d) crumpling. The names of the classes are self-explanatory. During routine analysis, deteriorated grains were recorded only as indeterminable - deteriorated, but a note of the kind(s) of exine deterioration was recorded.

As the state of preservation of pollen examined was generally very good the numbers of unidentified pollen were so low they were usually aggregated into one category as unidentified - indeterminate.

Since the pollen counts were undertaken at different times during a three year period, 1979 - 82, they are of varying degrees of detail. Thus, for example, no morphological separation of spores of Polypodiaceae was attempted during the analysis of the samples from the first site described - Broxmouth. Furthermore, an examination of the diagrams reveals that the number of types identified grew with the increasing competence of the investigator.

3.7 Chemical investigations of lake sediments:

Changes were investigated in the inorganic chemistry of the lake sediments since these are a reflection of changes in the catchment area related to differing rates of soil erosion and leaching (Mackereth 1965,1966; Pennington et al 1972).

Chemical Methods:

Determination of percentage carbon:

The method adopted for measuring the percentage of organic carbon in samples taken from each of the cores was a modification of the Walkley - Black calorimetric method as shown below:

(1) Similar samples of between 0.3 and 0.5 grams of finely ground (< 70 mesh sieve) air dried sample were weighed into a 200 mls flask.

(2) 15 mls of approximately 4N sodium dichromate solution ($Na_2Cr_2O_7$) were then added slowly taking care to avoid spattering of the fine particles. The flask was shaken to mix the sample completely into the solution.

(3) a. 30 mls of concentrated sulphuric acid solution (H_2SO_4) were

then poured in and the contents of the flask were briefly swirled.

b. A blank determination was set up, dichromate and acid only, for later use in zeroing the calorimeter.

(4) The flasks were left to stand for ten minutes.

(5) 100 mls of distilled water were added to each flask and thoroughly mixed.

(6) The flasks were left for between 4 and 6 hours.

(7) The supernatant was poured into a centrifuge tube taking care not to disturb the sediment at the bottom of the flask.

(8) The samples were then centrifuged at 2,000 rpm for 10 - 15 minutes.

(9) The solution in each tube was poured into a separate colorimeter tube. The blank determination was used to zero the calorimeter. The absorption of each of the samples was measured using the filter provided in the EEL calorimeter. The reading was recorded and the percentage of carbon read from the standard curves prepared.

Determination of cations:

In the following procedure ammonium was used as the saturating in the determination of the concentration of each of the four

cations: sodium (Na^{+}), potassium (K^{+}), magnesium (Mg^{2+}) and calcium (Ca^{2+}).

(1) 10 grams of each air dried sample were accurately weighed out. The samples were then transferred to conical flasks and 50 mls of 1N ammonium acetate pH 4.5 added.

(2) The flasks were stoppered and mechanically shaken for 30 minutes.

(3) Each sample was filtered through a Whatman No 3 paper into boiling tubes.

(4) 10 mls of the filtrate was then pipetted into a 100 mls volumetric flask and made up to the volume with distilled water.

The concentrations of cations in the solutions obtained were determined using an EEL 100 Flame Photometer for Na^{+} and K^{+} and an EEL 140 Absorption Spectrophotometer for Ca^{2+} and Mg^{2+}. In each case the galvanometer readings were related to a graph constructed from the standard samples and results expressed in milli-equivalents per 100 grams of sediment (Buckmann and Brady, 1969).

Determination of calcium carbonate:

The percentage of carbonate in samples can be established by the amount of carbon dioxide (CO_2) gas released in the reaction between the sample and dilute hydrochloric acid (HCl). The volume of carbon

dioxide was measured using the Collins Calcimeter. A sample size of .2 gms was used for samples which were rich in carbonates; whereas 2.0 gms gms of sediment was required from level with a low carbonate content.

To conclude the principal field and laboratory methods employed in the research have been reviewed in this chapter. The emphasis has been placed upon critically evaluating modern techniques used by pollen analysts.

CHAPTER 4.

DATA PREPARATION AND PRESENTATION:

4.1 INTRODUCTION.

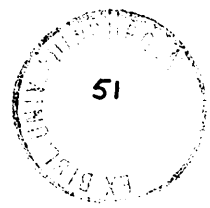
There are two types of pollen diagram in the thesis. First, there are relative diagrams on which the proportions of different pollen types, expressed as percentages of a pollen sum, have been plotted. The pollen sum chosen was that of total land pollen, excluding obligate aquatics and spores. Following Faegri and Iversen (1975, p.194), the calculation of the percentages of taxa outside the pollen sum has been based on a sum which consists of the pollen sum plus its own sum. On the second type of diagram the 'absolute' numbers of pollen grains of each taxon per unit volume of sediment have been plotted, estimated using the techniques described in the previous chapter.

4.2 POLLEN DIAGRAM CONSTRUCTION.

To draw the diagrams for the thesis the versatile computer program POLLDATA MARK V, written by Drs. H. J. B. Birks and B. Huntley (pers. comm.), was used. POLLDATA is a large complex program which does the data manipulation and calculations necessary to produce diagrams via a graph plotter. The diagrams plotted can be either a joined-up 'saw-edge' type or a bar histogram and of a pre-selected size. The program will also optionally calculate 95% 'confidence intervals' for percentage data (Maher, 1972), transform

the pollen counts by means of 'correction' factors (Andersen, 1970) and smooth the data using a running mean. The speed at which calculations are performed and diagrams drawn using POLLDATA means that various arrangements of pollen curves and different pollen sums can be tried in a few minutes; this process would take several weeks by hand. Furthermore there is the additional flexibility of being able to insert and remove types and levels as required. A further advantage is that the diagrams produced are of a standardised form and therefore readily compared one to another (Squires and Holder, 1970). Finally the dataset is stored on the computer and is therefore available for further statistical manipulation by, for example, ZONATION, PCA or MDS(X) (see below).

It should be noted that the POLLDATA program in its original form is machine dependent i.e. it can only be compiled and run on the Cambridge University IBM 370/165. The pollen diagram plotting sections of the program in particular use local Cambridge subroutines to control the graph plotter. These are exclusive to the University of Cambridge Computer Service and cannot be used elsewhere. Hence additional graphics translation subroutines were written , devised by the author, which call the local Edinburgh Regional Computing Centre (E.R.C.C.) Graphpack Routines to plot the diagrams, having provided the necessary parameter transformations - see flow diagram (fig. 4.2). Difficulties encountered in writing the translation routines included the fact that the plotter space conventions at Cambridge and Edinburgh are completely different, in addition there were the incompatible co-ordinate systems and internal code representation of the computers (EBCDIC - IBM 370/165 and ISO - ICL 2900) and the lack



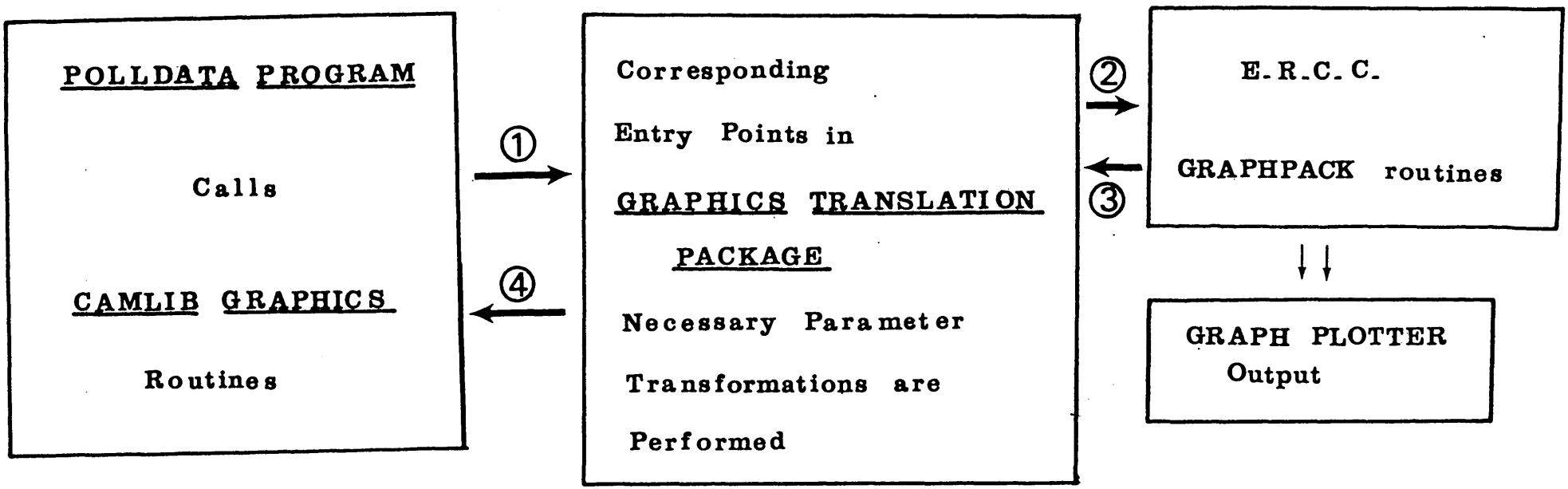


Fig 4.2 Flow diagram for graphics interface

of a variable height character facility at Edinburgh. The writing of the graphics translation routines was, however, successfully accomplished by the author and, together with a text conversion routine and a variable height character facility written by M.D. Brown of E.R.C.C., formed a package which enabled the POLLDATA program to be run in Edinburgh and to produce plotter output virtually indistinguishable from diagrams plotted in Cambridge. The POLLDATA program and the accompanying graphics translation package and program documentation are available for use in the software library - CONLIB (User Contributed Routines) of E.R.C.C. (Alexander, 1981). The graphics translation package was also used in conjunction with the ZONATION program, described in a later section of this chapter, to allow the diagrams of the pollen types zoned and the dendrogram output from the program to be plotted. This is also stored in CONLIB.

4.3 POLLEN DIAGRAM ZONATION. To facilitate the description and interpretation of the contents of a diagram and its comparison and correlation with other diagrams it is usual to divide it into pollen zones i.e. of differing pollen composition, so that the discussion of the vegetation changes is simplified.

Diagrams may be subdivided by examining changes in pollen spectra and placing zone boundaries at levels where there are significant changes in the amounts of one or more taxa. Although most diagrams are thus zoned on the basis of their biostratigraphy, some have been divided up on the basis of lithostratigraphy (Donner,

1957).

It is difficult to avoid subjectivity in zonation by eye since the investigator is always, at least subconciously, looking for similarities with other diagrams. Indeed the efforts of many British palynologists in zoning their diagrams to fit their data into the standard scheme of zones put forward by Godwin (1940,1956) led to the significance of many local and regional variations being lost. Godwin subdivided the Lateglacial and Postglacial periods on the basis of fluctuations in tree pollen that were associated with climatic changes: the subdivisions are often linked to the earlier scheme of climatic periods put forward by Blytt and Sernander (1927). Similar schemes were proposed for Europe by Firbas (1949) and for Ireland by Mitchell(1942,1956) and by Jessen (1949). The zones became associated with radiocarbon dates although there was no evidence for their synchroneity in different parts of the country: the asynchroneity of most pollen zone boundaries has now been demonstrated several times for dates from the Postglacial (Smith and Pilcher, 1973). The pollen zone therefore came to be regarded as a period with a particular climate which was reflected in the proportions of the various tree types present. The names of pollen zones also became linked to geomorphological events, as for example in the use of the term ' ZONE III glaciation '.

Generally there were few problems in applying Godwin's scheme to pollen diagrams from sites in southern Britain but in other areas, which have contrasting climatic regimes, local zonation schemes, such as that used by Walker (1966) for the Lake District, that can only be

tentatively correlated with the basic scheme have to be employed.

It was largely as a response to the difficulties in applying the broad framework of vegetation and climatic changes as worked out at lowland sites to upland sites in Scotland (O'Sullivan, 1974; Pennington et al, 1972; Vasari and Vasari, 1968; Walker, 1974) and to the confusion of climatic, temporal, stratigraphic and vegetational connotations attached to pollen zones that the concept of the Pollen Assemblage Zone was introduced to British Quaternary palaeaoecology (West, 1970; H. H. Birks, 1970, 1972a, 1972b, H. J. B. Birks, 1973a). The assemblage zone concept is based upon the American Code of Stratigraphic Nomenclature (1961). Its use was suggested by Cushing (1967) who defines it as:

> 'a body of sediment distinguished from adjacent sedimentary bodies by differences in kind and amount of its contained fossil pollen grains and spores, which were derived from plants existing at the time of deposition of the sediment.'

A pollen assemblage zone, which is a purely biostratigraphic unit free from implications regarding ecology, chronology or climate, is named after its most abundant or characteristic plant species. The pollen assemblage zones identified at one site may be compared with those from other sites in the area. If satisfactory correlations can be made at several sites, regional pollen assemblage zones can be defined and described within the region under consideration. The regional assemblage zones will reflect

vegetational changes that were synchronous or nearly so. Named pollen zones have the advantage over the traditional numbered zones that as sites are investigated named zones can be inserted or removed without disrupting the sequence H. H. Birks (1970, p.834). Zones are therefore built up on a regional basis with no attempt being made to fit the sites into a rigid zonation scheme based on sites elsewhere. If radiocarbon dates are available for the regional assemblage zones they can be mapped in both space and time, (Cushing, 1967; H. J. B. Birks, 1973a; Birks and Berglund, 1979), as can their inferred vegetation, thereby giving a picture of former vegetation patterns and changes through time. These may in turn be correlated with the standard chronostratigraphic sequences at specific type localities (West, 1970; Hibbert, Switsur and West, 1971; Pennington et al, 1972; Hibbert and Switsur, 1976). Watson and Wright (1980) provide a detailed discussion of the relationship between biostratigraphy and chronostratigraphy. From the inferred former vegetation it is also possible to make inferences about contemporaneous climates which can be mapped to provide an insight into the patterns of former climates and of climatic change.

4.4 NUMERICAL ZONATION.

Once it became accepted that pollen zones are biostratigraphic assemblage zones (sensu Hedberg, 1972a, p.222 - 227) mathematical methods were devised to subdivide pollen stratigraphic sequences (Adam, 1970,1974;Dale and Walker, 1970; Gordon and Birks,1972, 1974; Gordon 1973a; H. J. B. Birks, 1973a,1974,1976; Pennington, 1975a;

Pennington and Sackin, 1975; Birks and Berglund, 1979). The end product of using numerical zonation techniques is pollen zones which, because they are delimited solely on the basis of mathematical criteria and refer only to a single stratigraphic sequence, are local pollen assemblage zones (sensu Cushing,1967; Birks, 1973). If, on comparing several sequences, similar pollen assemblage zones are identified, regional pollen assemblage zones may be defined. Gordon and Birks (1974) developed several numerical methods to aid in the recognition and delimitation of regional pollen zones by comparing pollen sequences.

Five numerical methods for zonation of the pollen data were employed and are as follows:
(1) CONSLINK; (2) SPLITINF; (3) SPLITSQ; (4) PCA (5) MDS(X).

ZONATION PROGRAM.

The first three methods are implemented in the FORTRAN IV program ZONATION written by A.D. Gordon, H. J.B. Birks and B. Huntley (pers. comm.).

(1) Constrained single-link cluster analysis (CONSLINK; Gordon and Birks,1972) There are two stages to the analysis. Firstly, dissimilarity coefficients are calculated for every pair of contiguous samples on the basis of their pollen composition. The dissimilarity coefficient used was the city - block or Manhattan

metric (DC 1 of Gordon and Birks, 1972).

$$DC1(I,J) \sum_{k=1}^{t} | pKi - pKj |$$

where,

i and j are contiguous levels in the diagram.

pKi - proportion of pollen type K in sample i

pKj - proportion of pollen type K in sample j

t = total number of pollen types.

k = 1,2.....,t pollen types

Each measure of dissimilarity is therefore the sum of a series of subtractions and is affected both by changes in the presence of taxa and also in their proportions. The second stage is the grouping together of samples of similar pollen composition. The two samples which are stratigraphically adjacent with the lowest dissimilarity are grouped together first and then the process is repeated until all the samples are grouped together. CONSLINK is therefore an agglomerative technique. The results are represented as heights or values at which the levels are joined together in a dendrogram (Gordon and Birks, 1972 p.966). The lower the value the more similar the levels. At any particular value on the X-axis of the dendrogram a certain number of groups will have been formed and the final choice of zones is therefore reduced to the number of divisions required.

The results of CONSLINK tend to be difficult to interpret since there are problems in delimiting the exact extent of the clusters and hence the stratigraphic extent of pollen levels. This is especially true for larger datasets. CONSLINK is also particularly sensitive to transitional levels between distinct pollen assemblages, Gordon and Birks (1972,p.974), in that it tends to amalgamate these levels at a later stage.

(2) and (3). The other two methods in ZONATION, SPLITINF and SPLITSQ, are divisive procedures, (Gordon and Birks, 1972) which use as their starting point a single group, containing all the samples, and subsequently split it into an increasing number of groups until ultimately all the levels have been separated. The major divisions appear first and represent the zones. The methods both divide the original group in such a way that the total numerical information it contains is maximally reduced at each division. Again a contiguity constraint is employed i.e. the stratigraphic order is maintained. SPLITINF uses information theory to measure the initial total variability in terms of information content. It then proceeds by binary division to reduce that initial variability. SPLITSQ works by a similar procedure but a different measure of variability is used based on the sum of squared deviations method. The results are again plotted as dendrograms. It was found to be best to consider only divisions which represent 10% or more of the original variation. By comparing the zonations, suggested by the three mathematical methods, a series of consistent local or site pollen assemblage zones can be delimited.

Only those pollen and spore types with greater than 5% of the pollen sum at at least one level were used for the purposes of zonation. Those with values which are less than 5% are of little numerical importance, although they may be of great importance ecologically as indicator types, and have little effect on the numerical zonation. It should be emphasised that although the techniques described above objectively place the boundaries between groups of samples, the final choice of the number of zones to retain is subjective and is usually the minimum number required to simplify description and interpretation.

(4) PRINCIPAL COMPONENTS ANALYSIS.

Principal components analysis (PCA) presents multi-dimensional data in a few dimensions in relation to the principal component axes, that are aligned along the major directions of variation within the data, in such a way that the new distances between individuals reflect as accurately as possible the original distances between individual samples, was used on both the pollen and chemical data. To undertake the principal components analysis the FORTRAN IV program in Davis (1973, pps. 493-496) in a modified form was used in preference to the standard statistical packages (e.g. SPSS, SAS) so that control over standardisation of the variables and scaling of the eigenvectors could be exercised.

The following calculations are performed by the program:

(a) The data matrix of m samples scored on n variables is standardised by variables. To standardise the data for each variable the variable mean is subtracted from each of the m scores on that variable and the result divided by the standard deviation of the variable. After standardisation each variable therefore has zero mean and unit variance. The standardised data matrix is then printed. Standardisation of the variables has been employed by most palynologists who have used PCA although some have objected to it (Prentice, 1980). Standardisation is a means of combining those variables which were measured in different units, for example, chemical data (Pennington and Sackin, 1975). Standardising the pollen data has the effect of giving equal weight to each of the pollen types by giving more weight to the rare or less variable pollen types at the expense of the common or more variable ones. It should of course be emphasised that the rare types are often of considerable ecological importance as indicator species in the subsequent interpretaion of the data. However, since there is a high relative error associated with the pollen counts for rare types (see Faegri and Iversen, 1964) and also that the percentage representation of any taxon in a pollen count may be very different from its former representation in the vegetation, it would seem to be more objective to standardise the pollen data.

(b) A matrix of correlation coefficients between all pairs of n variables is calculated and printed out.

(c) The eigenvalues (latent roots) and eigenvectors (latent vectors) of the correlation matrix are obtained using the Jacobi algorithm. The elements of the eigenvectors are normalised so that the sum of squares of the elements is equal to one and were multiplied by the square root of the corresponding eigenvalue to give the component loadings. The component loadings represent the correlations between the original variables and the principal components and show the proportional importance of each variable within the component. The program prints out the eigenvalues and the percentage contribution of each, along with the eigenvectors and the loadings.

(d) The component scores (Morrison 1967; Davis 1973) are calculated for each sample by multiplying the standardised pollen frequencies (zero mean and unit variance) by the corresponding eigenvector and summing the products. The resultant matrix is printed.

The scores on the first three or four components that absorb most of the variance are then plotted stratigraphically cf. Adam (1970), Pennington (1973), Pennington and Sackin (1975); H. J. B. Birks (1974) and Birks and Berglund (1979). The plots summarize the major stratigraphic trends in the sequences and as H. J. B. Birks (1974, p.354) states; 'a pollen zone can be delimited here on the basis of stratigraphically adjacent samples with similar component scores'. Thus changes in the size and magnitude of the component scores can be used to delimit pollen zones. The results from PCA are

particularly useful since they show the nature of the transitions i.e whether gradual or sharp between zones. Indeed the placing of a zone boundary can often be rather arbitrary where there is a gradual transition.

Factor analysis was also used on the data, but the results are not discussed in the thesis because great difficulty was experienced in interpreting them. The likely reason for the difficulty in interpretation, as Prentice (1980, p.78) points out, is probably a result of the way in which factor analysis works and the assumptions employed in the method. In short, factor analysis tries to explain the total variance of each variable as resulting from a particular factor affecting only that one variable and unrelated to factors associated with other variables and also from a linear combination of underlying common factors. The distinction between particular and common factors is not valid for palynological work nor is the assumption of normality of the data which is usually associated with factor analysis.

(5) NON-METRIC MULTI-DIMENSIONAL SCALING.

The MINISSA non-metric multi-dimensional scaling program in the MDS(X) series of multi-dimensional scaling programs, which was originated by E. E. Roskham, University of Nijmegen The Netherlands, was used on the datasets. The purpose of the MINISSA program is given a matrix of dissimilarity coefficients between all pairs of n objects (stratigraphic levels) to find the coordinates of n points in

an r-dimensional space such that the distances among these points are in approximately the same rank order as the dissimilarities. The residual variance normalised is used as a measure of stress, Kruskal (1964a, 1964b). For any given configuration the stress measures how well that configuration matches the data. A mathematical discussion of the method is given in Roskham (1969). The dissimilarity coefficient employed was the DC 1 of Gordon and Birks (1974).

The results of the two-dimensional representation are presented as stratigraphic plots of the sample coordinates on two axes. Pollen zones are delimited on the basis of changes in the coordinate values. Samples with similar pollen composition are grouped together.

The zones delimited by using the methods described above are local site assemblage zones. If the zones at one site can be matched with those at other sites in the region then regional pollen assemblage zones can be defined and may be mapped in time and space (see Cushing, 1967b).

4.5 COMPARISON OF POLLEN SEQUENCES.

To compare the pollen stratigraphic sequences from one site with those at others the FORTRAN IV program - SLOTSEQ, which was written by A. D. Gordon and H.J.B.Birks (pers. comm.) was used. The program slots the two sequences under examination together using the degree of similarity between the proportions of the same pollen types at each site as the basic criterion for fitting and maintaining the

stratigraphic constraint.

The theory of the method is complex (Gordon,1973b; Birks,1974) and hinges on the use of the statistic (Ψ) which was devised by Gordon (1973b) to measure how well sequences fit together. The lower the value of (Ψ) the better and more reliable the fit. There is, however, no statistic available to test the significance of a particular value of (Ψ).

Once regional pollen assemblage zones have been worked out, they form the basis for discussion, correlation and interpretation of the pollen sequences within particular geographic areas. The regional pollen assemblage zones may also be correlated from region to region in time and space, but for this to be achieved absolute dates are essential. The first major use of the statistical methods described above was by Birks and Berglund (1979). The methods highlighted the problems and limitations of fitting the standard Nordic chronostratigraphic zonation system (Mangerud et al, 1974) to pollen data from two sites in Southern Sweden.

The numerical techniques described above have the great advantage that by applying a range of the methods and looking for consistency, they can aid the inexperienced analyst in making the right conclusions. The only serious disadvantage is that they require many thousands of calculations; though these can easily be handled by modern, fast, powerful computers. The ZONATION and SLOTSEQ programs are neither expensive in storage requirements nor processing time.

The objective zonation methods usually give results that largely agree with subjectively drawn-up zonation schemes. Any discrepancies between the objective and subjective divisions of diagrams are therefore of interest and require explanation. The methods can be valuable in focussing attention on certain aspects of the data and in forcing a closer examination of some of the main numerical changes. They can therefore often neglect minor changes that may be regarded as being important, for example, the elm decline. The reason is that the decrease in elm pollen is usually accompanied by only very minor changes in some ecologically important indicator species, such as, Plantago lanceolata and Pteridium aquilinum. The ZONATION programs, previously described, do allow for species to be individually weighted but this involves subjective decisions regarding the actual weighting to be allocated to each. The power of the objective zonation methods should not be overestimated; they represent a valuable tool which can be used to help to either eliminate much of the subjectivity in selecting zone boundaries or to confirm zonation schemes derived from subjective examination, but they should not be regarded as being capable of producing definitive zonation schemes.

Finally misplaced zone boundaries do not affect the validity of carefully collected data but they may obscure the picture of vegetational changes.

4.6 DESCRIPTION OF POLLDATA GRAPHICS CONVERSION PROGRAMS

This section outlines the technical aspects of the routines that

translate the graphics subroutines from the CAMLIB library enabling the program POLLDATA to be used at Edinburgh.

It was decided at an early stage in the work to use a computer both to do the necessary calculations and to produce the pollen diagrams thereby saving time that would otherwise be spent on purely mechanical tasks. Several computer programs have been written to assist in the construction of pollen diagrams (e.g. Squires, 1970; Squires and Holder, 1970; Dodson, 1972; Voorrips, 1973, 1974; King, 1976; Damblon and Schumacker, 1971; Birks and Huntley, 1978). As such programs already existed for processing and presenting graphically pollen data it was considered that it would be better to make any necessary alterations to an established program, so that it could be run at Edinburgh, rather than to start at the beginning and to write a completely new program. It was, however, appreciated that this might not be a simple task since the published pollen diagram programs, such as PALYNO (King, 1976) and those of Squires (1970) and Squires and Holder (1970), required the use of a graph plotter and associated machine dependent subroutines.

Three programs were examined in detail, RHS1 (Squires (1970); Squires and Holder, 1970), NEWPLOT (Shennan, 1980), which both originated at Durham and POLLDATA MKs IV and V (Huntley and Birks, 1978) which was written at Cambridge. All the above programs were written in IBM FORTRAN IV which meant that the basic code, at least in theory, was readily transportable to other computer installations.

RHS1 probably represents the first serious attempt to use a

computer to present pollen analytical data and is a fairly basic program that plots calculated percentages of a specified total for each taxon on a graph plotter as well as tabulating them on a printer.

NEWPLOT is a more advanced program which is in two parts: the first calculates and tabulates the data and the second draws the pollen diagram with the stratigraphy. Additionally it will calculate pollen concentrations and 95% confidence limits. The program calls graphics subroutines from *PLOTSYS at NUMAC (Northumbrian Universities Multiple Access Computer). *PLOTSYS is a variant of the Calcomp manufacturer's plotting routines. The routine parameter lists are not consistent in the type or number of parameters and therefore present traps for the unwary! Nevertheless these calls were successfully translated, at Edinburgh by the author, and satisfactory output produced.

The most versatile program, however, is POLLDATA. This accepts totals of counts of taxa presented either by taxon or by sample and

(a) prints raw and edited data matrices in whatever taxon and sample order is required

(b) sums selected totals for each sample

(c) calculates percentages of each taxon based on the selected sum for each sample

(d) calculates 95% confidence limits for the percentages of each taxon (Maher, 1972)

(e) transforms the pollen counts by means of suitable representation or 'correction' factors (Anderson, 1970) and smoothes the data by a

running mean

(f) graphs the raw counts, percentages, concentrations and influx rates for each taxon against sample depth, sample age, or any other order on the line printer

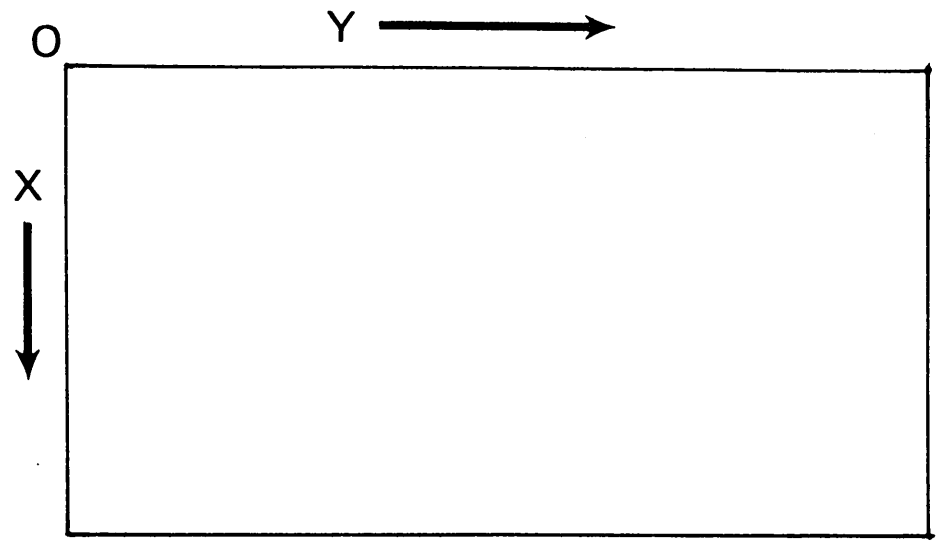
(g) plots raw counts, percentages, concentrations and influx rates for each taxon against sample depth, sample age or any other order on the graph plotter

There are a variety of plotting options producing joined - up 'sawedge' diagrams and bar histograms. Diagrams can be produced at different scales and at varying widths. The program also has facilities for handling plant macrofossil, Cladoceran, molluscan and surface pollen data. It also generates, if required, an output file in a format suitable for subsequent numerical analyses e.g. numerical zonation, principal components etc.

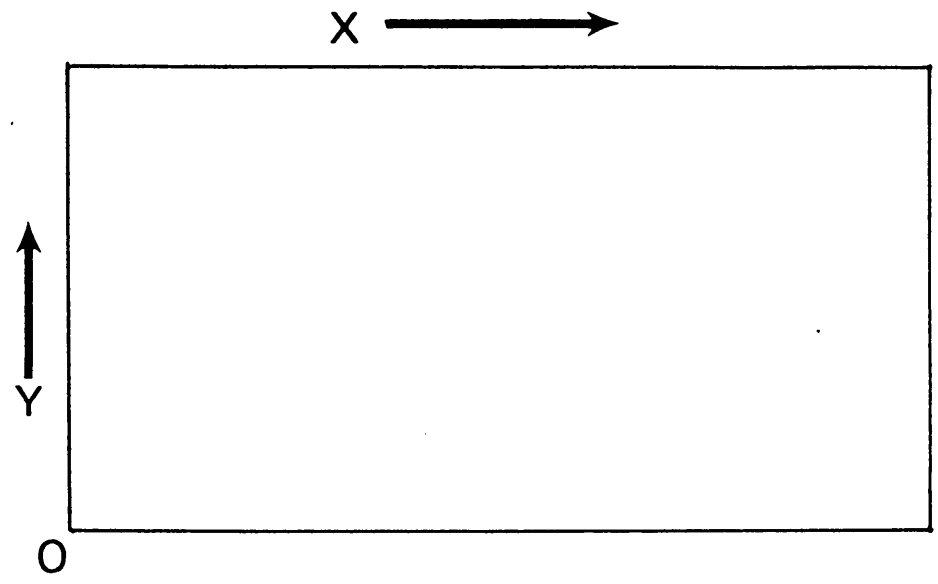
The POLLDATA program is however large, with over 2000 lines of code, and it is difficult to use. The initial development work at Edinburgh was greatly hampered by not having an example of a correct input file. In the subroutine POLPLT, which plots the pollen diagrams considerable use is made of subroutines from the CAMLIB library to control the plotter. Rather than modify the existing program two translation subroutines were written by the author, CRTPLOT and PLOTS, with entry points for the CAMLIB subroutine calls. Listings with comments of these suboutines are included in an appendix. Any conversion of the parameters on the CAMLIB subroutine calls is performed before calling the appropriate ERCC GRAPHPACK subroutine and returning control to the POLPLT subroutine. Whilst

writing the translation subroutines it was found to be an advantage to be able to make minor alterations to them and to re - compile the new versions separately from POLLDATA, which remained largely unchanged. Since POLLDATA has over 2000 lines of code the saving in machine time was quite significant.

As mentioned in chapter 4 several difficulties were encountered in the writing of the conversion subroutines. The first of these was that the plotter space conventions at Cambridge and Edinburgh are different. On drum plotters the paper is moved back and forth over a drum. A pen holder, which may contain one or more pens, moves above the drum and along the direction of its axis. Both drum and pen holder are driven in small increments by impulse driven stepping motors. Pens are raised or lowered by a solenoid in the pen holder. A combination of movements by drum and pen holder allows a line to be drawn in any direction within a resolution of two plotter increments (0.005 cms on the Calcomp). At Cambridge displacements on the plotter paper are measured in millimetres with respect to axes parallel to the edge of the paper, starting from an initial pen position at the lower left hand corner. The Y axis is therefore parallel to the edge of the paper and the X axis perpendicular. At Edinburgh, on the other hand, the convention is that the right hand end of the carriage is designated the base for plotter measurements and is termed the plotter origin. X movements are performed by drum revolution i.e. the X axis is parallel to the edge the paper. Y movements are performed by pen traverse i.e. perpendicular to the edge of the paper with Y increasing to the left (fig 4.1). Displacements may be measured in inches or centimetres.



Cambridge



Edinburgh

Fig 4.1 Graph plotter conventions at Edinburgh and Cambridge.

Transformations therefore had to be applied to take account of these differing conventions. Angles in plotter space are measured in radians rather than degrees at Cambridge but the conversion is straightforward.

The second problem was that a text space is separately defined at Cambridge. A text pointer specifies a position (I,J) on a grid of character positions whose size, orientation and origin are set in terms of the user's coordinate system. Character output is normally produced starting at this text pointer and when text output is completed the pen is restored to its previous position so that plotting may be continued using the user-defined coordinates. Therefore, scale factors, both text and user space, pen positions, origins etc were stored in COMMON so that they could be recalled. The FORTRAN IV COMMON statement provides access to data used by more than one part of the program.

A further problem was that the IBM 370/165 at Cambridge uses the EBCDIC internal code representation where ERCC ICL 2900 uses ISO. However, one can specify that the character codes referred to are in EBCDIC at Edinburgh and the conversion subroutines switch between ISO and EBCDIC as appropriate. POLLDATA contains references to standard Cambridge routines UNPAK and KCNVRT for text conversion. A routine UNPAKS, which performs the same functions was written by M. D. Brown of ERCC. An additional routine CHARHT written by M. D. Brown for inclusion in ERCC Graphpack allows the ratio between the width and height of characters to be altered so that the taxon names can be output with letters 1.5 times the normal height, thus making them

more legible and conforming with the practice at Cambridge.

Only two other modifications to POLLDATA were required. One was to re - dimension the arrays in the program to handle larger datasets with more than 100 samples (e.g. that from Balgone House). The other was to write an additional subroutine ASCALE that standardised all the counts to give exotic counts for a constant weight of exotic suspension added. A copy of the subroutine is given in the appendix.

Turning to the flow diagram (fig 4.2) the mechanism by which the graphics translation interface operates may be traced out.

Step (1) The POLLDATA program calls a graphical subroutine in the CAMLIB library. The program loader then locates the corresponding entry in the graphics translation package. Any transformations to the parameters of the CAMLIB routine call are performed.

Step (2) The appropriate subroutine in the ERCC graphics package - GRAPHPACK is called. This writes to a plot descriptor file (PDF) on logical device number 50. This file may be inspected on a graphical terminal, Tektronix storage tube display or similar, using locally TVIEW or PLOTEK. This was found to be an aid to program development and it is good practice to inspect the plots at a graphical terminal before submitting mistakes to the plotter! To obtain hard copy a post - processing program (GPLIST) is run to convert the plot to a form acceptable to a specific plotter.

Steps (3) and (4) Control is returned initially to the Graphics translation package and then to the POLLDATA program respectively.

Once the POLLDATA program and its accompanying conversion

routines had been thoroughly tested it was placed in a library of user contributed software (CONLIB) along with on - line documentation and a sample input data deck so that it would be available for general use (Alexander, 1981). The program has been used by a number of research students completing their theses (Robinson, 1981; Boyd, 1981; Wain - Hobson, 1981). It has also been used by undergraduate students in conjunction with practical classes in pollen analysis in the Departments of Botany at both Edinburgh and Glasgow and by students preparing palaeoecological dissertations as well as by research workers in a variety of fields, including Geophysics and Ecology.

Finally, following the model of the conversion subroutines described above it should be possible to use POLLDATA on most computers. The graphics routines called from CAMLIB are not complicated and are therefore relatively easy to emulate. Listings of the current version of the POLLDATA program should be available from the Sub - Department of Quaternary Research, Botany Department, Cambridge University.

It is recommended, however, that any future programs written by pollen analysts incorporate the Graphical Kernal System (GKS). GKS is intended to become the international standard for graphics and its adoption should greatly improve the ability to exchange software. This is particularly important since the resources for converting pollen programs are always likely to be limited.

CHAPTER 5

REVIEW OF PREVIOUS PALAEOECOLOGICAL WORK IN SCOTLAND

In this chapter a brief review of previous palaeoecological work in Scotland is presented. It is intended to show the developments in the techniques applied and the changing aims of the researchers. Since comprehensive reviews of the literature exist (Newey, 1965; Birks, 1973; Edwards, 1974; Crabtree, 1975;Lowe and Walker, 1977; Pears, 1977; Pennington, 1977a; Gray and Lowe, 1977, 1980 ; Price, 1983; Sissons, 1983) only the most significant papers are indicated and placed in their historical context. The present state of knowledge concerning the vegetation history of the Lateglacial and Postglacial periods in the study area is then outlined followed by a recap of the aims of the thesis.

In studies of the past vegetation of Scotland two stages are evident: the first being before 1923 and the second post 1923. In the first stage studies were based upon the observations of the preserved macro-remains and the macrostratigraphy of peats in various parts of Scotland. In the second the technique of pollen analysis has been increasingly refined and used to present a picture of vegetation development and chronology.

In the early investigations, of the first era, the identification of large fragments of plants in peat led to speculation about former vegetation and climate. Geikie (1866) showed that the stratified structure of peat mosses can be related to changes in climate during the Late Quaternary. In a series of papers Lewis (1905,1906,1907,1911) continued and developed the work of

Geikie. He made a detailed study of the macrostratigraphy of Scottish peat mosses and attempted a correlation of the climatic changes postulated by Geikie with the stratification of mosses. Samuelsson (1910) identified fossil remains, including pollen grains, in peat either in the field or after simple laboratory treatment. He also correlated the evidence for climatic, vegetation and physiographic changes in Scotland with that in Scandinavia.

Erdtman (1923,1924,1928) was the first to apply pollen analytical techniques to Scottish peat and lacustrine deposits in order to show the changing patterns of vegetation and the environmental history of the Quaternary period. He thus extended the earlier findings of Lewis and Samuelsson. Following this work and on the basis of data from English sites, Godwin (1940) devised a zonation scheme that could be applied to Postglacial vegetation changes in the British Isles. The findings of Fraser (1943) and Fraser and Godwin (1955) at two sites in Aberdeenshire and Lanarkshire suggested that the pollen spectra represented a northern extension of the sequence already established for England and Wales. The first pollen studies of the Lateglacial period were carried out by Mitchell (1948, 1952) and Godwin (unpubl.) who examined deposits from Berwickshire and from a site near Glasgow and demonstrated that the tripartite (I, II and III) sequence observed in Europe was also to be found in Scotland. Donner(1957, 1958) , after pointing out that few Lateglacial sites had been discovered in Scotland and that those that had been located were mostly in the southern half of the country, described the likely composition of Scottish vegetation in the Lateglacial period. He did not though investigate the Younger

Dryas sediments which he regarded as having an insignificant pollen content.

The work described above was followed by research projects that had clearly set out themes. Newey (1965, 1968) presented results of a study of vegetational changes at a number of sites at different locations in S.E. Scotland which builds up a regional history of vegetation. Durno (1967), on the basis of over thirty diagrams from all over Scotland, described the changing distribution of tree species. H. J. B. Birks (1973a), study of present day and past vegetation of the Isle of Skye, and Williams (1977) work on the Postglacial vegetational history of the Isle of Skye and the Morar peninsula, are good examples of the detailed regional approach. H.H. Birks (1970, 1972) worked out the sequence of changing patterns in the areas of natural oak and pine forests and Pears (1964, 1969) described the dynamics of woodland change in the Cairngorms, while O'Sullivan (1973) studied the changes in plant communities at a more local scale from analysis of mor humus.

From the results of pollen analytical investigations inferences have been attempted about former climates and climatic changes (Vasari and Vasari, 1968; Durno and Romans, 1969).These however tend to involve an inadequate knowledge of the climatic tolerances of many plants and the significance of other ecological factors, such as soil differences, plant competition, and rates of immigration (Smith, 1965). An added complication is that many pollen types are identifiable only to family or genus level taxonomic units that may comprise species with widely differing ecological requirements

(Moore, 1980). However, pollen taken in conjunction with results from other techniques can enable the reconstruction of past environments. For example, a temporary climatic deterioration between 12,000 BP and 11,800 BP has been identified by Haworth (1976) and Pennington (1977a) in cores from lochs in northern Scotland on the basis of a minor change in sedimentation rates, the presence of Artemisia pollen and increases in the amounts of bryophytes and aerophilous diatoms recorded. The bryophytes and aerophilous diatoms, in particular, indicate increased rates of soil erosion. Artemisia species are associated with well - drained soils and usually do not tolerate much snow cover. Abundant Artemisia therefore implies a dry arid climate with warm summers and xeric soils (Iversen, 1954). The percentages of Artemisia recorded at some Scottish Lateglacial sites (H. H. Birks and Matthewes, 1978; Macpherson, 1980; Sissons, 1974,1983) have been used to confirm the pattern of snowfall during the Younger Dryas as calculated by Sissons and Sutherland (1976).

Pollen analysis has been used to help answer questions in geomorphology. Newey (1966) and Brooks (1972) described and were able to suggest dates for the changes in vegetation associated with Lateglacial and Postglacial fluctuations in sea level in the Forth Valley. By analysing the deposits on either side of moraines thought to be related to the Loch Lomond Readvance Donner, 1957; Sissons et al 1973; Walker, 1974; Walker and Lowe, 1976,1977; Lowe, 1977; Walker and Lowe, 1979a sought to date and map the extent of glacial advance (Sissons, 1974, 1983). Their findings largely account for the distribution of Lateglacial sites in Highland Scotland as shown on

map 5.1, and for the relative paucity of such sites in the southern part of the country.

Attention has recently focussed on the use of other techniques to supplement the results of pollen analysis and to improve methodology. So that along with pollen are examined sediment chemistry, plant macrofossils, diatoms and sometimes archaeology in order to permit the palaeoecolgical reconstruction of past ecosystems. Pennington, Haworth, Bonny, Lishman (1972), Haworth (1976), Pennington (1977a, 1977b) in examining lake sediments from several lochs in Northern Scotland employed just such an interdisciplinary approach. They were able to relate changes in the pollen content to sediment composition. This was explained as the result of the lake sediments being derived from the changing soils of the catchments.

Radiocarbon dating has been used extensively to date pollen assemblage zones to enable correlation of regional chronozones and to remove the possibility of making false correlations between pollen records from sites both within Scotland and elsewhere (West, 1970; H. H. Birks, 1970; Switsur and Pilcher, 1973; Pennington, 1977a). There has also been an increasing awareness of the problems associated with hard-water error, incorporation of old carbon and also regarding the suitability of certain sediment types, for example, gytjjas for dating (Bowen, 1978; Olsson, 1979; Sutherland, 1980). For example, the radiocarbon dates obtained for basal gytjjas on Rannoch Moor, where the ice sheet during the Younger Dryas was several hundred metres thick, go back as far as 10,660 +/- 240 SRR1074 (Walker and

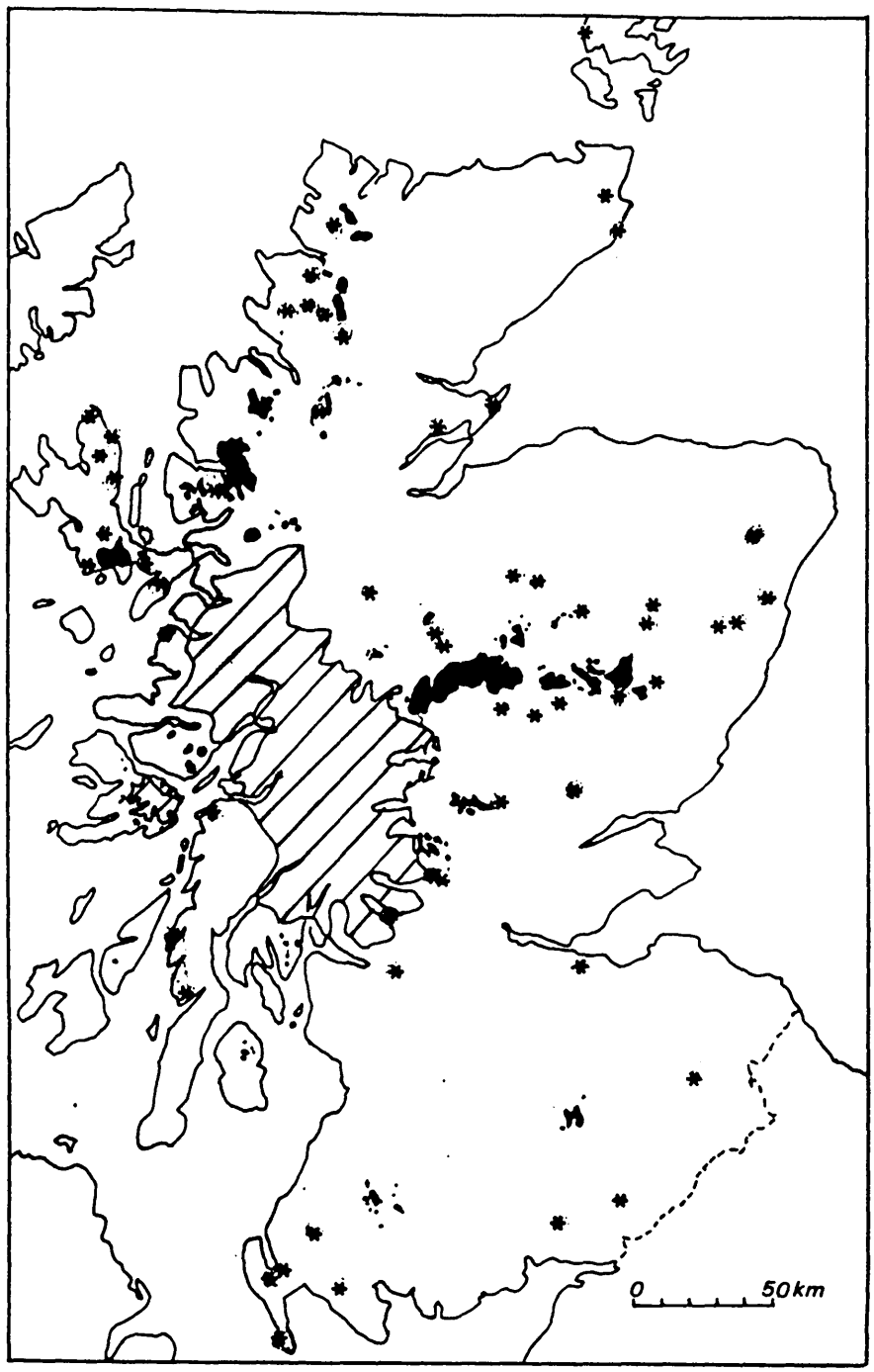


Fig 5.1 Distribution of Lateglacial pollen sites in Scotland (after Sissons, 1976).

Lowe, 1977, 1979; Lowe and Walker, 1980), however this date may be too old since it suggests that there was widespread decay of the ice sheet before the generally accepted date of 10,300.

The introduction of 'absolute' counting methods ~~have~~ has allowed concentrations of pollen in sediments to be calculated and, where a sufficient number of radiocarbon dates are available, also influx rates (Pennington and Bonny, 1970; Pennington et al, 1972; Pennington, 1977a). As outlined in an earlier chapter, statistical methods have been used, with the aid of computers, on pollen data as a means of reducing the subjectivity in the zonation of pollen diagrams solely by eye (H. J. B. Birks and Gordon, 1972) and also in investigating complex relationships (H. J. B. Birks and Deacon, 1973; Pennington and Leishman, 1975).

An examination of the classes of deteriorated pollen grains (Cushing, 1967a), along with a detailed analysis of the lithostratigraphy of several sites in Perthshire, led Lowe (1977, 1982) to suggest that collapse and erosion of marginal sediments in basins may have occurred throughout the Lateglacial and well into the Postglacial affecting both lithostratigraphy and, through the redepositon of pollen grains, biostratigraphy.

The pattern that has emerged from vegetational studies is of a general warming from 13,000 BP, interrupted by one major climatic deterioration, the Younger Dryas (11,000 BP - 10,000 BP). There is, however, evidence for an oscillation during the early interstadial that may be climatic. Oscillations in Lateglacial Interstadial

sediments are recorded in the literature, although causes other than climatic ones could account for some or all of them. Such sites are represented in Sutherland and in the Great Glen (Kirk and Godwin, 1963; Pennington et al, 1972; Pennington 1975a; Howarth, 1976), in the Grampians (Donner, 1957; Vasari and Vasari, 1968; Clapperton et al, 1975), in north west England (Smith, 1959; Oldfield, 1960; Evans, 1970; Pennington, 1973,1975a), in north east England (Walker and Godwin, 1954; Bartley, 1962), in Wales (Crabtree, 1969) and in Ireland (Watts, 1963). More recently double maxima for woody plant pollen have been reported from two sites in Scotland, at Corrydon in Glenshee and at Stormont Loch near Blairgowrie, and the authors cautiously suggest that these are equivalent to the Bolling oscillation (Walker, 1977; Caseldine, 1980). The evidence from most other sites in Scotland supports the conclusion offered by Gray and Lowe (1977) that vegetation succession and soil development progressed without interruption from 13,000 BP until the beginning of the Younger Dryas. The reason for this is not immediately apparent. It may be that the climatic change was so slight and short - lived, 200 years has been suggested by Pennington, (1977a), that its effects can only be discerned at sites that occupied critical locations either altitudinally or on the east - west climatic gradient between continentality and oceanicity or that previous analyses were of insufficient detail.

Climatic reconstructions from the populations of Coleoptera found at Lateglacial sites in the British Isles (Coope, 1977) conflict with the classical interpretations based upon the pollen record. These indicate a much warmer climatic amelioration (July

average of 17°C as opposed to 13°C that peaked earlier in the Lateglacial Interstadial and also a more rapid rise in temperature at the end of the Younger Dryas. The existence of which is consistent with both the Coleopteran and plant evidence. Coleopteran evidence from south west Scotland suggests a mean July temperature of around 15°C at about 13000 BP and that mean July temperatures had fallen by 3°C before 12000 BP (Bishop and Coope, 1977). Coope (op. cit.) proposes that the reason for the differences in the thermal environments indicated by the two types of evidence lies in the much faster rate that beetles move to colonise areas in response to climatic improvement compared to the more slowly migrating trees and shrubs that take time to reach maturity. Divergences of this nature are also evident in the Postglacial. For example, at around 9500 a thermophilous assemblage of Coleoptera indicating climatic conditions as warm or even warmer than today is found in south west Scotland associated with Betula woodland (Bishop and Coope, 1977).

Turning to the thesis study area the most recent substantial work there is that of Newey and the following summarises his conclusions as published in a series of papers (1966,1968,1970):

The Corstorphine site (Newey, 1970) provides evidence for environmental conditions and vegetation development in the region during the Lateglacial period. The sediment stratigraphy and pollen content exhibit the typical three-fold division which is found in Lateglacial sequences in the British Isles and in Europe. A basal

clay is separated from an upper horizon of sandy clays, both of which have a low pollen content, by a sequence of marls and clay-marls that has a much higher pollen content. The lower and upper clays were deposited as a result of solifluction and overland wash during periods of severe climate associated with deglaciation, and during the Younger Dryas (Loch Lomond) Stadial. Very abundant secondarily-derived Carboniferous spores in the upper clay provide evidence of soil instability and movement. The pollen is indicative of a sparse, open habitat with a herb-dominated, tree-less vegetation in which there were large areas of bare ground. In contrast the pollen in the more organic interstadial sediments suggests a more complete herbaceous grassland and dwarf shrub vegetation cover with a significant arboreal component consisting mainly of Betula and Salix. It is suggested that in favourable sheltered locations on south-facing slopes during the interstadial, there may have been small copses of tree birch (Newey 1970, p.1173). Warmer temperatures during this period are also indicated by the presence of pollen and macrofragments of a rich aquatic flora and fauna and also of Filipendula ulmaria - a thermophilous species. It is interesting to note that Coope (1968) from an examination of an insect collection from Corstorphine suggested that the area was subjected to cold easterly winds during the Lateglacial.

Newey's account of the Postglacial vegetation development (1965, 1968) may be viewed in the perspective of H. J. B. Birks' (1977) synthesis of forest history in Scotland.

In brief, after a short period of a few hundred years following the Younger Dryas Stadial in which Juniperus and Empetrum heaths were widespread along with herb-dominated open grass and sedge communities including competition-intolerant herbs, Betula expanded rapidly at about 9,800 to form open birch woods and willows with tall herbs such as Filipendula and ferns.

Around 8,500 BP Corylus avellana spread rapidly to form mixed birch-hazel woods. Edaphic factors may have affected the distribution of Betula and Corylus, with Corylus predominating on the richer soils and Betula being confined to the more acidic.

From about 8,500 BP the birch-hazel woodland was successively invaded by Ulmus and Quercus to form mixed deciduous woodland with Hedera helix, Sorbus aucuparia and Lonicera periclymenum. The pollen of Ulmus and Quercus is present in much higher frequencies than in diagrams from northern Scotland, probably as a result of more favourable soil and climatic conditions. In particular the recorded percentages of oak, which is normally under-represented, indicates that it was probably the dominant tree species even in upland areas. The altitude of the treeline is not known but work by H. H. Birks(1972a) in the Galloway Hills suggests that Betula, Populus tremula and Sorbus aucuparia may have grown at altitudes up to at least 610 meters O.D. Low pollen counts for Pinus, in contrast to sites in Highland areas (H. H. Birks, 1972b; Durno, 1958,1959; Erdtman, 1928; Pennington et al, 1972; Vasari and Vasari, 1968), are recorded from about 8,000 BP. Tilia counts are also low suggesting that this species was less common than further south.

From around 7,000 BP, high frequencies of Alnus are recorded. This appears to have expanded in response to a change towards a more oceanic climate and it largely replaced Salix and Betula in wetter habitats. Quercus remained abundant. The initial growth of blanket bog in the area largely dates from this time.

A sharp decline in Ulmus pollen occurs at 5,000 BP. It is not yet clear whether the Ulmus decline was the result of a climatic change (Iversen, 1941), agricultural activity (Troels-Smith, 1960 ;Garbett, 1981) or a disease that spread at a rate which radiocarbon dates cannot resolve (Rackham, 1980). Newey (pers. comm.) could find no evidence in the Lothians of human interference with the vegetation at the time of the Elm decline; but forest clearance, small-scale pastoral farming and phases of forest regeneration are obvious from about 2,000 BP, with large-scale clearance leading to the development of grassland, heath and bog during the Iron Age and into historic time, until the largely tree-less state of today was reached. Phases of clearance of woodland trees are interpreted from fluctuations in the tree pollen frequencies which led to the extension of heath and open-habitat herb species and the appearance of plantain (Plantago lanceolata) pollen, an indicator of agricultural activity and other pollen associated with disturbed soils, for example, composites, legumes, and grasses.

Planting of trees, largely of the coniferous species, Pinus and Picea, during the eighteenth century and at later dates can be detected by an increase in the amounts of these pollen types in pollen diagrams that extend to the present day.

The pollen evidence therefore indicates that oak forest with birch was the natural forest vegetation of the area and would have covered a large part of the lower ground of the region. This confirms the findings of McVean and Ratcliffe (1962) who proposed four potential vegetation regions for Scotland, (map 3.5), from an examination of the existing forest fragments. Of their four regions the Lothians would lie in the region where oak forest with birch would predominate.

Finally to recap briefly the objectives of the present research: The prime aim was to examine sediments of Late Quaternary age in the eastern part of the plain of the Lothians of Scotland. Pollen analysis was used to produce a picture of the former vegetation and of its changes during the Lateglacial and the following Postglacial periods. From the changes in the relative abundance of pollen and spores of particular plant species, palaeoclimatic inferences are presented. As has already been demonstrated, compared to northern Scotland, hitherto few modern investigations have been applied to the biological and climatic development of the lowland areas of south-east Scotland, apart from those of Coope (1968) and Newey (1970) for the Lateglacial. Both of these concentrated on deposits at one site, namely Corstorphine Loch, Edinburgh. Studies of the Postglacial sediments at several sites were undertaken by Newey (1965, 1968).

Three additional objectives were: First the critical examination of the laboratory techniques employed by pollen analysts, particularly the methods for 'absolute' counting. Second the uses of

a computer to perform the necessary calculations and also to produce pollen diagrams. Third the relative merits and weaknesses of the various multivariate and statistical techniques, which have been employed by palynologists to objectively zone diagrams, were assessed.

In conclusion, although the main aim of the research described in this thesis is essentially a pollen analytical one, the focus is much broader and covers a range of secondary topics. The work is geographical in context since in achieving the prime aim it includes the spatial and temporal prerequisites of all geographic research. In the chapters that follow, after a short review of each of the sites investigated, the data collected is first described and evaluated and then compared to that from other sites in Britain and Europe. In the final chapter the principal results are reviewed and the conclusions from the research are summarised.

CHAPTER 6

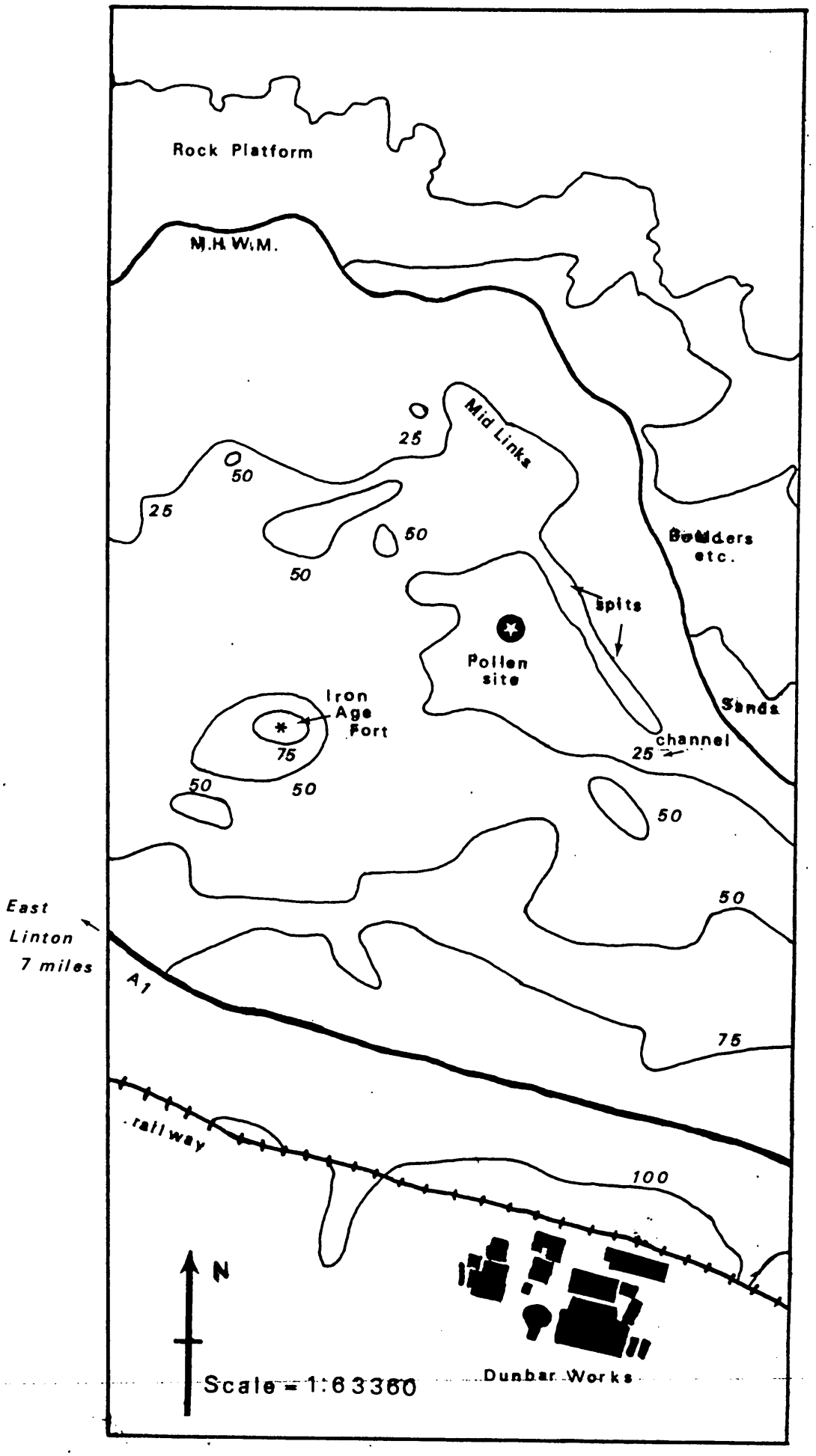
BROXMOUTH SITE:

6.1 Introduction

The first site to be investigated was at Broxmouth. The site (NT705775) was located near the the A1 approximately 12 km to the east of East Linton and to the north of the Associated Portland Cement Manufacturers Ltd, Dunbar Works (map 6.1) Attention was drawn to a series of kettle holes, filled with freshwater deposits and sealed with peat, by archaeologists working on the total excavation of an adjacent Iron Age fort (Hill, 1979). The excavation had been necessary because of the destruction that would result from the planned extension to quarrying operations for the continuation of the extraction of limestone from the area between the A1 and the sea from Broxmouth to Skateraw.

6.2 Stratigraphic Investigation

In the Geological Survey Memoir for East Lothian (1910, p185) the sediments of a former freshwater loch located between mounds of sand and gravel at Broxmouth, are described as being one of only two examples of Postglacial lacustrine deposits in the county worthy of mention; the other being in a glacial meltwater channel near Balgone House. A section of the deposits is described by Professor John Young:



Map 6.1 Location of Broxmouth site.

Thin sandy soil containing beach shells (probably blown sand)

Peat 2 to 10 inches in thickness

Marl, white tenacious, consisting almost entirely of Lymnaea, Planorbis, Pupa, and Cypris. It is divided by short seams of sand and peat.

At the wall next the sea a laminated clay underlies the marl; on the south side, a layer of sand resting on red sandstone

There is also an additional note to the effect that during the resurvey examples of Lymnaea and Succinea were found in large numbers in the "black-earth" that marks the site of the loch.

The core was taken from a large kettle hole, approximately 200 metres long, that matches the description of the old freshwater loch given above. The kettle hole was bounded on the seaward side by two parallel spits that did not quite seal it; there was a small channel at the south-eastern end. A stratigraphic investigation revealed that this channel was filled with gravel. To the seaward side of the spits there lay a raised beach, the altitude of which is 5.4 - 5.6m O.D. On the landward side of the kettle hole, there was a neighbouring kettle hole at a higher altitude and beyond that a kame upon which the Iron Age Fort was situated (map 6.1). Each of the features so far described has been subsequently obliterated by quarrying.

It was decided to study the stratigraphy of the kettle hole because of its proximity to the sea and the possiblity of marine incursions into the basin that could be related by pollen analysis to Ordnance Datum (O.D.). The stratigraphy of the deposits was investigated with the aid of a Hiller borer; all of the bores being levelled into O.D. 38 bores were made with the Hiller and revealed a complex but consistent stratigraphy largely made up of lacustrine deposits (fig 6.1). During the stratigraphic survey it was noted that the present day water table is only a metre or so below the surface which may account in part for the excellent preservation of much of the pollen. Consequently it may be that the height of the threshold of the newly-closed basin holds more relevance for the interpretation of events than the contemporary sea level.

The survey proved the existence of a basin of which the altitude of the deepest point is -2.14m O.D. A series of gravel ridges, at an altitude of 1 - 2m, was located and mapped by repeated probing with the Hiller (fig 6.1). The altitude of the gravel ridges rising in height inland corresponds to an extrapolated figure for the Perth Main Raised Shoreline of 5' or 1.5 m O.D. (Sissons et al, 1969). The ridges may therefore be related to that shoreline and hence have originated through marine action. Another possible origin for the ridges is that they could have been formed by slow melt out of buried ice. However, it is thought that this mode of formation is less likely because of their small size. They must pre - date the formation of the two parallel spits at 5 - 8m O.D since they lie beneath them.

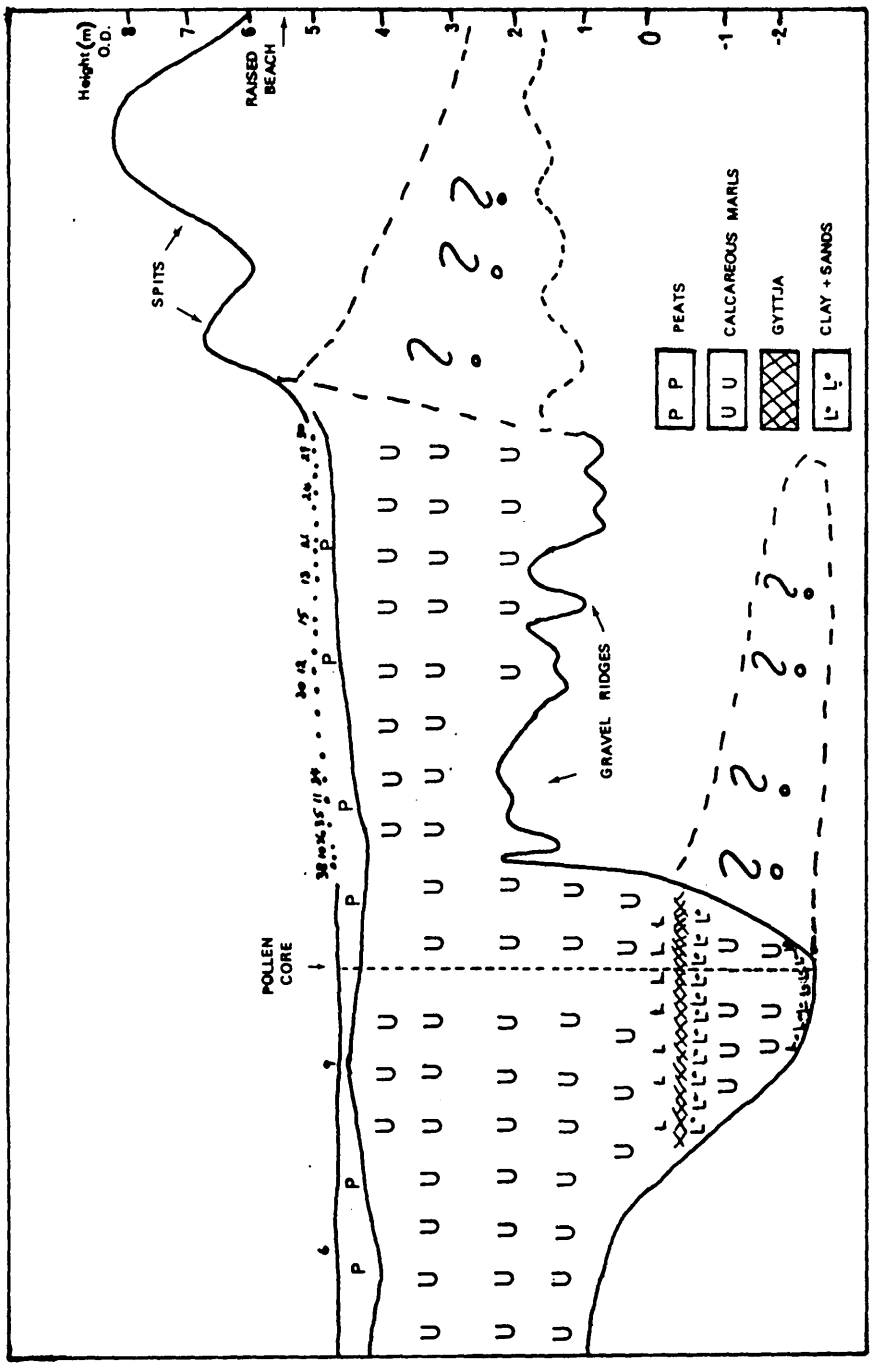


Fig 6.1 Section of lacustrine sediments at Broxmouth.

The stratigraphy of the basin was best developed at the deepest part, near the centre of the basin and samples for pollen analysis were taken from there using a modified Dachnowski corer. The gradients in the area surrounding the kettle hole are very slight and the superficial deposits consist largely of banded outwash gravels, sands and clays that are principally derived from rocks of Old Red Sandstone Age.

Stratigraphic description of core:

0 - 102 Disturbed, by ploughing, peat with sand

102 - 111 Brownish - yellow peaty - marl with silt and shell fragments

111 -132 Yellow shelly marl with Cyperaceae fragments

132 - 185 Light yellow marl with organic laminations, shells and Cyperaceae fragments

185 - 247 Dark olive grey marl with silt, wood and shell fragments. Layer of very compacted Cyperaceae at 191.5 cms.

247 - 289 Very coarse shelly marl with Characeae and whole Lymnaea.

289 - 314 Yellow / yellowish - brown marl with Characeae and bivalve shells.

314 - 369 Coarse shelly marl with whole Lymnaea peregra, organic fragments and pieces of Cyperaceae.

369 - 413 Pale yellow fine marl with some Characeae and shell and Cyperaceae fragments. Lymnaea peregra and bivalves present.

413 - 487 Pale olive marl, increasingly clayey with depth. Layer of

Cyperaceae fragments at 466 cms.

487 - 503 Light olive - grey clayey marl with organic fragments and Cyperaceae macro - remains.

503 - 508 Light brownish - grey fibrous marl with Cyperaceae fragments.

508 - 511 Olive grey clayey marl.

511 - 542 Dark brownish - grey clayey marl.

542 - 551 Almost black gyttja - like material with between 546 - 549 cms layer of fine sand.

551 - 563 Fine sand and clay

563 - 568 Light grey gritty organic clayey marl. No shells present.

568 - 624 Light yellow marl with some laminations. Shell fragments and plant remains present. 590 - 594.5 Much coarser marl with broken shells and plant remains.

594.5 - 610 Higher clay content.

624 - 679 Fine laminated clayey greyish - yellow marl with moss fragments but no shells.

679 - 709 Pale olive - grey clayey marl with shells

709 - 713 Reddish brown clay with red sandstone grit.

Since calcareous marls form a significant part of the sequence just described it is worth considering briefly the conditions under which they are formed. Marl formation is a biochemical process that requires the presence of lime in the water and algae, such as Chara or other aquatic plants eg Myriophyllum spp. The shells of common fresh water mollusca, including those in the genera Pisidium, Sphaerium, and Lymnaea, are often also present. Photosynthesis uses up the dissolved carbon dioxide and in the case of Myriophyllum spicatum (Hutchinson, 1970) bicarbonate ions can be utilised as well.

If the removal of bicarbonate persists the acidity of the water may decrease to such a point that the solubility product of calcium carbonate is exceeded and lime precipitates (Deevey, 1968). Such precipitation is favoured by high temperatures owing to the increased solubility of carbon dioxide. At Dunbar the Carboniferous limestone bedrock and calcareous till provided, through leaching, the sources of the base rich water. In shallow water the temperature and carbon dioxide concentration may be more favourable to marl deposition than in the deeper portions of a lake which are cooler and richer in carbon dioxide. Thus hard water lakes often have a littoral girdle of marly sediment (Deevey, 1968). For large amounts of shell marl to be deposited over a considerable length of time a continual supply of fresh water that is rich in dissolved lime is required as is clear open water that is free from silt or severe disturbance of lake bottom algal growth and also remains too deep for colonisation by Typha spp and Phragmites. The molluscan shells and amorphous calcium carbonate of shell marl largely resist compaction.

Samples from the core were treated using the Walkley - Black method described in an earlier chapter (p. 46) in order to obtain their percentage carbon content. The results are presented on the graph in fig 6.2. Three pronounced peaks in the percentages of carbon present are evident, between 430 and 570 cms, between 200 and 280 cms and also at around 125 cms. There is in addition a lesser peak near 700 cms. The peaks correlate with the higher proportion of organic / macrofragment remains already observed in the account of the stratigraphy.

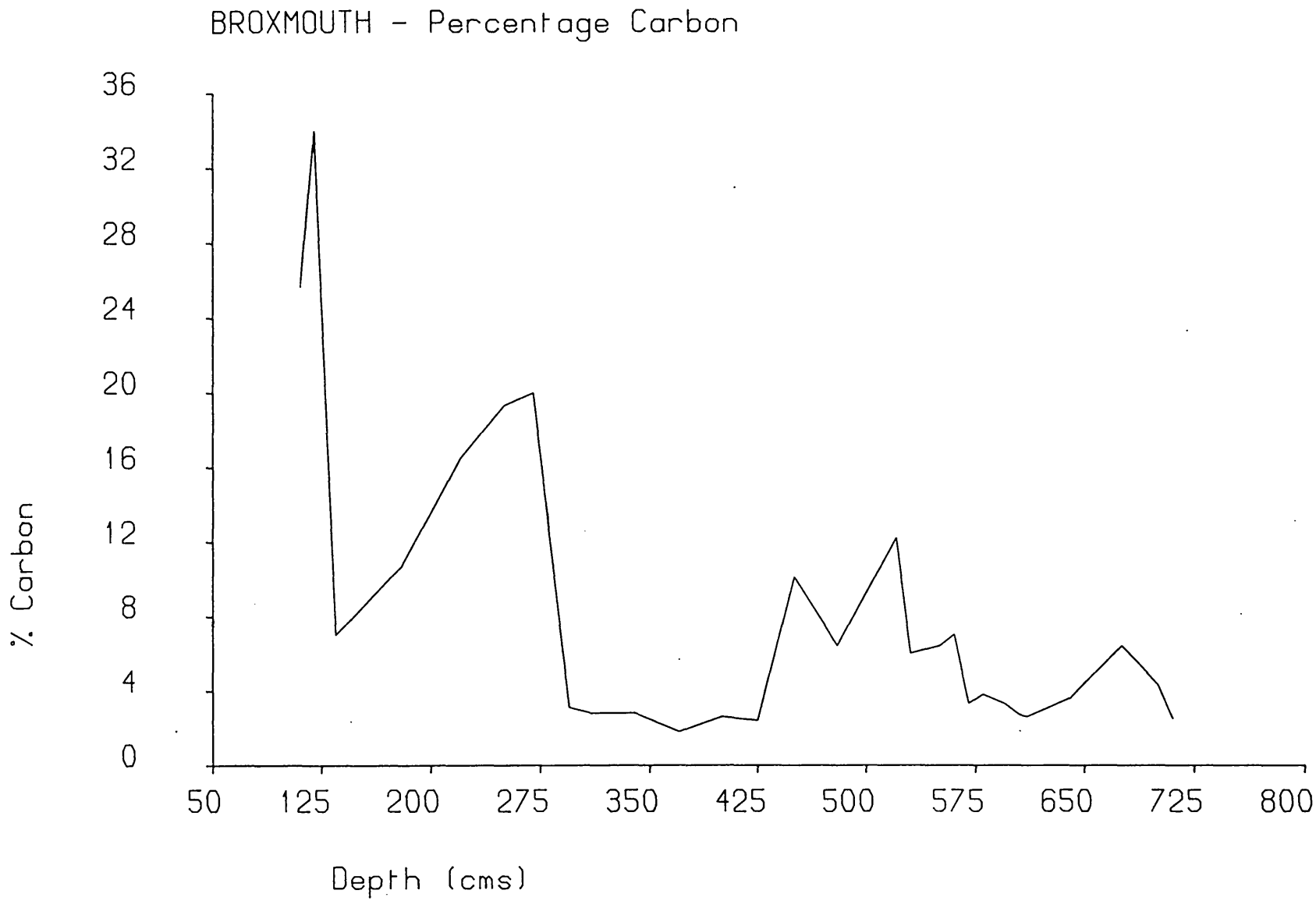


Fig 6.2 Graph of carbon content of sediments.

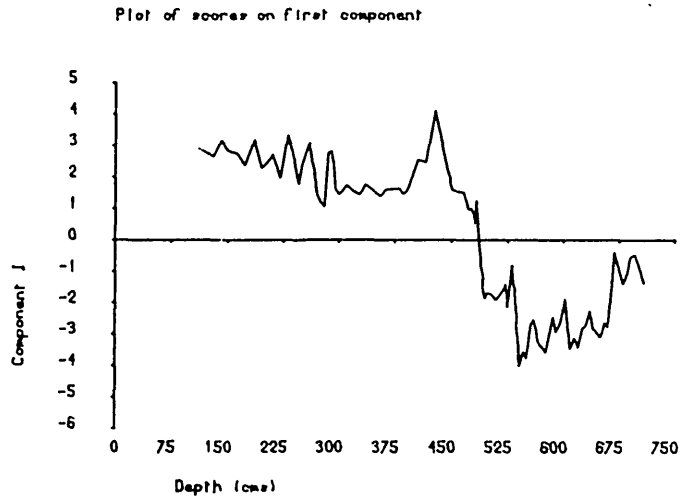
6.3 Preparation and Counting

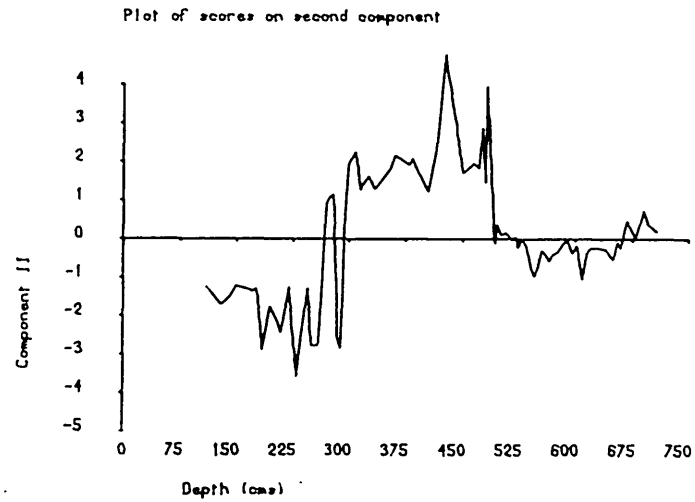
Initially samples from 81 levels were prepared and counted. The samples were spaced throughout the core and particular attention was paid to stratigraphic changes when selecting the levels be analysed. At most levels it was possible to count a minimum of 500 grains. Where there was a significant proportion of pollen of arboreal species a sum of at least 150 arboreal grains was counted. One problem that was encountered in the course of preparation of the samples was that slides prepared from levels between about 540 cms and 560 cms were obscured by pyritospheres - spheres of iron sulphide ($Fe_2 S$) of varying sizes (2 - 35μm). These were either removed by treatment with hot 10% nitric acid (HNO_3) (Vallentyne, 1963) or the samples were diluted, prior to mounting, to enable counting. During the counting it was noted that pollen concentrations in samples from the lower part of the core, from about 500 cms to the base, were much lower than those of samples from the upper part of the core. The pollen assemblages were equally distinct. However, this was only a qualitative assessment based on a rough estimate of the density of grains on slides because no 'absolute' concentration figures are available for this site as for the other two sites since the writer did not appreciate, in the early stages of the research, the potential value of such data. Therefore as well as drawing up a diagram for the complete core (fig 6.3), separate diagrams have been prepared for both the upper and lower parts of the core respectively (fig 6.7, 6.11) so that a closer inspection of the patterns of of changes in each may be made. An additional diagram (fig 6.15) for the lower part of the core was prepared , after extra samples had

been analysed at a later date.

6.4 Objective zonation

The data from the site have been objectively zoned using the ZONATION, PCA, and MDS(X) programs previously described. The results are presented in figs 6.4, 6.5, 6.6 and in table 6.1. The following pollen types which each accounted for at least 5% of the total pollen sum at one or more levels: Betula, Quercus, Ulmus, Alnus, Corylus, Salix, Juniperus, Hedera, Empetrum, Gramineae, Cyperaceae, Artemisia, Filipendula, Helianthemum, Rumex, Thalictrum, Nymphaea, Pteridophyta were used. From the plot of the results from the ZONATION programs; CONSLINK, SPLITINF, and SPLITSQ, it is clear that the pollen assemblages of the upper part of the diagram are quite different from those in the lower portion. CONSLINK produces two major groups of samples and is consistent with SPLITINF and SPLITSQ in identifying the boundary between the groups as occurring at about 490 cms. SPLITSQ differs slightly in placing the major split a few cms above, between samples 41 and 42, that of SPLITINF, but this is probably because it is more influenced by the dramatic changes evident in levels 41 and 42 and referred to later. SPLITSQ does, however, identify a lesser split that is consistent with the results from CONSLINK and SPLITINF. The results from MDS(X) and PCA (figs 6.5, 6.6) also pick out this major distinction between the upper and lower part of the diagram. It corresponds, as is confirmed by an examination of the loadings on the first principal component, with the change from levels with pollen assemblages indicative of open





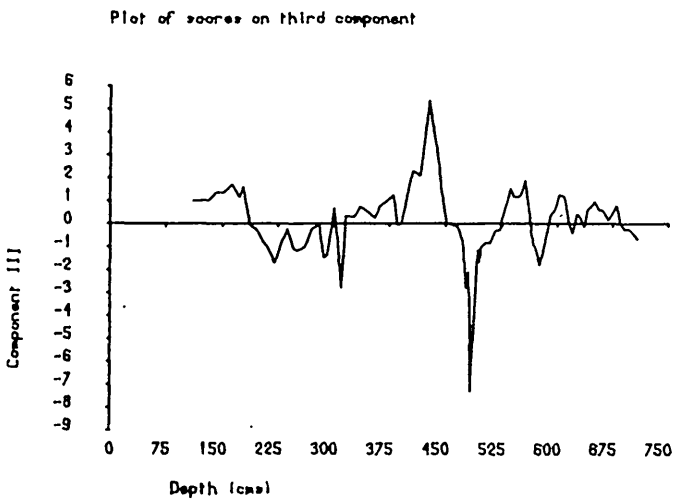
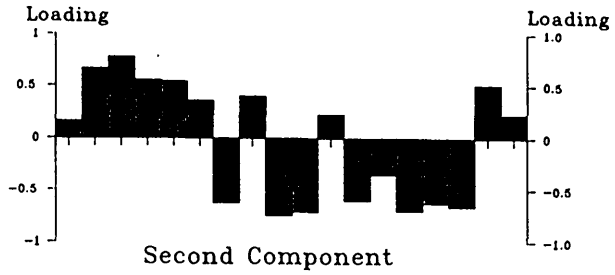


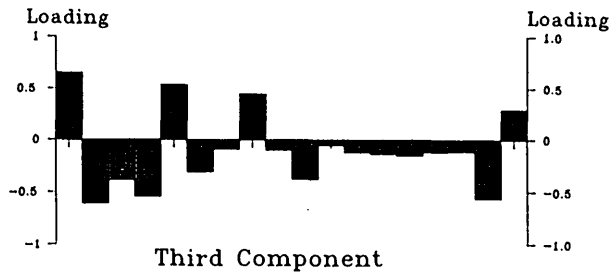
Fig 6.5a Plots of scores on first 3 components for complete core.

Principal Component Loadings – Broxmouth (complete)

First Component



Second Component



Third Component

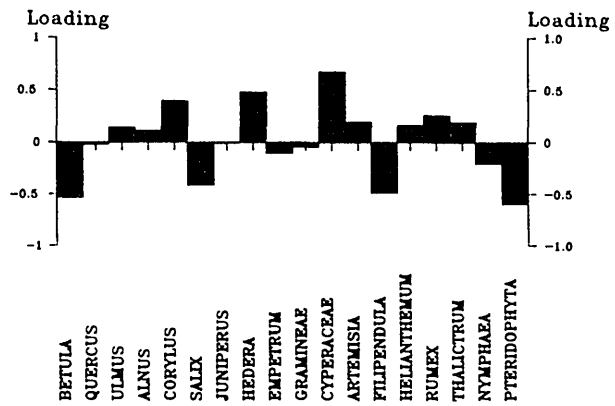


Fig 6.5b Loadings on first 3 components for complete core.

BROXMOUTH - PRINCIPAL COMPONENTS (Complete core)

	Components				
Taxon	I	II	III	IV	V
Betula	0.1644	0.6536	-0.5325	0.0670	0.0910
Quercus	0.6638	-0.6060	-0.0193	-0.0314	0.0523
Ulmus	0.7745	-0.3821	0.1415	-0.1327	-0.0759
Alnus	0.5517	-0.5413	0.1124	-0.1674	-0.1314
Corylus	0.5418	0.5367	0.3943	-0.0592	0.2860
Salix	0.3610	-0.3061	-0.4118	0.4002	0.4674
Juniperus	-0.6250	-0.0880	-0.0054	-0.5011	0.0809
Hedera	0.3988	0.4484	0.4771	-0.1236	0.3843
Empetrum	-0.7464	-0.0970	-0.1035	-0.3461	0.3140
Gramineae	-0.7114	-0.3750	-0.0432	-0.0924	0.0271
Cyperaceae	0.2258	-0.0475	0.6728	0.0305	0.4944
Artemisia	-0.6035	-0.1178	0.1960	0.5352	0.1166
Filipendula	-0.3502	-0.1337	-0.4867	-0.2576	0.5481
Helianthemum	-0.7030	-0.1481	0.1642	-0.2281	0.1055
Rumex	-0.6264	-0.1142	0.2585	0.5471	0.0514
Thalictrum	-0.6602	-0.1089	0.1926	0.2900	-0.0006
Nymphaea	0.5093	-0.5590	-0.2037	0.1249	0.2838
Pteridophyta	0.2243	0.2950	-0.5968	0.1808	0.0937
Eigenvalues	5.6105	2.6724	2.5777	1.4674	1.1916
% of trace	31.1701	14.8469	14.3212	8.1522	6.6204
Cumm % of trace	31.1701	46.0170	60.3382	68.4903	75.1107

Trace = 18.0

Table 6.1 PCA results for complete core.

Broxmouth - complete core MDS(X)

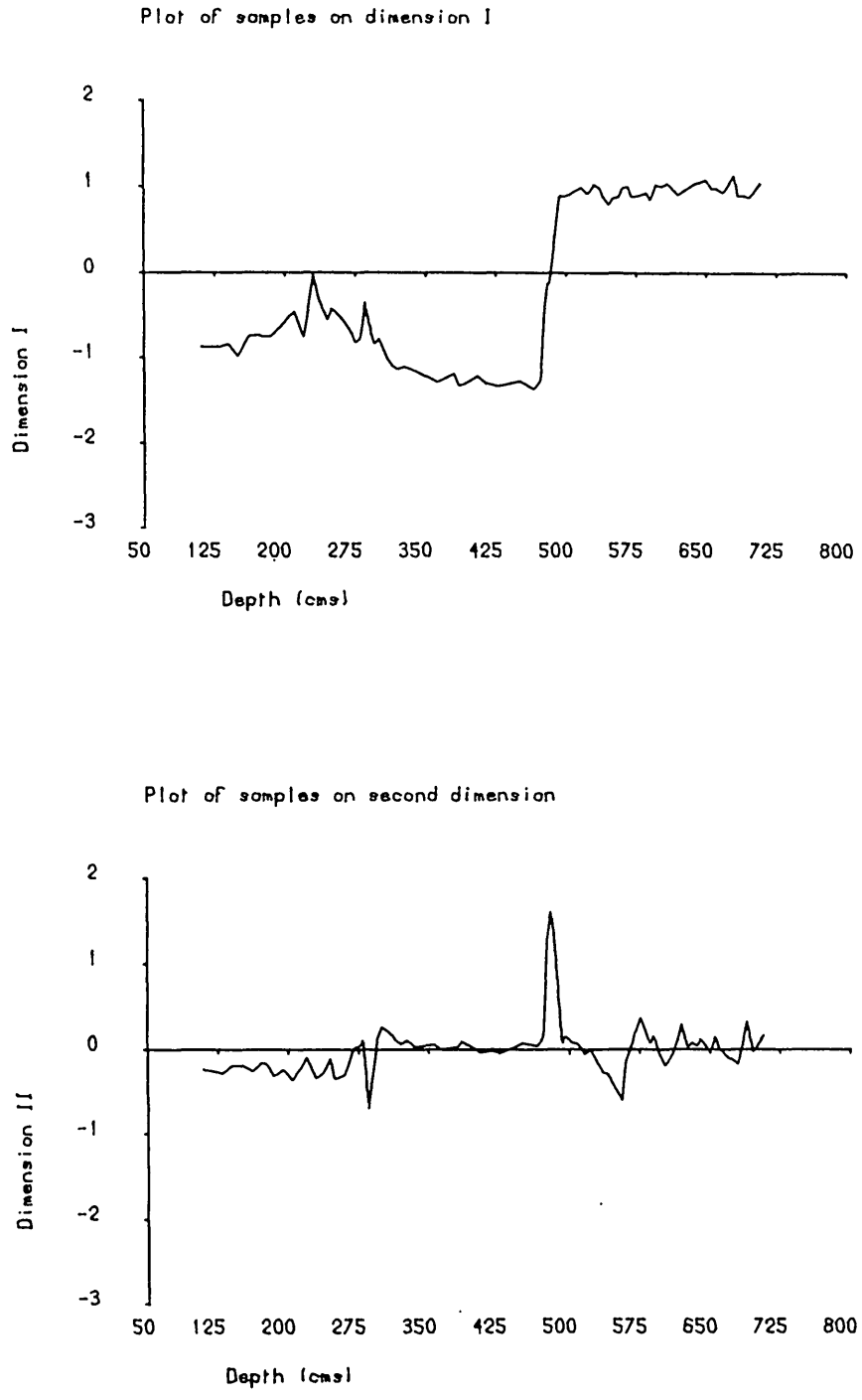
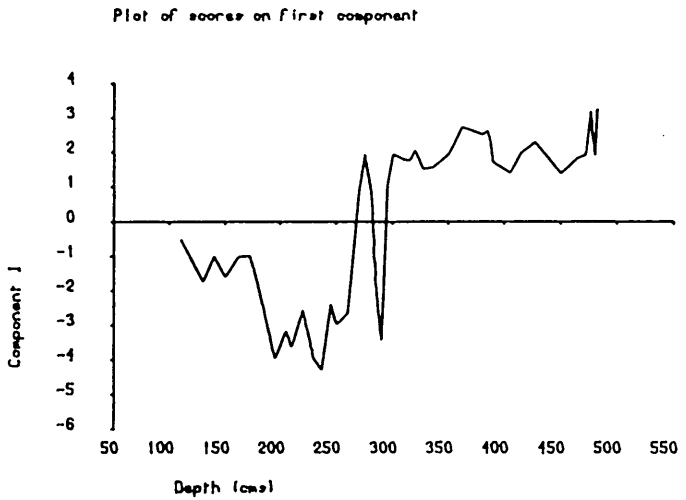


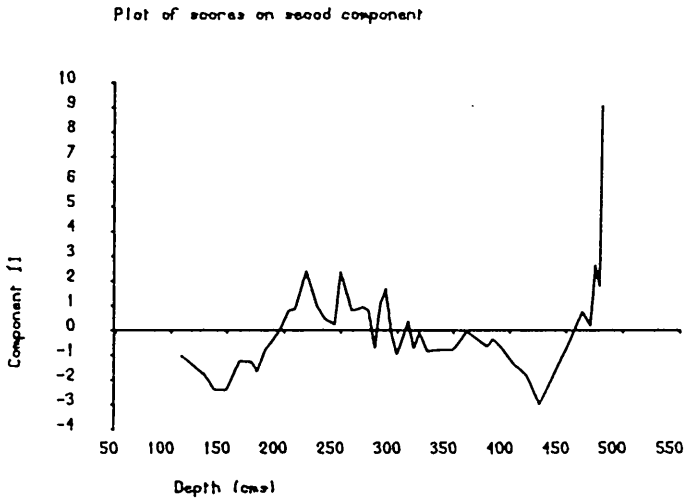
Fig. 6.6 MDS(X) results for complete core.

habitat shrub, heath and herb communities and those dominated by thermophilous broad leaved trees and shrubs. Within the upper part of the diagram four zones are identified. SPLITSQ and CONSLINK place the most significant division as being at 305 cms. SPLITINF is inconsistent in placing the boundary between 290 and 295 cms, just below two levels (21 and 22) that CONSLINK has picked out as being transitional and that it therefore amalgamates at a late stage. However, samples 21 and 22 form part of a larger group of samples identified as being similar by CONSLINK so the zone boundary has been placed beneath them. The next most important divide is placed by CONSLINK, SPLITINF and SPLITSQ at 475 cms between levels 40 and 41. CONSLINK separates out levels 40 and 41 as being transitional and, as above, they are therefore grouped together at a late stage. These levels mark the change from high percentages of Betula to dominance by Corylus. The last sub - division in the upper part of the diagram occurs at around 180 cms and is delimited by CONSLINK and SPLITINF only.

On fig 6.7 the data from the upper part of the site have been drawn up. The data have been zoned using the ZONATION, PCA and MDS(X) programs. The results are presented on figs 6.8, 6.9, 6.10 and in table 6.2. The zones picked out are consistent with those from the complete data set even though different pollen types have been selected, using the criteria previously described, for zoning. The first three principal components account for 60.0491% of the total variance. Betula and Corylus have high positive correlations with the first component while Ulmus, Quercus and Fagus have significant negative correlations. This component, which represents

Broxmouth - Principal Components (Upper core)





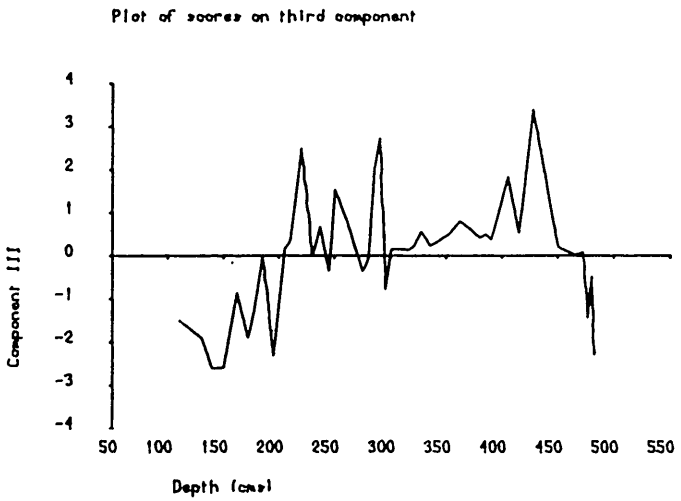


Fig 6.9a Plots of scores on first 3 components for upper core.

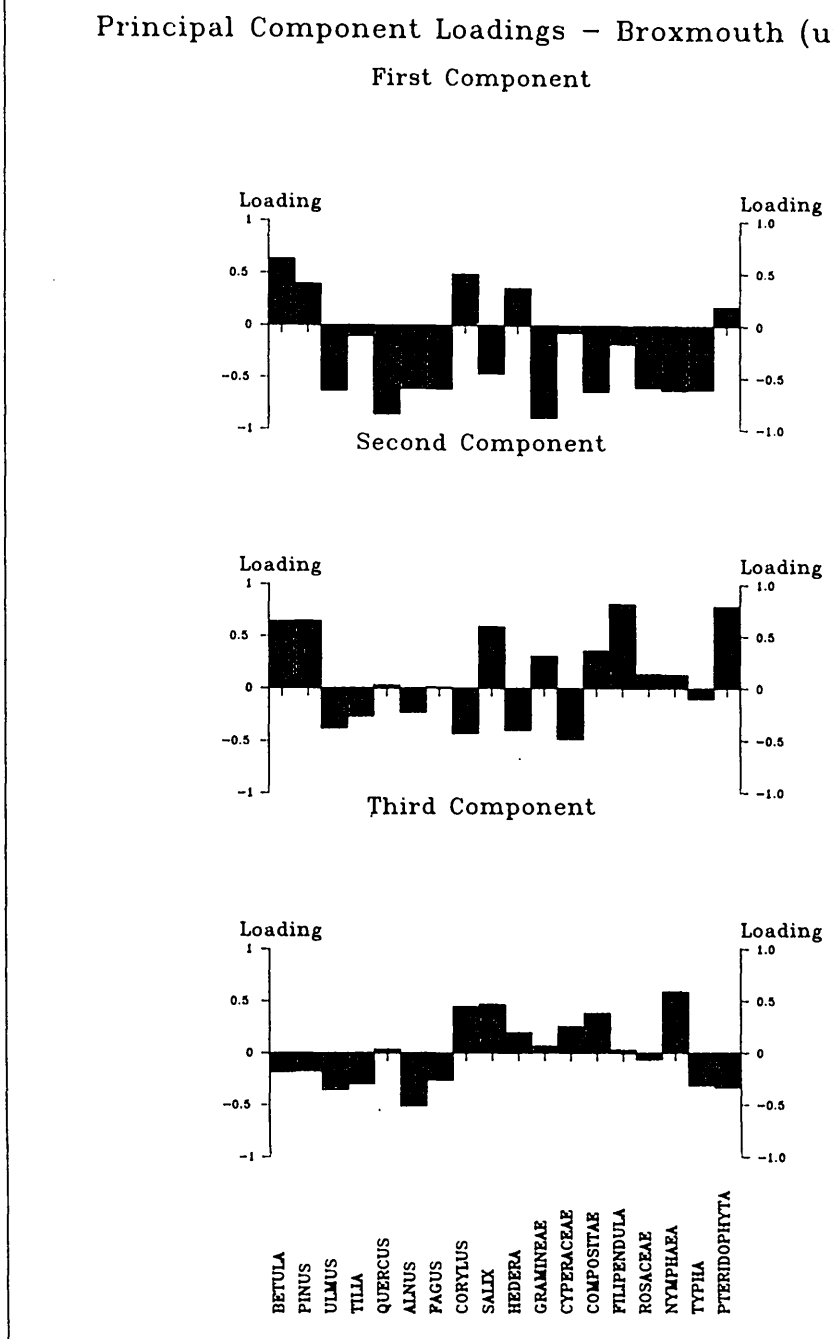


Fig 6.9b Loadings on first 3 components for upper core.

BROXMOUTH - PRINCIPAL COMPONENTS (upper core)

	Components				
Taxon	I	II	III	IV	V
Betula	0.6303	0.6416	-0.1832	0.1040	0.1349
Pinus	0.3939	0.6470	-0.1739	0.2471	0.2988
Ulmus	-0.6326	-0.3810	-0.3539	0.1921	-0.2300
Tilia	-0.1044	-0.2689	-0.3008	0.4164	-0.1733
Quercus	-0.8557	0.0276	0.0354	0.0697	0.0724
Alnus	-0.6099	-0.2300	-0.5114	0.3160	-0.1877
Fagus	-0.6146	0.0113	-0.2601	-0.0721	0.5075
Corylus	0.4876	-0.4291	0.4454	0.2775	0.2595
Salix	-0.4671	0.5930	0.4671	0.0718	-0.0430
Hedera	0.3572	-0.3976	0.1960	0.3905	0.2124
Gramineae	-0.8892	0.3101	0.0662	0.0791	0.0017
Cyperaceae	-0.0667	-0.4828	0.2549	0.6773	0.0740
Compositae	-0.6339	0.3636	0.3811	0.0334	-0.2242
Filipendula	-0.1743	0.8130	0.0285	0.2760	-0.1334
Rosaceae	0.5934	0.1399	-0.0622	0.1466	0.0020
Nymphaea	-0.6200	0.1315	0.5682	0.1039	0.1901
Typha	-0.6123	-0.0966	-0.3126	-0.1068	0.6128
Pteridophyta	0.1836	0.7912	-0.3347	0.3582	0.0194
Eigenvalue	5.4015	3.5902	1.8168	1.3409	6.0884
% of trace	30.0090	19.9463	10.0938	7.4499	6.0467
Cumm % of trace	30.0090	49.9553	60.0491	67.4990	73.5457

Trace = 18.0

Table 6.2 PCA results for upper core.

Broxmouth - upper core MDS(X)

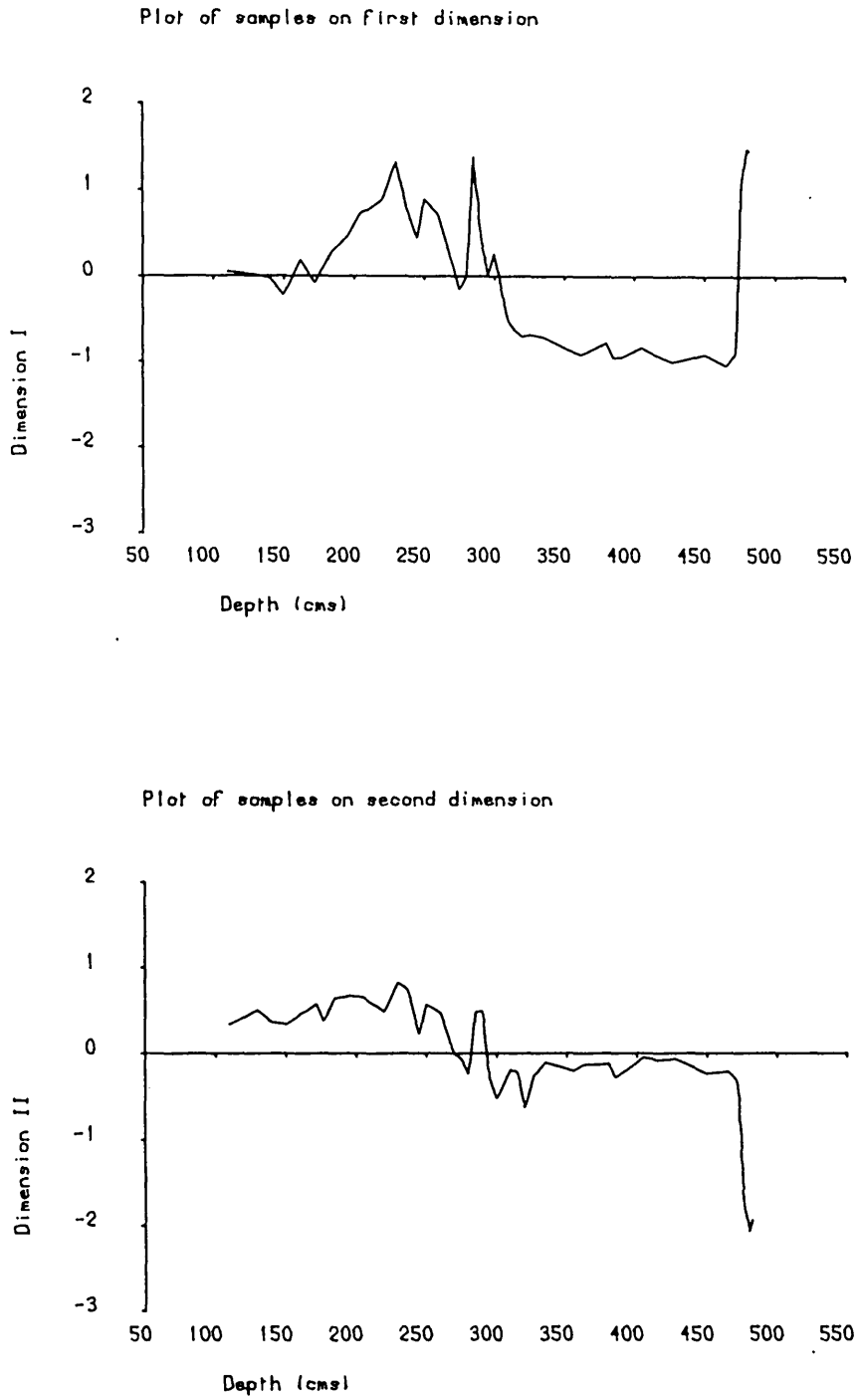


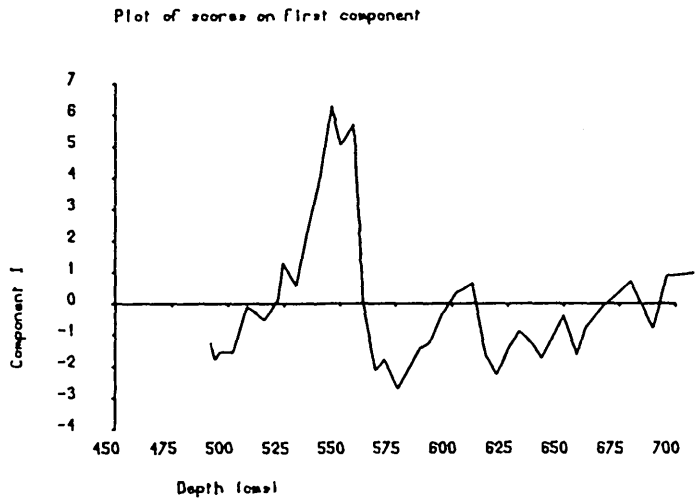
Fig 6.10 MDS(X) results for upper core.

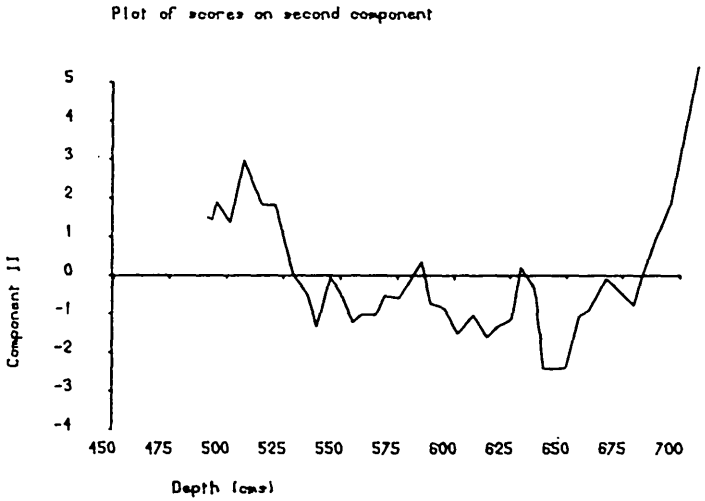
30.009% of the total variance, therefore reflects the distinction between dominance of Betula and Corylus in the levels below 300 cms and of the thermophilous broad - leaved tree species, Ulmus, Quercus and Fagus. The second principal component accounts for 19.9463% of the variance and has high positive correlations with Betula, Pinus, Hedera, Filipendula and Pteridophyta and high negative correlations with Corylus and Cyperaceae. This component may be interpreted as being the result of the swing from the initial preponderance of Betula and Pinus to Corylus. Above 300cms the growth of Cyperaceae fen communities in which Filipendula played an important role is reflected in the plot of the scores on the second component. The third component, accounting for only 10.0938% of the total variance has high positive correlations with Corylus, Salix and Nymphaea and high negative correlations with Alnus. It indicates the varying proportions of Corylus and Alnus in samples. The plots of samples from the upper part of the core on both dimensions of the 2 - dimensional MDS(X) solution highlight the divisions previously picked out by the ZONATION and PCA programs.

In the lower part of the diagram SPLITSQ produces no further splits. To obtain an objective zonation of the lower part of the diagram the data is therefore zoned separately (fig 6.12). The pollen types used in the ZONATION were Betula, Salix, Juniperus, Empetrum, Gramineae, Cyperaceae, Artemisia, Caryophyllaceae, Compositae, Cruciferae, Filipendula, Galium, Helianthemum, Ranunculaceae, Rosaceae, Rumex, Thalictrum and Pteridophyta all of which contributed 5%, or more, to the pollen sum at at least one level. Seven major zones were identified. The most significant

split is placed by SPLITSQ between samples 9 and 10 at 533 cms which are regarded by CONSLINK as transitional levels between two distinct groups of samples. SPLITINF, however, places its most important divide further down between levels 15 and 16. CONSLINK groups together samples 15 - 38 which, apart from the few basal levels, appear to be largely similar before amalgamating them to samples 1 -14. SPLITSQ then splits out a group of samples between levels 21 and 22 and levels 23 and 24 which are also recognised as forming a distinct group by CONSLINK. A further group is split out in this manner by SPLITINF between levels 32 and 33 and levels 35 and 36. These groups identified by SPLITINF largely correspond to the pattern of amalgamations performed by CONSLINK. The results from SPLITSQ, however, are not as consistent. The probable reason for this, as shown by CONSLINK, is that the pollen assemblages of samples in the lower part of the diagram are not, statistically speaking, that dissimilar from each other. Turning to the results from MDS(X) and PCA (figs 6.12 6.13 6.14 and table 6.3) the plots of the samples on the first and second dimensions for MDS(X) appear to confirm the zonation scheme outlined above. An examination of the plot of the scores on the first principal component, which accounts for 24.9218% of the initial variance, and of the corresponding loadings, high positive correlations for Salix, Artemisia, Caryophyllaceae, Compositae and Rumex and high negative correlations for Betula, Juniperus, Empetrum, and Gramineae, shows that the zones are largely based on the distinction between groups of samples that are dominated by species of open - habitats and colonisers of disturbed ground from those which clearly suggest that shrub heath had developed.

Broxmouth - Principal Components (Lower core MKI)





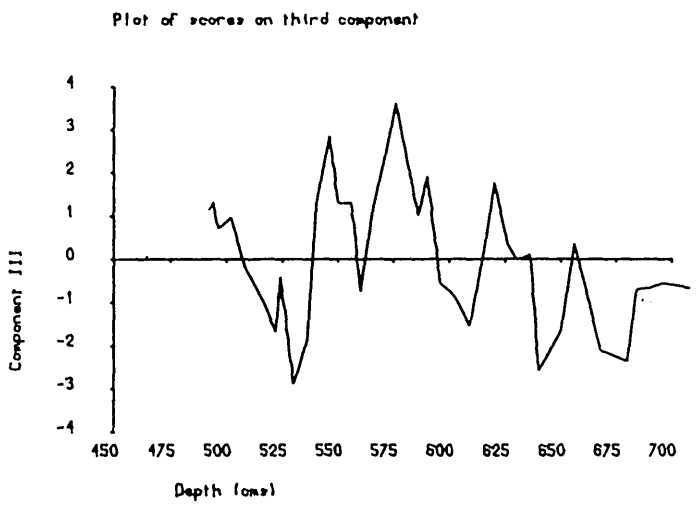
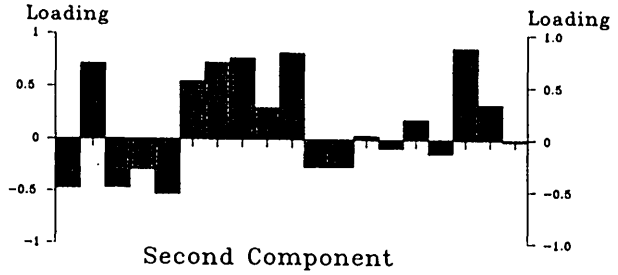


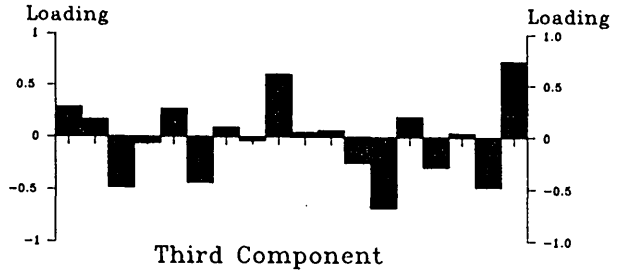
Fig 6.13a Plots of scores on first 3 components for lower core.

Principal Component Loadings – Broxmouth (lower core I)

First Component



Second Component



Third Component

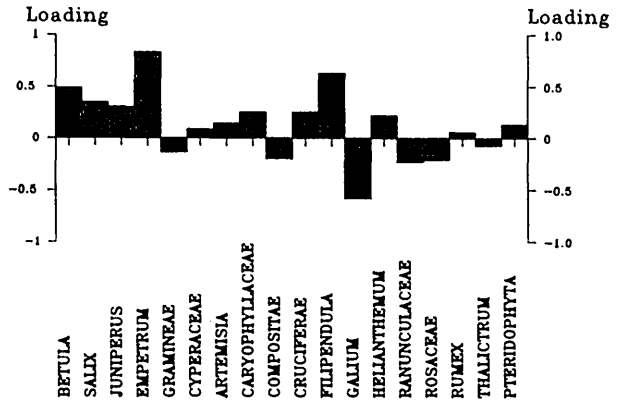


Fig 6.13b Loadings on first 3 components for lower core.

BROXMOUTH - PRINCIPAL COMPONENTS (Lower core)

Taxon	Component I	II	III	IV	V
Betula	-0.4716	0.2842	0.4899	-0.0651	0.0693
Salix	0.7097	0.1650	0.3476	-0.1648	0.0809
Juniperus	-0.4685	-0.4837	0.3047	-0.0870	0.0530
Empetrum	-0.2917	-0.0593	0.8330	0.2460	0.0870
Gramineae	-0.5285	0.2674	-0.1383	0.1791	0.5790
Cyperaceae	0.5452	-0.4383	0.0867	0.4725	0.1380
Artemisia	0.7213	0.0914	0.1458	0.0712	0.1553
Caryophyllaceae	0.7673	-0.0366	0.2525	-0.1458	0.0071
Compositae	0.2985	0.6074	-0.1991	-0.2368	0.2316
Cruciferae	0.8187	0.0452	0.2542	0.0346	0.0316
Filipendula	-0.2648	0.0632	0.6306	0.3800	0.2402
Galium	0.0353	-0.2476	-0.5808	0.4919	0.1228
Helianthemum	-0.0791	-0.6804	0.2221	-0.0755	0.1633
Ranunculaceae	0.1933	0.1937	-0.2315	0.7576	0.2549
Rosaceae	-0.1316	-0.2879	-0.2129	-0.4125	0.6218
Rumex	0.8734	-0.0382	0.0583	0.0600	-0.0064
Thalictrum	0.3386	-0.4760	-0.0736	-0.3558	0.4699
Pteridophyta	-0.0162	0.7389	0.1337	-0.1060	0.3069
Eigenvalue	4.4858	2.4125	2.2734	1.7159	1.3209
% of trace	24.9218	13.4031	12.6303	9.5332	7.3386
Cumm % of trace	24.9218	38.3249	50.9552	60.4884	67.8270

Trace = 18.00

Table 6.3 PCA results for lower core.

Broxmouth - lower core (MKI) MDS(X)

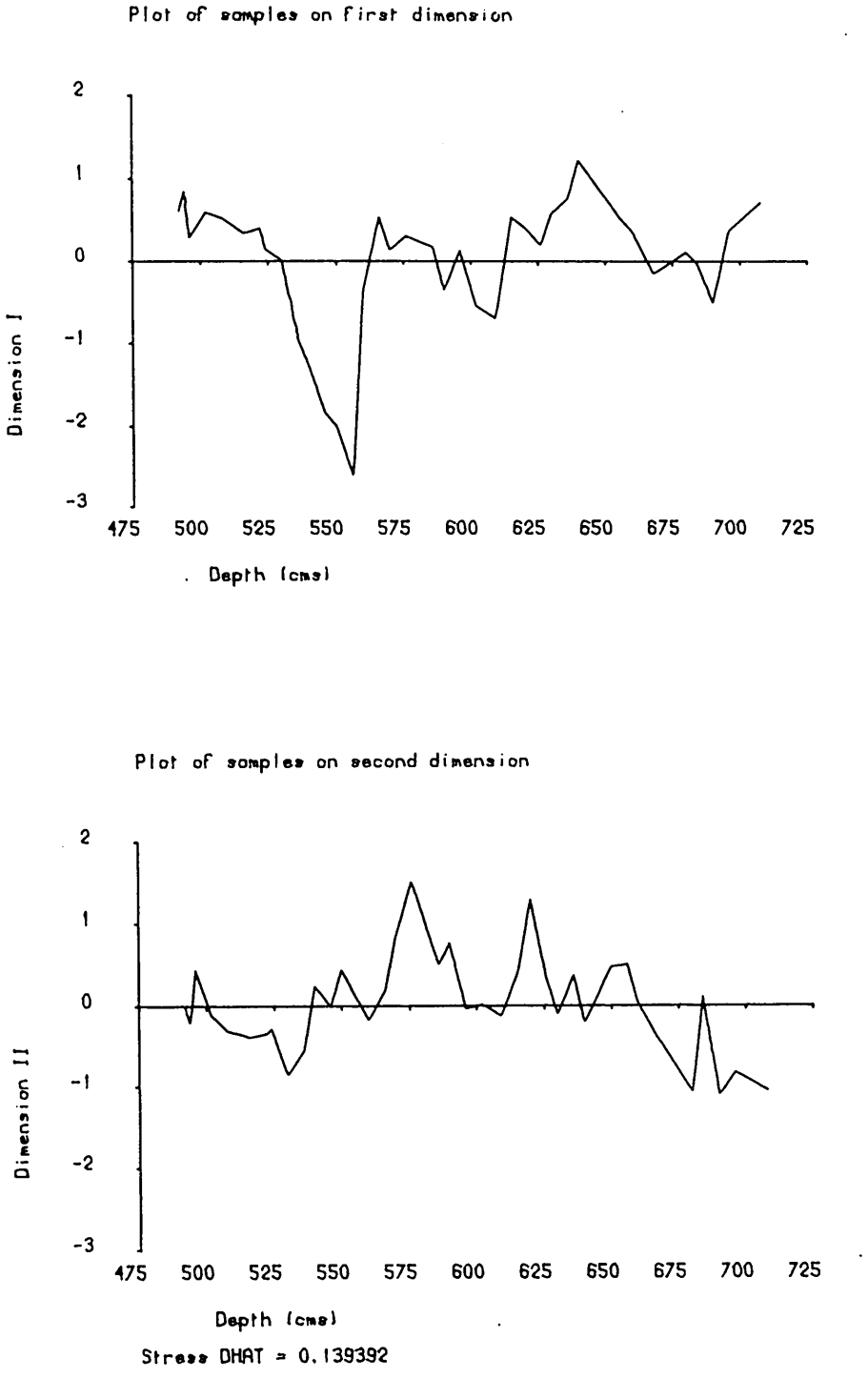


Fig 6.14 MDS(X) results for lower core.

6.5 Description of local pollen assemblage zones

It was decided to retain the eleven zones thus far distinguished by the zonation techniques as being the minimum number necessary to describe the significant changes on the diagrams. The zones have been labelled Br I to Br XI from the base to the top. The pollen assemblages of each zone are described below:

Zone BrI Betula, Salix, Gramineae, Rumex 687 - 708 cms.

Gramineae and Cyperaceae account for much of the pollen identified in this zone. Gramineae declines from about 65% at the base to about 46% whilst Cyperaceae increases from 3% to 6%. The only other significant herb is Rumex which is present at about 10% of the total pollen sum in each level of the zone. The percentages of Betula, some of which was noted as being B. nana, rises from almost 10% to over 25%. Pinus is recorded at low values of between 0.5% and 2% as is Salix which is present at between 1 and 6%. Two other shrubs, Juniperus and Empetrum first appear near the top of the zone. Pteridophyta make up almost 10% of the pollen sum at the base of the zone then decline rapidly.

Zone BrII Gramineae, Cyperaceae, Galium, Rumex 664 - 687 cms

Gramineae and Cyperaceae still form a large proportion of the total pollen sum; Cyperaceae increasing its average representation over the previous zone to between 10 and 15%. Apart from Rumex, which has decreased to around 5% the only other important herb is Galium which is consistently present at between 2 and 4%. Plantago spp (c.f. major) appears at one level only at over 8%. Betula decreases from near to 8% to zero. At the same level Pinus registered over 10%. Salix, Juniperus and Empetrum are all present at less than 5% of the total pollen sum.

Zone BrIII Betula, Juniperus, Empetrum and Gramineae 612 - 664 cms

The average percentage of Betula present in this zone is around 7 - 8%. Salix and Pinus maintain a presence. Increases in the percentages of Juniperus and Empetrum are recorded. Juniperus attains a maximum of over 20% at 620 cms while Empetrum peaks at around 7% at the same level. Gramineae and Cyperaceae continue to dominate the herbaceous pollen identified. Galium, Helianthemum, Rumex, Thalictrum and Umbelliferae are the only other herbs consistently present. Towards the top of the zone Filipendula first appears.

Zone BrIV Gramineae, Cyperaceae, Rumex 593 - 612 cms

Betula, Juniperus and Empetrum all decline in this zone. Gramineae

and Cyperaceae remain the most dominant herbaceous species with Cyperaceae percentages increasing to over 20%. Of the other herbs, Rumex is the most important, being recorded at increased levels of between 5 and 7%. Artemisia, Filipendula, Galium, Helianthemum and Thalictrum are also present.

Zone BrV Betula, Juniperus, Empetrum, Filipendula 558 - 593 cms

The percentages of Betula, Juniperus almost recover to the levels noted in zone BrIII. Empetrum is, however, present at higher percentages of between 7 and 15%. The amounts of Cyperaceae and Rumex pollen recorded decline quite markedly although Gramineae and Cyperaceae still form a large proportion of the pollen sum. Filipendula peaks at around 5% towards the middle of the zone and then decreases. Galium and Helianthemum are also present along with low percentages of Myriophyllum alterniflorum and other aquatic species.

Zone BrVI Salix, Cyperaceae, Rumex 533 - 558 cms

Betula, Juniperus, Empetrum, Gramineae, Filipendula are all recorded as being present at lower percentages than in the previous zone. Pinus and Salix both have increased representation in this zone as have Cyperaceae and especially Rumex which accounts for up to 25% of

the pollen sum. Artemisia, Caryophyllaceae, Cruciferae, Filipendula, Galium, Helianthemum and Thalictrum are all present.

Zone BrVII Betula, Empetrum 533 - 487 cms

The percentages of Betula and Gramineae have both recovered to the levels recorded in BrV whilst the frequencies of both Salix and Rumex have decreased. Gramineae and Cyperaceae still represent a large proportion of the pollen sum. The Pinus curve has remained static at around 5% of the pollen sum as have the levels of Empetrum. Pollen of aquatic and aquatic species, such as Potomageton and Typha, as well as Pteridophyta spores have a significant presence.

Zone BrVIII Betula, Corylus, Salix, Pteridophyta 487 - 474 cms

Betula percentages increase rapidly to over 60% of the total pollen sum along with significant percentages of Pinus, Salix and Corylus. Gramineae and Cyperaceae on the other hand decrease to low levels. Filipendula is the only other significant herb. Pteridophtya account for between 5 and 15% of the total.

Zone BrIX Corylus, Betula, Cyperaceae 474 - 305 cms

Betula percentages decrease sharply to less than 10% of the total while Corylus expands dramatically and makes up a very large proportion, between 80 and 95% of the pollen sum at most levels in the zone. Cyperaceae is the only herbaceous species present in significant amounts. Pteridophyta spores appear, at almost 20%, at the top of the zone.

Zone BrX Quercus, Corylus, Salix, Gramineae, Nymphaea 305 - 181 cms

Betula percentages increase at the base of the zone to just over 20% and then decrease to an average level of less than 5%. Pinus is also present at slightly higher percentages than previously. Quercus, Ulmus, Tilia, Alnus and Fagus are all recorded in this zone with Quercus averaging 10% and Ulmus and Alnus at less than 5%. The Corylus curve is quite erratic with percentages that range between 25% and 55%. Other important taxa present include: Hedera, Filipendula and the aquatics Nymphaea and Typha. Pteridophyta spores are also significant. Some evidence of secondary pollen deposition was noted along with derived Carboniferous spores.

Zone BrXI Quercus, Corylus, Cyperaceae 110 - 181 cms

The levels of Pinus, Quercus, Ulmus, Tilia, Alnus and Fagus recorded remain largely the same as were recorded in the previous zone. The

percentages of Corylus are more stable than before averaging about 55%. Salix is much reduced while Gramineae and Betula are present at lower than average frequencies. However, a slightly higher incidence of Cyperaceae is noted. Aquatics and Pteridophyta remain significant.

6.6 Vegetation reconstruction

In the following paragraphs an attempt to establish a reconstruction of the vegetation and a basic chronology for the site is set out.

Examining the upper part of the diagram first, zones BrVII to BrXI covering 487 - 110 cms depth appear to represent a vegetational sequence of change fairly characteristic of the Postglacial, although atypical in some respects. In zone BrVIII Betula forms a high proportion of the pollen identified and is present at much increased frequencies compared to those of the previous zone BrVII. This is probably a result of the rapid colonisation of much of the area around the site by Betula which had previously been growing only locally where it was sheltered from cold east winds. The zone therefore represents a phase of dominance by Betula pre - dating the massive and rapid expansion of Corylus in the ensuing zone, BrIX. Corylus accounts for such a large part, up to 90%, of the total pollen sum at most levels in that zone that it could only have been one of the most prominent constituents of the vegetation. Corylus pollen is usually strongly over - represented in pollen spectra since

the bushes flower at an early age and pollen is produced in great abundance. However, Corylus flowers sparsely if shaded by a dense tree canopy so that it is likely, therefore, that it out - competed Betula for space on the base - rich well - drained gravels and was growing as pure hazel copses or at the least as marginal to stands of Betula. Birks (1977) puts a date of 9700 BP on the expansion of Betula / Corylus based on the published work from sites in south and west Scotland (H. H. Birks, 1972,1975a; Durno, 1965; Fraser and Godwin, 1955; Moar, 1969; Nichols, 1967).

In zone BrX the pollen of the main thermophilous broad leaved deciduous species first appear at significant frequencies. Quercus is consistently present at between 10 and 20% along with Ulmus and sporadic low frequencies of Tilia and Fagus. Alnus, which requires high soil moisture, also appears and there are increased frequencies of Salix, Gramineae and Cyperaceae. Taking this in conjunction with the lower percentages on the more erratic Corylus curve it is suggested that this zone represents a period when the water table rose as a result of a marine transgression or it may be a local effect of constriction of the outflow from the basin. Credence is lent to this suggestion by evidence, in the form of differential stain acceptance, of secondary pollen deposition and the previously noted presence of derived Carboniferous spores. The picture that emerges of the vegetation at this time is of an Alnus fen type community with Salix surrounding the basin with on the drier ground Corylus and Betula. The rising water table may have reduced the performance of trees on soils that had become waterlogged. Quercus, Ulmus and Tilia were presumably the major contributors to the

regional pollen rain. This zone therefore presents a striking picture of Scotland's primeval forest development. The larger deciduous trees, such as Quercus and Ulmus, are advancing as a result of two influences, soils that are richer in nutrients than those of the earlier landscape (having supported Betula / Corylus scrub) and also a climate that provides both higher temperatures in the summer and a longer growing season.

It is known that the main increase in Alnus occurred in Galloway and the southern Scottish lowlands at about 7,000 BP (Birks, 1975) and this correlates quite closely with the date for the maximum of the Main Postglacial Transgression of around 6,800 BP (Sissons pers. comm.). Since there appears to be little evidence for marine incursion into the basin the growth of the spits, referred to earlier, must have kept pace with the rising sea level.

In the topmost zone BrXI the percentages of Corylus recorded recover slightly while Gramineae and Salix decline in importance. There is no evidence for a decline in Ulmus pollen so deposition in the basin probably ceased sometime before 5,000 BP.

Turning to the lower part of the diagram it is rather more difficult to construct a chronology. If it is accepted that the minor stratigraphic change at approximately 540 - 560 cms, which correlates to BrVI, represents the Younger Dryas Stadial then zones BrI to BrV must cover the Lateglacial Interstadial whilst BrVII would clearly be equivalent to the early Postglacial. If, on the other hand, the lower part of the core is not Lateglacial then

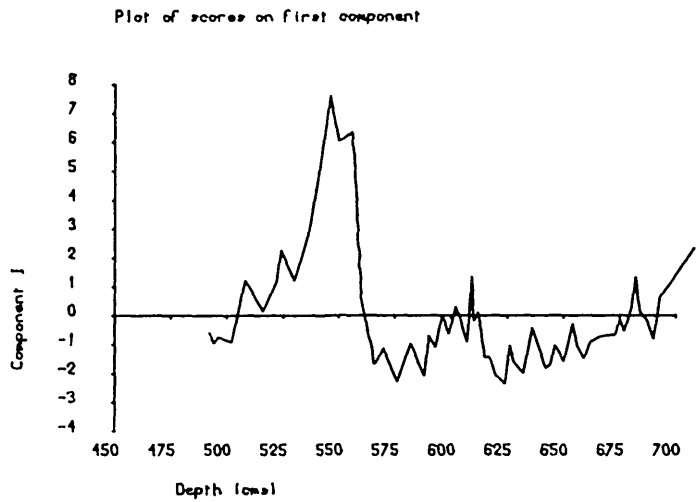
approximately two metres of deposits were laid down in about one thousand years, an average deposition rate which amounts to 2cm / 10 years. Although rapid this is not impossible. Walker (1970), for example, quotes rates of accumulation of calcareous mud of 210 cm / 1000 years for Urswick Tarn, (Oldfield and Stratham, 1963) and 206 cm / 1000 years for Hawes Water, (Oldfield, 1960), for the period 7000 - 5400 BC (9000 - 7400 BP). The rapid sediment accumulation rates would account for the low pollen concentrations observed, but the stratigraphic change at 540 - 560 cms would be more difficult to explain.

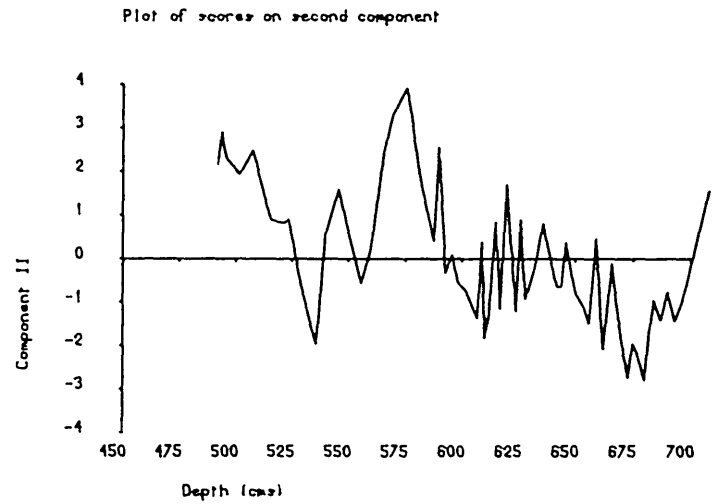
There are, though, a number of questions associated with the former interpretation. First, why is the stratigraphic evidence for Younger Dryas so poor? Second, where is the early Postglacial Juniperus maximum peak, so often observed at other sites? Is it represented by the subdued peak at ca. 500 cms? If so, why is it so suppressed? Third, where is the early Postglacial increase in aquatics that is usually found in pollen diagrams? Fourth, does the higher clay content at ca. 590 - 610 cms represent a climatic deterioration or is it only a local fluctuation? Fifth, why are the curves so erratic throughout the 'Lateglacial'?

Taking the first point, at some sites in East Anglia the Younger Dryas oscillation was not registered by a change in lithology perhaps as a result of gentle topography and highly porous soils or lower precipitation (Godwin, 1968). It is therefore likely that the lack of clear stratigraphic evidence for the Younger Dryas is because of the low-lying coastal nature of the site, the very low gradients,

freely drained sands and gravels around the site and the low rainfall and milder climate referred to earlier. Inwash following solifluction of surface material could only have been negligible for the above reasons. This situation should be contrasted with that of the Corstorphine site, to be discussed in a later chapter, where a large hill with steep slopes flanks the site and produced a deep minerogenic layer. Certainly the average temperatures of the lake water must have dropped below the threshold necessary for the formation of marls. It is therefore likely that the lake changed from being eutrophic to more mesotrophic / oligotrophic at this time. The presence of pyritospheres may also be indicative of a change in the sedimentary environment at this time since they are a by - product of the anaerobic decomposition of sulphur compounds. Leaching and podsolization of the soils of the catchment may have released significant amounts of iron (Fe) and manganese (Mn) as humus developed. The lack of a clear Juniperus peak could be the result of shading out by Betula, for example, that migrates and expands quite rapidly. However, Juniperus is a common shrub in both Pinus and Betula forests in Scotland at the present day so that as a woodland plant it is certainly not shade - intolerant as Godwin (1975) suggests. Of course, the Juniperus pollen may be that of J. communis nana, the dwarf juniper, which may not be shade tolerant. A more likely explanation is that the low amount of soil disturbance in the catchment and the grass - sedge communities deprived Juniperus the open disturbed soils required for seedling establishment. The reason for the lack of the usual early Postglacial peak in aquatics is not obvious. It may be a result of shading of the shallow water at the margins of the loch or brackish spray / water entering the loch. The

'higher clay content' at ca. 590 - 610 cms correlates with biostratigraphic evidence for a very minor phase of retrogressive vegetation development which may be equivalent to the Older Dryas event noted elsewhere. The erratic nature of the curves in the lower part of the core could be a function of the sedimentary environment in what is a relatively small basin or it could be related to the sampling interval used. It was therefore decided to take more samples from the core to try to fill in the gaps and to verify the trends. Twenty additional samples were therefore prepared and analysed and a new diagram (fig 6.15) for the lower part of the core incorporating the data from these samples was drawn. This data was also zoned using the ZONATION, PCA and MDS(X) programs (figs 6.16, 6.17, 6.18 and table 6.4). Examining the new diagram it may be seen that the new pollen assemblages fit in with the trends established by the original samples especially in confirming the existence of the phase of retrogressive vegetation development already observed in the levels around 600 cms. Turning to the ZONATION plots (fig 6.16) the results displayed are consistent in picking out the same zones as before. It is interesting that the degree of correspondence between the results from the individual zonation programs is higher than before suggesting that the insertion of additional levels has increased the inter - zonal differences, thus making the operation of the programs more precise. This is an important observation since it brings to light a potential source of bias. This comes about since pollen analysts invariably select a sampling scheme from sediment cores that takes account of changes in stratigraphy and insert levels where intuitively it is felt that significant changes in the biostratigraphy will occur or else to confirm those changes. It now





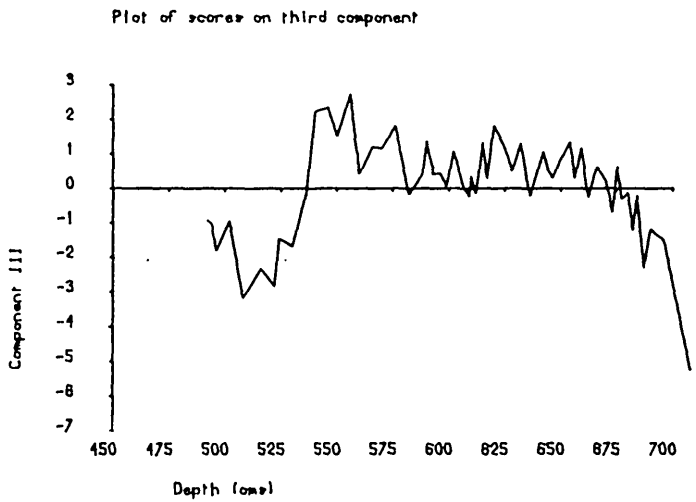
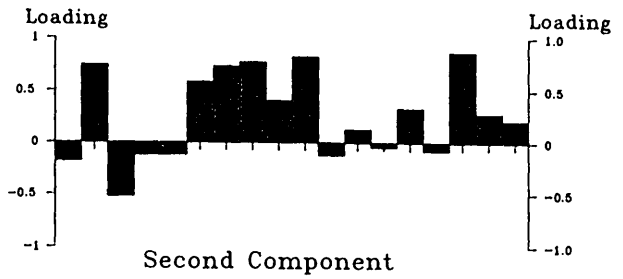


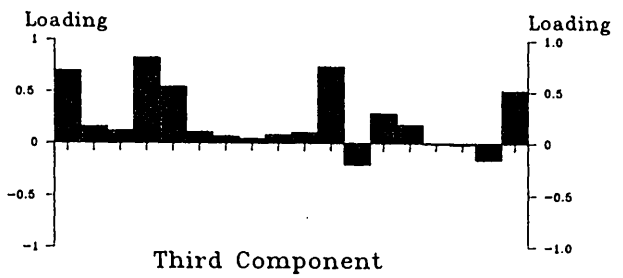
Fig 6.17a Plots of scores on first 3 components for lower core (MK II)

Principal Component Loadings – Broxmouth (lower core II)

First Component



Second Component



Third Component

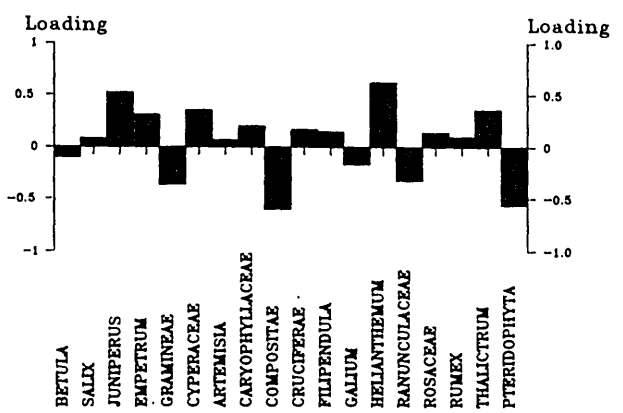


Fig 6.17b Loadings on first 3 components for lower core (MK II)

BROXMOUTH - PRINCIPAL COMPONENT (Lower core MKII)

	Components				
	I	II	III	IV	V
Taxon					
Betula	-0.1820	0.7000	-0.1018	-0.0673	0.1806
Salix	0.7416	0.1596	0.0813	-0.3072	0.1312
Juniperus	-0.5222	0.1210	0.5200	-0.1225	0.0066
Empetrum	-0.1215	0.8284	0.3114	-0.1284	-0.1631
Gramineae	-0.1201	0.5466	-0.3663	0.5050	0.1841
Cyperaceae	0.5805	0.1080	0.3541	0.4599	-0.2721
Artemisia	0.7276	0.0669	0.0695	-0.0662	-0.0089
Caryophyllaceae	0.7697	0.0426	0.2034	-0.2021	0.1151
Compositae	0.4043	0.0810	-0.6017	-0.0827	0.3055
Cruciferae	0.8188	0.1041	0.1701	-0.1592	-0.0338
Filipendula	-0.1249	0.7427	0.1493	0.0075	-0.2151
Galium	0.1261	-0.2060	-0.1689	0.6659	-0.2345
Helianthemum	-0.0457	0.2916	0.6163	0.3008	0.1498
Ranunculaceae	0.3293	0.1788	-0.3282	0.4831	-0.4906
Rosaceae	-0.0805	-0.0083	0.1393	0.4264	0.6834
Rumex	0.8623	-0.0161	0.0987	0.0218	-0.0536
Thalictrum	0.2769	-0.1595	0.3551	0.3786	0.5063
Pteridophyta	0.2089	0.5126	-0.5661	-0.0981	0.2560
Eigenvalue	4.1901	2.5501	2.0952	1.7769	1.4483
% of trace	23.2791	14.1677	11.6403	9.8721	8.0465
Cumm % of trace	23.2791	37.4468	49.0871	58.9593	67.0058

Trace = 18.0

Table 6.4 PCA results for lower core (MK II).

Broxmouth - lower core (MKII) MDS(X)

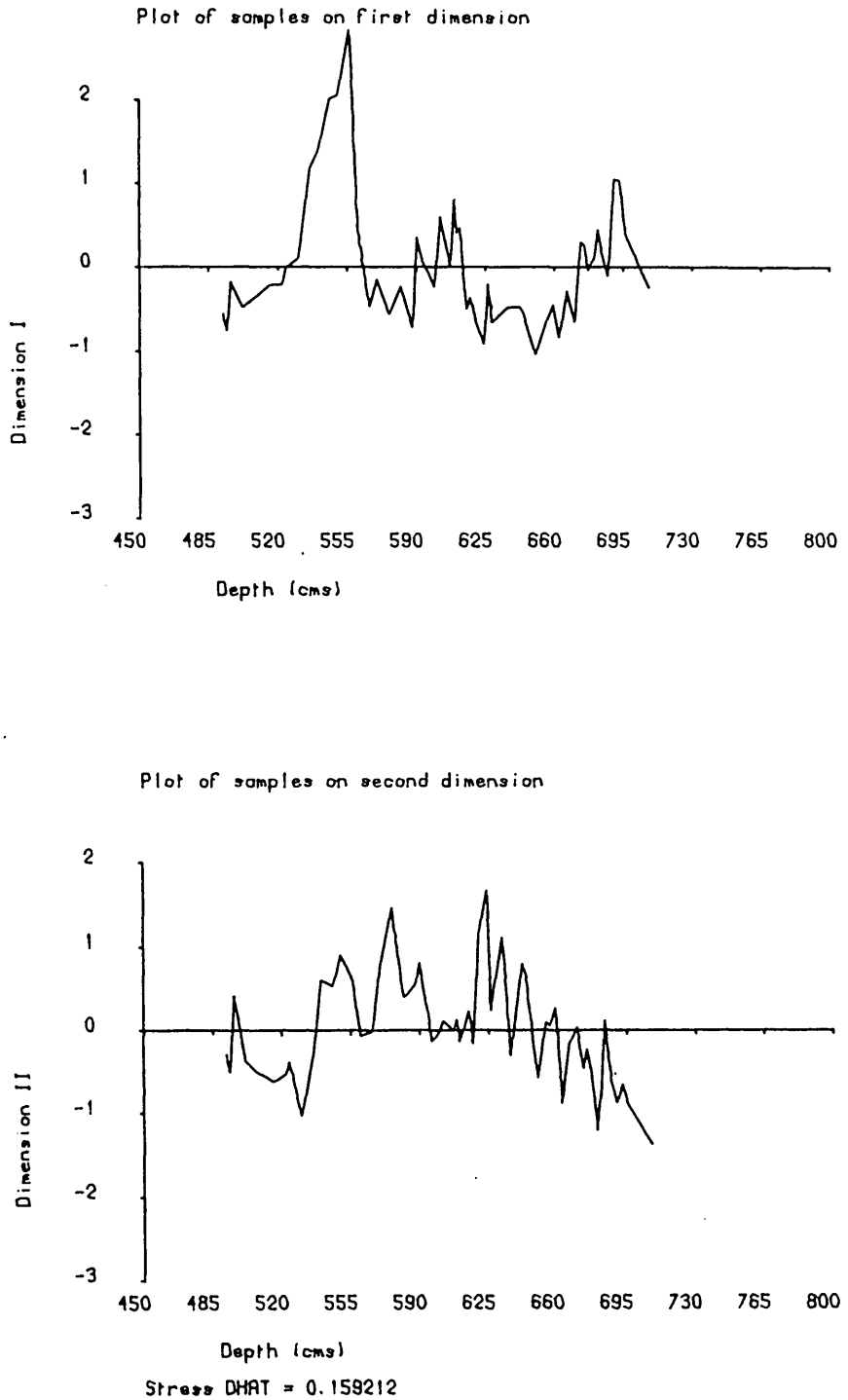


Fig 6.18 MDS(X) results for lower core (MK II)

appears that the operation of the zonation programs may be affected by the numbers of samples and where they are placed in relation to each other.

A reconstruction of the vegetation for each zone in the lower part of the diagram is presented below.

Zone BrI Gramineae and Cyperaceae were clearly the most important species in a herb dominated vegetation. The presence of Rumex and Salix as well as a significant proportion of Pteridophyta spores at the base of the zone suggest that the vegetation was open with some disturbed ground. Much of the Betula recorded was noted as being likely to be B. nana and this with the low frequencies of Pinus observed, which were probably a result of long distance transport of grains, indicate that trees were rare. The shrubs Juniperus and Empetrum first appear at the top of the zone suggesting that climatic conditions were beginning to improve as well as the development of soils. The pollen spectra therefore reflect both a tundra vegetation and an Arctic climate.

Zone BrII Gramineae and Cyperaceae were still the dominant herbs along with open habitat species such as Rumex and Galium. Juniperus and Empetrum formed an insignificant part of the vegetation on the basis of their pollen frequencies but the flowering of Juniperus may have been suppressed by the climatic conditions (Iversen, 1954; Birks, 1973b). The decrease in Betula and the corresponding increase

in Pinus may be a consequence of a feature of percentage diagrams that a change in one component will produce compensatory changes in all other components. Thus if there is a change in the proportion of local pollen there will be a related change in the proportion of non - local pollen. The only way to resolve this would be to use 'absolute' pollen methods, as was done for both the Balgone House and Corstorphine sites.

Zone BrIII The Graminaeae / Cyperaceae dominated herbaceous communities in this zone have a more diverse range of species including Filipendula, Helianthemum, Thalictrum and Umbelliferae and this suggests enrichment of the swamp / marsh flora. The expansion of Juniperus and Empetrum presumably indicate that climatic conditions had improved sufficiently for these species to flourish, with more stable soils and probably a tendency towards a closed vegetation cover. The low average percentages of Betula indicate that it was not abundant and was probably restricted to sheltered habitats out of the cold east winds that occur in this coastal area.

Zone BrIV There is evidence for a minor phase of retrogressive vegetation development in this zone. The decline in Betula, Juniperus and Empetrum is matched by an increase in the proportion of pollen of herbaceous species, especially Gramineae and Cyperaceae. Rumex increases quite markedly and suggests that the area of open disturbed habitats must have increased for a short time.

Zone BrV In this zone Betula and the shrubs Juniperus and Empetrum recover whilst the amounts of Artemisia Cyperaceae and Rumex decline suggesting that conditions had once again improved. This is reinforced by the presence of the thermophilous Filipendula and Helianthemum (Iversen, 1954, 1973). Myriophyllum alterniflorum, a very typical obligate aquatic of the Lateglacial, is also present.

Zone BrVI This zone is characterised by slightly lower Betula values, virtually no Juniperus, lower Empetrum and Gramineae, higher Cyperaceae, Artemisia and especially higher Rumex, a large proportion of which was later identified as being c.f. Oxyria digyna (S. Peglar pers. comm.) Rumex acetosa and Oxyria digyna are both plants of unstable minerogenic especially base rich substrata (Iversen, 1954; Birks, 1973b). A group of herbaceous species commonly associated with Artemisia, such as the genera Caryophyllaceae, Compositae and Cruciferae, all of which indicate an open steppe type of tundra, become more prominent. The fact that hardly any Juniperus pollen is recorded whilst Betula frequencies drop only slightly is intriguing since Juniperus can grow and regenerate in harsher conditions with lower temperatures and a higher degree of wind exposure than can Betula. This is could be another illustration of the suppression of flowering of Juniperus by harsher conditions (Iversen, 1954; Birks, 1973b). These changes could indicate colder more open conditions and there is a stratigraphic change associated with a palynological one. It is probable though that the coastal situation of the site would modify any climatic deterioration associated with the Younger Dryas.

Zone BrVII Betula recovers slightly in this zone and this in conjunction with higher Empetrum, Gramineae and aquatics and lower Rumex suggests that conditions have improved once more. One might expect Juniperus to expand as a first response to the climatic amelioration, however, it flowers poorly under a Betula canopy.

6.7 Radiocarbon Dating:

The presence of a deposit largely composed of calcareous marl, as mentioned earlier, is clear evidence that these sediments accumulated under hard water conditions. It must therefore be assumed that any radiocarbon dates that could have been obtained from the sequence would probably have reflected the incorporation in the marls of ^{14}C deficient, i.e. containing infinitely old carbon, carbonate minerals derived from the limestone bedrock and the superficial drift. As outlined by Shotton (1972) the conventional ^{14}C ages measured for such materials are an over - estimate of their true date of deposition. This hard water effect may be avoided if a sufficient quantity of material of terrigenous origin e.g. wood fragments, leaves etc can be identified and recovered from the sediment matrix. Unfortunately no such quantities of macro fossil remains were evident in the samples collected from Broxmouth despite multiple - shot coring. Radiocarbon dating of much smaller amounts (3 - 5 mg) of terrestrially derived material preserved in calcareous sediments might be made possible in the future with the development of cyclotron or Van der Graaf accelerator dating (Muller, 1977; Mugh, 1978; Bennett, 1979).

Harkness, in Keating and Dickson (1979), presents two independent methods for calculating corrections to account for the combined influence of hard water effects and finite age on conventional radiocarbon dates. The first is based on the assumption that the input of organic debris and the rate of sedimentation have remained constant. Extrapolation of the measured 'organic' age / depth curve to the sediment surface then provides an estimate of the hard water error throughout the profile. Clearly the basic assumptions of this method are invalid for few sites satisfy the criteria of both uniform organic input and even sedimentation rates.

The second method, the model approach, which is admitted to be speculative is based on using variations in the stable (^{13}C / ^{12}C) isotropic ratios to assess the relative proportions of terrigenous to aquatic derived carbon in the organic component of the sediments. This information in conjunction with the measured (^{14}C / ^{12}C) enrichment values would then allow an evaluation of the radiocarbon age / depth relationship which would be independent of the previous assumptions as to the constancy in the rate of organic deposition. However, assumptions are made about hydrogeochemistry and about maximal hard water conditions throughout deposition that may or may not be valid. It is felt that little confidence could be expressed about corrections derived using these two methods even though Harkness points out that they do produce consistent results.

It was therefore decided not to attempt to radiocarbon date the material from the Broxmouth site, or from the other two sites - Balgone House and Corstorphine, though it is hoped that this will

prove possible in the future.

6.8 Conclusion

In conclusion, the Broxmouth site is thought to exhibit a stratigraphy dating from the early Lateglacial with deposition ceasing at sometime in the mid - Postglacial. There are two contrasted environments, one belonging to the Lateglacial and a later one showing the early development of the thermophilous deciduous woodland characteristic of the Postglacial "Boreal" period. The site itself indicates the rich aquatic, marsh and swamp marginal plant communities that flourished throughout the time represented being especially rich in the later period. The organic productivity of the site is thus shown to increase rapidly in the Postglacial with the establishment of the dominant Quercus and Ulmus, broad leaf deciduous genera. These were accompanied by the shrubs, Corylus, Salix, and Ilex. A rich ground or field layer is also indicated by the pollen of herbs of woodland conditions, Rosaceae, Labiatae, Compositae, Gramineae, Pteridophyta. The presence of Ilex, Hedera and Tilia confirm the characteristics of the later "Boreal" climate with reduced incidence of frosts. In the absence of radiocarbon dates, for the reasons explained above, it has not been possible to make correlations with other sites except in a very general way. It was decided therefore to try to locate another site close to Broxmouth, in East Lothian, that had a clear tripartite division of the Lateglacial sediments and to examine these in detail with a view to making comaprisons with the results from Broxmouth. A site that

fulfilled the necessary criteria was located at Balgone House and is described in the next chapter.

CHAPTER 7

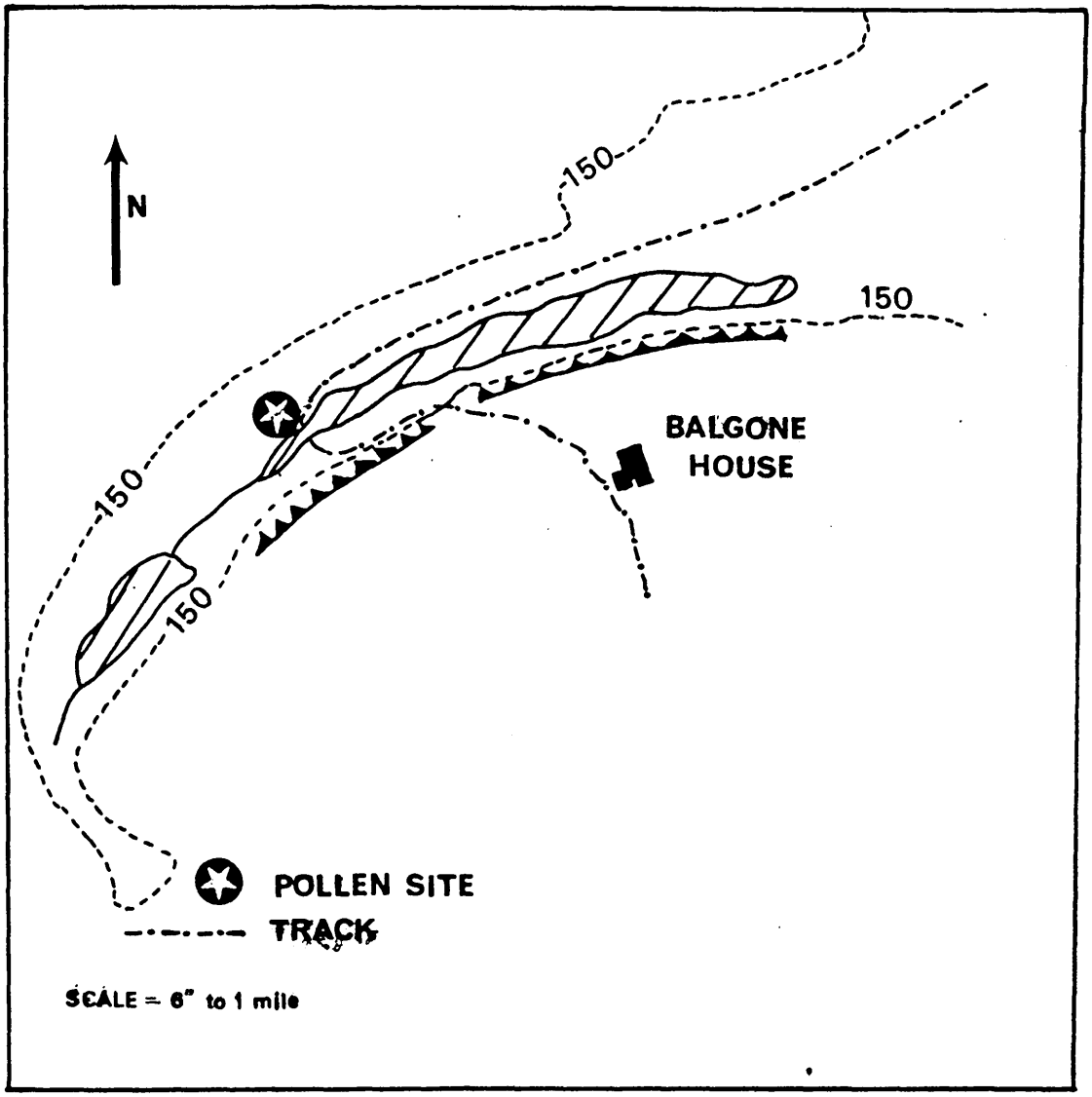
BALGONE House site:

7.1 Introduction:

The second site to be studied was at Balgone House (NT563824), map 7.1, just to the south of North Berwick Law in East Lothian. The site is located between two ornamental lakes, dug from the peat (see section description below) in the last century, in a glacial drainage channel. The peat accumulated following the infilling of the lake, with sediment, that existed at deglaciation. As mentioned in the previous chapter a section of the lacustrine deposits, exposed in a sinking made to receive a gasometer, is given in the Geological Survey Memoir (1910) for East Lothian (p 185). No signs of the gas holder or its shaft could be found despite engaging the assistance of the estate workers. It must therefore be assumed that the holder was removed and the hole left behind filled in sometime before the Second World War.

The section as recorded by Sir Roderick Murchison in the paper referred to above is as follows:

Modern debris of clay and fragments from adjacent cliff.
Black peat, with a few Lymnaea in its lower part, and thickening to 8 - 10 ft, in the centre of the depression.
Shell marl with Lymnaea; a few inches thick only on this side of the loch but thickening towards the centre of the valley. On this rested bones and shells.
Coarse glacial drift, 3 ft
Finely laminated grey sand 2 to 3 ft. (water beneath)



Map 7.1 Map showing location of Balgone House site.

The bones mentioned in the above description, were according to the Memoir, present in large numbers and included the remains of red deer (Cervus elaphus), wild boar (Sus scrofa), aboriginal oxen (Bos taurus primigenius), horse (Equus caballus) etc in association with human skulls. The bones were given to Professor Huxley who apparently found nothing "remarkable" in them. It is suggested (Geol. Surv. op. cit.) that when the narrow valley was occupied by a lake, in which Lymnaea lived, there was a settlement near its edge and that the bones of animals slaughtered were cast into the water. It is further suggested that a very long time has elapsed since they were buried. The presence of human skulls, as recorded above, in the lake sediments is intriguing since it seems unlikely, to the writer, that they were thrown into the lake along with the other remains. Perhaps they represent evidence for a prehistoric accident, ritual killing / burial or just general mayhem?

7.2 Site stratigraphy:

A stratigraphic survey was conducted using a Hiller borer, concentrating mainly on the area between the two lakes. The ground between them was traversed at regular intervals in order to build up a picture of the straigraphy. It was found that the depth of the deposits decreased quite rapidly moving away from the end of either of the two lakes to a minimum of around 150 cms at a point approximately midway between them. At this point the cores, after passing through a sequence of peats hit, sand through which it was

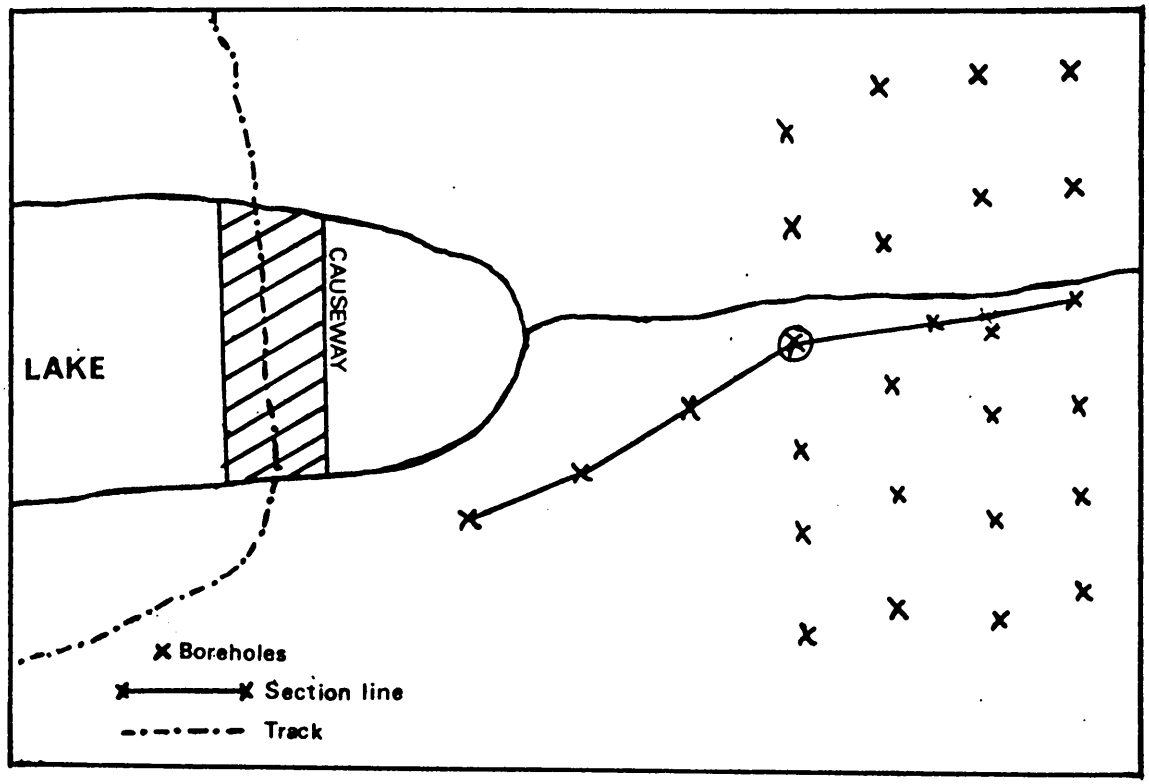
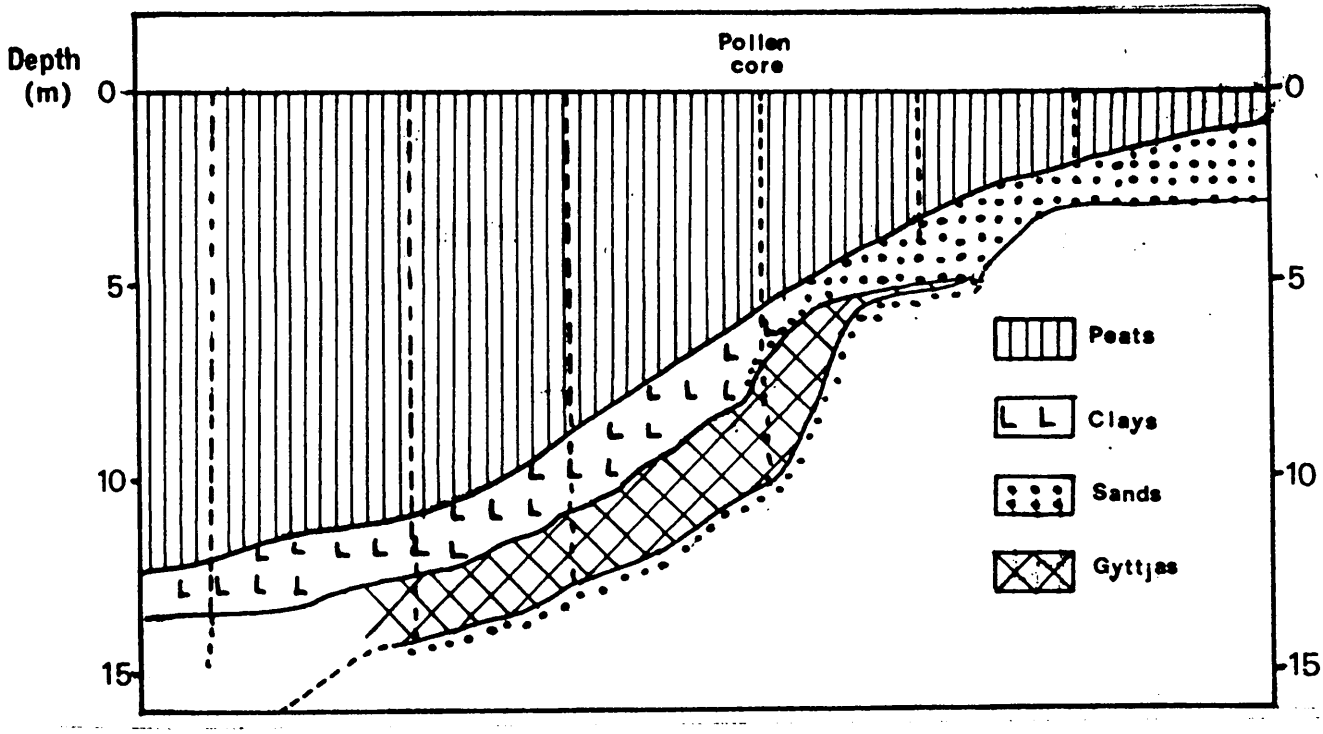


Fig 7.1 Diagrams showing section of deposits and borehole traverses.



not possible to penetrate even using the augur attachment. The depth of the peats increased as has already been mentioned and at around 4.5 metres depth the basal sand gave way to clays (fig 7.1). The core for analysis was taken from the deepest point that could be sampled using the Dachnowski corer and over 9 metres of deposits were sampled. With the Hiller a maximum of 14 metres depth was recorded.

The stratigraphy of the core taken for analysis was as follows:

Cms depth

0 - 120 Disturbed peat

120 - 130 Well-humified peat with Cyperaceae/Phragmites rootlets, stems etc

130 - 301 Well-humified dark brown peat with wood fragments cf Betula.

301 - 589 Coarse well-humified dark brown peat with wood fragments. Some Cyperaceae/Phragmites macrofragments/remains

589 - 599 Band of highly compressed Cyperaceae fragments

599 - 604 Cyperaceae peat

604 - 610 Transitional to calcareous marl

610 - 622 Calcareous marl with abundant shell fragments. Faint laminations. Decreasing humic content with depth.

622 - 643 Dark olive grey gyttja with very fine matrix and some shell fragments

643 - 663 Olive shell marl, more humic material present than in the marl above

663 - 667 Transitional marl to grey clay

667 - 678 Dark grey clay with grit and Cyperaceae fragments

678 - 747 Greyish brown clay with abundant Cyperaceae remains throughout.

747 - 760 Coarse sand

760 - 795 Clayey gyttja. Black in colour when freshly exposed, rapidly turns greyish - brown (2.5Y 5/2)

795 - 859 Pale olive calcareous gyttja/gravel

859 - 861 Sand

861 - 878 Greyish - brown clay

878 - 895 Mixture sand and clay

895 - 910 Sand

See chronological data — p. 176

The stratigraphy at this site strongly resembles that of other sites in the British Isles that have been shown to be of Lateglacial provenance. The lowermost clays and sands were found to be non - polleniferous. They probably represent sediments washed into the lake during and immediately following deglaciation.

7.3 Sample preparation and counting:

105 samples from the core were analysed. At each level a pollen sum, based on dry land taxa, excluding obligate aquatics and spores, of 500 grains or more was counted, though this was not always possible when counting slides prepared from minerogenic horizons. To each sample during preparation, "pollen" tablets (Stockmarr, 1970) were added and a tally of the exotic Lycopodium spores was recorded so that concentrations could be calculated. Percentage and concentration pollen diagrams were drawn up for the site. As a

result of the dataset being over 100 samples the arrays in POLLDATA and ZONATION had to be enlarged to take the additional samples; a relatively straightforward procedure. Since the samples in the lower part of the diagram are so closely spaced it was decided to draw up separate diagrams for this part of the core.

The dataset was objectively zoned using the ZONATION, PCA and MDS(X) programs. The data from the complete core and that from the lower part of the core were zoned separately because of the large number of samples taken from near the base of the core and their close spacing.

7.4 Results for objective zonation:

The following taxa, which all exceeded 5% of the pollen sum at at least one level, were used: Betula, Ulmus, Quercus, Alnus, Corylus, Salix, Juniperus, Empetrum, Gramineae, Cyperacae, Artemisia, Filipendula, Helianthemum, Rumex, Thalictrum, Myriophyllum, Pteridophyta and secondarily - derived Carboniferous spores. On examining the results from the ZONATION program (fig 7.3 and appendix 2), it is apparent that the first major split is not consistently identified by SPLITINF and SPLITSQ. SPLITINF places the major divide between levels 41 and 42 while SPLITSQ puts it between levels 40 and 41. The zone boundary is placed between levels 41 and 42 beneath three levels that CONSLINK identifies as transitional and therefore amalgamates in late. The next most important split is placed by SPLITINF between samples 18 and 19. SPLITSQ again places the zone

boundary above a sample regarded by CONSLINK as transitional i.e. between levels 17 and 18. The third most important split is placed between samples 58 and 59 separating off the lower part of the core. No further splits are distinguished in this part of the core by SPLITSQ and only one by SPLITINF. Splits are identified by SPLITINF and SPLITSQ between levels 49 and 50, and between 44 and 45. Levels 44 and 45 are identified by CONSLINK as being distinctly transitional and the zone boundary is placed betweeen them. An additional split is placed by SPLITINF between levels 31 and 32 and by SPLITSQ between levels 30 and 31 while CONSLINK identifies distinct groups of samples above and below level 30.

Turning to the results from PCA for the complete dataset (figs 7.4, 7.5 and table 7.1) the first three principal components account for 60.3382% of the total variance. The plot of the scores of samples on the first principal component, accounting for 31.1701% of the total variance, which has high positive loadings for Ulmus, Quercus, Alnus, Corylus and high negative loadings for Empetrum, Gramineae, Cyperaceae, Rumex and Myriophyllum, shows the distinction between those samples with a dominance of tree species and those with largely shrub and herbaceous communities.

On the plot of scores of samples on the second principal component, accounting for 14.8469% of the total variance, that has high positive loadings for Betula, Ulmus, Salix and Juniperus and negative loadings for Quercus, Alnus and Corylus illustrates the pattern of the expansion of Betula, followed by Corylus and Quercus and latterly Alnus.

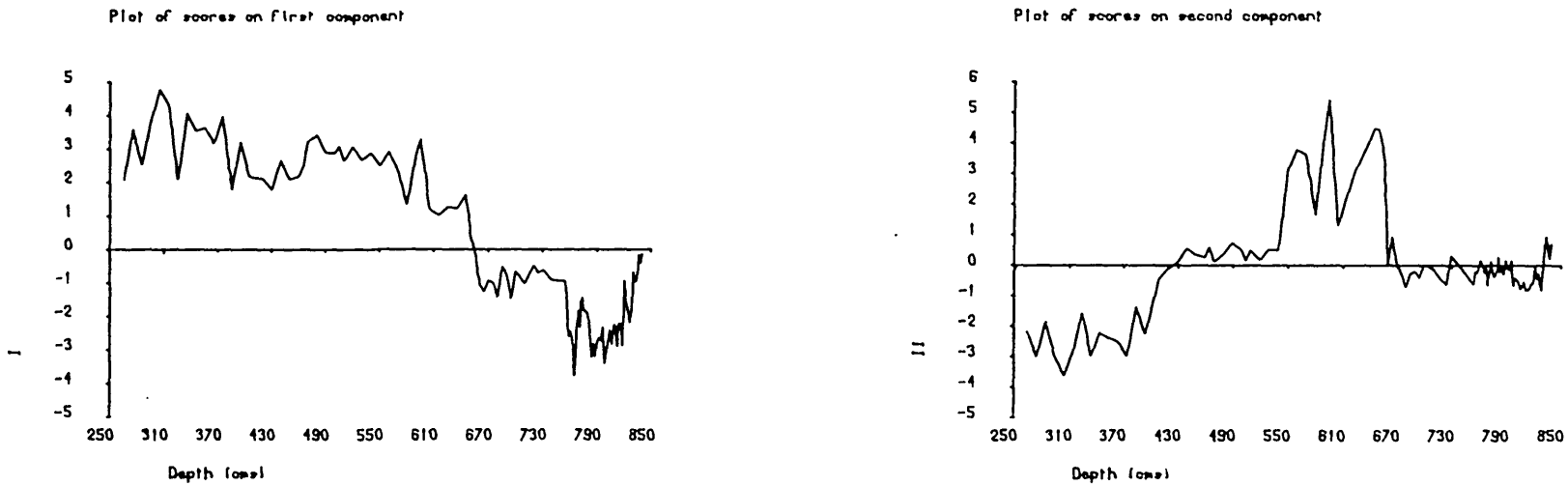
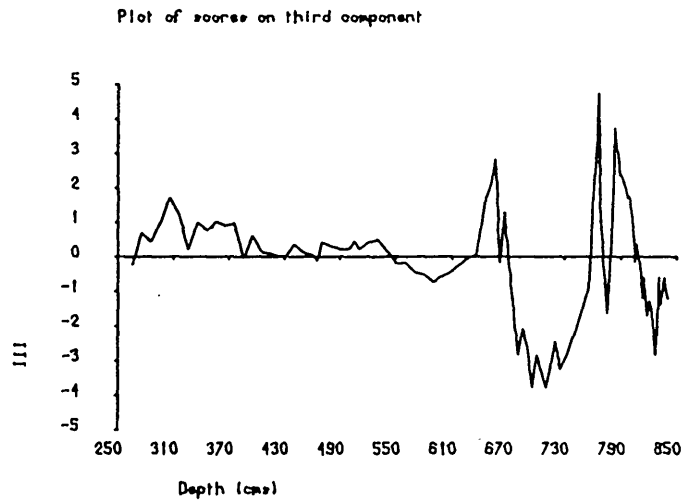


Fig 7.4 Plots of scores on first 3 components for complete core.



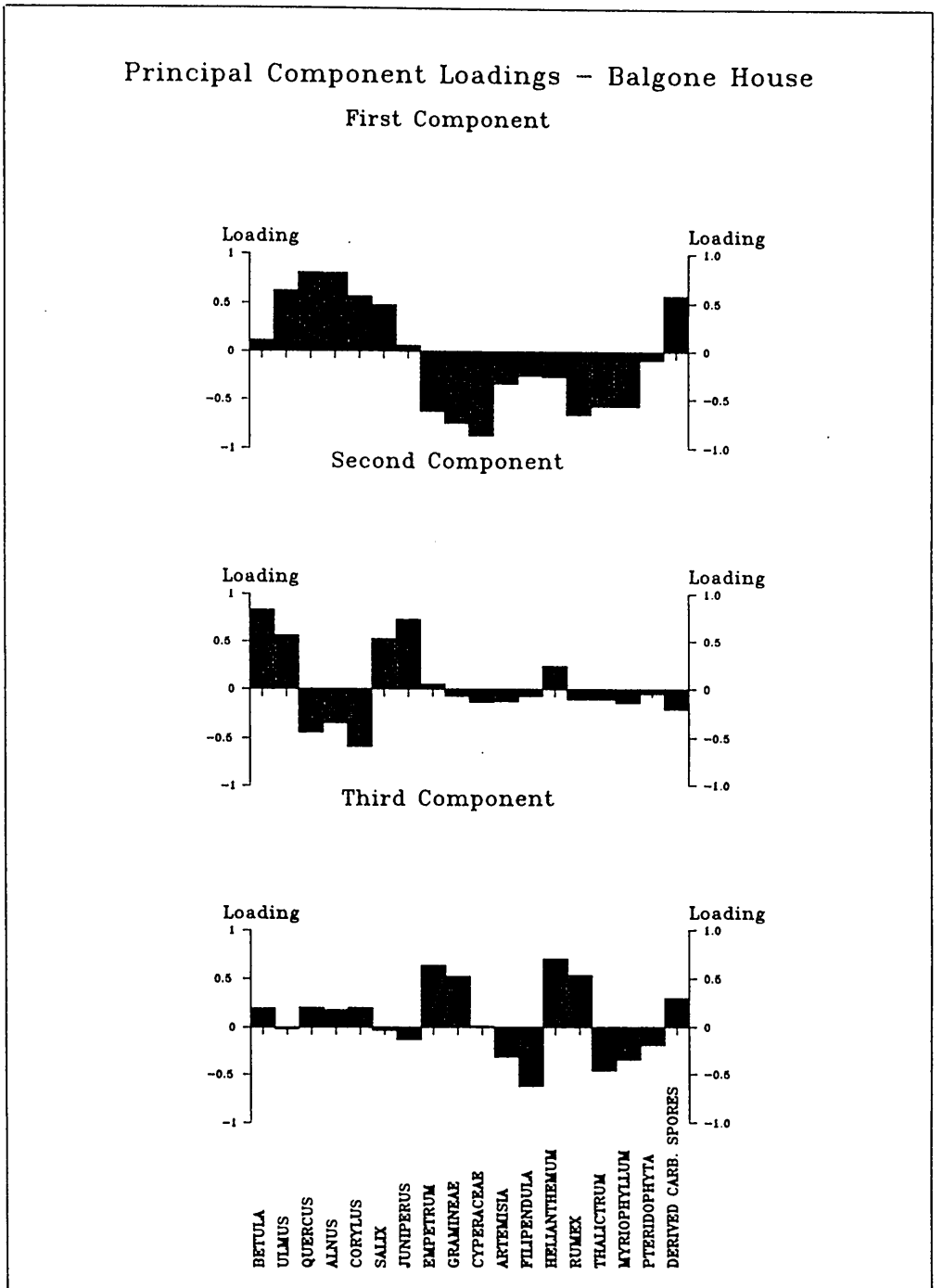


Fig 7.5 PCA loadings on first 3 components for complete core.

BALGONE HOUSE - PRINCIPAL COMPONENTS (complete)

	Components				
Taxon	I	II	III	IV	V
Betula	0.1153	0.8346	0.1994	0.0929	0.0658
Ulmus	0.6225	0.5632	-0.0182	-0.3067	0.0562
Quercus	0.8056	-0.4406	0.2059	-0.0028	-0.0126
Alnus	0.7998	-0.3445	0.1835	-0.1186	-0.0215
Corylus	0.5670	-0.5881	0.2046	0.1597	-0.0278
Salix	0.4767	0.5255	-0.0310	-0.4163	-0.0799
Juniperus	0.0608	0.7343	-0.1307	0.5586	-0.0480
Empetrum	-0.6234	0.0498	0.6349	0.0504	-0.0830
Gramineae	-0.7437	-0.0709	0.5237	-0.1515	-0.0394
Cyperaceae	-0.8709	-0.1309	0.0116	-0.1537	0.2135
Artemisia	-0.3390	-0.1235	-0.3162	0.3707	0.2627
Filipendula	-0.2548	-0.0693	-0.6217	0.2991	-0.3933
Helianthemum	-0.2668	0.2399	0.7016	0.3919	0.1098
Rumex	-0.6553	-0.1021	0.5351	-0.1638	-0.1375
Thalictrum	-0.5694	-0.1003	-0.4611	0.0128	0.2919
Myriophyllum	-0.5702	-0.1382	-0.3453	0.0296	-0.3803
Pteridophyta	-0.0893	-0.0448	-0.1902	-0.1263	0.7805
Carb. spores	0.5752	-0.2019	0.3018	0.6053	0.1624
Eigenvalue	5.6105	2.6724	2.5777	1.4674	1.1916
% of trace	31.1701	14.8469	14.3212	8.1522	6.6204
Cumm % of trace	31.1701	46.0170	60.3382	68.4903	75.1107

Trace = 18.0

Table 7.1 PCA results for complete core.

The third principal component that absorbs 14.3212% of the original variance is less easy to interpret. It has high positive loadings for Empetrum, Gramineae, Helianthemum and Rumex and high negative loadings for Filipendula, and Thalictrum. The oscillating curve in the lower part of the plot, from 670 cms down, presumably reflects the changing dominance of communities by different herbaceous species.

Results for MDS(X) are not available for the complete core because the dataset containing over 100 samples is too large to be processed without using inordinate amounts of computer time in performing the iterations.

On fig 7.7 the results from the ZONATION program for the lower part of the core are plotted. The following taxa were used, which all exceeded 5% of the pollen sum at at least one level: Betula, Corylus, Salix, Juniperus, Empetrum, Gramineae, Cyperaceae, Artemisia, Filipendula, Galium, Helianthemum, Ranunculaceae, Rumex, Thalictrum, Myriophyllum, Pteridophyta, Selaginella and secondarily - derived Carboniferous spores. The results from CONSLINK, SPLITINF and SPLITSQ are all consistent with those from ZONATION of the complete dataset in identifying zone boundaries at 657.5 cms, 682.5 and 756 cms. The remaining zones are largely identified by the grouping of samples by CONSLINK and by the splits produced by SPLITSQ and to a lesser extent by SPLITINF. Zone boundaries are placed between samples 25/26 (766 cms), 37/38 (783 cms), 46/47 (801 cms), 54/55 (817 cms) and 62/63 (833 cms).

The results from PCA are presented in figs (7.8, 7.9) and in table (7.2). The first three principal components account for 56.0988% of the total variance. On the plot of the scores of samples on the first principal component, that accounts for 22.1092% of the total variance and has high positive loadings for Juniperus, Empetrum, Filipendula, Helianthemum and high negative loadings for Cyperaceae, Artemisia and secondarily - derived Carboniferous spores, the distinction between samples showing shrub development including heliophytes Juniperus and Helianthemum and those with open - habitat herbs such as Artemisia, Rumex and Thalictrum, is highlighted.

The second component principal component accounting for 21.5471% of the total variance and having high positive loadings for Betula, Salix and Pteridophyta and high or moderate negative loadings for Empetrum, Gramineae, Galium, Helianthemum, Ranunculaceae, Rumex and Thalictrum appears to indicate the difference between samples that suggest heath and herb communities and those with either a high Betula and Salix content or a predominance of spore types.

The plot of scores on the third principal component, which accounts for 12.4425% of the total variance and has high positive loadings for Galium and Rumex and significant negative loadings for Juniperus, Empetrum, Artemisia, Filipendula, Helianthemum, Selaginella and secondarily - derived Carboniferous spores, reveals the contrast between samples indicative of communities dominated by open - habitat species such as Galium and Rumex and those with either more diverse shrub/heath communities or with a large proportion of

BALGONE HOUSE - PRINCIPAL COMPONENTS

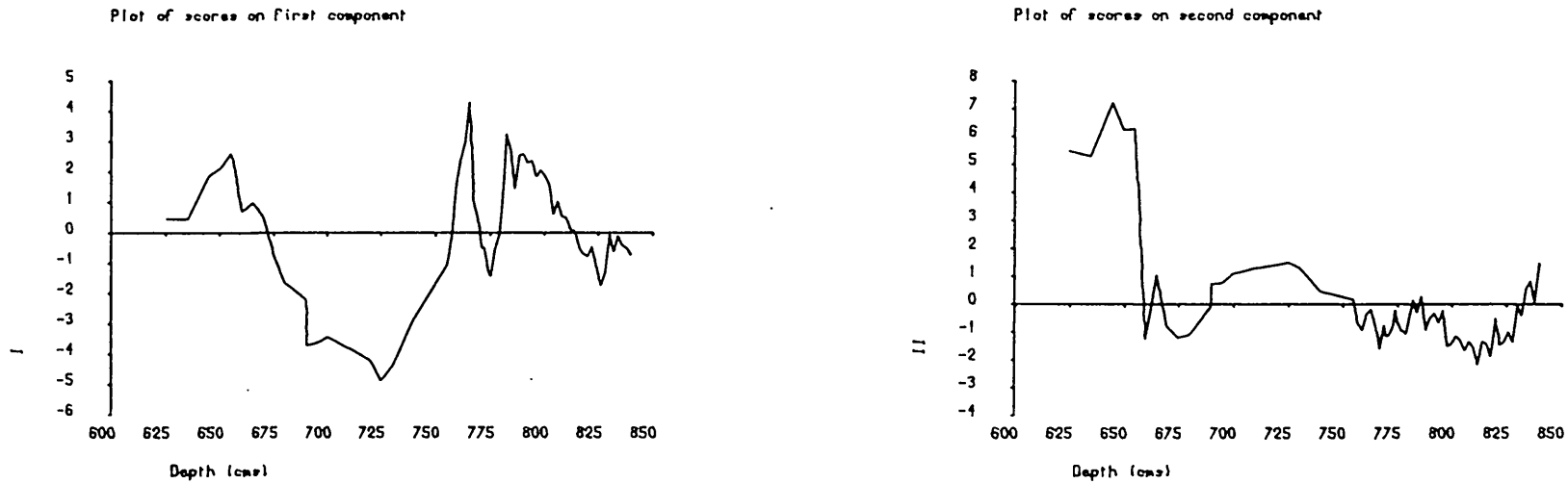
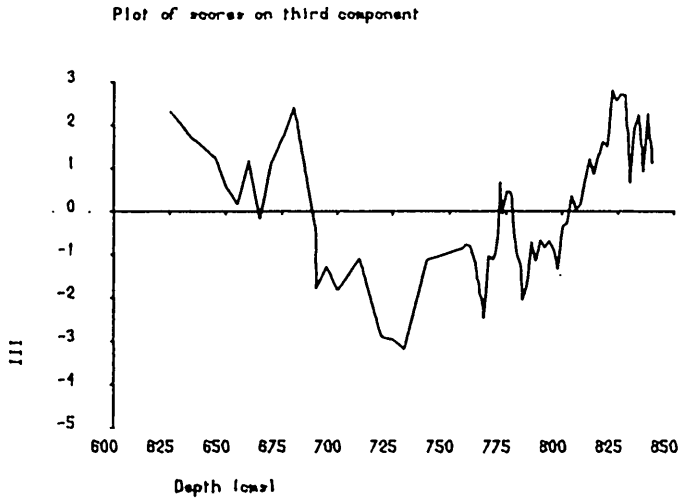


Fig 7.8 Plots of scores on first 3 components for lower part of core.



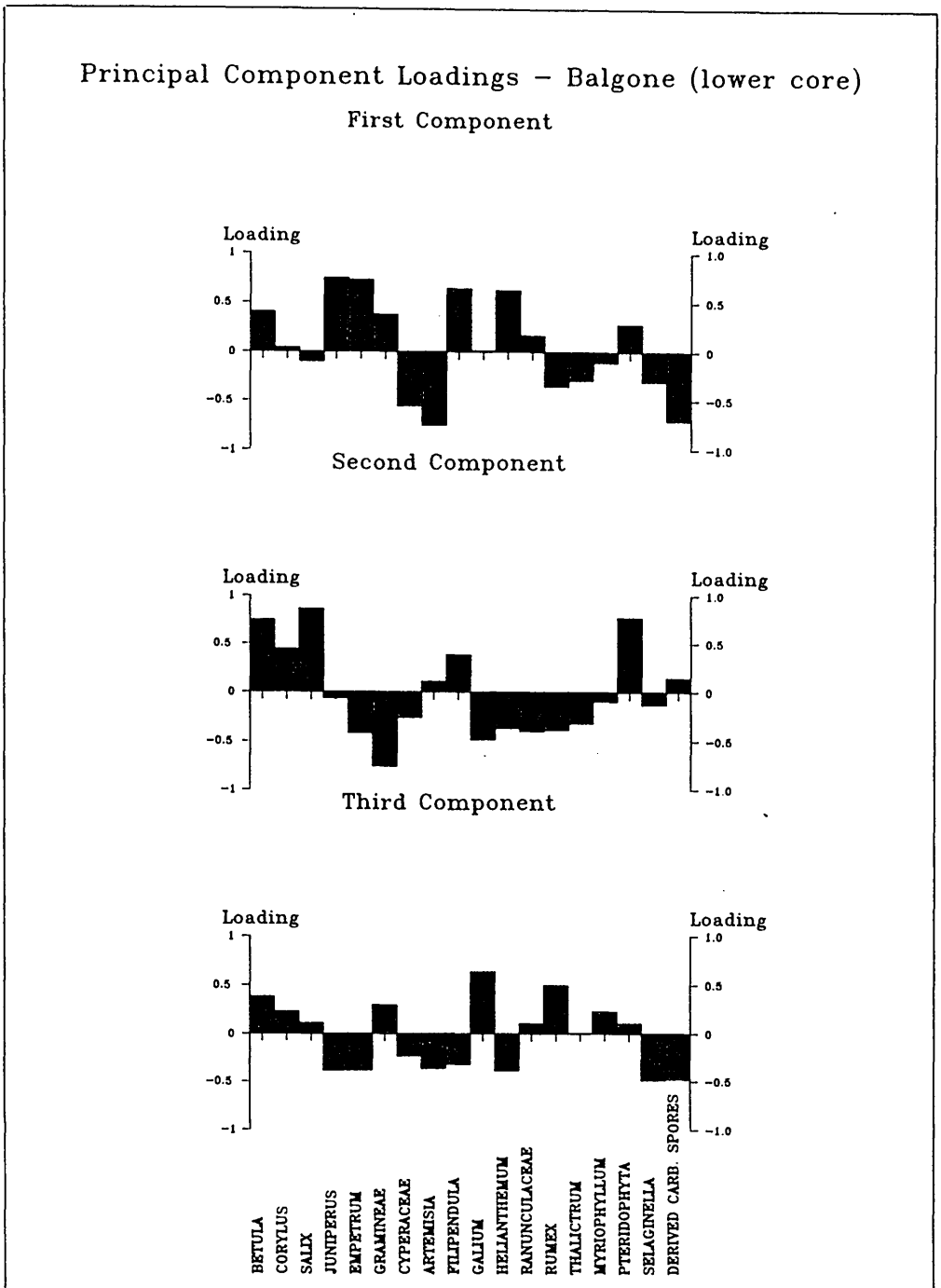


Fig 7.9 PCA loadings on first 3 components for lower part of core.

BALGONE HOUSE - PRINCIPAL COMPONENTS (lower core)

	Components				
	I	II	III	IV	V
Taxon					
Betula	0.4035	0.7468	0.3823	-0.0610	-0.0888
Corylus	0.0388	0.4411	0.2280	-0.2357	-0.6797
Salix	-0.1012	0.8620	0.1115	0.1171	0.3483
Juniperus	0.7420	-0.0635	-0.3870	-0.0997	0.0783
Empetrum	0.7221	-0.4164	-0.3873	-0.0160	-0.0329
Gramineae	0.3771	-0.7593	0.2974	0.1311	0.0743
Cyperaceae	-0.5563	-0.2587	-0.2353	0.4638	-0.0075
Artemisia	-0.7537	0.1052	-0.3684	-0.2457	0.1404
Filipendula	0.6378	0.3812	-0.3226	0.2658	0.2409
Galium	0.0125	-0.4810	0.6347	-0.2023	0.2815
Helianthemum	0.6211	-0.3638	-0.3889	-0.1594	-0.0045
Ranunculaceae	0.1677	-0.3957	0.1048	0.2732	0.0022
Rumex	-0.3538	-0.3816	0.4967	0.3099	0.2163
Thalictrum	-0.2938	-0.3156	0.0042	-0.5822	0.3629
Myriophyllum	-0.1069	-0.0920	0.2292	0.4002	-0.3164
Pteridophyta	0.2806	0.7720	0.1056	0.2241	0.4022
Selaginella	-0.3055	-0.1261	-0.4899	0.4140	-0.0039
Carb. spores	-0.7052	0.1407	-0.4796	-0.1216	-0.0245
Eigenvalue	3.9795	3.8784	2.2396	1.4190	1.2020
% of trace	22.1092	21.5471	12.4425	7.8835	6.6781
Cumm % of trace	22.1092	43.6563	56.0988	63.9823	70.6604

Trace = 18.0

Table 7.2 PCA results for lower part of core.

BALGONE HOUSE - MDS(X)

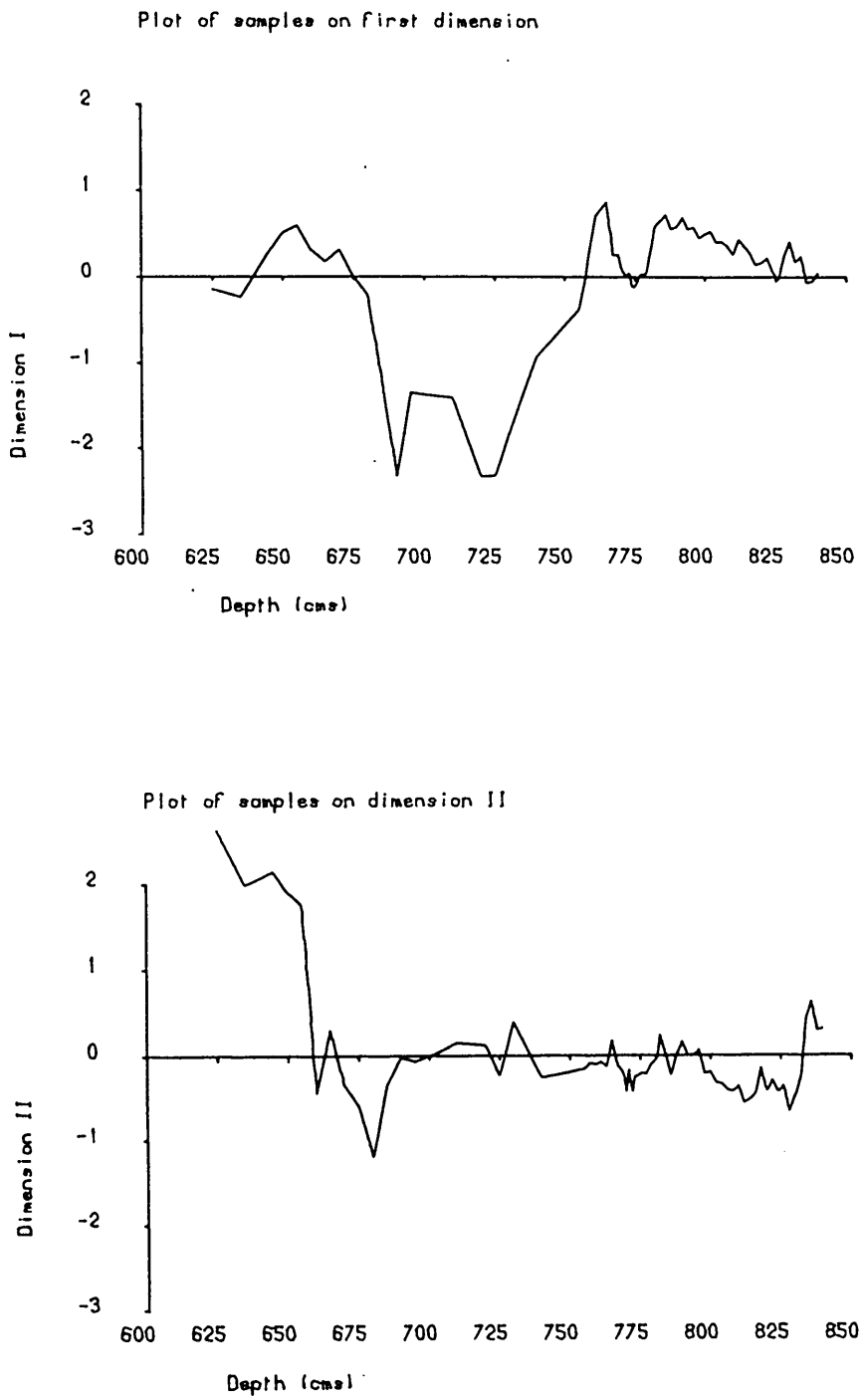


Fig 7.10 MDS(X) results for lower core.

Selaginella or secondarily - derived Carboniferous spores.

The results from MDS(X) for the lower part of the core are presented in fig(7.10). On the plot of samples on the first dimension, the zones identified by ZONATION, especially BaII, BaV and BaVII, are clearly distinguishable.

7.5 Description of pollen zones:

Zone BaI Gramineae, Cyperaceae, Betula (cf nana), Rumex 833 - 840 cms

Pollen of herbaceous species, particularly Gramineae and Cyperaceae, form between 57.5% (836 cms) and 66.11% (840 cms) of that identified in this zone. The percentages of Gramineae range between 31.33% and 44.63% and Cyperaceae is recorded as having lower incidences of between 6.61% and 13.92%. The only other herb present in significant amounts is Rumex which rises to attain a maximum of just over 7% at the top of the zone. Other herbaceous species recorded include Artemisia, Caryophyllaceae, Chenopodiaceae, Compositae, Cruciferae, Epilobium, Galium, Helianthemum, Papaveraceae, Ranunculaceae, Thalictrum and Umbelliferae. A single grain of Gypsophila was recorded at 838 cms and the significance of this find is discussed in a later section in this chapter. Betula, much of which was noted as being comparable to B. nana, occurs at percentages ranging from 23.34% (838 cms) to 37.34% (836 cms). Also present are low percentages of Pinus, Juniperus, Salix, and Empetrum.

Aquatics, including Myriophyllum, Nymphaea and Potamageton and spores form an insignificant proportion of the pollen sum in this zone.

Zone BaII Gramineae, Cyperaceae, Rumex, Betula 817 - 833 cms

The herbaceous component of the pollen sum is larger in the levels making up this zone compared to the previous zone (BaI). Herbaceous species make up between 75.29% (832 cms) and 91.80% at (828 cms). Gramineae is the most important herb being recorded at higher average frequencies of around 50%. Cyperaceae is present at 10 - 15% of the pollen sum. Rumex peaks at 16.21% at 828 cms. The only other herbs present in significant amounts are Galium and Thalictrum. Filipendula first appears in this zone. Betula percentages have declined to an average figure of around 10% with the maximum of 14.29% being recorded at 832 cms at the base of the zone and a minimum of 6.05% at 828 cms. Pinus, Juniperus and Salix maintain their presence. Empetrum is present at 2% at the top of the zone.

Zone BaIII Juniperus, Gramineae, Cyperaceae 801 - 817 cms

Betula is consistently recorded at less than 10% in this zone whilst Juniperus increases from 2% at the base of the zone to reach just over 10% at the top. Herbaceous species maintain their dominance at 75 - 85% of the total with Gramineae averaging 55% and Cyperaceae 10%. Rumex noticeably declines to around 2%. Galium,

Helianthemum and Thalictrum are the only other herbs recorded in significant amounts.

Zone BaIV Juniperus, Betula, Filipendula 817 - 756 cms

Betula percentages recover slightly in this zone with higher average percentages, of between 8 - 16%, being recorded. Juniperus attains a maximum of over 20% at 786 cms with a minimum of 7.98% at 800cms. Empetrum is present at 3 - 5% of the total pollen sum. Herbaceous species account for a lesser proportion of the total, than in the previous zone, of around 60 - 70%. Percentages of Gramineae range between 40% and 50% and those for Cyperaceae 5 - 10%. Filipendula peaks at 8.7% at the top of the zone. The levels of Rumex are similar to those recorded in BaIII.

Zone BaV Betula, Rumex, Gramineae, Carboniferous spores 682.5 - 756 cms

Betula is present at between 5 and 15% of the total. Pinus is recorded at higher average values c.f. zone BaIV of 1.5 - 2.5% peaking at 3.45% at 774 cms. Juniperus percentages are lower with a minimum of 1.19% at 771 cms and a maximum of 9.38% at 781 cms. Empetrum peaks 5% at the top of the zone whilst Salix reaches a maximum of 3.65% at 775 cms. Herbaceous species have an increased representation in this zone accounting for over 70% of the total pollen sum at all levels with a maximum of 87.78% at 772 cms.

Gramineae averages between 40 and 60% of the pollen sum where Cyperaceae is present at between 10 to 20%. Rumex peaks at 9.42% at 775 cms and 2% Artemisia is recorded at the same level. The maximum of 14.26% for Filipendula occurs at the base of the zone. A minimum of less than 1% is reached towards the middle of the zone before Filipendula once again recovers to 4.92% at the top. Significant amounts of Carboniferous spores are recorded in the zone.

Zone BaVI Juniperus, Betula, Filipendula and Empetrum 756 -766 cms

In this zone Juniperus almost recovers to the levels previously noted in BaIV with recorded frequencies of between 6.85% and 16.21% at 761 cms. Empetrum attains its maximum of 9.51% at the base of the zone. Herbaceous pollen accounts for a lower proportion of the total pollen sum than in the previous zone. Gramineae percentages range between 40 and just under 50% while Cyperaceae is present at between 5 and 25%. Filipendula reaches a maximum of 13.73% at 763 cms. Rumex frequencies are lower only increasing to 4.89% at the top of the zone. Other herbs include Galium, Helianthemum, Ranunculaceae, Thalictrum and Umbelliferae. Insignificant amounts of Carboniferous spores are present.

Zone BaVII Gramineae, Cyperaceae, Artemisia, Carboniferous spores 682.5 - 756 cms.

Betula drops to low frequencies of 2 - 5%. Pinus increases and

averages 2 - 4% with a maximum of 10.65% at 690 cms. Salix has increased representation reaching a maximum of 12.55% at 690 cms near the top of the zone. Herbaceous species account for between 80 and almost 90%. The frequencies of Gramineae are much reduced in this zone while Cyperaceae increases reaching in excess of 50% at 690 cms. Artemisia is an important herb peaking at 24.74% at 725 cms as are Caryophyllaceae, which reaches a maximum of 11.43% at 700 cms and Cruciferae, which attains its highest value of 5.83% at 730 cms in this zone. Rumex rises to almost 10% at 740 cms and Thalictrum is present at between 2 - 5%. The spores, include a large proportion of secondarily - derived Carboniferous spores.

Zone BaVIII Betula, Salix, Juniperus, Myriophyllum 657.5 - 682.5 cms

Betula rises from 4.18% at the base of the zone to reach a maximum of 13.43% at 665 cms. Pinus percentages fluctuate between 3 and 5%. The shrubs Salix, Juniperus and Empetrum are each present at low average percentages. Corylus makes its first appearance in this zone. Herbaceous species remain important forming between 72.14% (665 cms) and 90.18% (680 cms). Gramineae is the most important herb ranging from 35.07% at 665 cms and 59.92% at 680 cms. Cyperaceae, is recorded at lower percentages than in the previous zone BaVII, with a minimum of 9.07% at 660 cms and a maximum of 18.84% at 665 cms. Filipendula reaches 12.63% at 665 cms. Rumex and Ranunculaceae are the only two other herbaceous species recorded in noticeable amounts. Aquatics expand quite dramatically at the base of the zone with Myriophyllum alterniflorum in particular accounting for 57.52% of the

pollen sum. Pteridophyta undiff. and secondarily - derived Carboniferous spores between them average 5 - 10% of the pollen sum. Other spore types present include Dryopteris type and Polypodium vulgare.

Zone BaIX Betula, Juniperus, Filipendula 640 - 657.5 cms

The percentages of Betula recorded increase markedly in this zone to between 35 and 50% of the pollen sum. Pinus is present at similar frequencies to those of the previous zone while Salix averages approximately 11%. Juniperus peaks at 13.5% and then declines rapidly. Empetrum is much diminished with only a trace being recorded. Herbaceous species amount to between 30 and 40% of the total pollen sum of which the major part is made up of Gramineae and Cyperaceae. However, Filipendula is an important herb in this zone peaking at 15.25% at 655 cms. Spores, including Pteridophyta undiff. and Dryopteris type, form a significant proportion of the microfossils identified with over 25% in each level and a maximum of 41.88% at 655 cms.

Zone BaX Corylus, Betula 535 - 640 cms

Corylus forms the major part of the pollen identified at most levels in this zone reaching a maximum of almost 90% at 595 cms. However, Betula is initially the dominant species at over half of the pollen sum at 625 and 635 cms. Pinus, Ulmus and Quercus are also

present with low frequencies. Herbs, mainly Gramineae and Cyperaceae with Filipendula, are less important numerically than hitherto.

Zone BaXI Corylus, Quercus, Betula, Ulmus 435.0 - 535.0 cms

Betula percentages are largely similar to those in the previous zone BaX while the representation of Pinus and Ulmus have increased slightly. Quercus percentages though increase quite markedly and average 15 - 20 % of the pollen sum but Corylus percentages are lower averaging 40 - 50%.

Zone XII Alnus, Quercus, Ulmus 265.0 - 435.0 cms

Alnus is the dominant species in this zone rising rapidly from the base of the zone to reach a maximum of over 85% at 305 cms. Betula, Quercus, Ulmus and Pinus are all recorded at lower levels than in the previous zone BaXI. Pteridophyta and Cyperaceae both increase quite sharply towards the top of the zone.

On the two concentration diagrams (figs 7.11, 7.12) the zone boundaries of BaI to BaXII have been marked. In table 7.3 the minimum, maximum and average concentrations of pollen in samples from each zone are presented. Examining the column for average concentrations it may be seen that there is an almost twofold increase in the average concentration between zones BaI and BaII. Zones BaII to BaV exhibit markedly similar average concentrations.

The mean concentration of pollen in zone BaVI is nearly three times as high as that in zone BaV and is practically five times higher than that recorded in zone BaVII. The figures for zones BaVIII to BaX show a moderate increase, 1.5 - 2.5 times, between zones. Zone BaXI breaks this trend by recording a decrease in average concentration to less than half that in the previous zone BaXI. The figure for zone BaXII is over two times as high as that for BaXI and is therefore approximately the same as that for BaX.

ZONE	Minimum	Maximum	Mean
BaI	2.9642×10^4	4.2849×10^4	3.37×10^4
BaII	3.7721×10^4	9.2366×10^4	6.44×10^4
BaIII	3.0498×10^4	8.2973×10^4	5.58×10^4
BaIV	4.0798×10^4	7.1336×10^4	5.56×10^4
BaV	4.6843×10^4	1.1184×10^5	5.59×10^4
BaVI	1.3648×10^5	1.77×10^5	1.49×10^5
BaVII	1.7051×10^4	4.8837×10^4	3.25×10^4
BaVIII	7.397×10^4	8.8723×10^4	7.97×10^4
BaIX	6.9615×10^4	1.55×10^5	1.23×10^5
BaX	9.7891×10^4	3.4655×10^5	2.27×10^5
BaXI	3.7128×10^4	1.6176×10^5	1.03×10^5
BaXII	4.9891×10^4	3.014×10^5	2.24×10^5

Table 7.3 Minimum, Maximum and mean pollen concentrations by zone

The concentration diagrams confirm features already observed above on the percentage diagrams. There are clearly marked peaks in the concentrations of Juniperus Filipendula, and Rumex, in the lower part of the diagram, in zones BaIV and BaVI. The maximum concentrations of Juniperus (2.673 X 10^4 grains/cubic cm) and Filipendula (2.2275 X 10^4 grains/cubic cm) in zone BaVI are between two and four times as large as the corresponding figures for zone BaIV of (1.2175 X 10^4 grains/cubic cm and 6.1524 X 10^3 grains/cubic cm). Empetrum attains its maximum concentration of 1.6842 X 10^3 grains/cubic cm at 765 cms. Betula concentrations show less overall variation in the lower part of the diagram than might be expected from an examination of the percentage diagram. In particular the concentrations of Betula in zone BaI are largely similar to those in zone BaVI which is in sharp contrast to the corresponding percentages in which there is a threefold decrease from over 30% to around 10% of the total pollen sum. This is an illustration of one of the advantages of concentration data has over percentage counts in that the pollen concentrations are independent of the interrelations of taxa within the pollen sum and give the true fluctuations of each taxon. Carboniferous spores are recorded as reaching their highest concentration of 2.7122 X 10^4 grains per cubic cm at 720 cms. Aquatics, largely Myriophyllum alterniflorum peak at 4.2507 X 10^4 grains /cubic cm at 680 cms. This peak is succeeded by peaks for Filipendula of 2.3561 X 10^4 grains / cubic cm, Juniperus of 2.093 x 10^4 grains / cubic cm and Salix of 1.6983 X 10^4 grains / cubic cm at 655 cms and for spores of 6.4943 X 10^4 grains / cubic cm at 650 cms. There then follows the expansions in the concentrations of the various tree and shrub species. Betula expands rapidly from a minimum

of 4.3646 X 10^2 grains / cubic cm at 725 cms to a maximum of 1.3479 X 10^5 grains / cubic cm at 625 cms in zone BaX. This Betula maximum is followed by a maximum concentration for Corylus of 2.7499 x 10^5 grains / cubic cm at 590 cms in the same zone, BaX. Quercus attains its highest value of 2.8037 X 10^4 grains / cubic cm at 480 cms in zone BaXI with the highest recorded concentration for Alnus of 2.3398 X 10^5 grains / cubic cm at 355 cms. Alnus and Ulmus are recorded as having lower average concentrations than the species above.

7.6 Vegetation reconstruction

Zone BaI Gramineae, Cyperaceae, Betula (c.f. nana), Rumex

The vegetation was clearly dominated by open habitat grass and sedge communities. Trees and shrubs form an insignificant proportion of the total recorded. The Pinus pollen noted was probably derived from long distance transport. The Salix identified is likely to have been S. herbaceae, often used as evidence for cold conditions and is frequently found today around the peripheries of late snowbeds at high altitudes (Gjaervoll, 1950). Rumex may not have been as important as the diagrams suggest as its pollen is consistently over - represented in surface pollen studies (Birks, 1973b) as a result of its high pollen productivity. Additionally it is not easy to draw inferences from its presence since the genera possesses a wide ecological tolerance. The presence of Polemonium caerulium, which has a clearly recognisable grain, is an indication of the presence of

calcium carbonate in the soil. This species is therefore strongly calcicolous and is also confined to a characteristic tall herb community described by Holdgate (1955). The combination of Papaveraceae and Artemisia suggests that areas of exposed mineral soil subject to very little snow-lie may have existed somewhere in the catchment, perhaps along the top of the cliff overlooking the south side of the lake. A pollen grain of Gypsophila, which has only one published record, known to the author, in Britain for Beanrig Moss, Roxburghshire (Webb and Moore, 1982) there being no mention of this genera in Godwin (1975), is recorded in this zone. Gypsophila grains are very distinctive indeed (Faegri and Iversen, 1975; Erdtman, 1969). The ecological preferences of Gypsophila fastigiata / repens are discussed in detail by (Webb and Moore, 1982). Briefly G. fastigiata is a calcicolous 'continental' species (Iversen ,1954; Berglund, 1966) which grows as a member of open base rich short herb communities while G. repens is a more southern species found as a member of pioneer communities on sandy, rocky soils in mountain areas throughout Central Europe.

Zone BaII Gramineae, Cyperaceae, Rumex, Betula

The vegetation communities of this zone must have been largely similar to those described for zone BaI, being open - habitat dominated by herbaceous species. The presence of Empetrum, a plant characteristic of acid soils, towards the top of the zone suggests the beginnings of leaching of the soils in the catchment though this was probably a very local feature. The appearance of Filipendula

indicates that climatic conditions had improved sufficiently for this thermophilous species (Iversen, 1954). The Rumex recorded may be indicative of open disturbed ground.

Zone BaIII Juniperus, Gramineae, Cyperaceae

The open - habitat herbaceous species maintain their dominance of the vegetation. Juniperus, of which traces were present in the previous zone, expands probably as a result of the more prolific flowering of plants already present in response to rising temperatures (Iversen, 1954; Birks, 1973b)

Zone BaIV Juniperus, Betula, Filipendula

Juniperus has increased its representation over the previous zone though this does not necessarily indicate that its areal coverage had increased since the higher incidence of pollen of this species may be attributable to the flowering of plants formerly stunted by colder conditions. The amounts of Filipendula recorded also suggest that average temperatures were rising.

Zone BaV Betula, Rumex, Gramineae, Carboniferous spores

This zone represents a phase of retrogressive vegetation development. Juniperus declines quite dramatically and there are twin peaks for Filipendula at the base and at the top of the zone.

Herbaceous species have increased representation with the records for Artemisia and Rumex in particular suggesting an increase in the area of disturbed soils. The amounts of secondarily - derived Carboniferous spores recorded indicate renewed inwash of minerogenic material from the catchment into the lake basin. Empetrum is also higher which may be an indication of increased leaching of any remaining stable soils in the catchment. The higher incidence of Pinus, which is most likely to have been a result of long distance transport of pollen to the site, is probably a reflection of the lower pollen production of local species, though in the absence of radiocarbon dates it is not possible to calculate pollen influx.

Zone Ba VI Juniperus,Filipendula, Betula, Empetrum

In this zone the vegetation reflects improved conditions over the previous zone with Juniperus and Filipendula both attaining maxima near the top. The presence of Empetrum indicates that leaching of the soils was a continuing process. On the basis of the evidence for warmer conditions it is probable that this zone correlates with the Allerod period prior to the Younger Dryas. It may be speculated that the deposition of clays during the succeeding zone (Ba VII) may have removed / redeposited sediments laid down during this zone.

Zone BaVII Gramineae, Cyperaceae, Artemisia, Carboniferous spores

The pollen counts recorded for samples in this zone clearly indicate that conditions had deteriorated once more. Pollen of the tree species, Betula and Pinus falls quite sharply whilst the increase in Salix, which may be Salix herbaceae, could indicate the presence of late snowbed communities. Herbaceous species are more dominant than in the previous zone. Of these the chionophilous Artemisia is clearly the most important but is present with many genera / species of open habitats and disturbed ground e.g. Caryophyllaceae, Cruciferae, Rumex, and Thalictrum. Some of the grains of Artemisia were thought to resemble closely those of A. norvegica (Birks, 1973a) which may point to the presence of Artemisia communities dominated by Juncus trifidus, as described by McVean and Ratcliffe (1962).

The clay sediments deposited in this zone suggest that surface runoff over the surrounding slopes, which were probably poorly vegetated, was an important process. This is borne out by the proportion of secondarily - derived Carboniferous spores recorded. This zone clearly represents the Younger Dryas both stratigraphically and biostratigraphically.

Zone Ba VIII Betula, Salix, Juniperus, Myriophyllum

The expansion of aquatics at the base of this zone is its most characteristic feature. The dramatic increase in the amounts of Myriophyllum alterniflorum recorded, in conjunction with the precipitation of calcareous marl is taken to indicate the onset of warmer conditions at the start of the Postglacial.

Zone Ba IX Betula, Juniperus, Filipendula

Juniperus expands initially and is then superseded by Betula. The rise in Juniperus is probably related to the increased pollen production of plants already present in response to warmer conditions as mentioned earlier. Of the herbaceous species Filipendula is noteworthy as it may have formed a part of a developing hydrosere. Pteridophyta clearly formed a significant part of the woodland and shrub communties present.

Zone Ba X Corylus, Betula

After a phase of Betula dominance Corylus takes over as the dominant species. Corylus was probably present initially as an undershrub in birchwoods but the sheer amounts of pollen recorded mean that it must also have grown as a dominant in natural scrub unless a few favoured individuals grew by the edge of the lake and shed whole anthers into the water.

Zone Ba XI Corylus, Quercus, Betula, Ulmus

Corylus is less important, numerically, than in the previous zone but remains the dominant species. It is now accompanied, however, by significant records for Quercus and Ulmus. This is

consistent with the evidence from other parts of the Midland Valley of Scotland (Donner, 1962; Newey, 1968; Brooks, 1976), as outlined in an earlier chapter, suggesting that Quercus and Ulmus were the important components of the mid - Postglacial woodlands. Newey (1968) attributes the representation of Quercus and Ulmus in south east Scotland to the favourable edaphic and climatic conditions.

Zone Ba XII

In this final zone Alnus pollen predominates. Even allowing for its high pollen productivity it must have been very common in the general forest cover in the vicinity of the site. It may be speculated that conditions had become wetter so that all flat or gently sloping ground in the catchment became increasingly waterlogged leading to the creation throughout the mixed oak forest of wet open spaces with Alnus and Salix. The increase in sedge pollen may be associated with the increase in the area of wet habitats. There is no evidence for a decline in Ulmus pollen which suggests that pollen was not preserved in sediments younger than 5000 BP , the accepted date for the Ulmus decline, perhaps as a result of oxidation through periodic drying out of surface peat.

The results of slotting the Broxmouth and Balgone House sequences are shown in fig(7.13). The slotting of the sequences was based upon the following species that occurred in significant amounts in both diagrams: Betula, Pinus, Salix, Juniperus, Empetrum, Gramineae, Cyperaceae, Artemisia, Caryophyllaceae, Filipendula,

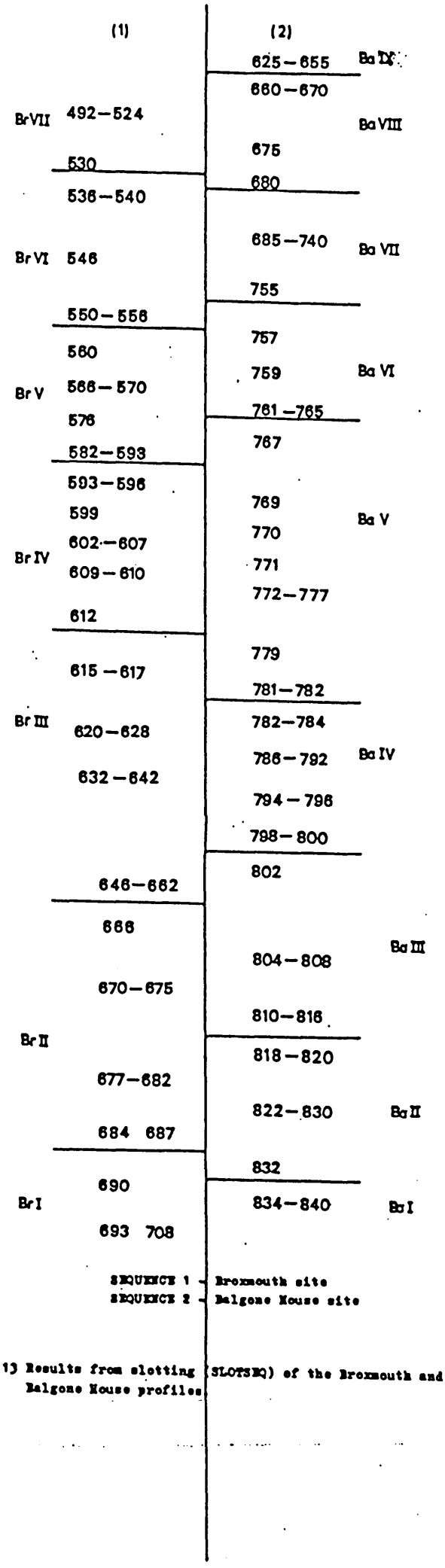


Fig 7.13 Results from slotting (SLOTSEQ) of the Broxmouth and Balgone House profiles

Galium, Helianthemum, Rumex, and Thalictrum. The value for psi (ψ) obtained 1.3878, which is low suggesting a good fit although as was stated in an earlier chapter there are no formal statistical tests in terms of probability that can be applied to test the significance of (ψ). As may be seen from fig (7.13) the degree of fit between the two sequences is quite good with a considerable degree of correspondence between the zones delimited in each sequence. In particular zones BrVI at Broxmouth and zone BaVII at Balgone House, which are considered to represent the Younger Dryas overlap, as do zones BrIV and BaV which correlate with a phase of retrogressive vegetation development at both sites during the Lateglacial Interstadial

To summarise, deposition probably commenced in the lake shortly after deglaciation around 13,000 BP. The Lateglacial Interstadial is characterised by vegetation communities with diverse shrub and herb species indicative of warmer conditions. Judging by the range of species recorded and the calculated pollen concentrations, plant productivity must have been quite high throughout the period. There is, however, evidence for a phase of retrogressive vegetation development in the Interstadial but there is no clear associated stratigraphic evidence. The Younger Dryas is clearly represented both stratigraphically and biostratigraphically and is succeeded by a Postglacial sequence of vegetation up to just before the Ulmus decline. The Lateglacial sequence at Balgone House is very similar to that for Corstorphine, discussed in the next chapter, where an unusually deep layer of lake marls, almost two metres, reflects the warmer conditions of the Interstadial. The Younger Dryas at Balgone

House is represented by a much shallower horizon (≈50 cms) than at Corstorphine.

7.7 Chemical investigations of lake sediments

It was decided to investigate changes in the inorganic chemistry of the lake sediments since these are a reflection of changes in the catchment area related to differing rates of soil erosion and leaching (Mackereth, 1965, 1966; Pennington et al, 1972; Pennington and Sackin, 1975).

Mackereth (1965, 1966) completed much of the basic work on lake sediment chemistry using sediments from the Lake District. Mackereth confirmed an earlier suggestion by Pearsall et al (1960) that lake muds were derived from soils eroded from the catchment area. He argued that since sodium (Na) and potassium (K) are highly soluble it therefore followed that any sodium and potassium found in the mineral fraction of the sediments would have been derived from soil erosion as any available soluble sodium or potassium would have been leached from the soils and been incorporated in the organic and water fractions of the sediments. He discovered that the amounts of sodium and potassium when plotted against depth correspond to periods of soil erosion and stablility as had been interpreted from pollen data. There was also a close relationship between the amounts of mineral matter present in the sediment and the amounts of sodium and potassium in the mineral matter. The curve for magnesium (Mg) was roughly the same as those for sodium and potassium suggesting that it

behaves in a similar fashion. It was found that the curve for carbon (C) was the inverse of those for sodium, potassium, and magnesium which indicated that the amounts of carbon were relatively constant and that its proportion varied according to the amount of mineral matter in the sediment.

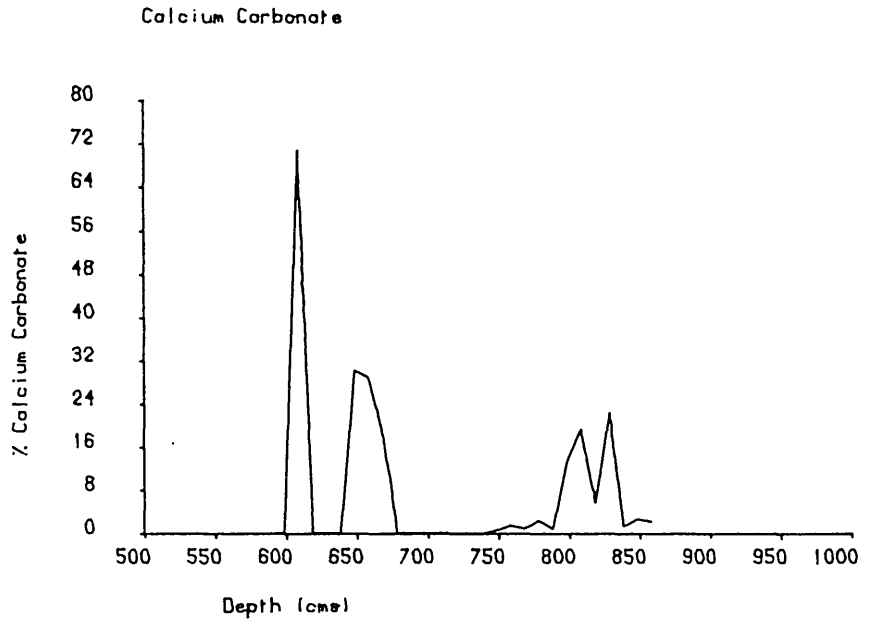
Calcium (Ca), so Mackereth discovered, behaves rather differently to the other cations. It is easily leached, being highly soluble, out of mineral matter and is only present therefore in sediments during periods of very high erosion rates when deposition of unleached material containing a high proportion of calcium occurs. At other times calcium is strongly leached from soils.

The chemistry of lake sediments therefore gives information on changes in the soils in the catchment. Pennington and Sackin (1975) compared chemical and pollen analytical data from lake sediments using principal components analysis. Stratigraphic plots of the principal component scores of the chemical data showed that major changes in the sediment chemistry correspond with major changes in the pollen stratigraphy. It is inferred that the soils of the catchment affect both the vegetation and the sediments.

7.8 Results from chemical investigation:

Samples were removed from the core at 10cm intervals from the core between 588 - 858 cms. The chemical data is presented in fig (7.14, 7.15) and in table (7.4). Examining the graphs in turn:

BALGONE HOUSE - CHEMICAL DATA



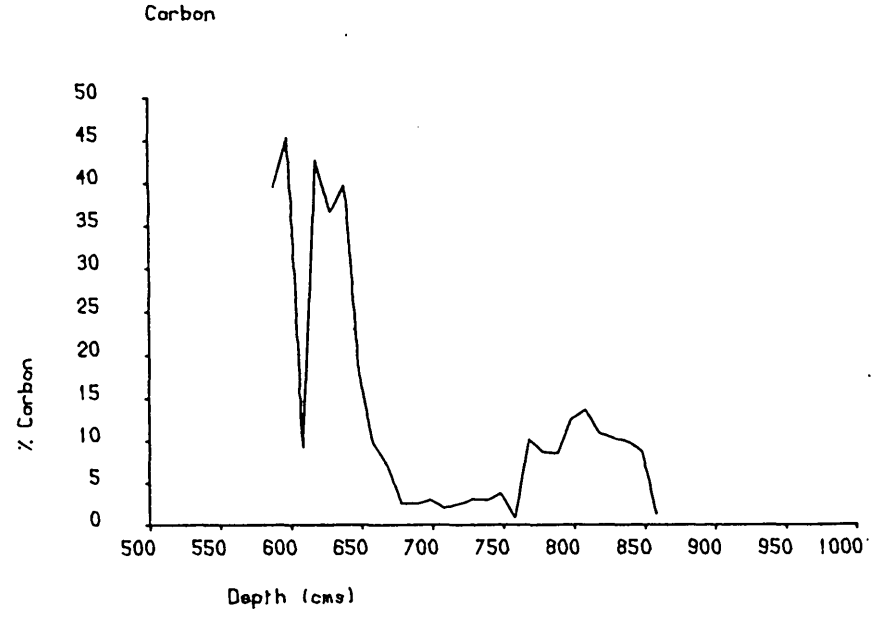


Fig 7.14 Plots of chemical data for calcium carbonate and carbon.

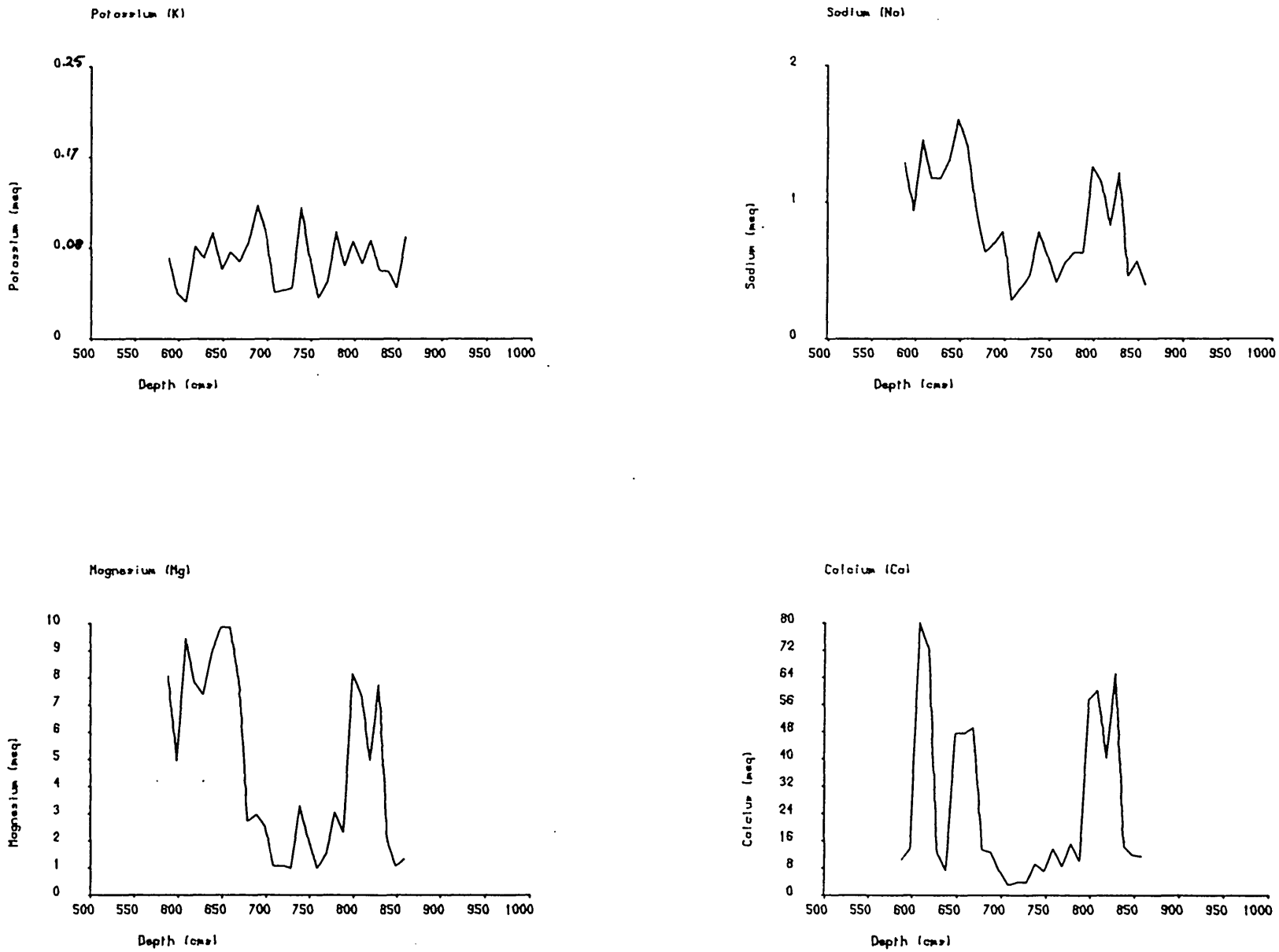


Fig 7.15 Plots of chemical data for potassium, sodium, magnesium, and calcium.

Table 7.4 Raw chemical data

Depth	$CaCO_3$ (%)	C (%)	K (meq)	Na (meq)	Mg (meq)	Ca (meq)
588	0.0	39.6	0.0889	1.2803	8.0556	10.5
598	0.0	45.33	0.0495	0.9331	4.932	13.5
608	70.88	9.16	0.0406	1.4539	9.453	80
618	0.0	42.66	0.1016	1.1718	7.809	72.5
628	0.0	36.6	0.0889	1.1718	7.398	12.5
638	0.0	39.66	0.1167	1.302	9.042	7.25
648	30.34	18	0.0762	1.6058	9.864	47.5
658	28.99	9.6	0.0953	1.4105	9.864	47.5
668	18.39	7.1	0.0851	0.9331	7.891	49
678	0.0	2.5	0.1053	0.6293	2.712	13.25
688	0.07	2.5	0.1472	0.6944	2.959	12.5
698	0.026	2.9	0.1167	0.7812	2.548	7
708	0.078	2.0	0.0508	0.2821	1.068	3
718	0.0175	2.4	0.0533	0.3689	1.068	3.75
728	0.035	3.0	0.0588	0.4557	0.9864	3.75
738	0.0	2.9	0.1447	0.7812	3.288	9
748	0.578	3.7	0.0901	0.6076	2.055	7
758	1.42	0.79	0.0446	0.4123	0.9864	13.5
768	0.897	10.1	0.0622	0.5642	1.4796	8.5
778	2.34	8.6	0.118	0.6293	3.0414	15
788	0.876	8.4	0.08	0.6293	2.3016	10
798	13.49	12.6	0.1067	1.2586	8.1378	57.5
808	19.45	13.6	0.0826	1.1501	7.398	60
818	5.518	10.8	0.108	0.8246	4.932	40
828	22.6	10.2	0.0749	1.2152	7.7268	65
838	1.35	9.8	0.0736	0.4557	1.9728	14
848	2.67	8.7	0.0558	0.5642	1.0686	11.75
858	2.19	1.16	0.1117	0.3906	1.3152	11.25

The first shows the percentages of Ca CO_3 plotted against depth. There are three peaks evident on the graph at 608 cms (70.88%), 648 cms (30.34%) and at 828 cms (22.6%). The percentage of Ca CO_3 varies between zero and 70%.

Fig (7.14) shows the percentage of carbon against depth. Carbon percentages reach a maximum at 598 cm (45.33%). Lower percentages occur between 678 cms and a minimum at 758 cms (0.79%). There is a secondary peak centred on 808 cms (13.6%).

On fig (7.15) the data for potassium is displayed. The plotted curve is very erratic, oscillating about the mean of 0.087 meq. The minimum value is at 608 cms (0.0406 meq) and the maximum at 688 cms (0.14732 meq).

The pattern of fig (7.15) for sodium is clearer with two maxima at 648 cms (1.6058 meq) and 798 cms (1.2586 meq) and a minimum at 708 cms (0.2801 meq).

The graph for magnesium exhibits a markedly similar trend to that for sodium. The two peaks are at 648 - 658 cms (9.864 meq) and 798 cms (8.1378 meq) with the lowest value of (0.9864 meq) at 728 cms.

Finally on the calcium graph there are three maxima at 608 cms (80%), 668 cms (49%) and 828 cms (65%). The lowest value for calcium is at 708 cms (3%).

Examining the graphs in conjunction with the stratigraphy it may be seen that the high values for calcium carbonate and calcium, as might be expected, correspond with parts of the core where calcareous marl was recorded. High percentages of carbon are present where there is peat or gyttja and low percentages in the minerogenic clays. As previously noted there is no obvious pattern in the potassium curve but sodium and magnesium are present at low values in the minerogenic sediments and at high values in the organic.

In table 7.5 below is presented the lower half of a symmetric matrix containing the Pearson correlation coefficients for the chemical variables. Examining the correlation coefficients confirms that there are significant high positive correlations for magnesium and sodium (0.97), calcium and calcium carbonate (0.75), calcium and magnesium (0.73), calcium and sodium (0.69), sodium and calcium carbonate (0.61) and for magnesium and calcium carbonate (0.61). There are also moderate positive correlation coefficients significant at the 0.1% level for sodium and carbon (0.56) and for magnesium and carbon (0.56) suggesting that there may be a relationship between these variables. Potassium records very low correlation coefficients with all other chemical variables.

Table 7.5 Correlation matrix for chemical variables:

(1)	1.00					
(2)	-0.08	1.00				
(3)	-0.28	-0.01	1.00			
(4)	0.61	0.56	0.13	1.00		
(5)	0.61	0.56	0.12	0.97	1.00	
(6)	0.75	0.16	-0.06	0.69	0.73	1.00
	(1)	(2)	(3)	(4)	(5)	(6)

(1) = Calcium carbonate

(2) = Carbon

(3) = Potassium

(4) = Sodium

(5) = Magnesium

(6) = Calcium

On the fig 7.16 plots of the scores on the first three principal components, which account for 94.3029% of the initial variance , have been plotted. On the plot of sample scores on the first principal component, which has high positive loadings for Ca CO_3, Na, Mg and Ca (table 7.6, fig 7.17) the distinction between minerogenic and organic samples may be observed. The relationship is, though, the inverse of what would be expected from the findings of Mackereth (1965, 1966) as already outlined. A similar observation was made by a previous research worker at Edinburgh (Walker, 1974). It is thought by the

BALGONE HOUSE - PRINCIPAL COMPONENTS

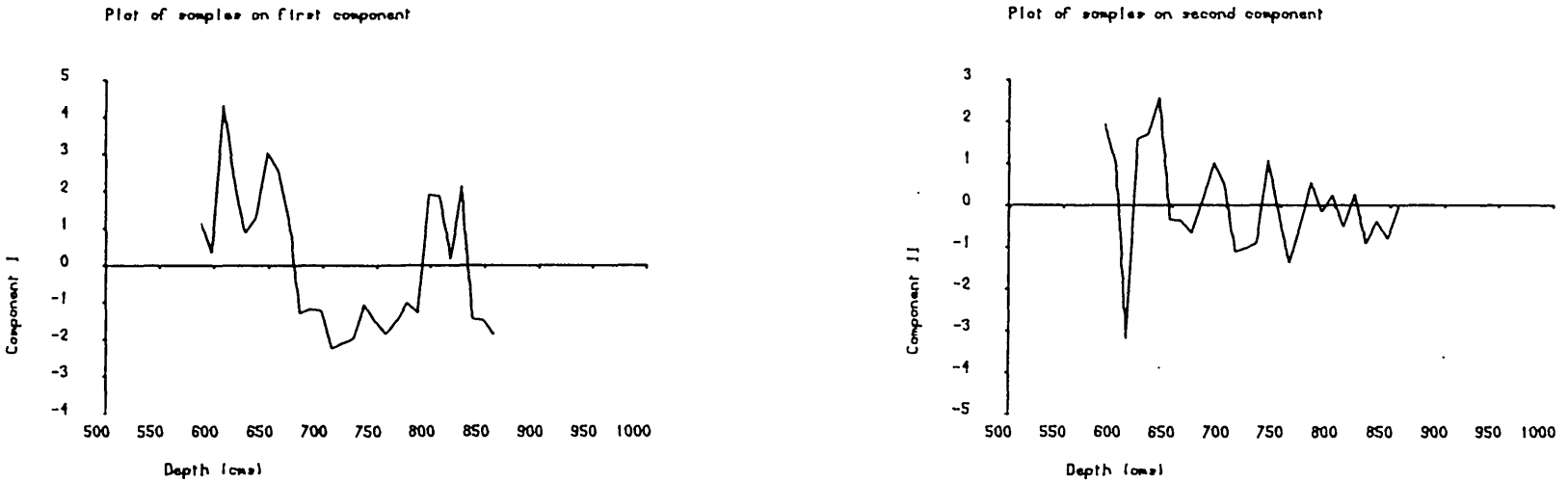
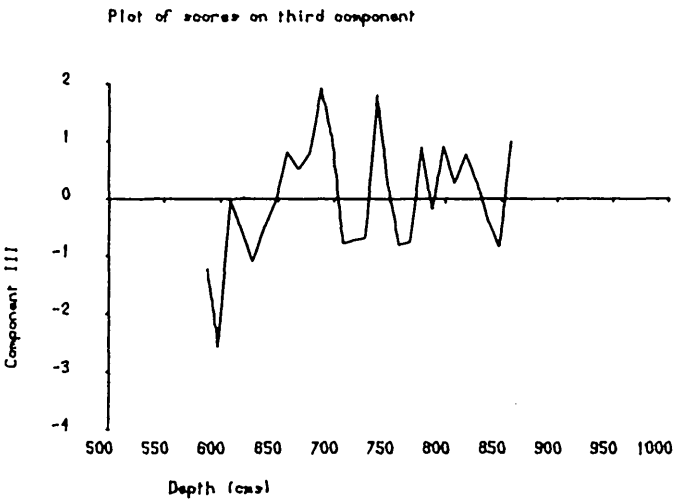


Fig 7.16 Plots of scores on first 3 components for chemical data.



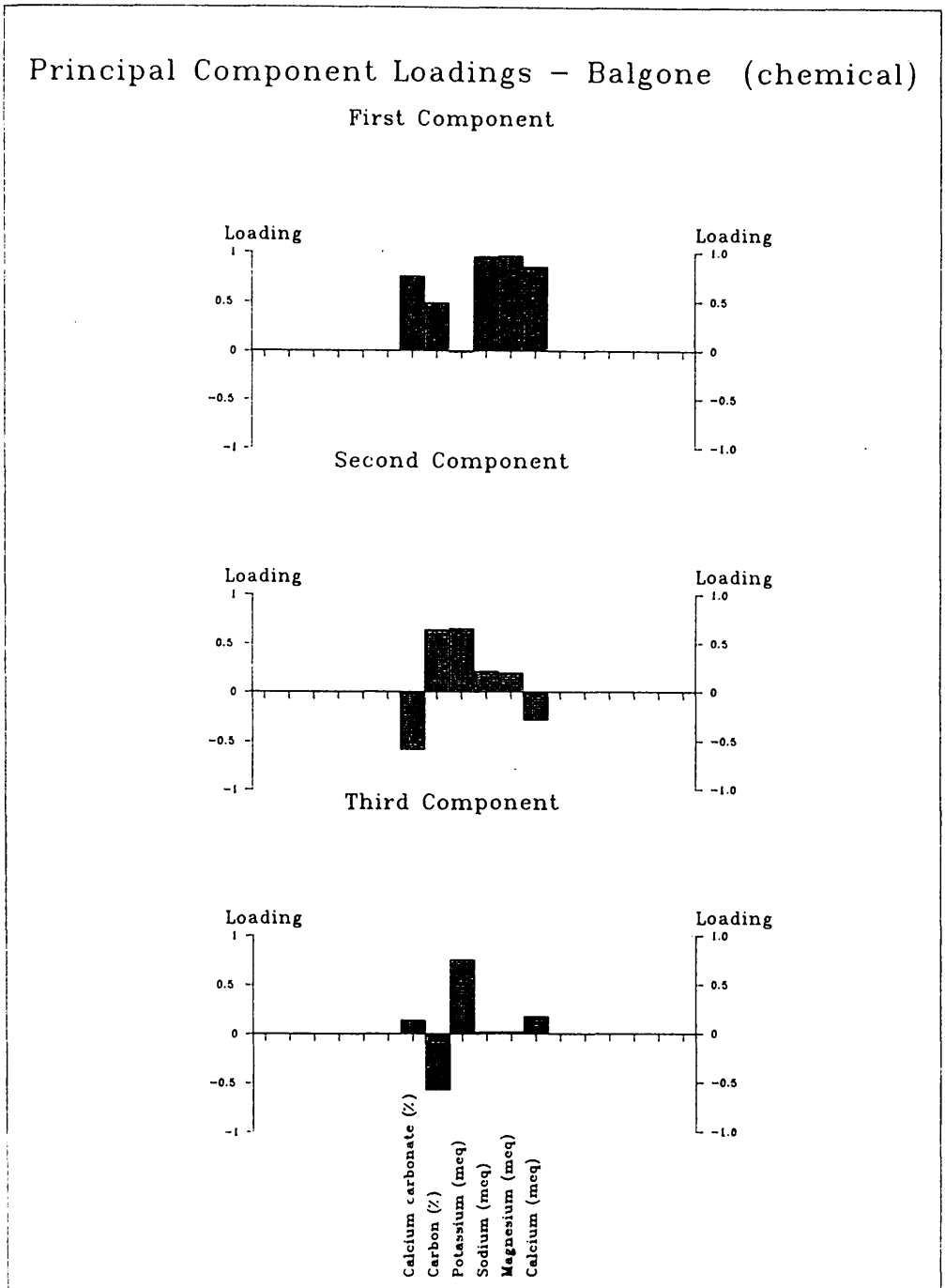


Fig 7.17 PCA loadings on first 3 components for chemical data.

BALGONE HOUSE - PRINCIPAL COMPONENT LOADINGS (Chemical data)

	Components				
	I	II	III	IV	V
Calcium carbonate	0.7520	-0.5904	0.1374	-0.1955	-0.1691
Carbon (%)	0.4857	0.6407	-0.5738	0.0742	-0.1371
Potassium	-0.0118	0.6520	0.7540	0.0039	-0.0787
Sodium	0.9539	0.2082	0.0175	-0.1610	0.0843
Magnesium	0.9639	0.1924	0.0193	-0.0827	0.1155
Calcium	0.8503	-0.2864	0.1751	0.4050	0.0013
Eigenvalue	3.3635	1.3466	0.9481	0.2405	0.0740
% of trace	56.0589	22.4428	15.8012	4.0086	1.2336
Cumm % of trace	56.0589	78.5017	94.3029	98.3115	99.5450

Trace = 6.0

Table 7.6 PCA results for chemical data.

present author, examining the details of the chemical preparation given by Mackereth (*op. cit.*), that the likely explanation is that Mackereth totally decomposed the mineral matter in his samples in hydrofluoric acid (HF) overnight thus releasing the sodium and potassium content of the mineral matter in the sediment. The standard preparation employed in this research and outlined in a previous chapter, on the other hand, merely leaches out the sodium and potassium content of the organic fraction of the sediment.

7.9 Conclusion:

The deposits at Balgone House provide a detailed picture of the vegetation changes from deglaciation around 13,000 BP to approximately the mid - Postglacial. The most important feature of the site is the evidence that it provides for a phase of retrogressive vegetation development in the Lateglacial Interstadial.

CHAPTER 8

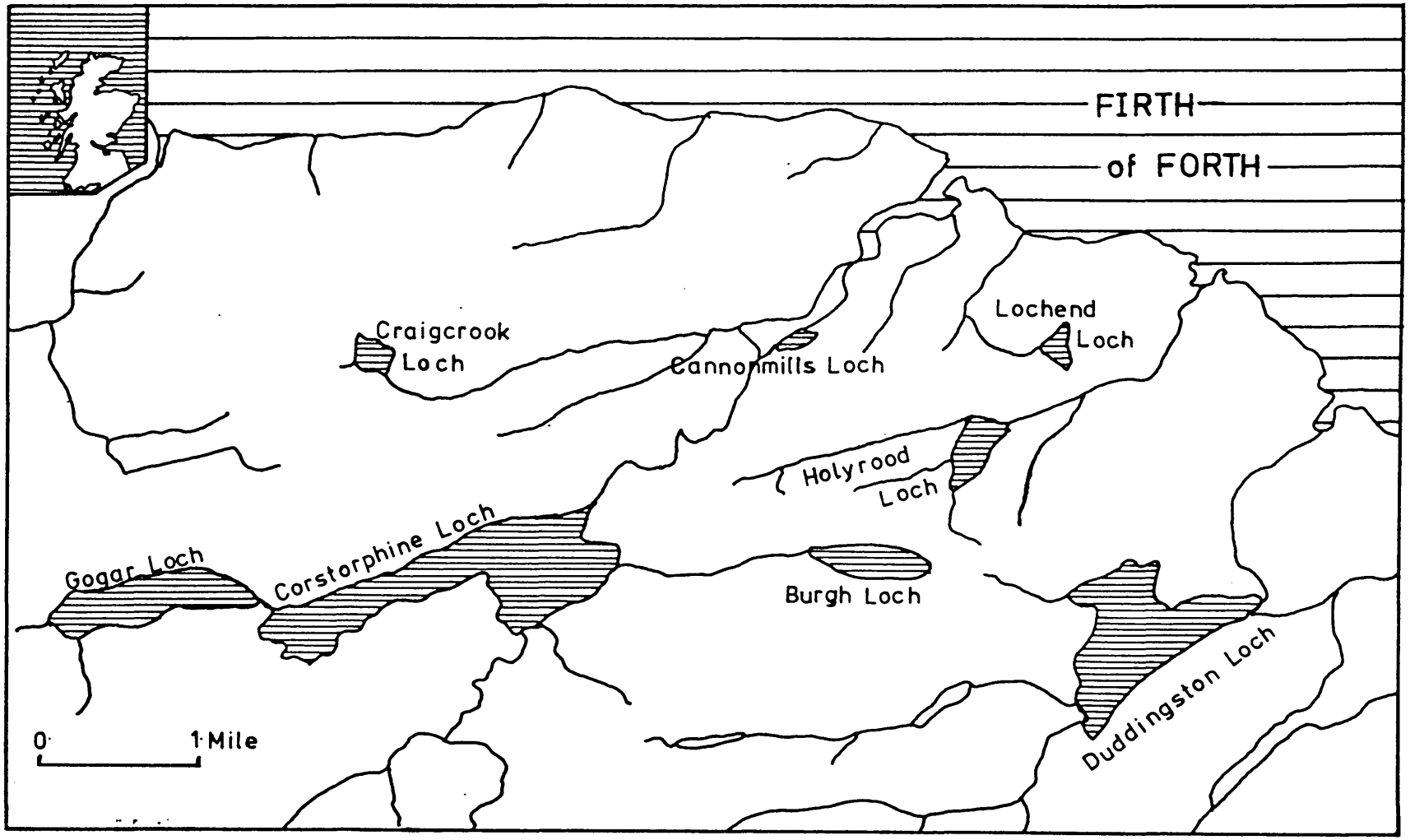
CORSTORPHINE site:

8.1 Introduction

The third site to be investigated was at Corstorphine in western Edinburgh. The lacustrine deposits of the former Corstorphine Loch, the extent of which was satisfactorily mapped by Cadell (1913) before the area was built over, map 8.1, lie within a broad glacially-eroded trough that trends west to east. The loch formerly stretched from Haymarket to Broomhouse where it was separated from the Gogar Loch by a ridge of till. Corstorphine Loch existed until quite recently appearing on early maps. The loch was partially drained and reclaimed in 1670 by digging the Stank drainage ditch with the final reclamation taking place in 1837 when the Stank was deepened and enlarged to prevent flooding. The Gogar Loch was drained in 1766.

8.2 Previous work on the sediments of the former Corstorphine Loch

Several workers have studied the stratigraphy and the preserved plant and animal remains in the deposits of the former Corstorphine Loch. The earliest work was that of Bennie (1891, 1894) who described the sequence of sands/silts, clays and organic layers with abundant shell and arctic plant fragments and seeds, that lay upon a bed of fine red laminated clay which in turn rested upon sand and boulder clay. A series of sections was later described in more detail by Tait (1934) and mention is made of grey shelly marls with



Map 8.1 Map showing extent of Edinburgh lochs in early Postglacial period.

plant remains and of the finding of an antler of Cervus giganteus. Reid (1899) identified plant fragments obtained from the 'Arctic Plant Beds' described by Bennie and affirmed that they were of Lateglacial age. Coope (1968) examined the Coleoptera collected by Bennie and, after pointing out that they consist only of large conspicuous animals picked out by eye, suggests that they are indicative of a marshy environment under sub-arctic conditions.

This previous work has shown that the lacustrine deposits consist of two organic horizons: the lower being marls, clays and silts of Lateglacial age and the upper thin muds and silty layers + peats dating from the Postglacial phase of the loch. Sandwiched between the two organic layers are beds of sand and gravel that Sissons (1967) suggested represent floodwater deposits of the Water of Leith which entered the loch at its eastern end, since gravels predominate in the east and farther westwards the minerogenic layer thins out and red-yellow sands that are current-bedded in places and waterlaid become more important.

Newey (1965) made detailed stratigraphic and pollen analytical investigations at sites in the Corstorphine area. Samples from peats, organic muds and silts resting upon the sand and gravel horizon at Gogar (NT181725) and Carrick Vale golf course (NT214727) were analysed and found to be of Postglacial age.

At Gogar two distinct phases of deposition are indicated. Peat and lake muds were laid down during the early Postglacial, then deposition ceased until the late Postglacial when the site was once

again covered by water and a younger deposit was formed. The peat from the Carrick Vale site dates from a late phase of deposition and exhibits similar pollen assemblages to the younger part of that from Gogar. It appears that at this time the lake was bordered by birch and alder woodlands and was fringed with sedge and reeds.

At Meadowhouse Road, a section was exposed in a temporary excavation (NT201727); this site lies near to the centre of the old lake as mapped by Cadell (1913), and the tripartite stratigraphic division of the deposits there resembles that from other British Lateglacial sites. The lowest deposit is a red clay, above which there are calcareous muds with abundant plant fragments and at the top, silts and clays. In the top layers of silts and clays the pollen and spores are mainly of species characteristic of sub - arctic or open conditions, such as Artemisia, Chenopodiaceae, Compositae, Thalictrum and Selaginella selaginoides, characteristic of open soil conditions with few or no trees. Below this in the calcareous marls tree pollen, although still scarce, rises from 10 - 11 % to approximately 30% suggesting warmer conditions. Betula pollen attains its highest values whilst Gramineae and Cyperaceae decline. In the lowest deposits there is little but Cyperaceae pollen suggesting a different climatic regime with colder conditions and a very sparse vegetation.

8.3 The work by Newey at Corstorphine

The only published Lateglacial pollen diagram for the Lothians

is that of Newey (1970). He reports the results of an investigation of the stratigraphy, pollen and other organic material of samples taken using a Hiller borer from deposits at a site near the Stank drainage ditch at the edge of the Carrick Vale golf course (NT210727). As reviewed in an earlier chapter, the deposits demonstrate the herbaceous dominance of the vegetation during the Lateglacial, although higher tree pollen percentages along with other organic and stratigraphic evidence do suggest warmer conditions in the middle of the period. Dr. Newey has provided the writer with his pollen counts from this investigation and these were coded up and processed by the POLLDATA, ZONATION, PCA and MDS(X) programs so that they might be more easily compared in this standard form with the results from the writer's other two sites: Broxmouth and Balgone House.

The stratigraphy of the site as outlined by Newey (1970) is given below:

Centimetres from surface

0 - 45 Disturbed peaty clay

45 - 85 Clay with bands of sandy and coarse gravelly material

85 - 130 Brown - grey silty clay and sandy clay with finely - comminuted shells

130 - 295 Brown - grey clay with thin layers of silt or sand

295 - 325 Grey clay with shell fragments

325 - 342 Dark - grey marl (black between 334 and 338 cm) with shell and plant fragments

342 - 450 Dark - grey clay marl with shells and plant fragments

450 - 490 Grey clay marls and silty clays with fine shell fragments

490 - 560 Grey marl with shells and plant fragments

560 - 575 Grey - black clay - marl with shells and plant fragments

575 - 595 Pink - grey clay

595 - 610 Pink clay

610 - 620 Very stiff pink clay with shell fragments

The pollen counts have been expressed as percentages of the total sum excluding pollen of aquatic species and spores. On the diagram (Fig 8.1) the features described by Newey (op cit) may be clearly seen. To recap briefly with additional comments:

In the basal two samples, from the pink and the grey - black clay

marl respectively, Cyperaceae and Gramineae pollen account for almost 70% of the total. Making up the remainder of the herbaceous pollen are low percentages of Artemisia, Caryophyllaceae, Compositae, Filipendula, Succisa pratensis, Umbelliferae and Urtica. There is also a trace of Myriophyllum alterniflorum with spores of Selaginella selaginoides. Secondarily - derived Carboniferous - type spores attain almost 600% of the pollen sum at this level. The percentages of tree pollen are very low, at around 8% of the total, most of which is Pinus, that has probably been transported over long distances. The high level of secondarily - derived Carboniferous - type spores and the low pollen content noted suggest that these deposits have been formed as a result of solifluction and overland wash and reflect a severe climate.

Moving up into the calcareous marls, from about 550 cm, tree pollen frequencies represented by Betula, some of which is identified as being Betula nana, rise quite sharply. There is a second peak in Betula between 330 and 360 cms that is not, however, accompanied by a corresponding rise in Salix, as it is further down. The shrubs Juniperus and Empetrum both first appear at around 530 cm and Empetrum in particular shows increasing percentages up to about 320 cm, probabaly in response to the podsolisation of the soils and the development of heath. The predominant pollen is that of herbaceous species especially Gramineae and Cyperaceae along with pollen of open - habitat species such as Artemisia, Galium, Rumex, Thalictrum and that of the thermophilous Filipendula and Helianthemum. The aquatics Myriophyllum alterniflorum and Potomageton are also present. The secondarily - derived Carboniferous - type spores have declined to

comparatively low levels suggesting more stable soils that may have been base - rich as is evidenced by the low counts of Helianthmum (Proctor and Lambert, 1961).

Between the two maxima in the tree pollen the herbaceous species reach their highest values in the calcareous marls, at over 85% of the total pollen sum. This relates to a slight stratigraphic change with a higher proportion of silt in the samples and also of secondarily - derived Carboniferous - type spores suggesting renewed inwash into the lake. Artemisia rises to almost 15% of the total and other open - habitat light - demanding species such as Galium and Rumex are also recorded as having higher percentage frequencies. The presence of Filipendula and higher levels of Cyperaceae may suggest an increased area of marshy habitats. The counts of Pinus and Ephedra both rise and may be a result of a greater influx of long distance transported pollen at a time of lower production of pollen locally. As Newey (op. cit.) points out there is, however, no consistent evidence for a climatic change.

At the boundary with the silty and sandy clays, at about 320 cms, there is a sharp decrease in the percentage of Betula, Salix increases from about 4% to around 8% of the total presumably as the increases in the areas of late snowbed communities, (of which Salix herbacea is an important component), and of disturbed ground. The dominance of non - tree pollen is reasserted. Gramineae and Cyperaceae were the most important constituents of the vegetation, which also included representatives of Compositae and Umbelliferae together with Rumex, Urtica and Empetrum. These along with B. nana

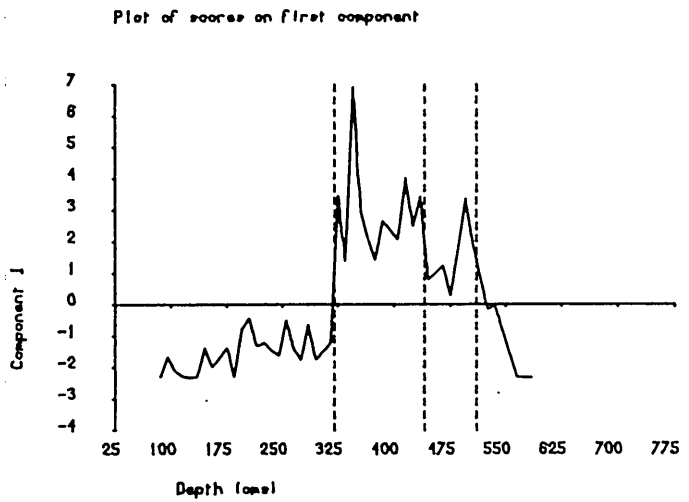
emphasise the open character of the vegetation. The secondarily - derived Carboniferous - type spores again reach their former high percentages and with the sharp decline in Empetrum frequencies reveals renewed soil movement and the disappearance of the heath communities.

8.4 Objective zonation of Newey's Corstorphine data

Newey (op cit) distinguishes two zone boundaries on his diagram; one at 350 cms and the other at 550 cms. The three zones, as delimited, are then equated with Godwin's (1956) zones I, II and III.

Newey's data has been objectively zoned using the programs in ZONATION, PCA and MDS(X) previously described. The following eighteen pollen and spore types, which all reached values of over 5% in at least one level in the diagram, were used: Betula, Salix, Juniperus, Empetrum, Gramineae, Cyperaceae, Artemisia, Caryophyllaceae, Compositae, Filipendula, Galium, Helianthemum, Rumex, Thalictrum, Urtica, Myriophyllum, Selaginella and secondarily - derived Carboniferous - type spores. The Carboniferous - type spores were included because, although they are not contemporaneous with the rest of the pollen and spores, they represent an important indicator of sedimentary conditions as well as forming a substantial proportion of the identified spores at any level. The results are presented on Figs 8.2, 8.3, 8.4 (8.12) and the principal component loadings are tabulated in table 8.1.

Corstorphine - Principal Components (WWN)



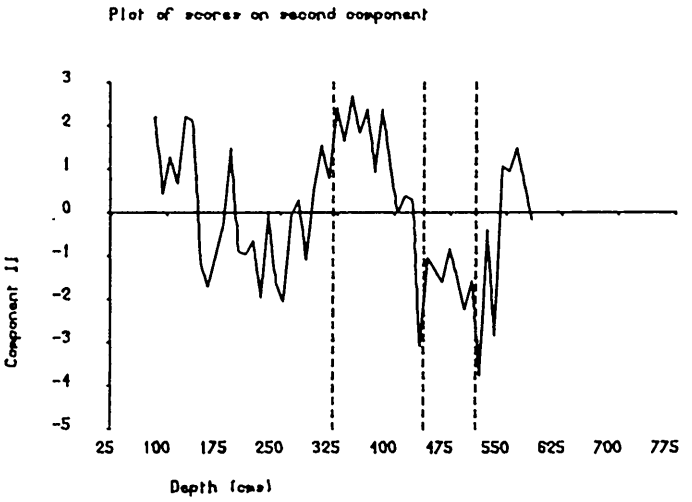
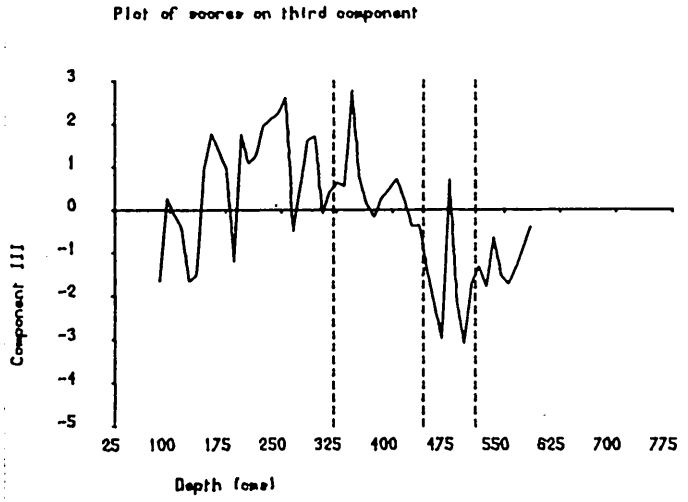


Fig 8.3 PCA results (WWN).



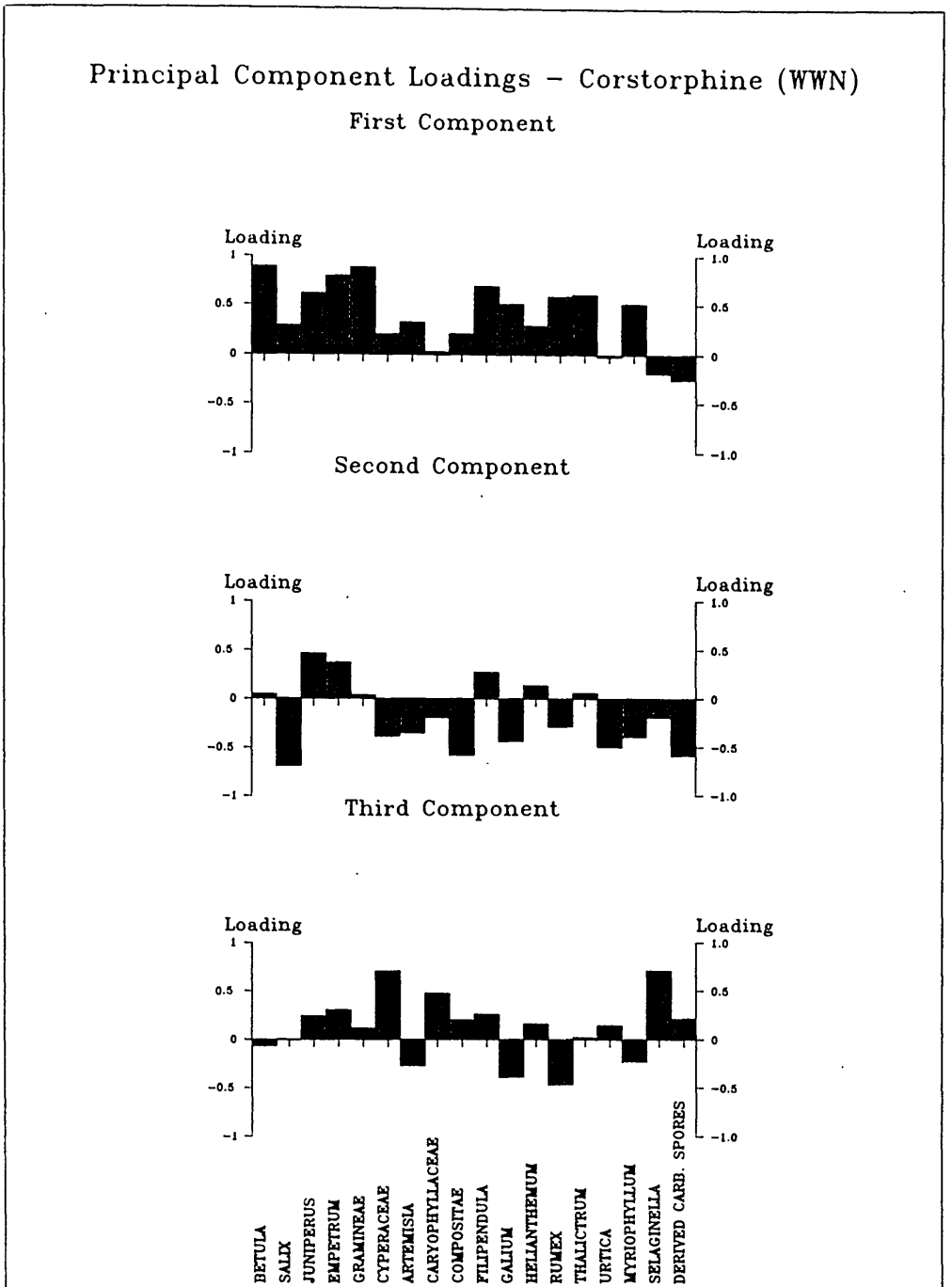


Fig 8.12 Loadings on first 3 components for Corstorphine (WWN).

Corstorphine Principal Component Loadings (WWN)

	Component				
	I	II	III	IV	V
Taxon					
Betula	0.8896	0.0485	-0.0646	0.1729	0.0308
Salix	0.2889	-0.6934	-0.0037	-0.0188	0.0009
Juniperus	0.6108	0.4642	0.2424	-0.0258	0.2480
Empetrum	0.7910	0.3693	0.3034	0.1602	-0.1615
Gramineae	0.8796	0.0358	0.1140	-0.1969	0.0646
Cyperaceae	0.2040	-0.3831	0.7017	-0.1387	0.3310
Artemisia	0.3237	-0.3488	-0.2716	0.1301	0.1430
Caryophyllaceae	0.0291	-0.1912	0.4742	-0.5421	-0.2907
Compositae	0.2089	-0.5804	0.1993	0.0161	-0.4211
Filipendula	0.6880	0.2708	0.2592	0.3458	-0.0351
Galium	0.5066	-0.4355	-0.3910	-0.2373	0.1446
Helianthemum	0.2901	0.1332	0.1598	0.4448	-0.6290
Rumex	0.5848	-0.2841	-0.4668	-0.0901	-0.0296
Thalictrum	0.6015	0.0569	0.0191	-0.5364	-0.0726
Urtica	-0.0186	-0.4949	0.1456	0.5437	0.4331
Myriophyllum	0.5111	-0.3904	-0.2277	0.1742	0.0405
Selaginella	-0.1898	-0.1865	0.7072	0.0370	0.2892
Derived					
Carboniferous	-0.2556	-0.5845	0.2142	0.1205	-0.4342
Spores					
Variance	4.7191	2.6149	2.0795	1.4372	1.3699
(eiginvalue)					
Percent of total					
variance	26.2182	14.5279	11.5532	7.9846	7.6108
Cummulative					
Percent of total variance	26.2182	40.7461	52.2993	60.2839	67.8947

Total variance (trace) = 18.0

Table 8.1 PCA results for Corstorphine (WWN)

Corstorphine MDS(X) (WWN)

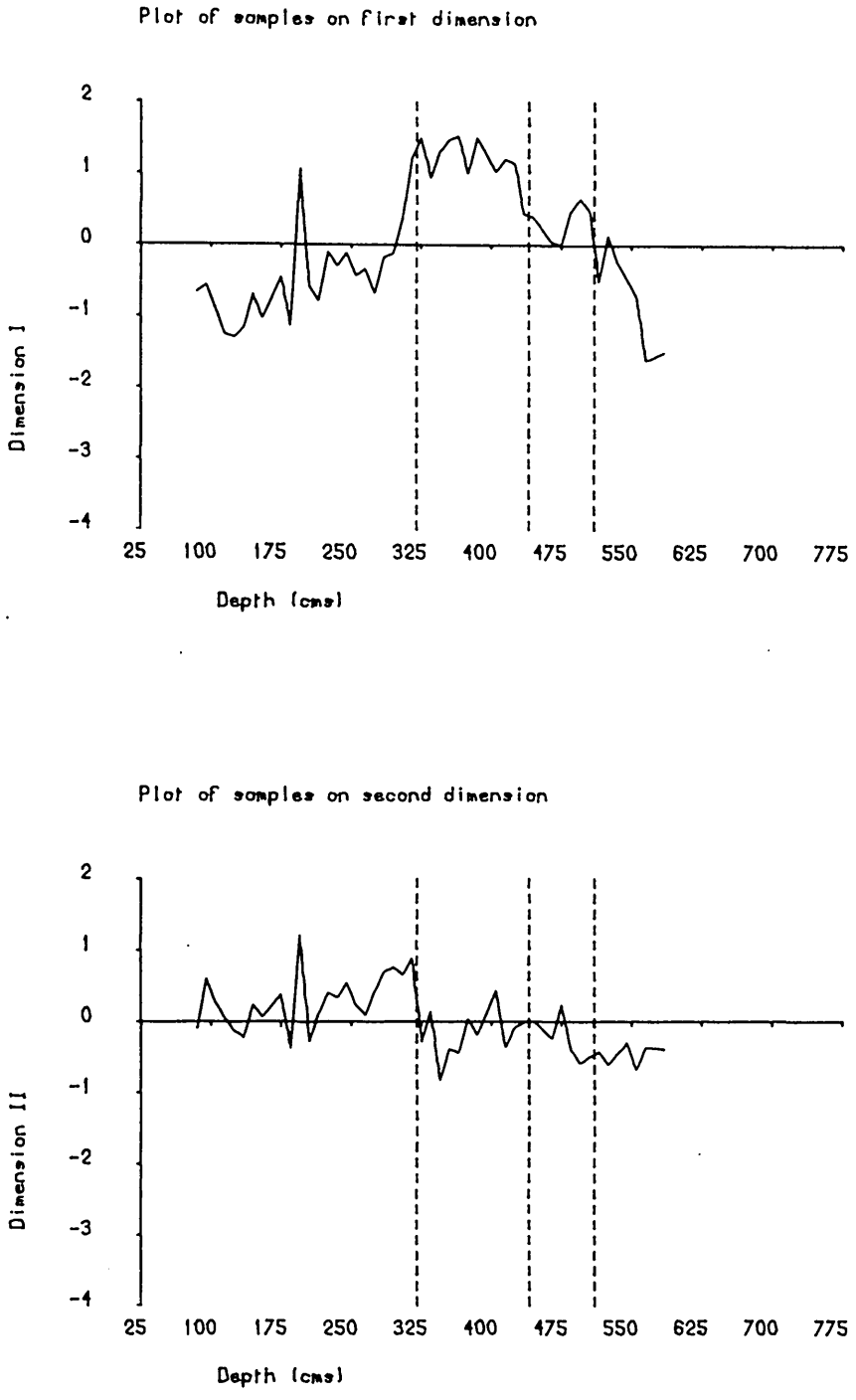


Fig 8.4 MDS(X) results (WWN)

SPLITINF and SPLITSQ divide the diagram into two parts at 320 and 310 cms respectively, while CONSLINK distinguishes two major groups of samples; those above 320 cms and those below. The discrepancy between the results from the SPLITINF and SPLITSQ programs is probably a function of the differing algorithms, previously described (p 56), employed by each method in splitting up the data to create zones. This corresponds to the Lateglacial Stadial boundary / Lateglacial Interstadial boundary. PCA and MDS(X) also identify this major boundary by sharp changes in the trend of the curves on the stratigraphic plots. The principal component plots show the nature of the transition between zones. The transition between the Lateglacial Stadial sediments and the Lateglacial Interstadial sediments at Corstorphine is thus very sharp. The delimitation of the zone in the mid - Lateglacial Interstadial sediments is also equally clear. In particular this is evident on the plot of the scores on the first principal component, which accounts for 26.22% of the total variance, and has high positive correlations with Betula, Juniperus, Empetrum and Filipendula reflecting the distinction between the richer tree, shrub and herbaceous cover of the Lateglacial Interstadial and the more open species - poor conditions in the Stadial. CONSLINK identifies a series of levels between 510 cms and 440 cms as forming a clear group. The second major split by SPLITINF occurs at 440 cms and by SPLITSQ at 510 cms. PCA and MDS(X) also separate out these levels. They have already been pointed out as coming between the two Betula maxima in the Lateglacial Interstadial and are quite different stratigraphically and biostratigraphically. The objective zonation techniques therefore confirm that these levels are quite distinct.

The samples that Newey (op cit) analysed were, as has already been stated, collected using a Hiller borer. It is well - known that the Hiller has disadvantages. It is difficult to obtain uncontaminated samples using this type of coring instrument since the chamber is not sealed. It is thus possible for younger material to leak into it contaminating older deposits. Sediment and plant fibres catching on the fin as it travels downwards can also become incorporated. The Hiller has added drawbacks in the problems of keeping the chamber clean; churning of the sediment sampled, which masks minor stratigraphic changes; and of having to remove samples for analysis in the field. The end result is that the final pollen diagram may be distorted by the 'smearing - out' of the peaks of the more abundant pollen types.

8.5 Corstorphine site re-investigation and stratigraphy

It was decided, therefore, to re - sample the site using the improved corer - the Dachnowski - that was used to core the other two sites, so that it could be studied in more detail. Employing the Dachnowski corer to sample the site and transporting the cores taken back to the laboratory for examination allowed for a more detailed and accurate description of the deposits compared with the immediate - in the field - description made by Newey (1970). Following Dr. Newey's guidance, a core was taken from a point, as close as possible to the original sampling site. In the intervening years the Stank drainage ditch, from the banks of which the original core samples were taken, had been infilled and culverted. It was relatively

straightforward to trace the line of the original ditch. An augur was used to penetrate the two metres or so of shale that had been used to fill it and also the coarse sands and gravels, already referred to, that lie above the Lateglacial sediments. A Hiller borer was then used to verify the stratigraphy before the actual coring began. This revealed that the Lateglacial sediments had not been disturbed by the engineering work.

The stratigraphy recorded for the site sampled at Corstorphine is as given below:

Cms depth from surface

0 - 205 Disturbed material and fill consisting of broken shale and coarse sands and gravels

205 - 257 Brown - grey clay with sand and organic laminations at 228 / 229 cms. Increasing sand content from 233 cms.

257 - 298 Reddish - brown clay with silty bands

298 - 380 Brown - grey tenacious clay

380 - 384 Coarse sand and thick grey clay with shell fragments

384 - 473 Yellow calcareous marl with faint laminations between

473 - 478 Yellowish / green calcareous marl with abundant Characeae

478 - 523 Olive - green clayey marl (black when fresh)

523 - 533 Yellowish - green calcareous marl cf. 473 - 478

533 - 568 Yellow calcareous marl and broken shells

568 - 614 Greenish - grey clayey marl - increasing proportion of clay with depth. Shells and plant fragments present.

614 - 673 Olive - green clay with faint yellow laminations

673 - 673.5 Fine sand

673.5 - 690 Red -brown clay - faintly laminated

Comparing this stratigraphy record to that already given for Newey's site above it may be seen that they are quite different in detail though a similar series of deposits is noted in each. Of most interest is the stratigraphy between 478 - 523 cms where an olive - green marl is recorded as being sandwiched between two light yellowish - green coloured calcareous marls. There is no doubt that this is a genuine stratigraphic change since this sequence was taken in the one core sample and was not therefore a feature of

stratigraphic changes over the short distance (1 - 2 metres) between the two boreholes used for taking the alternate core samples.

8.6 Objective zonation of diagrams

As far as was possible a pollen sum, that included land - based taxa, of 300 grains was counted at the 50 levels sampled. Pollen tablets (Stockmarr, 1972) were added to each sample so that the concentrations of pollen could be calculated. Both percentage pollen and pollen concentration diagrams have been drawn up for the site (figs 8.5, 8.6).

The percentage diagram has been calculated on the basis of total land pollen excluding aquatics and spores. Secondarily - derived Carboniferous - type spores which appeared as yellow - green and were trilete, were recorded separately as an indicator of erosion in the catchment and fig 8.7 graphs their relative abundance as a percentage of the pollen sum. The percentage data has been objectively zoned, using ZONATION, PCA and MDS(X), and the results are presented on figs (8.8, 8.9, 8.10) 8.13 and in table 8.2. The following pollen types were used in the zonation, all of which accounted for at least 5% of the total pollen sum at one level or more: Betula, Salix, Juniperus, Empetrum, Gramineae, Cyperaceae, Artemisia, Caryophyllaceae, Compositae, Filipendula, Galium, Helianthemum, Rumex, Thalictrum, Umbelliferae, Myriophyllum, Selaginella, secondarily - derived Carboniferous spores. CONSLINK, SPLITINF and SPLITSQ, consistently identify the major subdivision in the diagram as occuring at 385 cms.

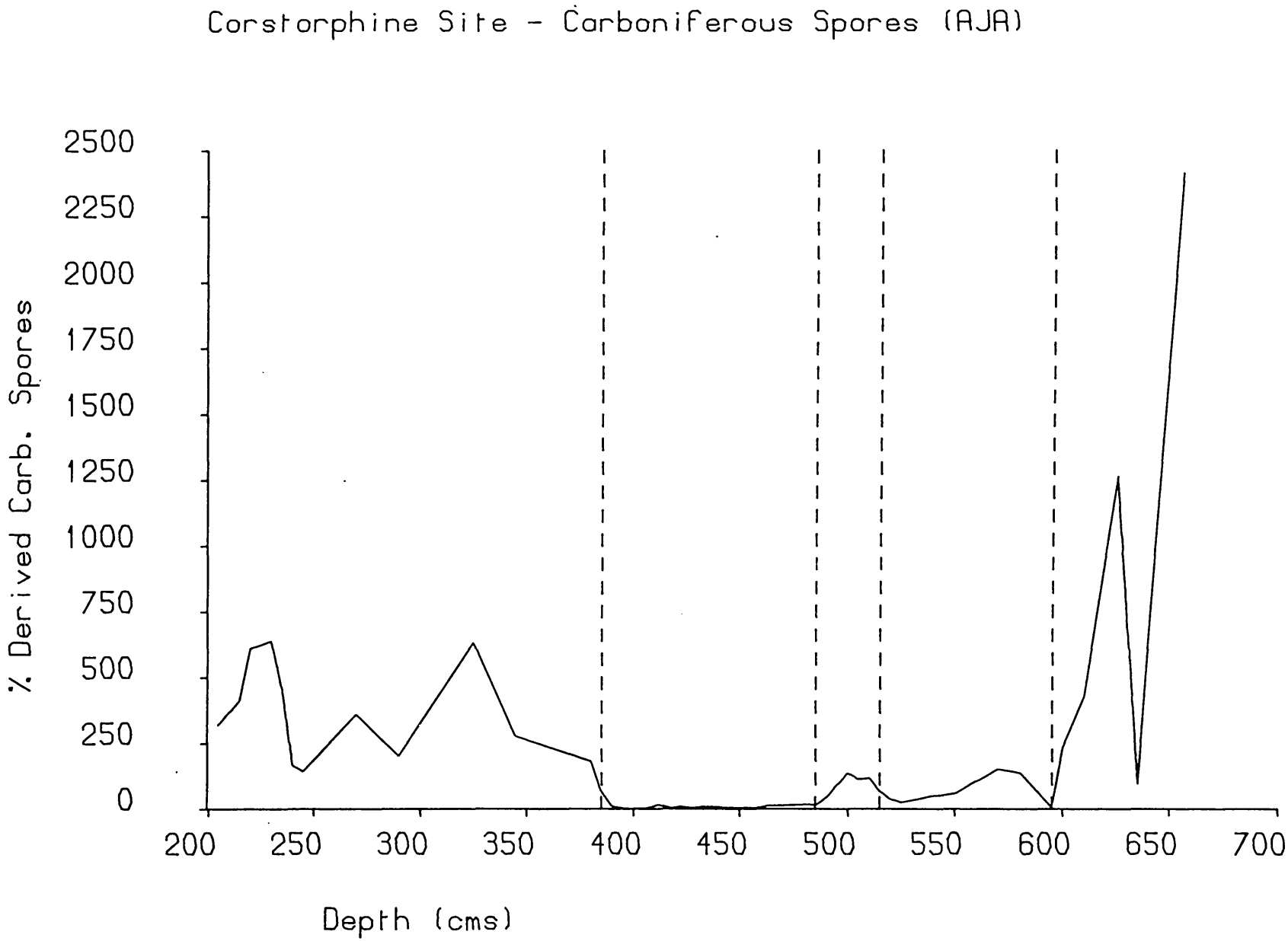
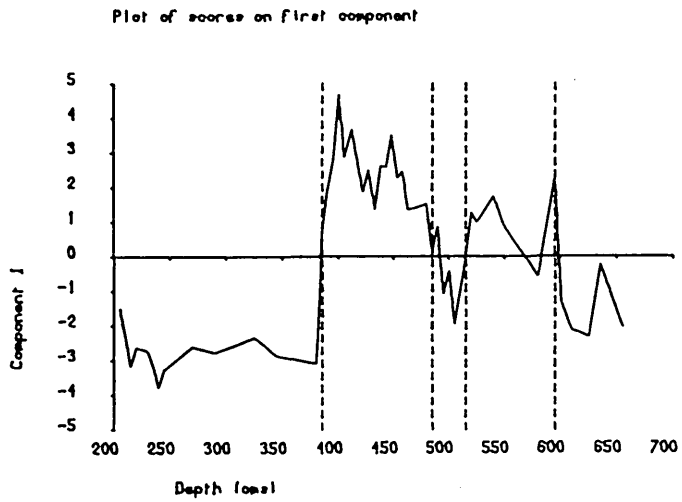
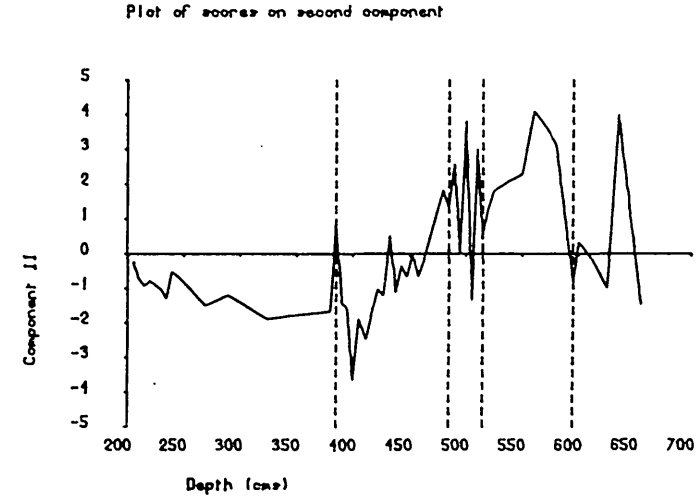


Fig 8.7 Percentage secondarily-derived Carboniferous-type spores.

Corstorphine - Principal Components (AJA)





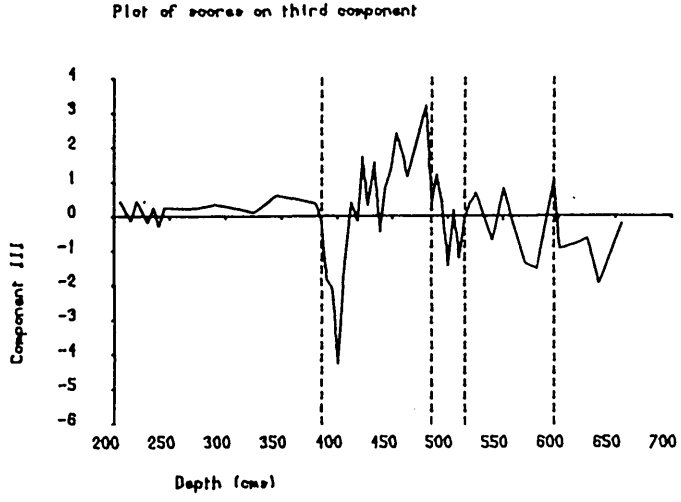


Fig 8.9 PCA results (AJA)

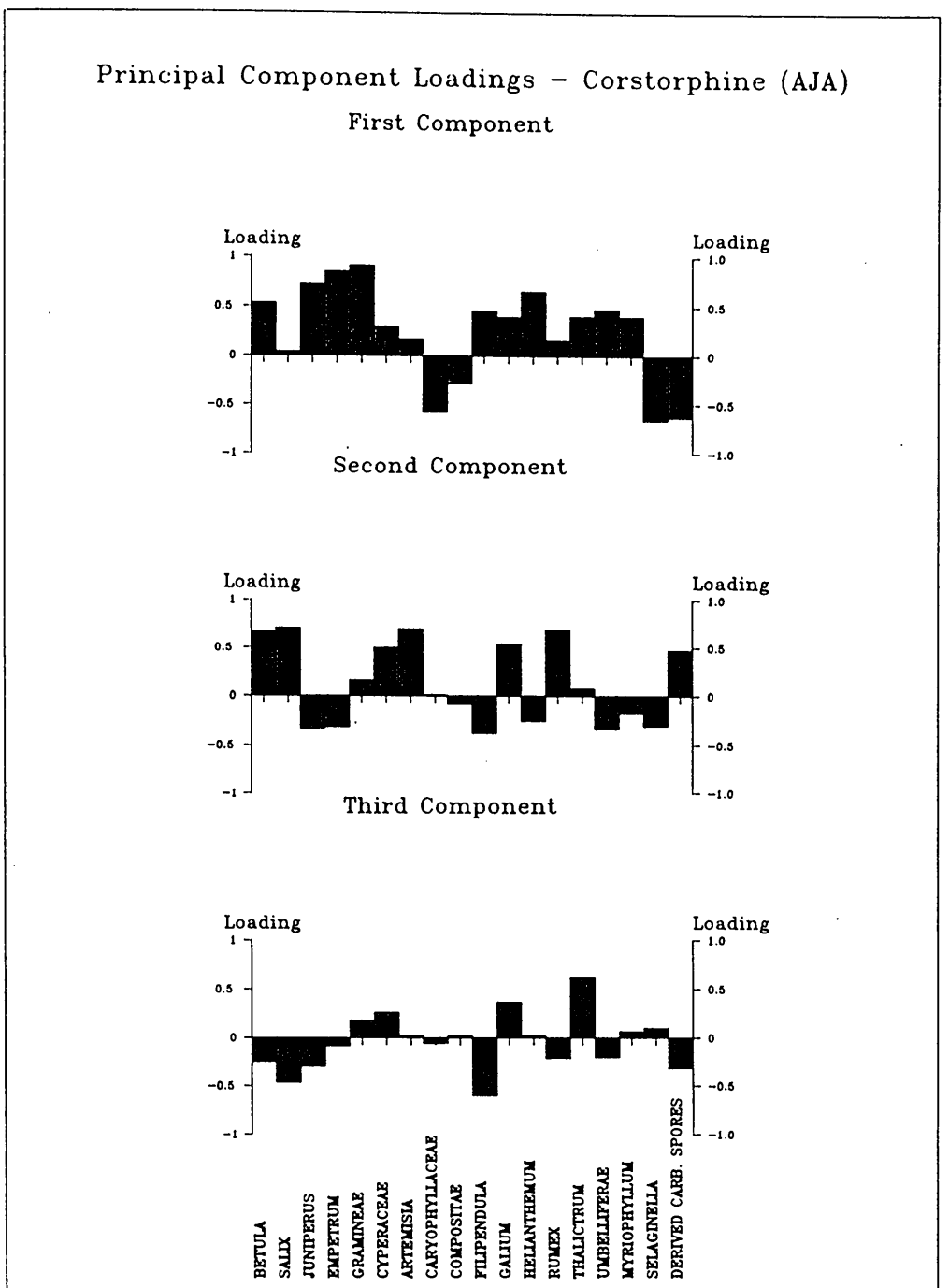


Fig 8.13 Loadings on first 3 components for Corstorphine (AJA)

Corstorphine Principal Component Loadings (AJA)

	Component				
	I	II	III	IV	V
Taxon					
Betula	0.5325	0.6673	-0.2497	-0.0341	-0.1182
Salix	0.0412	0.7046	-0.4662	0.0258	0.0341
Juniperus	0.7176	-0.3327	-0.2995	0.0994	-0.0650
Empetrum	0.8485	-0.3173	-0.0852	0.1306	0.1189
Gramineae	0.9069	0.1606	0.1801	0.0974	0.0234
Cyperaceae	0.2980	0.4980	0.2625	0.5441	0.1252
Artemisia	0.1720	0.6951	0.0273	0.0672	-0.2264
Caryophyllaceae	-0.5786	0.0101	-0.0574	0.6386	0.2023
Compositae	-0.2848	-0.0844	0.0218	0.3485	-0.2511
Filipendula	0.4583	-0.3799	-0.6018	0.1822	-0.2797
Galium	0.3986	0.5379	0.3690	0.0077	0.0116
Helianthemum	0.6527	-0.2561	0.0233	0.0091	0.2999
Rumex	0.1595	0.6885	-0.2150	0.1769	0.1263
Thalictrum	0.4033	0.0740	0.6174	0.1231	-0.3206
Umbelliferae	0.4752	-0.3273	-0.2041	0.3854	-0.1647
Myriophyllum	0.4011	-0.1697	0.0672	0.0309	0.7309
Selaginella	-0.6588	-0.3051	0.1003	0.5086	-0.0013
Derived Carboniferous spores	-0.6293	0.4741	-0.3193	-0.0171	0.2315
Variance (eiginvalues)	5.0766	3.3499	1.5669	1.3564	1.1070
Percent of total trace	28.2044	18.6112	8.7054	7.5360	6.1501
Cummulative percent of total trace	28.2044	46.8156	55.5210	63.0570	69.2072

Total variance (trace) = 18.0

Table 8.2 PCA results for Corstorphine (AJA)

Corstorphine - MDS(X) (AJA)

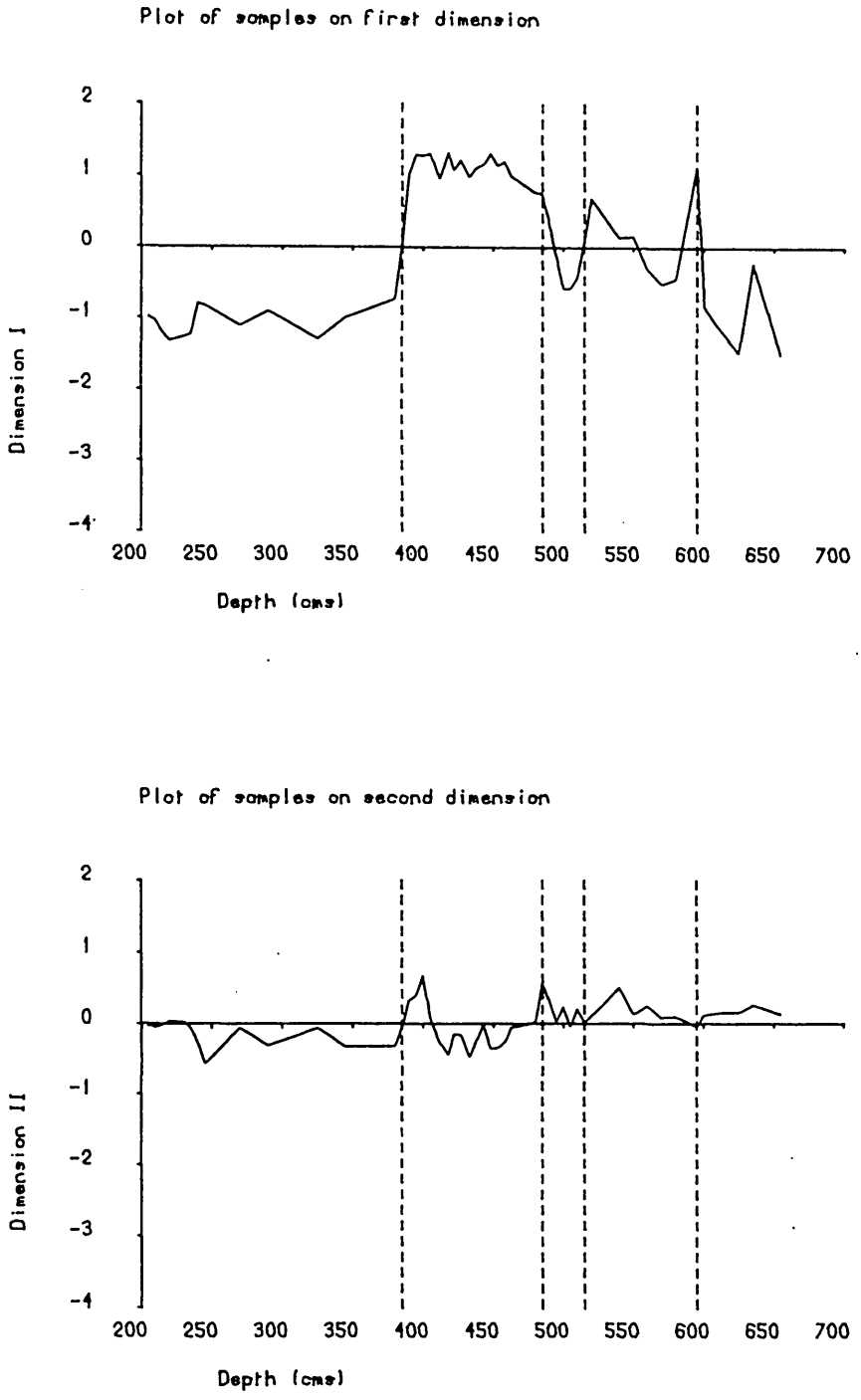


Fig 8.10 MDS(X) results (AJA)

The stratigraphic plots of the scores on the first three principal components and the MDS(X) curves conformed closely with this. Further down both SPLITINF and SPLITSQ mark the next most important split as being at 485 cms, just above a cluster of levels that CONSLINK separates out as forming a group. This group of levels is also distinguished on the PCA and MDS(X) plots. The SPLITINF and SPLITSQ programs are not consistent, however, in identifying a split immediately beneath these levels. The third most significant split that exists in the diagram is at 595 cms.

The first three principal components account for 55.521%, or over half of the total variance. Betula, Juniperus, Empetrum, Gramineae, and Helianthemum all have high positive correlations with the first principal component where Caryophyllaceae, Selaginella and secondarily - derived Carboniferous - type spores have significant negative correlations. This component represents 28.2044% of the total variance and reflects the distinction between levels with species from shrub, heath and herbaceous communities and those from open habitat vegetation on disturbed ground with indicators of soil instability. The second principal component accounts for 18.6112% of the variance and has high positive correlations with Betula, Salix, Artemisia, Galium and Rumex and indicates the relative importance of open - habitat herbaceous communities.

The third component, accounting for only 8.7054% of the total variance has a high positive correlation with Thalictrum and a high negative correlation with Filipendula and is less easy to interpret.

8.7 Description of local pollen assemblage zones

It was decided that the five zones picked out by the objective zonation techniques were the optimum number to retain to facilitate discussion of the main features of the diagrams (fig 8.5). The zones have been named COR I to V and the pollen assemblages are described below:

COR I Betula, Salix, Gramineae and Cyperaceae, Rumex 595 - 665 cms

Secondarily - derived Carboniferous - type spores account for up to 250% of the total pollen identified in this zone. Betula rises quite sharply from the base of the zone to 30% at 600 cms then falls away to around 8% and increases again up to approximately 35%. Pinus peaks at over 8% when Betula is at a minimum. Salix reaches almost 15% at 625 cms and then declines. The shrubs Empetrum and Hippophae are both present. Pollen of herbaceous species make up between 50 and 90% of the total; Gramineae and Cyperaceae being the dominant herbs along with Rumex. There are low, but significant, percentages of Artemisia, Compositae, Epilobium and Filipendula. Aquatics are poorly represented with only traces of Nymphaea, Sparganium and Typha being recorded. Modest percentages of Filicales and Polypodium vulgare make up the spore component.

COR II Betula, Juniperus, Empetrum, Gramineae, Cyperaceae 515 - 595 cms

Betula accounts for over 10% of the total at all levels in this zone peaking at almost 30% at 540 cms. Very low percentages of Pinus are present. Salix fluctuates between just under 1% and over 5%. Juniperus and Empetrum both expand to over 5% at the base of the zone, fall back towards the middle and then recover slightly near the top. Gramineae and Cyperaceae again account for a large proportion of the herbaceous pollen. Gramineae increases very rapidly at the base of the zone to 50% of the total but fluctuates between 30% and 40% in much of the rest of the zone. Cyperaceae remains fairly constant at around 15 - 25%. After Gramineae and Cyperaceae, Galium and Rumex are the most abundant herbs. Rumex represents between 4 and 8% and Galium amounts to over 2% from around 560 and 525 cms. Filipendula and Thalictrum both appear as small peaks of about 2 - 3% at the base of the zone. Other herbaceous species present include Artemisia, Caryophyllaceae, Compositae, Epilobium, Helianthemum and Plantago. A variety of aquatic or marsh genera are recorded: Menyanthes, Myriophyllum, Nymphaea, Potomageton and Sparganium. Low percentages of Filicales, Polypodium vulgare and Selaginella are also present. Secondarily - derived Carboniferous - type spores peak at 15% at 570 cms.

Zone COR III Betula, Gramineae, Cyperaceae, Rumex 487 - 515 cms

The representation of trees and shrubs in this zone is sharply reduced compared to COR II. Betula for much of the zone occurs with values of less than 15% and only reaches almost 20% near the top. Pinus and Salix are present but only as 2% or less of the total sum.

Empetrum and Juniperus are both reduced. The percentages of Gramineae decrease from over 40% to about 12% in the middle of the zone at about 500 cms and then increase to 46% at the top at 490 cms. Cyperaceae fluctuates between 15 and 25% with a maximum of over 30% at 505 cms. Rumex peaks at approximately 27% at 500 cms and Galium is barely present. Cruciferae pollen first appears in this zone but in low amounts compared to zone COR V. Secondarily - derived Carboniferous - type spores reach a maximum of 135% at 500 cms.

Zone COR IV Betula, Juniperus, Empetrum, Filipendula 385 - 487 cms

Betula recovers to a maximum of 28% and thereafter percentages vary between 7 and 15%. Low values of Pinus are present along with Salix. Juniperus and Empetrum each reach their maximum in this zone; Juniperus peaking at just over 12% and Empetrum at approximately 9% thus contributing to the increased proportion of shrubs that may be seen in the compound summary. Gramineae reaches over 60% of the total. Filipendula is present as a clearly - marked peak of 15% towards the top of the zone. Artemisia, Galium, Helianthemum, Rumex and Thalictrum maintain a presence though none of these types exeeds 5%. Of the aquatics, Potomageton reaches a maximum of 100% at 433 cms. Secondarily - derived Carboniferous - type spores are present at lower percentages, than hitherto, of 4 - 15 % only rising to over 60% at the boundary with zone COR V.

Zone COR V Cyperaceae, Gramineae, Selaginella selaginoides 205 - 385

cms

Tree and shrub species are much diminished in this zone with only very low percentages being recorded. Gramineae percentages decline to around 15%, but Cyperaceae has a greatly increased presence at 40 - 60% of the total. Caryophyllaceae, Cruciferae, Compositae, Rumex and Thalictrum are the only other significant herbs. Percentages of Selaginella selaginoides rise abruptly at the bottom of the zone to over 45% and remain between 10 and 25% before decreasing to less than 5% near the top. Secondarily - derived Carboniferous - type spores once again form a large part of the total sum averaging 400% and attaining a maximum of just over 630%.

8.8 Concentration diagram

Turning to the concentration diagram (fig 8.6), on which the zone boundaries of COR I to COR V have been marked, the first point to note is the pattern of the concentrations of grains in the pollen sum at the right - hand side of the diagram. These vary between a minimum at 6.7568×10^{2} grains per cubic cm at 655 cms and a maximum of 6.8409×10^{4} grains per cubic cm at 418 cms depth. Zones COR II and COR IV clearly have higher average pollen concentrations than zones COR I, III and V (table 8.3). The concentration diagram confirms features already observed above on the percentage diagram. There are two peaks in Betula, Gramineae and Cyperaceae concentrations in zones COR II and COR IV with lower average values in the intervening zone COR III. Juniperus and Empetrum have higher

concentrations in zone COR IV than in any other zone; the highest concentration for Juniperus being 7.9918 x 10^3 and for Empetrum 5.3278 x 10^3 Filipendula reaches a maximum of 9.8361 x 10^3 grains per cubic cm at 400 cms in zone COR IV and Rumex peaks at 3.9402 x 10^3 grains per cubic cm in zone COR III. There is a marked peak in aquatic pollen at 433 cms of 5.1389 x 10^3 per cubic cm. Spores are less important in concentration in zone COR V than would be suggested by examining the percentage diagram. This is an illustration of the advantage concentration data have over percentage counts in that the pollen counts are independent of the interrelations of taxa within the pollen sum and give the true fluctuations of each taxon.

Table 8.3

Corstorphine Site Summary Concentrations

Zone	Range (grains per cubic cm)	Mean (grains per cubic cm)
COR I	6.7568 x 10^2 -> 2.2619 x 10^4	7.2 x 10^3
COR II	9.7074 x 10^3 -> 4.1712 x 10^4	1.877 x 10^4
COR III	5.2481 x 10^3 -> 4.1304 x 10^4	1.5411 x 10^4
COR IV	1.51 x 10^4 -> 6.8409 x 10^4	5.027 x 10^4
COR V	1.5931 x 10^3 -> 1.959 x 10^4	7.148 x 10^3

The results of slotting the two Corstorphine sequences are shown

in fig (8.11). The slotting of the sequences was based on the following species that occurred in significant amounts in both diagrams: Betula, Pinus, Salix, Juniperus, Empetrum, Gramineae, Cyperaceae, Artemisia, Caryophyllaceae, Filipendula, Galium, Helianthemum, Rumex and Thalictrum. The value of psi (Ψ) obtained was 1.0375, which is quite low suggesting a good fit although, as was stated in an earlier chapter, there are no formal statistical tests in terms of probabalities that can be applied to test the significance of (Ψ). As may be seen from fig 8.11, the degree of fit between the two sequences is quite good with a considerable degree of correspondence between the zones delimited in each sequence.

8.9 Vegetation Reconstruction:

In the following paragraphs an attempt is made to reconstruct the vegetation communities of the zones described above and to make inferences about the prevailing environmental conditions.

Zone COR I

The high levels of secondarily - derived Carboniferous - type spores recorded in this zone suggest that there may have been a significant inwash of material from the catchment area into the lake at this time as a result of extensive soil movement or solifluction. The erratic nature of changes in the incidence of the Carboniferous spores, however, also raises the possibility of slumping of the

Comparison of Corstorphine sequences by slotting.

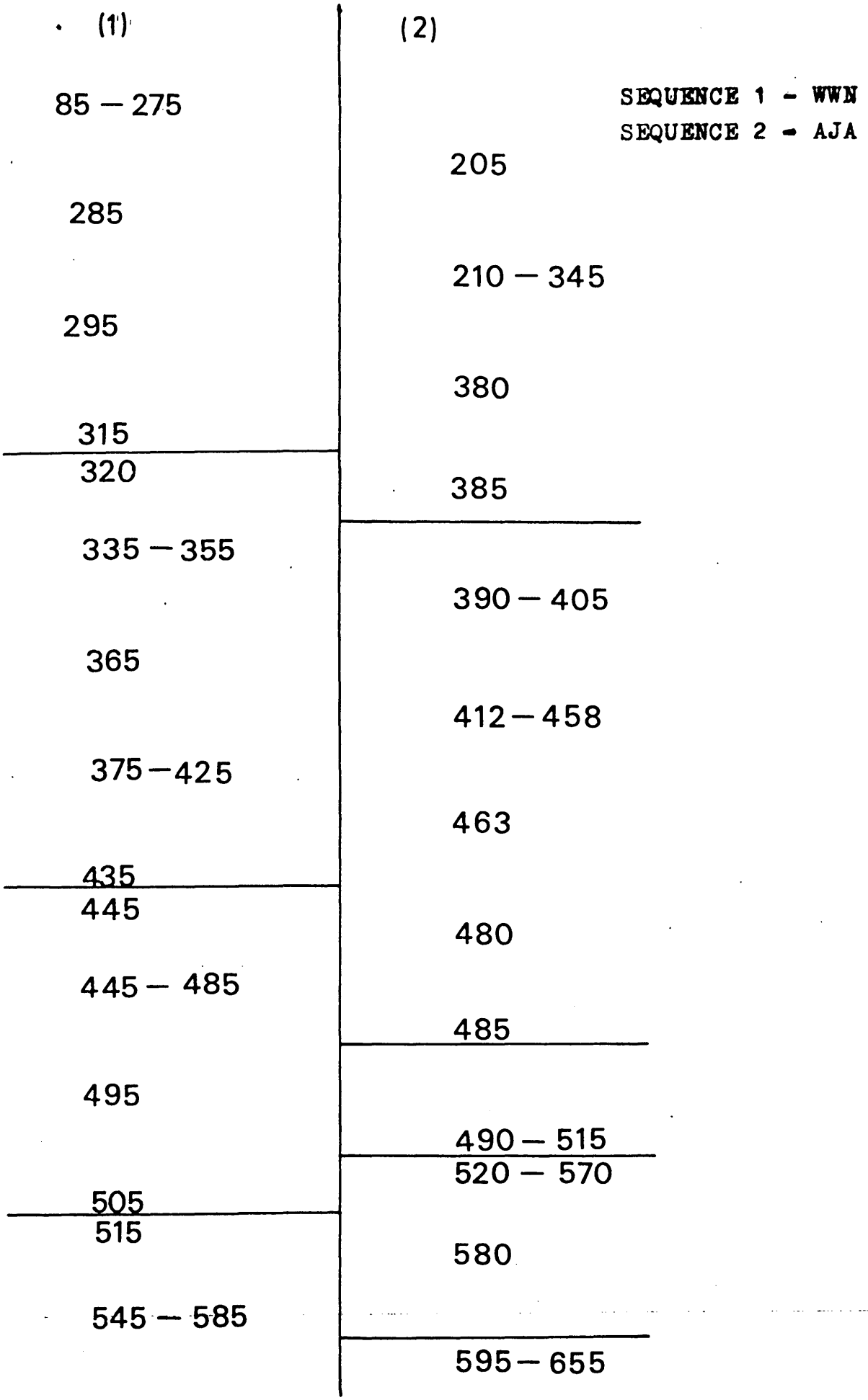


Fig 8.11 Results for SLOTSEQ for two Corstorphine sequences.

marginal sediments of the lake thus re-depositing spores previously incorporated in the till that lines the floor of the basin. The amounts of Betula and Pinus pollen present are unlikely to have originated solely from the production of trees growing locally. The presence of Betula nana - type pollen in this zone was noted and Pinus is well - known as a prolific producer of winged pollen that may be transported long distances by wind. The Salix pollen could well have come from Salix herbaceae, macrofragments of which were identified by Reid (1899), growing as part of late snowbed communities on Corstorphine Hill or perhaps on freshly - disturbed soils. Salix herbaceae is found on soliflucted soils in southern Norway (Dahl, 1956) and in Scotland (McVean and Ratcliffe, 1962). The presence of Hippophae rhamnoides completes the picture of a shrub vegetation that may have been dense locally on sites of periglacial activity. Empetrum was another member of this shrub community. The presence of Empetrum at this stage is interesting since this species usually occupies podsolized, mature base - poor soils where there is little competition from trees. Here, however, the assumption is that the soils were highly disturbed, colluvial, immature and therefore likely to be richer in bases as leaching would not yet have taken effect, and hence they were less likely to support Empetrum. However, according to Gimmingham (1972) Empetrum successfully colonises open, especially moist, mineral soils, and as Persson (1964) points out Empetrum and other heath plants invade pioneer communities on substrates exposed by glaciers after 12 years. Also it may be that conditions on the north and west facing slopes of Corstorphine Hill with lower insolation were wetter, leading to leaching and consequently to the development of more acid, humus -

rich soils more favourable to the establishment of Empetrum.

The dominance of Gramineae and Cyperaceae along with light - demanding ruderal and weed species such as Artemisia, Epilobium, and Rumex indicates that open herbaceous communities were quite extensive. The Cyperaceae component suggests that soils or sites with poor drainage or open water existed. In addition some of the Gramineae grains are likely to be Phragmites, a plant that is tolerant of arctic / sub - arctic conditions. It is assumed that the climate was not favourable for flowering / seed production of the herbaceous dicotyledons but had less effect on the anemophilous monocotyledons, especially Cyperaceae and Gramineae, species. The low levels of pollen of aquatic species such as Nymphaea, Sparganium, Typha suggest that there was little in the way of littoral or hydroseral vegetation at this stage.

Zone COR II

The very low percentages of Pinus are indicative of the much - decreased long - distance transported pollen to the site. The decline in the percentages of Pinus is probably a direct result of a feature of percentage diagrams already referred to i.e. that a change in one component is reflected by compensatory changes in all other components. An examination of the concentrations of Pinus reveals that they are consistently low and show little change. The levels of secondarily - derived Carboniferous - type spores are also much lower suggesting more stable conditions in the catchment area. Most

authors regard tree birch pollen at 20% of the total pollen sum as the lowest amount indicative of open birchwoods and this is supported by the surface pollen studies of Birks (1973b). Juniperus, a heliophyte, expands at the base of the zone presumably in response to rising temperatures for, as Iversen (1954) explains, a peak in Juniperus pollen may be the result of a rapid response to ameliorating climate by Juniperus that was already present but stunted and sparsely flowering. Birks (1973b) records that high level 'prostrate' Juniperus may contribute as little as 5% to the total pollen rain, even though the 'cover - abundance' is 50% so that few inferences can be made about the quantities of Juniperus vegetation at this time. The Juniperus rise correlates with a rise in pollen concentrations, probably as a result of a combination of reduced sediment accumulation rates and increased pollen productivity. Gramineae and Cyperaceae dominated herbaceous communities remain important with quite a variety of accompanying forbs such as Epilobium, Filipendula, Helianthemum, Galium, Plantago and Thalictrum with members of the Caryophyllaceae and Compositae families. The pollen assemblages of this zone are indicative of a much more continuous shrub and herbaceous cover supported by soils that were, in general, more mature and stable than was the case in the previous zone. Additionally, competition between plant species was clearly increasing as the plant cover became more complete. The range of aquatic species recorded presumably means that the temperature of the water had risen sufficiently and it also correlates with the deposition of calcareous muds as opposed to silty clays.

Zone COR III

Several factors suggest that this zone represents a phase of retrogressive vegetation development with perhaps renewed soil disturbance. These include:

The much - reduced presence of trees and shrubs and the increase in the amounts of pollen recorded of herbaceous species such as Rumex and Cruciferae along with higher levels of secondarily - derived Carboniferous type spores, the stratigraphic change to deposition of silty marls and the lower average pollen concentrations already noted. The higher levels of Rumex in particular indicate an increase in the area of open ground and discontinuous plant cover. Additionally the much lower amounts of Juniperus pollen probably mean that flowering of this species had been suppressed by the onset of colder conditions (Iversen, 1954).

Zone COR IV

In this zone the proportions of tree and shrub pollen are markedly higher than in the previous zone COR III. The amounts of Betula pollen indicate that it is likely to have been present in copses, perhaps where there is more shelter from the cold east winds (a conspicuous feature of the site at the present day). It should also be noted that the slope of Corstorphine Hill overlooking the sampling site has a southerly aspect as well as shelter and that these two factors are very important, affecting insolation and soil

moisture content and hence the resultant soil type. The amounts of Juniperus and Empetrum pollen present are probably a reflection of the development of shrub/heath communities in response to warmer temperatures and more stable soils. The lower average levels of secondarily - derived Carboniferous - type spores confirm that there was less inwash of minerogenic material into the lake than formerly. There were still a large number of open - habitat species present and this, in conjunction with the high proportion of Gramineae and Cyperaceae pollen, suggests that grass/sedge communities were still an important component of the vegetation. The clearly - marked peak in Filipendula may be a consequence of an expansion of this species under warmer conditions since it is thought to be thermophilous (Iversen, 1954) but, as previously noted, it could equally be a function of an increase in the area of marshy habitats, and indeed the representation of aquatic species reaches its maximum in this zone. Artemisia with pollen values of less than 2% may not have been present locally because of its high pollen production and dispersal (Maher, 1963). The sediments deposited during this zone largely consist of calcareous marls that contain the remains of Characeae and large numbers of fragments of freshwater molluscs, such as Lymnaea peregra Muller and Planorbis albus. The presence of these provides evidence of leaching of the soils in the surrounding area.

Zone COR V

Severe climatic conditions are indicated by the greatly - reduced representation of trees and shrubs and the restricted

herbaceous flora that largely consists of pioneer species which are adapted to open disturbed habitats. The vegetation appears to have been dominated by communities with an important Salix, Gramineae, Cyperaceae component. The amounts of secondarily - derived Carboniferous - type spores once again rise to high levels and demonstrate that there must have been significant soil movement in the catchment area and appreciable inwash of material into the lake, leading to the deposition of sandy/silty clays. The megaspores of Selaginella selaginoides were identified in significant numbers emphasising the arctic nature of the prevailing climatic regime.

Finally one may seek to place the zones at Corstorphine in their chronological context: The sediments deposited in zone COR V quite clearly correlate with the Younger Dryas Stadial and those of COR I to COR IV with the Lateglacial Interstadial. The sediments formed in COR III are tentatively equated with those of the Older Dryas (Mangerud et. al., 1972), as have been identified elsewhere in eastern Scotland (Newey, 1970; Vasari, 1977; Walker, 1977; Caseldine, 1980) and also with part of the Windermere Interstadial (Coope and Pennington, 1977). There is little indication of the thermal improvement that would mark the beginning of the Postglacial in the diagrams.

To summarise this research, on the Corstorphine site, confirms much of what had been discovered by earlier workers (Bennie, 1891,1894; Reid, 1899; Newey, 1965, 1970; Coope, 1968). In particular it establishes that a phase of retrogressive vegetation development did occur during the Lateglacial Interstadial at

Corstorphine. In addition it is clear that Newey, in practice, had overcome the deficiencies of the Hiller borer.

8.10 Summary and speculation:

The Lateglacial Interstadial at all three sites is characterised by a phase of retrogressive vegetation, with Rumex and Cyperaceae, development sandwiched between zones which are dominated by the tree and shrub species Betula, Empetrum and Juniperus and by thermophilous species such as Filipendula. It is suggested, by the author, that this phase of retrogressive vegetation development may be correlated with the Older Dryas of continental stratigraphers (Mangerud et al, 1974). The calculated concentration figures for Balgone House and ~~Broxmouth~~ Corstorphine show that average pollen concentrations are lower during the Older Dryas implying either an increased sedimentation rate or reduced pollen productivity for this period.

A similar pattern has been found in eastern Scotland, at Stormont Loch near Blairgowrie, by Caseldine (1980) and by Walker (1977) at Corrydon, in Glenshee. At Corrydon, Walker describes a sequence of vegetation that shows a greater degree of revertence, during the Older Dryas, towards more chionophilous and open - habitat vegetation communities than is evident in the sites from lower altitudes. At sites in northern Scotland (Pennington, 1977a) the Older Dryas is represented by a Rumex - Artemisia assemblage zone whilst at Loch of Park in north east Scotland, Vasari (1977) found similar evidence. The oscillation is, however, not present at most

other Scottish Lateglacial sites e.g. Rhoineach Mor and Tynasprit 2 (Lowe and Walker, 1977).

The Older Dryas, it has been suggested by Pennington (1977a), on the basis of data from sites in northern Scotland and in the Lake District, lasted for only 200 years between 12000 and 11800 B.P. It may be that the short - lived nature of this oscillation and the fact that it occurs over a relatively short distance in the cores accounts for its not having been more widely detected at sites where, for example, a wider sampling interval has been employed.

The occurence of a deterioration in climate at around 12000 BP has been established on the basis of evidence from both Coleoptera and pollen (Pennington, 1977a; Coope, 1977). It will be recalled though that, as reviewed earlier, there are conflicting interpretations based on Coleopteran and botanical data as to the climate of the Lateglacial Interstadial. In recent years several individuals have begun to think about changes in continentality and oceanicity during the Lateglacial, for example, (Van Geel and Kolstrop, 1978; Kolstrop, 1982).

By plotting the changes in the percentages of planktonic foraminifera, such as Globergina pachyderma, in ocean floor cores the movements of the oceanic polar front, or transition from polar water to temperate water, may be traced since the species present and their abundance are related to ocean temperature and salinity. By dating and correlating cores an impression has been gained of how ocean conditions have changed through time over the eastern Atlantic

(Ruddiman et al, 1977; Ruddiman and McIntyre, 1981).

At the maximum of the last glaciation c. 18000 BP the oceanic polar front lay at about the latitude of Spain. Subsequently it began to retreat northwards, clearing Britain around 13,500 BP and brought the marked warming at that time evident in fig(8.14). Sissons (1981) suggests that as a result of the climatic change associated with the replacement of polar by warmer water a very large part of Scotland was ice free by 13000 BP. Around 13000 BP temperatures in Britain were as warm as, or warmer, than at the present time (Pennington, 1977a; Gray and Lowe, 1977), but as shown in fig (8.14) there was a subsequent climatic deterioration with a return to arctic conditions by 10,500 BP. It is thought that this was related to a return of polar water to the vicinity of Britain, the polar front reaching North Spain. The location of the polar front is crucial to the formation of glaciers during Younger Dryas (Sissons and Sutherland, 1976 ; Sissons, 1980). Peacock (1983) has suggested from a study of molluscan assemblages that sea temperatures, particularly in the period 12,500 - 12000 BP, were 3 ^{o} C lower than they are today, except for the surface water, implying that the North Atlantic Drift at that time was weaker than the present where it extends into the Norwegian Sea.

It is hypothesised by the present author that as the Polar Front, on deglaciation around 13500 - 13000 BP, retreated to higher latitudes to the north of Britain the climate progressively changed from one which was predominantly cyclonic to one which was predominantly anticyclonic, as the influence of the Polar Front

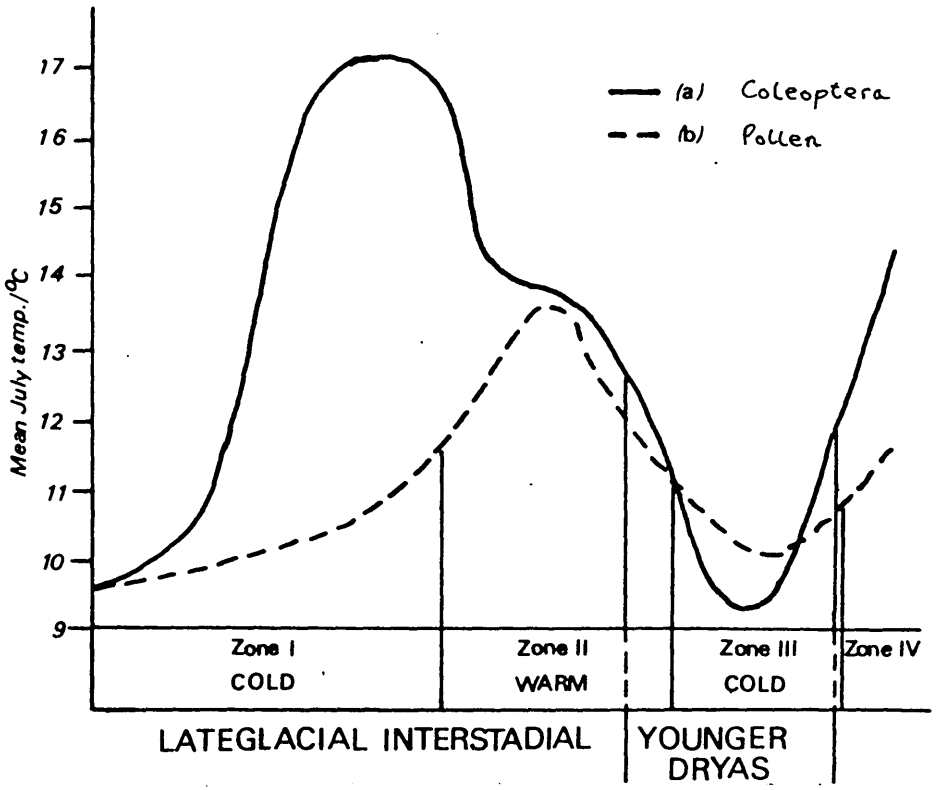


Fig 8.14 Graph showing mean Lateglacial July temperatures for Lowland Britain inferred from Coleopteran and Pollen evidence (after Coope and Pennington, 1977).

diminished.

It is further suggested that the Older Dryas period represents the period of maximum continentality of climate when the polar front would have been at its highest latitudes. The climate of Older Dryas would therefore have been anticyclonic with cold east winds, reduced cloud cover, high insolation in summer and intensely cold winters.

Pennington and Lishman (1975) show that carbon, iodine and Lateglacial pollen curves for Blea Tarn indicate that a recession in the interstadial iodine curve coincides with a temporary change from a Juniperus - Gramineae - Salix assemblage to a Betula nana - Cyperaceae - Lycopodium selago assemblage below the most organic interstadial sediments. Penningon (1970) suggested that this temporary recession towards a more snow - tolerant plant association might have resulted from a change to an easterly direction in the prevailing winds accounting for both the higher snowfall and a lower rate of iodine supply. However, during the Lateglacial the bed of the southern North Sea was dry land. It is therefore felt by the present author that the limiting factor for the flowering of Juniperus was not necessarily increased snowfall as suggested by Pennington (1970, pps 51 - 52), in fact snowfall may have been lower rather than higher and combined with a severe winter and spring climate. The exact climatic regime probably has no precise equivalent in Europe today. The significant point, however, is that the lower amounts of iodine suggest that less precipitation originated over the Atlantic i.e. there may well have been an increase in the non - cyclonic proportion of precipitation. It is

further suggested that climatic conditions were more continental on the eastern side of Britain than on the western which would still have been under the, albeit diminished, oceanic influence of the Atlantic.

It was perhaps this period of cold winters during the Older Dryas that "sparked - off" the movement of the polar front southwards again, possibly through a cooling of the waters of the North Atlantic and that led to the climate of the British Isles becoming increasingly oceanic (cyclonic).

Godwin (1975 p 432 - 433) makes the point that the absence of trees from a flora alone does not indicate low summer temperatures because there are features of the extreme continental type of climate which are unfavourable for trees irrespective of summer temperatures - very cold winters, severe wind exposure, severe spring thaw and floods or unstable soils. The persistence of any one of the above features may have limited the expansion of trees in the Lateglacial which would explain the evidence that the development of tree birches was not always in equilibrium with temperatures as deduced from the present day ranges of other species present. The non - appearance of Corylus and indeed of thermophilous tree species in the Lateglacial (H.J.B. Birks, 1973a; Pennington, 1977a) would therefore be explained following the hypothesis as set out above by the fact that only for a short period in the later part of the interstadial were both edaphic and climatic conditions suitable. Corylus shows a preference for an oceanic climate associated with a need for mild winters in a shrub flowering as early as hazel does. It is well known that the stigmas

are sensitive to late spring frosts c.f. Fagus and Ulmus. Too short a time was therefore available to allow migration of Corylus especially since conditions were probably already changing. Another line of evidence for continentality preceding Older Dryas is the restricted but consistent occurence of Hippophae pollen. It occurs for example in the Betula paz(12500 - 12000 BP) at Low Wray Bay, Windermere (Pennington, 1977a) and its presence has been held to imply continentality of climate (West, 1968).

Coope and Joachim (1980 p. 67) state that the insect fauna suggests that summer temperatures in the first part of the interstadial were as warm, or warmer, than today to account for the frequencies of the most southern species of Coleoptera. This, it is contended here, is entirely in keeping with a more continental - type of climate than at the present day.

In conclusion therefore by invoking a continental climate in the early half of the interstadial replaced by a more oceanic climate in the later half one may resolve the conflict between the Coleoptera and botanical evidence. Further detailed studies of Coleoptera and botanical data are, however, required. The ultimate causes of the oceanic changes outlined above are not yet known, but it is important that their effects are understood since it is as a result of the North Atlantic drift that there is a mild oceanic climate in Britain at the present. It is clear from the above that Britain is located in one of the most sensitive areas for monitoring climatic changes during the late Quaternary.

CHAPTER 9

REVIEW OF RESULTS AND CONCLUSIONS:

This chapter provides a review of the results of the writer's research on the palaeogeography of the eastern part of the Midland Valley of Scotland during the Late Quaternary period. In particular it provides a discussion of the evidence for changes in the physical geography and the biogeography of this area during the Lateglacial and the succeeding Postglacial though special emphasis is placed on the Lateglacial. Almost all the many Scottish Lateglacial sites so far described have been in the Highlands. The present research breaks new ground by investigating Lateglacial sites in the eastern Scottish lowlands, an area of distinctive regional climate, soils and vegetation. At the many Lateglacial pollen sites studied a characteristic sequence of deposits occurs beneath the Postglacial sediments. This consists of a basal minerogenic horizon associated with the final stages of the Devensian glaciation. Above this is an organic layer representing the milder Lateglacial Interstadial related to the Allerod phase known in Europe. This organic layer is succeeded by an upper minerogenic horizon, deposited during the Loch Lomond Advance or Stadial.

At the sites studied in this thesis, namely Balgone House, Broxmouth and Corstorphine, a Lateglacial stratigraphy is evident followed by a partial Postglacial sequence at two of the sites: Balgone House amd Broxmouth.

At all three sites the Lateglacial Interstadial commences with open herbaceous communities dominated by Gramineae and Cyperaceae and by light demanding ruderals and weed species, such as Artemisia, Epilobium and Rumex. The Rumex, in particular, may be indicative of open disturbed ground. Trees and shrubs form an insignificant proportion of the total with, for example, much of the Pinus pollen probably being derived from long distance transport. Continuing soil instability at this time is indicated by the high levels of secondarily - derived Carboniferous - type spores recorded at Corstorphine along with Salix (c.f. S. herbacea), a plant of late snowbed communities and common on soliflucted soils. Also at Corstorphine there is evidence for a Hippophae rhamnoides - Empetrum shrub community that may well have been locally dense on sites of periglacial activity. The presence of Empetrum is an indicator of the start of leaching in the soils in the catchment. At Balgone House the grains of Polemonium caeruleum indicate the presence of calcium carbonate as well as a characteristic tall herb community. Additionally at this site, the presence of Papaveraceae and Artemisia may mean that areas of exposed mineral soil, subject to very little snow-lie, existed somewhere in the catchment, perhaps along the top of the cliff overlooking the site.

As climatic conditions improved, a more continuous, species-diverse shrub and herbaceous cover developed, supported by soils that were, in general, more mature and stable. As a result of the more complete plant cover, competition between species probably increased. The more diverse range of species included, Filipendula, Helianthemum, Plantago and Thalictrum with members of the

Caryophyllaceae and Compositae. Juniperus expanded probably as a result of the more prolific flowering of plants already present, in response to the rising temperatures.

The low average percentages of Betula indicates that it was probably not abundant and was restricted to habitats sheltered from the cold east winds characteristic of this coastal area. The range of aquatic species recorded, as well as the enrichment of the swamp / marsh flora, presumably means that the temperature of the water had risen sufficiently. This is associated with the deposition of calcareous muds as opposed to silty clays.

There then follows evidence for a minor phase of retrogressive vegetation development marked by a decline in Betula, Juniperus and Empetrum that is matched by an increase in the proportion of pollen of herbaceous species, especially Gramineae and Cyperaceae. Rumex increases quite markedly and suggests that the area of open disturbed habitats with discontinuous plant cover must have increased for a short time. The presence of increased amounts of secondarily - derived Carboniferous - type spores at Balgone House and Corstorphine indicate renewed inwash of mineral material into the lakes at this time. This temporary recession corresponds to evidence recorded by previous work at other sites as noted above.

Subsequently the vegetation at all three sites once again reflects improved conditions, suggesting the development of shrub / heath communities, with Juniperus and Empetrum both attaining maxima whilst the amounts of Artemisia and Rumex decline. This observation

is reinforced by the presence of the thermophilous Filipendula and Helianthemum. Myriophyllum alterniflorum, a very typical obligate aquatic of the Lateglacial, is present in significant amounts at Broxmouth and generally the levels of aquatic species recorded suggest an increase in the area of marshy habitats. The lower average amounts of secondarily - derived Carboniferous - type spores recorded indicate less inwash of minerogenic material into the sites. Indeed the sediments deposited at this time largely consist of calcareous marls, an indication of increased leaching. The amounts of Empetrum recorded at the sites studied are generally low which should be contrasted with the higher figures for northern and western Scotland, areas with higher precipitation and more oceanic conditions (Brown, 1971; Walker, 1975b).

The Younger Dryas (Loch Lomond Stadial) is clearly marked in the lithostratigraphy at Balgone House and, especially, at Corstorphine by a predominantly minerogenic upper horizon, indicating soil instability in the respective catchments. This minerogenic horizon correlates with a growth in the representation of plants suggesting an increase in the severity of climate and in the area of soils without a continuous plant cover. These include Rumex, Caryophyllaceae, Ranunculaceae, Thalictrum and Artemisia, all of which indicate a type of tundra with affinities with the continental steppe type of vegetation, together with a decline in the frequencies of Betula and Juniperus. There is, however, no exact modern day equivalent of this plant formation. No equivalent minerogenic horizon marks the Younger Dryas at the Broxmouth site. It is thought that the lack of clear stratigraphic evidence in this instance is

related to the low - lying coastal nature of the site, the very low gradients, freely - drained sands and gravels around the site and the low rainfall and milder climate. Inwash following solifluction of surface material would seem likely to have been negligible for the above reasons. At the Corstorphine site the presence of Selaginella selaginoides suggests that mineral base - status may have increased nutrient status as a result of cryoturbation processes in the soils. There is additional evidence for soil movement during the Younger Dryas at Corstorphine in the form of the very high proportion of secondarily - derived Carboniferous spores recorded. Clearly there was considerable inwash of material from the steep slopes of Corstorphine Hill, which flanks the site, resulting in the deep minerogenic layer.

As noted earlier, the Lateglacial Interstadial at all three sites is characterised by a phase of retrogressive vegetation development, with Rumex and Cyperaceae, sandwiched between zones which are dominated by the tree and shrub species Betula, Empetrum and Juniperus and by the thermophlious species such as Filipendula. It is suggested that this retrogressive phase may be correlated with the Older Dryas of continental stratigraphers (Mangerud et. al., 1974). The calculated concentration figures for Balgone House and Corstorphine show that the average pollen concentrations are lower during the Older Dryas, implying either an increased sedimentation rate or reduced pollen productivity for this period. Since clear stratigraphic evidence for Older Dryas exists only at the Corstorphine site, where there was renewed inwash of material down the steep slopes of Corstorphine Hill, it seems that reduced pollen

productivity at this time is the more likely.

As mentioned earlier there is a partial Postglacial vegetation sequence at two of the sites: Balgone House and Broxmouth.

At Balgone House the Postglacial commences with a dramatic increase in the amount of the aquatic Myriophyllum alterniflorum recorded and is accompanied by the deposition of a calcareous marl. This is taken to represent the onset of warmer conditions and a less active sedimentary environment than before. Following this there is a phase when Juniperus expands initially, probably a response to the warmer conditions by Juniperus plants already present, but this is superseded by the spread of Betula. The presence of Filipendula, as well as being an indicator of warmer conditions, may point to the development of a hydroseral succession. Pteridophyta formed a significant part of the woodland and shrub communities present.

At Broxmouth, on the other hand, there is no initial peak in Juniperus; it appears that Betula was more dominant at this site and Juniperus flowers poorly under a Betula canopy. The site itself indicates that the rich aquatic, marsh and swamp marginal plant communities which flourished throughout the time represented, were especially rich in the later period. So, following an early phase with higher Empetrum, Gramineae and aquatics and lower Rumex suggestive of warmer more stable conditions, Betula at Broxmouth increases rapidly to form a high proportion of the pollen recorded. It may be speculated that this was as a result of rapid colonisation of much of the area around the site by Betula, which had previously

only grown locally where it was sheltered from cold east winds.

At both of the sites there was then a large expansion in the amounts of Corylus recorded. At Broxmouth Corylus reached as high as 90% of the total pollen recorded and clearly out-competed Betula for space on base - rich well - drained gravels where it grew as pure hazel scrub or at least as marginal to Betula woodland. At Balgone House it appears that Corylus may have been, at least, initially an undershrub in Betula woods.

This phase of Corylus dominance is latterly accompanied by significant records at both sites for pollen of the main thermophilous broad-leaved deciduous tree species, Quercus and Ulmus and low frequencies of Tilia and Fagus. This is consistent with the evidence from other parts of the Midland Valley of Scotland (Donner, 1962; Newey, 1968; Brooks, 1974) as outlined in an earlier chapter, suggesting that Quercus and Ulmus were important components of the mid - Postglacial woodlands. The organic productivity of the sites is thus shown to have increased rapidly. The broad-leaved deciduous genera were accompanied by the shrubs Corylus, Salix and Ilex. A rich ground flora is indicated by the pollen of herbs of woodland conditions, Rosaceae, Labiatae, Compositae, Gramineae and Pteridophyta. The presence of Ilex, Hedera and Tilia confirm the characteristics of the later 'Boreal' climate with a reduced incidence of frosts. The lack of Pinus, in contrast to northern Highland Postglacial sites, is possibly the result of the heavier, deeper, and richer soils of the Lothian plain and the longer and warmer period of summer growth which favoured the deciduous trees in

competition with Pinus.

At both the Balgone House and Broxmouth sites Alnus and other plants e. g. Hedera expanded during the thermal maximum of the 'Atlantic' period following the immigration and colonisation of the area by the thermophilous broad-leaved deciduous trees. Even allowing for its high pollen productivity, Alnus, which requires high soil moisture, must have been very common in the general forest cover in the vicinity of the sites. At both of the sites there is evidence for wetter conditions with increased frequencies of Salix, Cyperaceae and Gramineae. It is therefore likely that local waterlogging of the soils on the uneven drift-covered plain led to the creation of local societies of Alnus and Salix within the predominantly oak forest.

Since there is no evidence in either of the Postglacial diagrams for an Ulmus decline, the forest cover that has been reconstructed appears most likely to pre-date the appearance of anthropological clearance. This was to come later, around 5000 years ago.

General conclusions:

The writer had an advantage over earlier workers in that the opportunity existed to apply a range of more modern techniques and tools. The actual sediment sampling was carried out by use of a piston corer not a Hiller borer, which makes it easier to control sampling errors.

Sampling at close intervals of the Lateglacial sequences at each

site gave more detailed results than hitherto achieved. The enhanced detail of the pollen flora permits a fuller interpretation of the character of the Lateglacial Interstadial and has led to the indication of phenomena not hitherto known, or ignored, in the Lothians lowlands. These include a detailed description of the Interstadial horizon and of the many fluctuations of the plant cover that took place prior to the Younger Dryas together with the identification of both a colder phase, with retrogressive vegetation development, correlated with Older Dryas, and of a warmer phase preceding it - the Bolling Interstadial.

The application of absolute counting techniques means that each pollen curve on the absolute diagrams can be considered as an independent variable rather than, as is the case with the relative diagrams, an interdependent percentage. Also comparison of absolute and relative data allows the evaluation of changes in pollen spectra through time, and of their relationship to the former vegetation. Additionally, absolute counts can be used to resolve whether oscillations represent a real change in pollen deposition or only a small percentage fluctuation.

Changes in the inorganic chemistry of the lake sediments, which had not been previously studied in the Lothians, were investigated since these are a reflection of changes in the catchment area related to differing rates of soil erosion and leaching.

The computer program, POLLDATA MKV, was used to do both the necessary calculations and to produce the pollen diagrams, thereby

saving time that would otherwise have been spent on purely mechanical tasks. The speed at which calculations are performed and the diagrams drawn using POLLDATA, means that various arrangements of pollen curves and different pollen sums may be tried in a few minutes; a process that would take several weeks by hand. Furthermore there is the additional flexibility of being able to insert and remove types and levels. A further advantage is that the diagrams produced are of a standard form and therefore readily comparable one to another. Finally the dataset is stored on the computer and is therefore available for further statistical manipulation.

The ZONATION, PCA, MDS(X) and SLOTSEQ programs were used to objectively zone and to compare pollen stratigraphic sequences. The writer considers that their theoretical benefits were borne out in practice to a useful degree. The application of a range of numerical techniques, where there is consistency in the results, can aid in the process of making the correct conclusions. The methods can also be valuable in focussing attention on certain aspects of the data, in forcing a closer examination of some of the main numerical changes and in the generation of hypotheses. The objective zonation methods represent a valuable tool that can be used to help either to eliminate much of the subjectivity in selecting zone boundaries or to confirm zonation schemes derived from subjective examination. It was felt that the the application of these methods did indeed allow improved recognition of pollen zones in Lothian sites and allowed greater confidence in the validity of the results presented.

Suggestions for further research:

There are two main suggestions that may be put forward for further palaeo - ecological research in the study area.

First that there should be a further search for and investigation of Lateglacial sites in this region, which has been largely neglected compared to Highland Scotland. These should include sites of both the numerous upland areas of the Scottish Midland Valley and also the adjacent lowlands. The aim should be to increase the coverage of the area and to examine differences in the response and development between upland and lowland vegetation communities. Where possible a multidisciplinary approach, encompassing not only pollen but also, for example, sediment chemistry, diatoms, palaeomagnetism and macrofossil studies, should also be applied.

Second, radiocarbon dating or newer dating techniques, as they become available, should be applied to sediments from suitable sites i.e. where there is a minimal chance of 'hard - water' error, in order to establish a basic chronology.

Finally it is recommended that pollen analysts should beware of subconsciously discounting the presence of supposed 'contaminant' grains. It has been shown in this thesis that a significant proportion of the grains in this category can be largely attributed to grains derived from an impure exotic suspension. However, it must be appreciated that only in rare instances is it likely to be

possible to locate definitively the precise origin of grains of particular species.

BIBLIOGRAPHY

Adam, D.P. (1970) Some palynological applications of multivariate statistics. Ph.D. thesis (upubl.), University of Arizona.

Adam, D.P. (1974) Palynological applications of principal component and cluster analysis. J. Res. U.S. Geol. Surv. 2, 727-741

Alexander, A.J. (1981) New contribution to CONLIB: POLLDATA ERCC Newsletter Vol 15 No 11 pp 6-7

American Commission on Stratigraphic Nomenclature (1961) Code of stratigraphic nomenclature. Amer. Assoc. Petroleum Geologists Bull. 45, 645-55

Andersen, S.Th. (1961) Vegetation and its environment in Denmark in the Early Weichselian Glacial (Last Glacial) Danm. Geol. Unders. 2 rk. 75. 175pp.

Andersen, S.Th. (1970) The relative pollen productivity and pollen representation of North European Trees, and correction factors for tree pollen spectra. Danm. Geol. Unders. Ser II 96, 99pp.

Bailey, E.B. et al (1910) The Geology of East Lothian Mem. Geol. Surv.

Bartley, D.D. (1962) The stratigraphy and pollen analysis of lake deposits near Tadcaster, Yorkshire. New Phytol. 61, 277

Bates, C. D., Coxon, P. and Gibbard, P. L. (1978) A new method for preparation of clay-rich sediment samples for palynological investigation. New Phytol. 81(2) 459-464

Bennet, C.L. (1979) Radiocarbon dating with accelerators. Amer. Scient. 67, 450-457

Bennie, J. (1891) The Ancient Lakes of Edinburgh. Proc. R. phys. Soc. Edinb., 10, 126

Bennie, J. (1894) Arctic plants in the old lake deposits of Scotland.

Ann. Scot. Nat. Hist. p.46

Benninghof, W.S. (1962) Calculation of pollen and spore density in sediments by addition of exotic pollen in known quantities. Pollen Spores 4, 332-3

Berglund, B.E. (1966) Late-Quaternary vegetation in Eastern Blekinge, South-Eastern Sweden. Op. bot. Soc. bot. Lund. 12(1) 180pp

Berglund, B.E. (1979) The deglaciation of southern Sweden 13,500 - 10,000 BP Boreas, 8, 89-118

Birks, H.H. (1970) Studies in the vegetational history of Scotland I. A pollen diagram from Abernethy Forest, Inverness-shire. J. Ecol. 58, 827-46

Birks, H.H. (1972 a) Studies in the vegetational history of Scotland. II. Two pollen diagrams from the Galloway Hills, Kirkcudbrightshire. J. Ecol. 60, 183-217

Birks, H.H. (1972 b) Studies in the vegetational history of Scotland. III. A radiocarbon dated pollen diagram from Loch Maree, Ross and Cromarty. New Phytol. 71, 731-54

Birks, H.H. (1975) Studies in the vegetational history of Scotland IV. Pine stumps in the Scottish blanket peats. Phil. Trans. R. Soc. Lond. B. 270, 181-226

Birks, H.J.B. (1968) The identification of Betula nana pollen. New Phytol. 67, 309-14

Birks, H.J.B. (1973 a) Past and Present Vegetation on the Isle of Skye - a palaeoecological study. Cambridge

Birks, H.J.B. (1973 b) Modern pollen rain studies in some arctic and alpine environments. In Quaternary Plant Ecology, ed. Birks, H.J.B. and West, R.G. Blackwell, Oxford, pp143-68

Birks, H.J.B. (1974) Numerical zonations of Flandrian pollen data.

New Phytol. 73, 351-58

Birks, H.J.B. (1976) Late Wisconsin vegetational history at Wolf Creek, central Minnesota. Ecol. Monogr, 46, 395-429

Birks, H.J.B. (1977) The Flandrian forest history of Scotland: a preliminary synthesis. In British Quaternary Studies: Recent Advances (ed. F.W. Shotton) Clarendon Press, Oxford.

Birks, H.J.B. & Berglund, B.E. (1979) Holocene pollen stratigraphy of southern Sweden: a reappraisal using numerical methods. Boreas, 8,pp 257-79

Birks, H.J.B. & Deacon, J. (1973) A numerical analysis of the past and present flora of the British Isles. New Phytol. 72, 877.

Birks, H.J.B. & Huntley, B. (1978) Program POLLDATA MK 5 Documentation relating to FORTRAN IV program. Unpublished manuscript

Birks, H.J.B. & Matthewes, R.W. (1978) Studies in the vegetational history of Scotland. V. Late Devensian and early Flandrian pollen and macrofossil stratigraphy at Abernethy Forest, Inverness-shire. New Phytol. 80, 455-484

Bishop, W.W. & Coope, G.R. (1977) Stratigraphical and faunal evidence for lateglacial and early Flandrian environments in South-West Scotland. In Gray, J.M. and Lowe, J.J. (eds.). Studies in the Scottish Lateglacial environment, 61-88 Oxford.

Bonny, A.P. (1972) A method for determining absolute pollen frequencies in lake sediments. New Phytol 71,393-405

Bowen, D.Q. (1978) Quaternary Geology. Oxford.

Boyd, W.E. (1982) The stratigraphy of late Quaternary raised coastal deposits in Renfrewshire and Ayrshire, western Scotland. Ph.D. thesis (upubl.), University of Glasgow.

Brookes, D. & Thomas, K.W. (1967) The distribution of pollen grains

on microscope slides. I. The non-randomness of the distribution. Pollen Spores. 9, 621-9

Brooks, C.L. (1972) Pollen analysis and the Main Buried Beach in the western part of the Forth Valley. Trans. Inst. Br. Geogr. 55: 161-70

Brooks, C.L. (1976) Pollen analysis of the late- and post-glacial deposits in the western Forth valley. Ph..D. thesis (upubl.), University of Edinburgh.

Brown, A.P. (1971) The Empetrum record as a climatic indicator in the Late Weichselian and early Flandrian of the British Isles. New Phytol. 70: 841-9

Buckman, H.O. & Brady, N.C. (1969) The Nature and Properties of Soils, Macmillan, London.

Burke, M.J. (1969) The Forth Valley: an ice moulded lowland. Trans. Inst. Br. Geogr. 48, 51-9

Cadell, H.M. (1913) The Story of the Forth Maclehose, Glasgow

Caseldine, C.J. (1980) A Lateglacial site at Stormont Loch, near Blairgowrie, eastern Scotland. In Studies in the Lateglacial of North-West Europe, eds Lowe, J.J., Gray, J.M. & Robinson, J.E. pps 69-89, Pergammon, Oxford.

Clapham, A.R., Tutin, T.C. & Warburg, E.F. (1962) Flora of the British Isles Cambridge University Press, London

Clapperton, C.M., Gunson, A.R. & Sugden, D.E. (1975) Loch Lomond Readvance in the eastern Cairngorms. Nature, 253, 710-12

Colinvaux, P.A. (1978) On the use of the word 'Absolute' in pollen statistics. Quaternary Research, 9, 132-33

Coope, G.R. (1968) Fossil beetles collected by James Bennie from the Late- glacial silts at Corstorphine, Edinburgh. Scott. J. Geol. 4(4): 339-348

Coope, G.R. (1977) Fossil Coleopteran assemblages as sensitive indicators of climatic changes during the Devensian (last) cold stage. Phil. Trans. Roy. Soc. Lond. 280B, 313-37

Coope, G.R. & Brophy, J.A. (1972) Late glacial environmental changes indicated by a coleopteran succession from North Wales. Boreas, 1, 97-142

Coope, G.R. & Joachim, M.J. (1980) Lateglacial environmental changes interpreted from fossil Coleoptera from St. Bees, Cumbria, NW England. In Lowe, J.J., Gray, J.M. & Robinson, J.E. (eds.) Studies in the Lateglacial of North-West Europe, pps 55-68 Pergamon, London.

Coope, G.R. & Pennington, W. (1977) The Windermere Interstadial of the Late Devensian. Phil. Trans. R. Soc. Lond. B. 280, 337-39

Crabtree, K. (1975) A Review of Methodological advances in Pollen Analysis. In Processes in Physical and Human Geography. Bristol Essays (eds) Peel, R., Chisholm, M. and Haggett, P. pps 266-281.

Cundill, P. & Whittington, G. (1983) Anomalous arboreal pollen assemblages in Late Devensian and Early Flandrian deposits at Creich Castle, Fife, Scotland. Boreas, 12, 297-311

Cushing, E.J. (1961) Size increase in pollen grains mounted in thin slides Pollen Spores, 3, 265-74

Cushing, E.J. (1964) Re-deposited pollen in Late-Wisconsin pollen spectra from east-central Minnesota. Am. J. Sci. 262, 1075-88

Cushing, E.J. (1967 a) Evidence for differential pollen preservation in late Quaternary sediments in Minnesota. Rev. Palaeobotan. Palynol. 4, 87-101

Cushing, E.J. (1967 b) Late-Weichselian pollen stratigraphy and the glacial sequence in Minnesota. In Quaternary Palaeoecology, ed. Wright, H.E. and Cushing, E.J. Yale University Press, New Haven and

London, pp. 59-88.

Cushing, E.J. (1967 b) Evidence for differential pollen preservation in Late Quaternary sediments in Minnesota. Rev. Palaeobotan. Palynol. 4, 87-101

Dahl, E. (1956) Rondane: mountain vegetation in south Norway and its relation to the environment. Skr. norkse Videnskaps-Akad. I. Mat.-Nat., 3.

Dale, M.B. & Walker, D. 1970 (1970) Information analysis of pollen diagrams, I. Pollen Spores 12, 21-37

Damblon, F & Schumacker, R. (1971) New prospects for study of palynological data: the use of computers. Pollen Spores 13, 609-614

Davis, J.C. (1973) Statistics and Data Analysis in Geology. J. Wiley and Sons, New York. 550pp

Davis, M.B. (1968) Pollen grains in lake sediments: redeposition caused by seasonal water circulation. Science, 162,769-9

Davis, R.B., Brewster, L.A. & Sutherland, J. (1969) Variations in pollen spectra within lakes. Pollen Spores, 11, 557-71

Davis, M.B. & Deevey, E.S. (1964) Pollen accumulation rates: estimates from late-glacial sediment of Rogers Lake. Science, 145, 1293-5

Dinham, C.H. & Haldane, D. (1932) Economic Geology of the Stirling and Clackmannan coalfield. Mem. Geol. Surv.

Dodson, J.R. (1972) Computer programs for the pollen analyst. Pollen Spores 14, 455-465

Donner, J.J. (1957) The geology and vegetation of late-glacial retreat stages in Scotland. Trans. R. Soc. Edinb. 63, 221-64

Donner, J.J. (1958) Loch Mahaick, a late-glacial site in Perthshire.

New Phytol. 57: 183-6

Donner, J.J. (1962) On the Post-glacial history of the Grampian Highlands of Scotland. Soc. Sci. Fenn. Comm. Biol., 22: 1-13

Durno, S.E. (1958) The dating of the Forth Valley carse clay. Scott. Geogr. Mag. 74, 47-8

Durno, S.E. (1959) Pollen analysis of peat deposits in the Eastern Grampians. Scott. Geogr. Mag. 75: 102-11

Durno, S.E. (1965) Pollen analytical evidence of 'Landnum' from two Scottish sites. Trans. bot. Soc. Edinb. 40: 13-9

Durno, S.E. (1967) Scottish woodland history since boreal time as revealed by pollen analysis of peat. Ph.D. thesis (upubl.), University of Aberdeen

Durno, S.E. & Romans, J.C.C. (1969) Evidence for variations in the altitudinal zonation of climate in Scotland and Northern England since the Boreal period. Scott. Geogr. Mag. 85: 31-3.

Edwards, K.J. (1974) A half century of pollen analytical research in Scotland Trans. Bot. Soc. Edinb. 42, 211-22

Erdtman, G. (1923) Iakttagelser fram en mikropaleontologisk undersokning at nordskotska, Hebridiska, och Shetlandska torvmarker. Geol. For. stockh. Forh. 45, 538-45

Erdtman, G. (1924) Studies in micropalaeontology of Post-glacial deposits in Northern Scotland and the Scotch (sic) Isles, with especial reference to the history of the woodlands. J. Linn. Soc. (bot). 46: 449-504

Erdtman, G. (1928) Studies in the post arctic history of the forests of North-western Europe I, investigations in the British Isles. Geol. For. Stockh. Forh. 50:123-92

Erdtman, G. (1943) An Introduction to Pollen Analysis. Chronica

Botanica, Waltham, Mass.

Erdtman, G. (1960) The acetolysis method. Svensk. bot. Tidskr. 50, 135-41

Erdtman, G. (1969) Handbook of Palynology. An introduction to the study of pollen grains. Muunksgaard,Copenhagen

Erdtman, G., Berglund, B. & Praglowski, J. (1961) An Introduction to a Scandinavian Pollen Flora. Vol I. Almqvist and Wicksell, Stockholm and in Grana. Palynol. 2 (3) 3-92

Erdtman, G., Praglowski, J. & Nilsson, S. (1963) An Introduction to a Scandinavian Pollen Flora. Vol II. Almqvist and Wicksell, Stockholm.

Evans, G. H. (1970) Pollen and diatom analyses of Late Quaternary deposits in the Blelham basin, north Lancashire. New Phytol. 69, 821-74

Faegri, K & Iversen, J. (1975) Textbook of pollen analysis. London

Faegri, K. & Iversen, J. (1964) Textbook of Pollen Analysis Copenhagen

Fenton, E.W. (1951) The influence of man on plant and animal life. In. Scientific Survey of South-Eastern Scotland British Association for the Advancement of Science, Edinburgh

Firbas, F. (1949) Spat- und Nacheiszeitliche Waldegeschichte Mitteleuropas nordlich der Alpen. Bd. 1. Allgemeine Waldgeschichte. Gustav Fischer, Jena

Fraser, G.K. & Godwin, H. (1955) Two Scottish pollen diagrams: Carnwath Moss, Lanarkshire and Strichen Moss, Aberdeenshire. Data for the study of Postglacial history, XVII New Phytol. 54. 216-21

Frey, D.G. (1955) A differential flotation technique for recovering micro- fossils from inorganic sediments. New Phytol. 54. 257

Garbett, G. G. (1981) The Elm decline : depletion of a resource. New Phytol. 88, 573-585

Geikie, J. (1866) On the buried forests and peat mosses of Scotland and the changes of climate which they indicate. Trans. Roy. Soc. Edinb. 24, 363

Geikie, J. (1894) The Great Ice Age and its relation to the antiquity of man London

Gimmingham, H. (1972) Ecology of Heathlands, London

Gjaerevoll, O. (1950) The snowbed vegetation in the surroundings of Lake Tornetrask, Swedish Lappland. Svensk bot. Tidskr. 44, 387-440

Godwin, H. (1940) Pollen analysis and forest history of England and Wales New Phytol. 39. 4. 370.

Godwin, H. (1940) Pollen analysis and forest history of England and Wales. New Phytol. 39. 4. 370

Godwin, H. (1956) The History of the British Flora. Cambridge

Godwin, H. (1968) Organic deposits at Old Buckenham Mere, Norfolk. New Phytol. 67, 95

Godwin H. (1975) The History of the British Flora. 2nd edition. Cambridge University Press, Cambridge.

Gordon, A.D. (1973) Classification in the presence of constraints Biometrics 29, 821-27

Gordon, A.D. & Birks, H.J.B. (1972) Numerical methods in Quaternary Palaeoecology. I. Zonation of pollen diagrams. New Phytol. 71, 961-79

Gordon, A.D. & Birks, H.J.B. (1974) Numerical methods in Quaternary Palaeoecology, II. Comparison of pollen diagrams New Phytol. 73, 221-49

Gray, J.M. & Lowe, J.J. (1977) The Scottish Lateglacial environment:

a synthesis. In Gray, J.M. and Lowe, J.J. (eds.) Studies in the Scottish Lateglacial Environment, 163-181. Oxford.

Gregory, S. (1954) In Chandler, T. & Gregory, S. (1968) The Climate of the British Isles. London

Chandler, T.J. & Gregory, S. (1968) The climate of the British Isles. London

Gunson, A.R. & Edwards, K.J. (1978) A procedure for the determination of exotic pollen concentrations with a Coulter counter. Pollen Spores, 2: 303-9

Hafsten, U. (1959) Bleaching + HF + Acetolysis a hazardous preparation process. Pollen Spores 1: 77-9

Haworth, E.Y. (1976) Two lateglacial (late Devensian) diatom assemblages profiles from northern Scotland. New Phytol. 77, 227-256

Hedberg, H.D. (ed.) (1972) An international guide to stratigraphic classification, terminology and usage. Lethaia 5: 283-295

Hibbert, F.A., Switsur, V.R. & West, R.G. (1971) Radiocarbon dating of Flandrian pollen zones at Red Moss, Lancashire. Proc. R. Soc., B 177, 161

Hill, P. (1979) Broxmouth Hillfort Excavations, 1977-78. An Interim Report. Dept. of Archaeology, Univ. of Edinburgh. Occ. Paper 2

Holdgate, M.W. (1955) The vegetation of some British upland fens. J. Ecol. 43, 389-403

Hutchinson, G.E. (1970) A Treatise on Limnology, New York 2nd edition

Hyde, H.A. & Adams, K.F. (1958) An Atlas of Airborne Pollen Grains. London

Iversen, J. (1941) Landnam i Danmarks Stenalder. En pollenanalytisk Undersolgelse over det forste Landbrug Indvirkning paa Vegetationsudviklingen. Danm. geol. Unders., RII no. 66

Iversen, J. (1954) The late-glacial flora of Denmark and its relation to climate and soil. Danm. Geol. Unders., 96, 87

Jessen, K. (1949) Studies in Late Quaternary deposits and flora history of Ireland. Proc. R. Irish Acad. 52 (B.6) 85.

Keating, T.H. & Dickson, J.H. (1979) Mid-Flandrian changes in vegetation on mainland Orkney. New Phytol. 82, 585-612

Kendall, P.F. & Bailey, E.B. (1908) The Glaciation of East Lothian south of the Garleton Hills. Trans. Roy. Soc. Edinb. Vol XLVI, part I, pp 1-31

King, L. (1976) Pollenanalyse und computer: Erfahrungen mit PALYNO Programme zur Berechnung und Darstellung Pollenanalytischer Daten. Pollen Spores 18, 93-104.

Kirby, R.P. (1968) The ground moraines of Midlothian and East Lothian. Scot. J. Geol. 4, 209-20

Kirby, R.P. (1969 a) Morphometric analysis of fluvioglacial terraces in the Esk basin, Midlothian. Trans. Inst. Br. Geogr. 48, 1-18

Kirk, W. & Godwin, H. (1963) The Late-glacial site at Loch Droma, Ross and Cromarty. Proc. R. Soc. Edin., 65, 225

Kolstrop, E. (1982) Late-glacial pollen diagrams from Hjelm and Draved Moss, (Denmark) with a suggestion of the possibility of drought during the Earlier Dryas. Rev. Palaeobotan. Palynol. 36, 35-63

Kruskal, J.B. (1964 a) Multidimensional scaling by optimising goodness of fit to a nonmetric hypothesis. Psychometrica, 29, 1

Kruskal, J.B. (1964 b) Nonmetric multidimensional scaling: a numerical method. Psychometrica, 29, 115

Lewis, F.J. (1905) The plant remains in the Scottish peat mosses. Part I. Trans. Roy. Soc. Edinb. 41, 699-723

Lewis, F.J. (1906) The plant remains in the Scottish peat mosses. Part II. Trans. Roy. Soc. Edinb. 335-60

Lewis, F.J. (1907) The plant remains in the Scottish peat mosses. Part III. Trans. Roy. Soc. Edinb. 46, 33-70

Lewis, F.J. (1911) The plant remains in the Scottish peat mosses. Part IV. Trans. Roy. Soc. Edinb. 47, 793-833

Lowe, J.J. (1977) Pollen analysis and radiocarbon dating of Lateglacial and early Flandrian deposits in southern Perthshire. Ph.D. thesis (upubl.), Univ. of Edinburgh.

Lowe, J.J. (1982) Three Flandrian pollen profiles from the Teith Valley. Perthshire, Scotland II. Analysis of deteriorated pollen. New Phytol. 90, 371-385

Lowe, J.J. & Gray, J.M. (1980) The stratigraphic subdivision of the Lateglacial of NW Europe: a discussion. In Lowe, J.J., Gray, J.M. & Robinson, J.E. (eds.) Studies in the Lateglacial of North-West Europe, pps 157-176. Pergammon, Oxford.

Lowe, J.J. & Walker, M.J.C. (1980) Problems associated with dating the close of the Lateglacial period in the Rannoch Moor area, Scotland. In Lowe, J.J., Gray, J.M. & Robinson, J.E. (Eds.). Studies in the Lateglacial of North-West Europe. 123-138 Pergammon, Oxford.

Mackereth, F.J.H. (1965) Chemical investigations of lake sediments and their intepretation. Proc. R. Soc., B, 161, 295-309

Mackereth, F.J.H. (1966) Some chemical observations on Post-glacial lake sediments. Phil. Trans. R. Soc. B., 250, 165-213

Macpherson, J.B. (1980) Environmental change during the Loch Lomond Stadial: evidence from a site in the upper Spey valley, Scotland. In Lowe, J.J., Gray, J.J. & Robinson, J.E. (Eds.). Studies in the Lateglacial of North-West Europe. pps 89-102, Pergamon, Oxford.

Maher, L. (1972) Nomograms for computing 0.95 confidence limits of pollen data. Rev. Palaeobot. Palynol. 13, 85-93

Maher, L.J. (1963) Pollen analyses of surface materials from Southern Juan mountains. Bull. geol. Soc. Am. 74, 1485-1504

Mangerud, J., Andersen, S.Th., Berglund, B.E. & Donner, J.J. (1974) Quaternary stratigraphy of Norden, a proposal for terminology and classification. Boreas, 3, 109-26

Matthews, J. (1969) The assessment of a method for the determination of absolute pollen frequencies New Phytol. 68, 161

Maugh, T.H. (1978) Radiocarbon dating: direct detection extends range of the technique. Science, 200, 635-637

McVean, D.N. & Ratcliffe, D.A. (1962) Plant communities of the Scottish Highlands H.M.S.O. London

Meiklejohn, A.K.M. (1951) Agriculture. In. Scientific Survey of South-Eastern Scotland. British Association for the Advancement of Science, Edinburgh

Mitchell, G.F. (1942) A composite pollen diagram from Co. Meath, Ireland. New Phytol. 41, 257-61

Mitchell, G.F. (1948) Late-glacial deposits in Berwickshire. New Phytol. 47: 262-4

Mitchell, G.F. (1952) Late-glacial deposits at Garscadden Mains, near Glasgow. New Phytol. 50: 277-86

Mitchell, G.F. (1956) Post-Boreal pollen diagrams from Irish raised bogs. Proc. R. Irish Acad. B. 57, 185-251

Mitchell, G.F., Penny, L.F., Shotton, F.W., & West, R.G. (1973) A correlation of Quaternary deposits in the British Isles. Geol. Soc. Lond., Special Rep., 4, 99pp.

Moar, N.T. (1969) Late Weichselian and Flandrian pollen diagrams from

south-west Scotland. New Phytol. 68: 433-67

Moore, P.D. (1980) The reconstruction of the Lateglacial environment: some problems associated with the interpretation of pollen data. In Lowe,J.J. Gray, J.M. & Robinson, J.E. (eds.) Studies in the Lateglacial of North-West Europe. pps 151-156 Pergammon, Oxford

Moore, P.D. & Webb, J.A. (1978) An Illustrated Guide to Pollen Analysis. Hodder and Stroughton, London

Morrison, D.F. (1967) Multivariate Statistical Methods McGraw-Hill, New York. 338 pp

Muller, R.A. (1977) Radioisotope dating with a cyclotron. Science, 196, 489-94

Newey, W.W. (1965) Post-glacial vegetational and climatic changes in part of south-east Scotland. Ph.D. Thesis (upubl.), University of Edinburgh.

Newey, W.W. (1966) Pollen analysis of sub-carse peats of the Forth Valley. Trans. Inst. Br. Geogr. 39: 53-9

Newey, W.W. (1968) Pollen Analyses from south-east Scotland. Trans. Bot. Soc. Edinb. 40: 424-34

Newey, W.W. (1970) Pollen analysis of Late-Weichselian deposits at Corstorphine, Edinburgh. New Phytol. 69: 1167-77

Nichols, H. (1967) Vegetational change, shoreline displacement and the human factor in the Late Quaternary history of south- west Scotland. Trans. Bot. Soc. Edinb. 67: 145-87

O'Sullivan P.E. (1973) Contemporary pollen studies in an native Scots pine ecosystem. Oikos, 24: 143-50

O'Sullivan, P.E. (1974) Two Flandrian diagrams fromt the East Central Highlands of Scotland. Pollen Spores, 16, 31-57

Oldfield, F. (1960) Studies in the Post-glacial history of the

British vegetation : Lowland Lonsdale. New Phytol., 59, 192

Oldfield, F. (1970) Some aspects of scale and complexity in pollen-analytically based palaeoecology. Pollen Spores

Oldfield, F. & Statham, D.C. (1963) Pollen-analytical data from Urswick Tarn and Ellerside Moss, North Lancashire. New Phytol. 62, 53-66

Olsson, I. U. (1979) A warning against radiocarbon dating samples containing little carbon. Boreas, 8, 203-207

Peacock, J. D. (1983) A model for Scottish Interstadial marine palaeotemperatures 13,000 to 11,000 BP Boreas 12, 73-82

Pearsall, W. H. & Pennington, W. (1973) The Lake District; a landscape history. New Naturalist, 53 London

Pears, N.V. (1964) The present tree-line in the Cairngorm Mountains of Scotland and its relation to former tree-lines Ph.D. thesis (upubl.), University of London.

Pears, N.V. (1969) Post-glacial tree-lines of the Cairngorm Mountains, Scotland: some modifications based on radiocarbon dating. Trans. bot. Soc. Edinb. 40:536-44 v6

Pears, N.V. (1977) Pollen analysis. A review of some developments and interpretation problems. Scott. Geogr. Mag. 93, 32-44.

Peck, R.M. (1974) A comparison of four absolute pollen preparation techniques. New Phytol. 73, 567-87

Pennington, W. (1970) Vegetation history in the north-west of England: a regional synthesis. In Walker, D. & West, R.G. Studies in the Vegetational History of the British Isles, Cambridge.

Pennington, W. (1973) Absolute pollen frequencies in the sediments of lakes of different morphometry. In Birks, H.J.B. & West, R.G. (eds.) Quaternary Plant Ecology, 79-104 Oxford

Pennington, W. (1977 a) The Late Devensian flora of Britain. Phil. Trans. R. Soc. Lond. B. 280, 247-71

Pennington, W. (1977 b) Lake sediments and the Lateglacial Environment in Northern Scotland. In Gray, J.M. & Lowe, J.J. (eds.) Studies in the Scottish Lateglacial Environment. Oxford pp. 119-42

Pennington, W. & Bonny, A.P. (1970) Absolute Pollen Diagram from the British Late-Glacial. Nature, 226, 871-873

Pennington, W. & Lishman, J.P. (1975) Iodine in lake sediments in northern England and Scotland Biol. Rev. 46, 279-313

Pennington, W. & Sackin, M.J. (1975) An application of principal components analysis to the zonation of two Late-Devensian profiles. New Phytol. 75, 419-453

Pennington, W., Haworth, E.Y., Bonny, A.P. & Lishman, J.P. (1972) Lake sediments in northern Scotland. Phil. Trans. Roy. Soc. B. 264, 191-294

Persson, A. (1964) The vegetation at the margin of the retreating glacier Skaftafellsjokull, southwestern Iceland. Bot Notiser., 117, 323-54

Prentice, I.C. (1980) Multidimensional scaling as a research tool in Quaternary palaeoecology: a review ot theory and methods. Rev. Palaeobotan. Palynol.

Price, R.J. (1983) Scotland's Environment during the last 30,000 years. Scottish Academic Press, Edinburgh.

Proctor, M.C.F. & Lambert, C.A. (1961) Pollen spectra from recent Helianthemum communities. New Phytol. 60, 21

Rackham, O. (1980) Ancient woodland its history vegetation and uses in England. Edward Arnold, London, 402pp.

Reid, C. (1899) The Origin of the British Flora. Dulau & Co.,

London.

Reitsma, T. (1966) Pollen morphology of some European Rosaceae. Acta. Bot. Neerl. 15, 290-307

Reitsma, T. (1969) Size modification of pollen grains under different conditions. Rev. Palaeobotan. Palynol. 9, 175-202.

Robinson, D.E. (1981) The vegetational and land use history of the west of Arran, Scotland Ph.D. thesis (upubl.), University of Glasgow

Roskham, E.E. (1969) Data theory and algorithms for nonmetric scaling, Part I and Part II, mimeo, Technical report. Department of Psychology (Math. Psychol. Group) Univ. of Nijmegen, Holland.

Ruddiman, W.F., Sancetta, C.D. & McIntyre, A. (1977) Glacial / Interglacial response rate of subpolar North Atlantic water to climatic change: the record in ocean sediments. Phil. Trans. R. Soc. Lond. B, 280, 119-42.

Ruddiman, W.F. & McIntyre, A. (1981) The North Atlantic during the last deglaciation, Palaeogeography, Palaeoclimatology, Palaeoecology, 35, 145-214.

Samuelsson, G. (1910) Scottish Peat Mosses. A contribution to the knowledge of the late-quaternary vegetation and climate of North-Western Europe. Bull. Geol. Inst. Uppsala, 10, 197-260

Shennan, I. (1980) Flandrian Sea-level Changes in the Fenland. Ph.D. Thesis (upubl.), University of Durham.

Shotton, F.W. (1972) An example of hard-water error in radiocarbon dating of vegetable matter. Nature, 240, 460-1

Shotton, F.W. & West, R.G. (1969) Appendix b0. Stratigraphic table of the British Quaternary. In recommendations on stratigraphic usage. Proc. Geol. Soc. Lond., 1656, 139-66

Sims, R.E. (1973) The anthropogenic factor in East Anglian

vegetational history: an approach using APF techniques. In Quaternary Plant Ecology, ed Birks, H.J.B. & West, R.G. Blackwell, Oxford. p 223

Sissons, J.B. (1958) Supposed ice-dammed lakes in Britain with particular reference to the Eddleston Valley, southern Scotland. Geogr. Ann. 40, 159-87

Sissons, J.B. (1967) The Evolution of Scotland's Scenery. Edinburgh

Sissons, J.B. (1971) The Geomorphology of central Edinburgh. Scot. Geogr. Mag. 87, 185-96

Sissons, J.B. (1983) Quaternary. In Geology of Scotland ed. Craig. G.Y. pps 399-424 Scottish Academic Press, Edinburgh.

Sissons, J.B. & Sutherland, D.G. (1976) Climatic inferences from former glaciers in the south-east Grampian Highlands, Scotland. J. Glaciol. 17, 325-46

Sissons, J.B., Lowe, J.J., Thompson, K.S.R. & Walker M.J.C. (1973) Loch Lomond Readvance in the Grampian Highlands of Scotland. Nature Phys. Sci., 244, 75-7

Sissons, J.B., Smith, D.E. & Cullingford, R.A. (1966) Lateglacial and postglacial shorelines in southeast Scotland Trans. Inst. Br. Geogr. 39, 9-18

Smith, A.G. The mires of south-western Westmorland: stratigraphy and pollen analysis. New Phytol. 58, 105-27

Smith, A.G. (1965) Problems of inertia and threshold ralted to post-Glacial habitat changes. Proc. Roy. Soc. b061: 331-42

Smith, A.G. & Pilcher, J.R. (1973) Radiocarbon dates and vegetational history of the British Isles. New Phytol. 72, 903-14

Smith, D.E., Sissons, J.B. & Cullingford, R.A. (1969) Isobases for the Main Perth Raised Shoreline in southeast Scotland as determined

by trend surface analysis. Trans. Inst. Br. Geogr. 46, 45-52.

Smith, R. (1900) Botanical survey of Scotland I. Edinburgh District II, North Perthshire. Scot. Geogr. Mag. 16, 385-441

Squires, R.H. (1970) A computer program for the presentation of pollen data. Dept. Geogr. Univ. of Durham Occ. Paper 11, 53 pp.

Squires, R.H. & Holder, A.P. (1970) The use of computer in the presentation of pollen data New Phytol. 69, 875-883

Stockmarr, J. (1972) Tablets with spores used in absolute pollen analysis. Pollen Spores 13: 615-621

Suggate, R.P. & West, R.G. (1967) The substitution of local stage names for Holocene and Post-glacial. Quaternaria, 9, 245-6

Sutherland, D.G. (1980) Problems of radiocarbon dating deposits from newly deglaciated terrain: examples from the Scottish Lateglacial. In Lowe, J.J., Gray, J.M. & Robinson, J.E. (eds.) Studies in the Lateglacial of North-West Europe. Pergammon, Oxford, pp. 139-50

Tait, D. (1934) Excavations in the Old Lake deposits at Corstorphine during 1930- 1932. Trans. Edin. Geol. Soc. 13, 110

Tittensor, R.M. & Steele, R.C. (1971) Plant communities of the Loch Lamond oakwoods. J. Ecol. 59, 561-82

Troels-Smith, J. (1960) Ivy, Mistletoe and Elm: climatic indicators-fodder plants. Danm. Geol. Unders. (IV), 4, 1-32

Tulloch, W. & Walton, H.S. (1958) The geology of the Midlothian coalfield. Mem. Geol. Surv. Scot.

Tulloch, W., & Walton, H.S. (1958) The Geology of the Midlothian coalfield Mem. Geol. Surv. Scot.

Vallentyne, J.R. (1963) Isolation of pyrite spherules from recent sediments. Limnol. Oceanography 8, 16-30

Van Geel, B & Kolstrup, E. (1978) tentative explanation of the Late

glacial and early Holocene climatic changes in NW Europe. Geol. Mjinb. 57, 1:87-9

Vasari, Y. (1977) Radiocarbon dating of the Lateglacial and early Flandrian vegetational succession in the Scottish Highlands and the Isle of Skye. In Gray, J.M. and Lowe, J.J. (eds.) Studies in the Scottish Lateglacial Environment. Oxford, 143-62

Vasari, Y. & Vasari, A. (1968) Late and Post- glacial macrophytic vegetation in the lochs of Northern Scotland. Acta. bot. fenn. 45: 193-217.

Voorrips, A (1973) An ALGOL-60 program for computation and graphical representation of pollen analytical data. Acta. bot Neerl., 22, 645-654

Voorrips, A. (1974) An ALGOL-60 program for pollen analytical data; the CDC version. Acta bot. Neerl., 23, 701-704

Wain-Hobson, T. (1981) Aspects of the glacial and postglacial history of north-west Argyll. Ph.D. thesis (upubl.), University of Edinburgh.

Walker, D. (1966) The late Quaternary history of the Cumberland lowland. Phil. Trans. R. Soc. B. 251, 1-210

Walker, D. & Godwin, H. (1954) Lake-stratigraphy, pollen analysis and vegetational history. Chap II. in Clarke, J.G.D. Excavations at Star Carr. Cambridge

Walker, M.J.C. (1974) Lateglacial and early Postglacial environments in part of the Grampian Highlands of Scotland. Ph.D. thesis (upubl.), University of Edinburgh.

Walker, M.J.C. (1975) Late Glacial and Early Postglacial environmental history of the central Grampian Highlands, Scotland. J. Biogeogr., 2, 265-84.

Walker, M.J.C. (1977) Corrydon: a Lateglacial profile from Glenshee, South- east Grampian Highlands, Scotland. Pollen Spore, 19, 391-406

Walker, M.J.C. & Lowe, J.J. (1976) The Abbey piston corer. Quaternary Newsletter, 19, 1-3

Walker, M.J.C. & Lowe, J.J. (1977) Postglacial environmental history of Rannoch Moor, Scotland. I. Three pollen diagrams from the Kingshouse area. J. Biogeogr., 4, 333-51

Walker, M.J.C. & Lowe, J.J. (1979) Postglacial environmental history of Rannoch Moor, Scotland. II. Pollen analyses and radiocarbon dates from the Rannoch Station and Corrour areas. J. Biogeogr., 6, 349-62

Walker. D. (1970) Direction and rate in some British Post-glacial hydroseres. In Studies in the vegetational history of the British Isles. Cambridge University Press,Cambridge. pps 117-40

Watson, R.A. & Wright, H.E. (1980) The end of the Pleistocene: a general critique of chronostratigraphic classification. Boreas, 9, pp 153-163

Watts, W.A. (1963) Late Glacial pollen zones in western Ireland. Ir. Geogr., 4, 367

West, R.G. (1967) The Quaternary of the British Isles. In Geologic Systems the Quaternary, ed. K. Rankama, vol 2, p. 1. Interscience, New York.

West, R.G. (1968) Pleistocene Geology and Biology. Longmans, London.

West, R.G. (1970 a) Pollen zones in the Pleistocene of Great Britain and their correlation. New Phytol. 69, 1179

Williams, W. (1976) The Flandrian vegetational history of the Isle of Skye and the Morar peninsula. Ph.D. thesis (upubl.), University of Cambridge.

APPENDICES

Appendix 1

Listings of raw pollen counts for following sites:

(a) Broxmouth - analyst A. Alexander

(b) Balgone House - analyst A. Alexander

(c) Corstorphine - analyst Dr. Newey

(d) Corstorphine - analyst A. Alexander

BROXMOUTH. ANALYSED BY A J ALEXANDER, 1979

COUNTS OF POLLEN AND SPORES

NO.	TYPE	SAMPLE DEPTH (CM.) 110	130	140	150	162	172	177	185	195	205	210	220	230	237
1	BETULA	16.	16.	23.	17.	34.	8.	43.	23.	20.	14.	17.	28.	15.	25.
2	PINUS	20.	10.	10.	10.	20.	14.	10.	18.	23.	20.	12.	21.	12.	14.
3	SALIX	1.	1.	3.	2.	0.	4.	4.	3.	15.	56.	79.	102.	29.	49.
4	CORYLUS	368.	316.	363.	447.	378.	346.	420.	318.	333.	269.	296.	272.	137.	269.
5	PRUNUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
6	JUNIPERUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
7	HIPPOPHAE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
8	EMPETRUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
9	ERICACEAE	0.	0.	1.	2.	0.	0.	0.	3.	2.	0.	1.	1.	0.	0.
10	GRAMINEAE	39.	36.	56.	24.	73.	84.	75.	88.	136.	142.	165.	31.	195.	195.
11	CYPERACEAE	84.	65.	62.	78.	133.	101.	131.	43.	36.	49.	58.	73.	55.	57.
12	ARTEMISIA	0.	2.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
13	CAMPANULACEAE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
14	CARYOPHYLLACEAE	1.	0.	0.	1.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.
15	CHENOPODIACEAE	16.	6.	2.	0.	0.	1.	0.	0.	2.	0.	0.	0.	0.	0.
16	COMPOSITAE - TUBULIFLORAE	1.	0.	0.	0.	1.	0.	0.	0.	0.	4.	1.	6.	6.	12.
17	COMPOSITAE - LIGULIFLORAE	0.	1.	0.	0.	0.	0.	0.	1.	0.	0.	8.	0.	0.	0.
18	CRUCIFERAE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.	0.	0.	0.
19	DROSERA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.	0.	0.
20	DRYAS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
21	EPILOBIUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.
22	FILIPENDUL[redacted]	0.	2.	0.	1.	2.	2.	3.	3.	2.	4.	5.	10.	7.	0.
23	GALIUM	0.	0.	0.	0.	1.	2.	1.	1.	0.	0.	0.	0.	0.	0.
24	GENTIANA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
25	GERANIUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
26	HELIANTHEMUM	0.	0.	0.	2.	0.	2.	0.	0.	0.	0.	0.	0.	0.	0.
27	LABIATAE	0.	0.	0.	1.	0.	0.	1.	3.	6.	5.	0.	0.	0.	0.
28	LEGUMINOSAE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
29	PLANTAGO LANCEOLATA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
30	PLANTAGO SPP	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.	0.
31	POLYGONUM SPP	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
32	POTENTILLA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
33	PRIMULA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
34	RANUNCULACEAE	2.	1.	0.	0.	0.	0.	1.	0.	1.	1.	1.	1.	0.	0.
35	ROSACEAE	1.	0.	3.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
36	RUMEX	1.	1.	0.	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.
37	SAXIFRAGACEAE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
38	SCROPHULARIACEAE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
39	SUCCISA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
40	THALICTRUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
41	UMBELLIFERAE	0.	2.	1.	2.	1.	0.	2.	1.	1.	0.	0.	0.	1.	2.
42	URTICA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
43	VALERIANA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
44	VICIA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
45	VIOLA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
46	HYDROCOTYLE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
47	MYRIOPHYLLUM ALTERNIFLORUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
48	MYRIOPHYLLUM SPP	0.	0.	0.	1.	0.	1.	1.	2.	0.	2.	0.	0.	1.	1.
49	MENYANTHES	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
50	NUPHAR	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

NO.	TYPE	SAMPLE DEPTH (CM.) 110	130	140	150	162	172	177	185	195	205	210	220	230	237
51	POTOMAGETON	1.	1.	2.	0.	0.	3.	1.	2.	4.	2.	2.	5.	0.	C.
52	TYPHA	2.	22.	4.	19.	5.	3.	22.	33.	60.	14.	15.	7.	2.	7.
53	PTERIDOPHYTA UNDIFF	31.	5.	6.	14.	16.	28.	10.	0.	14.	14.	25.	14.	26.	9.
54	SORBUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
55	ULMUS	21.	35.	29.	25.	17.	27.	22.	16.	12.	24.	19.	7.	31.	31.
56	TILIA	0.	0.	1.	1.	0.	0.	0.	0.	0.	0.	0.	5.	0.	C.
57	QUERCUS	78.	76.	69.	71.	89.	0.	61.	82.	82.	91.	57.	0.	89.	97.
58	ALNUS	15.	10.	17.	14.	13.	20.	14.	11.	9.	0.	12.	1.	14.	2.
59	FAGUS	0.	0.	1.	1.	0.	0.	0.	0.	4.	0.	2.	0.	2.	2.
60	FRAXINUS	1.	0.	0.	0.	0.	0.	0.	0.	0.	2.	0.	0.	0.	C.
61	HEDERA	2.	0.	4.	3.	2.	0.	1.	2.	1.	0.	0.	0.	0.	C.
62	ILEX	0.	0.	0.	0.	0.	0.	2.	0.	0.	0.	0.	0.	0.	0.
63	POLYGONUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
64	NYMPHAEA	0.	0.	1.	0.	0.	2.	1.	38.	14.	14.	11.	23.	24.	12.

NO.	TYPE	SAMPLE DEPTH (CM.) 245	250	260	270	275	280	285	290	295	300	310	315	320	327
1	BETULA	21.	25.	32.	72.	75.	102.	29.	23.	105.	106.	102.	112.	114.	127.
2	PINUS	0.	21.	13.	18.	29.	5.	12.	17.	15.	21.	31.	17.	27.	10.
3	SALIX	48.	40.	75.	19.	5.	6.	90.	77.	9.	2.	14.	13.	14.	19.
4	CORYLUS	360.	213.	297.	340.	405.	273.	122.	425.	275.	185.	667.	714.	1032.	843.
5	PRUNUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
6	JUNIPERUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
7	HIPPOPHAE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	30.	1.	0.	1.
8	EMPETRUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
9	ERICACEAE	0.	0.	3.	1.	0.	0.	0.	1.	0.	0.	1.	0.	1.	0.
10	GRAMINEAE	163.	116.	129.	63.	50.	28.	75.	162.	21.	11.	9.	5.	7.	3.
11	CYPERACEAE	34.	60.	63.	65.	56.	59.	58.	50.	34.	43.	51.	46.	66.	62.
12	ARTEMISIA	0.	0.	1.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
13	CAMPANULACEAE	0.	0.	0.	0.	0.	0.	0.	1.	0.	0.	0.	0.	0.	0.
14	CARYOPHYLLACEAE	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
15	CHENOPODIACEAE	0.	0.	0.	1.	3.	2.	0.	0.	1.	0.	0.	1.	0.	1.
16	COMPOSITAE - TUBULIFLORAE	5.	13.	2.	3.	1.	0.	1.	11.	0.	0.	1.	0.	0.	0.
17	COMPOSITAE - LIGULIFLORAE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
18	CRUCIFERAE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
19	DROSERA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
20	DRYAS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
21	EPILOBIUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
22	FILIPENDULA	6.	15.	5.	10.	6.	0.	6.	4.	5.	1.	3.	1.	2.	1.
23	GALIUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.	0.	0.	0.	0.
24	GENTIANA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
25	GERANIUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
26	HELIANTHEMUM	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
27	LABIATAE	0.	1.	1.	4.	0.	0.	0.	1.	0.	0.	1.	0.	0.	0.
28	LEGUMINOSAE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
29	PLANTAGO LANCEOLATA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
30	PLANTAGO SPP	0.	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
31	POLYGONUM SPP	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
32	POTENTILLA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
33	PRIMULA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
34	RANUNCULACEAE	0.	0.	0.	0.	0.	0.	0.	1.	0.	1.	0.	0.	0.	0.
35	ROSACEAE	0.	1.	0.	2.	4.	0.	0.	0.	2.	0.	1.	2.	2.	0.
36	RUMEX	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.	0.	0.	0.
37	SAXIFRAGACEAE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
38	SCROPHULARIACEAE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
39	SUCCISA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
40	THALICTRUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.	0.	0.
41	UMBELLIFERAE	0.	1.	1.	0.	1.	0.	1.	0.	1.	1.	0.	3.	0.	0.
42	URTICA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
43	VALERIANA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
44	VICIA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
45	VIOLA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
46	HYDROCOTYLE	0.	0.	0.	0.	0.	0.	0.	1.	0.	0.	0.	0.	0.	0.
47	MYRIOPHYLLUM ALTERNIFLORUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
48	MYRIOPHYLLUM SPP	0.	0.	0.	0.	1.	0.	0.	1.	0.	0.	0.	0.	0.	3.
49	MENYANTHES	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
50	NUPHAR	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

		SAMPLE DEPTH (CM.)													
NO.	TYPE	245	250	260	270	275	280	285	290	295	300	310	315	320	327
51	POTOMAGETON	0.	4.	4.	0.	0.	0.	0.	3.	0.	0.	0.	1.	0.	1.
52	TYPHA	4.	5.	11.	1.	0.	0.	3.	10.	0.	0.	0.	0.	0.	0.
53	PTERIDOPHYTA UNDIFF	23.	13.	22.	37.	25.	13.	9.	10.	11.	10.	160.	4.	9.	3.
54	SORBUS	0.	0.	0.	0.	0.	0.	0.	0.	2.	0.	0.	1.	0.	0.
55	ULMUS	15.	14.	18.	11.	11.	7.	7.	11.	22.	8.	5.	14.	5.	6.
56	TILIA	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
57	QUERCUS	0.	81.	78.	23.	10.	13.	100.	95.	8.	8.	18.	10.	21.	10.
58	ALNUS	9.	9.	9.	2.	0.	0.	2.	2.	2.	0.	0.	0.	1.	0.
59	FAGUS	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
60	FRAXINUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
61	HEDERA	0.	0.	1.	6.	3.	1.	1.	0.	2.	10.	0.	4.	2.	3.
62	ILEX	0.	0.	0.	0.	1.	0.	0.	0.	0.	0.	0.	0.	1.	0.
63	POLYGONUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.	0.	0.
64	NYMPHAEA	15.	24.	23.	0.	2.	0.	25.	31.	1.	1.	2.	4.	1.	1.

		SAMPLE DEPTH (CM.)													
NO.	TYPE	335	355	362	380	385	390	405	415	427	450	465	472	476	480
1	BETULA	102.	101.	125.	100.	108.	130.	101.	94.	108.	120.	123.	132.	384.	138.
2	PINUS	21.	12.	31.	35.	20.	17.	28.	34.	0.	9.	10.	14.	40.	19.
3	SALIX	3.	13.	12.	7.	14.	3.	29.	13.	17.	11.	11.	14.	15.	25.
4	CORYLUS	1098.	1163.	2070.	1177.	1141.	1597.	2080.	2423.	3595.	1333.	1832.	1073.	120.	11.
5	PRUNUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
6	JUNIPERUS	0.	0.	0.	0.	0.	0.	0.	0.	1.	0.	0.	1.	0.	0.
7	HIPPOPHAE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
8	EMPETRUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.	1.
9	ERICACEAE	0.	0.	0.	0.	0.	0.	1.	0.	0.	0.	2.	0.	0.	0.
10	GRAMINEAE	19.	0.	5.	6.	3.	4.	11.	12.	1.	5.	1.	7.	22.	6.
11	CYPERACEAE	77.	43.	89.	85.	0.	35.	161.	124.	182.	33.	12.	6.	11.	3.
12	ARTEMISIA	0.	0.	0.	0.	0.	0.	3.	0.	0.	0.	0.	0.	0.	0.
13	CAMPANULACEAE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
14	CARYOPHYLLACEAE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
15	CHENOPODIACEAE	0.	0.	0.	0.	0.	0.	0.	0.	1.	0.	0.	0.	0.	1.
16	COMPOSITAE - TUBULIFLORAE	0.	0.	1.	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.
17	COMPOSITAE - LIGULIFLORAE	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.	0.	0.
18	CRUCIFERAE	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
19	DROSERA	0.	0.	0.	0.	0.	0.	2.	0.	0.	0.	0.	0.	0.	0.
20	DRYAS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
21	EPILOBIUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
22	FILIPENDULA	0.	0.	1.	1.	0.	0.	1.	0.	1.	1.	0.	4.	0.	6.
23	GALIUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
24	GENTIANA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
25	GERANIUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
26	HELIANTHEMUM	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	2.	0.	0.	0.
27	LABIATAE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
28	LEGUMINOSAE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
29	PLANTAGO LANCEOLATA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
30	PLANTAGO SPP	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
31	POLYGONUM SPP	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
32	POTENTILLA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.
33	PRIMULA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
34	RANUNCULACEAE	0.	1.	3.	2.	0.	0.	2.	0.	0.	0.	0.	1.	0.	1.
35	ROSACEAE	1.	1.	0.	0.	3.	0.	0.	0.	3.	0.	1.	0.	3.	2.
36	RUMEX	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
37	SAXIFRAGACEAE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
38	SCROPHULARIACEAE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
39	SUCCISA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
40	THALICTRUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
41	UMBELLIFERAE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.
42	URTICA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
43	VALERIANA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
44	VICIA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
45	VIOLA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.
46	HYDROCOTYLE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
47	MYRIOPHYLLUM ALTERNIFLORUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
48	MYRIOPHYLLUM SPP	0.	1.	4.	1.	2.	0.	1.	0.	1.	0.	0.	0.	1.	2.
49	MENYANTHES	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.
50	NUPHAR	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

NO.	TYPE	SAMPLE DEPTH (CM.) 335	355	362	380	385	390	405	415	427	450	465	472	476	480
51	POTOMAGETON	0.	2.	0.	2.	0.	0.	0.	0.	1.	0.	0.	2.	1.	0.
52	TYPHA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
53	PTERIDOPHYTA UNDIFF	12.	12.	11.	4.	6.	11.	5.	15.	14.	9.	13.	6.	45.	32.
54	SORBUS	0.	0.	0.	0.	0.	0.	1.	0.	0.	0.	0.	0.	0.	0.
55	ULMUS	10.	5.	0.	7.	4.	7.	12.	9.	12.	12.	14.	3.	3.	0.
56	TILIA	0.	0.	0.	0.	0.	0.	0.	1.	0.	0.	0.	0.	0.	0.
57	QUERCUS	16.	8.	16.	8.	7.	7.	8.	13.	11.	10.	1.	0.	4.	1.
58	ALNUS	1.	0.	0.	0.	0.	0.	1.	0.	0.	0.	0.	1.	0.	0.
59	FAGUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
60	FRAXINUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
61	HEDERA	2.	3.	0.	5.	6.	0.	4.	5.	25.	1.	0.	1.	0.	0.
62	ILEX	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
63	POLYGONUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
64	NYMPHAEA	5.	2.	1.	1.	3.	6.	13.	4.	0.	0.	0.	0.	0.	0.

NO.	TYPE	SAMPLE DEPTH (CM.) 482	492	494	496	502	508	516	522	524	530	536	540	546	550
1	BETULA	616.	48.	51.	67.	66.	48.	24.	47.	42.	18.	16.	34.	33.	27.
2	PINUS	69.	20.	29.	17.	12.	19.	31.	15.	14.	19.	19.	33.	19.	21.
3	SALIX	68.	5.	8.	5.	6.	4.	3.	6.	12.	5.	5.	18.	51.	23.
4	CORYLUS	73.	8.	4.	1.	0.	0.	0.	3.	0.	1.	0.	0.	0.	0.
5	PRUNUS	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
6	JUNIPERUS	1.	15.	0.	21.	11.	7.	7.	3.	1.	1.	4.	4.	5.	19.
7	HIPPOPHAE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
8	EMPETRUM	1.	35.	42.	33.	21.	25.	24.	16.	19.	0.	0.	37.	26.	25.
9	ERICACEAE	3.	0.	1.	1.	0.	4.	0.	2.	0.	0.	0.	0.	0.	2.
10	GRAMINEAE	62.	292.	314.	245.	303.	295.	306.	295.	283.	306.	169.	175.	154.	148.
11	CYPERACEAE	11.	39.	37.	38.	44.	32.	47.	43.	54.	88.	55.	69.	93.	78.
12	ARTEMISIA	0.	1.	1.	2.	3.	7.	2.	4.	8.	1.	10.	10.	16.	6.
13	CAMPANULACEAE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
14	CARYOPHYLLACEAE	0.	0.	0.	1.	1.	3.	1.	2.	4.	0.	0.	13.	9.	4.
15	CHENOPODIACEAE	0.	0.	1.	0.	0.	0.	0.	2.	1.	0.	0.	3.	4.	0.
16	COMPOSITAE - TUBULIFLORAE	1.	2.	1.	0.	0.	2.	4.	5.	3.	0.	0.	1.	2.	4.
17	COMPOSITAE - LIGULIFLORAE	0.	0.	0.	0.	1.	0.	0.	2.	1.	1.	4.	0.	0.	1.
18	CRUCIFERAE	0.	2.	1.	0.	0.	1.	0.	1.	1.	1.	2.	1.	4.	5.
19	DROSERA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
20	DRYAS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
21	EPILOBIUM	0.	2.	4.	3.	5.	2.	3.	1.	5.	8.	1.	1.	0.	0.
22	FILIPENDULA	21.	16.	24.	8.	13.	9.	7.	8.	8.	3.	0.	9.	8.	12.
23	GALIUM	0.	1.	6.	6.	1.	7.	5.	12.	6.	12.	8.	9.	2.	4.
24	GENTIANA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
25	GERANIUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
26	HELIANTHEMUM	0.	0.	1.	0.	0.	1.	0.	0.	0.	0.	0.	5.	7.	4.
27	LABIATAE	0.	0.	0.	0.	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.
28	LEGUMINOSAE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
29	PLANTAGO LANCEOLATA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
30	PLANTAGO SPP	1.	0.	0.	0.	0.	0.	0.	0.	2.	1.	0.	2.	1.	0.
31	POLYGONUM SPP	0.	0.	0.	2.	0.	0.	0.	0.	0.	1.	0.	0.	0.	0.
32	POTENTILLA	0.	1.	1.	0.	0.	0.	0.	0.	0.	1.	0.	0.	0.	0.
33	PRIMULA	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	1.	1.	0.	0.
34	RANUNCULACEAE	1.	1.	1.	2.	0.	7.	2.	7.	6.	9.	5.	0.	2.	4.
35	ROSACEAE	2.	1.	0.	0.	0.	1.	2.	2.	0.	1.	0.	0.	1.	1.
36	RUMEX	0.	8.	3.	9.	9.	20.	30.	24.	28.	31.	62.	67.	58.	123.
37	SAXIFRAGACEAE	0.	0.	0.	0.	0.	2.	0.	0.	0.	2.	0.	0.	2.	0.
38	SCROPHULARIACEAE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
39	SUCCISA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
40	THALICTRUM	1.	1.	0.	3.	3.	0.	2.	0.	4.	1.	8.	12.	7.	8.
41	UMBELLIFERAE	1.	2.	3.	1.	1.	0.	0.	0.	0.	0.	1.	0.	0.	0.
42	URTICA	0.	0.	0.	0.	0.	0.	0.	1.	0.	0.	0.	0.	0.	0.
43	VALERIANA	1.	0.	0.	0.	0.	1.	0.	2.	1.	0.	0.	0.	0.	0.
44	VICIA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
45	VIOLA	0.	1.	0.	0.	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.
46	HYDROCOTYLE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
47	MYRIOPHYLLUM ALTERNIFLORUM	0.	1.	0.	0.	2.	0.	0.	2.	2.	0.	0.	0.	0.	0.
48	MYRIOPHYLLUM SPP	0.	0.	0.	0.	0.	3.	1.	0.	0.	0.	1.	0.	1.	0.
49	MENYANTHES	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
50	NUPHAR	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

NO.	TYPE	SAMPLE DEPTH (CM.) 482	492	494	496	502	508	516	522	524	530	536	540	546	550
51	POTOMAGETON	1.	1.	2.	18.	6.	33.	1.	3.	1.	3.	36.	0.	0.	2.
52	TYPHA	0.	0.	0.	0.	1.	6.	14.	10.	12.	12.	2.	0.	0.	0.
53	PTERIDOPHYTA UNDIFF	146.	10.	9.	31.	14.	33.	20.	5.	5.	3.	3.	6.	11.	3.
54	SORBUS	2.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
55	ULMUS	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
56	TILIA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
57	QUERCUS	5.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
58	ALNUS	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
59	FAGUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
60	FRAXINUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
61	HEDERA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
62	ILEX	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
63	POLYGONUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
64	NYMPHAEA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

NO.	TYPE	SAMPLE DEPTH (CM.)													
		556	560	566	570	576	586	590	596	602	609	615	620	626	630
1	BETULA	17.	27.	37.	60.	65.	45.	62.	18.	13.	55.	41.	59.	49.	49.
2	PINUS	34.	0.	10.	6.	8.	4.	7.	11.	8.	7.	8.	13.	3.	11.
3	SALIX	12.	3.	2.	4.	7.	2.	4.	5.	4.	5.	5.	8.	4.	5.
4	CORYLUS	0.	0.	0.	2.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
5	PRUNUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.	1.
6	JUNIPERUS	9.	9.	27.	40.	63.	46.	31.	36.	17.	14.	64.	112.	45.	23.
7	HIPPOPHAE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
8	EMPETRUM	17.	24.	37.	46.	72.	46.	54.	25.	12.	5.	18.	36.	33.	23.
9	ERICACEAE	0.	0.	0.	0.	0.	0.	1.	0.	0.	0.	0.	0.	0.	0.
10	GRAMINEAE	101.	255.	287.	226.	197.	260.	214.	290.	205.	661.	276.	212.	261.	307.
11	CYPERACEAE	91.	79.	44.	47.	37.	61.	70.	57.	94.	96.	45.	37.	55.	33.
12	ARTEMISIA	5.	1.	1.	6.	0.	3.	1.	3.	3.	2.	0.	2.	1.	4.
13	CAMPANULACEAE	0.	0.	0.	0.	0.	0.	2.	2.	0.	0.	0.	0.	1.	0.
14	CARYOPHYLLACEAE	16.	2.	0.	0.	0.	0.	1.	2.	0.	0.	1.	0.	0.	2.
15	CHENOPODIACEAE	0.	1.	0.	0.	0.	0.	0.	2.	1.	0.	0.	0.	0.	0.
16	COMPOSITAE - TUBULIFLORAE	2.	4.	1.	0.	0.	1.	0.	0.	0.	4.	0.	0.	0.	3.
17	COMPOSITAE - LIGULIFLORAE	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.
18	CRUCIFERAE	5.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
19	DROSERA	0.	0.	0.	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.
20	DRYAS	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.	0.	0.	0.	0.
21	EPILOBIUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.	2.
22	FILIPENDULA	1.	8.	25.	26.	29.	9.	1.	3.	3.	6.	9.	8.	3.	11.
23	GALIUM	1.	10.	7.	5.	2.	2.	2.	7.	3.	14.	5.	3.	4.	3.
24	GENTIANA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
25	GERANIUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.	0.
26	HELIANTHEMUM	7.	9.	13.	8.	3.	0.	13.	6.	7.	11.	9.	7.	7.	8.
27	LABIATAE	0.	1.	0.	0.	0.	0.	0.	0.	1.	0.	0.	0.	1.	0.
28	LEGUMINOSAE	0.	0.	0.	1.	0.	0.	0.	0.	1.	0.	0.	0.	0.	0.
29	PLANTAGO LANCEOLATA	0.	0.	0.	0.	0.	0.	1.	0.	0.	0.	1.	0.	0.	0.
30	PLANTAGO SPP	1.	1.	0.	2.	1.	0.	0.	0.	0.	0.	1.	1.	0.	0.
31	POLYGONUM SPP	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
32	POTENTILLA	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
33	PRIMULA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
34	RANUNCULACEAE	1.	0.	0.	3.	1.	3.	1.	2.	2.	5.	1.	1.	3.	0.
35	ROSACEAE	2.	0.	0.	4.	2.	0.	1.	0.	2.	0.	2.	1.	0.	0.
36	RUMEX	101.	47.	10.	10.	6.	8.	31.	38.	27.	52.	7.	7.	19.	15.
37	SAXIFRAGACEAE	0.	0.	0.	0.	0.	0.	0.	0.	1.	1.	1.	1.	0.	0.
38	SCROPHULARIACEAE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.
39	SUCCISA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.
40	THALICTRUM	4.	3.	1.	0.	4.	3.	0.	2.	3.	4.	8.	3.	5.	5.
41	UMBELLIFERAE	0.	0.	0.	4.	1.	1.	0.	0.	1.	0.	1.	4.	2.	4.
42	URTICA	0.	0.	0.	0.	1.	0.	0.	4.	0.	0.	0.	0.	0.	0.
43	VALERIANA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
44	VICIA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
45	VIOLA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
46	HYDROCOTYLE	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
47	MYRIOPHYLLUM ALTERNIFLORUM	0.	0.	8.	0.	8.	5.	2.	0.	0.	0.	0.	0.	0.	0.
48	MYRIOPHYLLUM SPP	0.	1.	2.	0.	4.	1.	4.	0.	0.	0.	0.	0.	0.	0.
49	MENYANTHES	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
50	NUPHAR	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

NO.	TYPE	SAMPLE DEPTH (CM.) 556	560	566	570	576	586	590	596	602	609	615	620	626	630
51	POTOMAGETON	0.	0.	0.	0.	0.	0.	0.	2.	0.	1.	0.	0.	0.	0.
52	TYPHA	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
53	PTERIDOPHYTA UNDIFF	6.	0.	3.	5.	3.	9.	16.	5.	5.	3.	8.	6.	1.	6.
54	SORBUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
55	ULMUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
56	TILIA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
57	QUERCUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
58	ALNUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
59	FAGUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
60	FRAXINUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
61	HEDERA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
62	ILEX	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
63	POLYGONUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
64	NYMPHAEA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

NO.	TYPE	SAMPLE DEPTH (CM.)										
		636	640	650	656	660	668	680	684	690	696	708
1	BETULA	27.	38.	17.	68.	33.	15.	0.	40.	78.	39.	46.
2	PINUS	3.	0.	1.	7.	5.	2.	34.	2.	2.	7.	8.
3	SALIX	14.	1.	8.	2.	3.	4.	5.	10.	4.	18.	20.
4	CORYLUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
5	PRUNUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
6	JUNIPERUS	76.	35.	79.	62.	18.	3.	1.	12.	0.	0.	0.
7	HIPPOPHAE	0.	0.	0.	0.	0.	1.	0.	0.	0.	0.	0.
8	EMPETRUM	24.	0.	7.	8.	25.	1.	2.	13.	6.	1.	1.
9	ERICACEAE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
10	GRAMINEAE	283.	317.	279.	266.	241.	97.	170.	157.	138.	160.	330.
11	CYPERACEAE	39.	33.	51.	46.	38.	29.	41.	28.	20.	20.	16.
12	ARTEMISIA	2.	0.	6.	4.	2.	3.	4.	3.	0.	1.	6.
13	CAMPANULACEAE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
14	CARYOPHYLLACEAE	1.	0.	2.	0.	0.	0.	1.	5.	2.	1.	3.
15	CHENOPODIACEAE	0.	0.	0.	1.	0.	0.	0.	0.	1.	3.	1.
16	COMPOSITAE - TUBULIFLORAE	1.	2.	0.	0.	2.	1.	1.	0.	2.	5.	10.
17	COMPOSITAE - LIGULIFLORAE	0.	0.	0.	0.	0.	1.	0.	0.	0.	0.	5.
18	CRUCIFERAE	0.	0.	0.	0.	0.	0.	0.	0.	0.	2.	0.
19	DROSERA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.
20	DRYAS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.
21	EPILOBIUM	0.	0.	0.	1.	2.	1.	2.	3.	5.	5.	6.
22	FILIPENDULA	2.	1.	0.	0.	1.	0.	0.	0.	0.	0.	0.
23	GALIUM	3.	7.	16.	1.	3.	9.	7.	8.	5.	0.	1.
24	GENTIANA	0.	0.	0.	0.	0.	0.	0.	0.	0.	3.	0.
25	GERANIUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
26	HELIANTHEMUM	4.	8.	9.	9.	9.	1.	0.	3.	0.	1.	0.
27	LABIATAE	0.	0.	0.	0.	0.	0.	0.	0.	0.	2.	0.
28	LEGUMINOSAE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
29	PLANTAGO LANCECLATA	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.	0.
30	PLANTAGO SPP	5.	2.	0.	0.	0.	14.	0.	2.	0.	0.	0.
31	POLYGONUM SPP	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
32	POTENTILLA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
33	PRIMULA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
34	RANUNCULACEAE	2.	0.	0.	0.	1.	0.	0.	1.	0.	0.	0.
35	ROSACEAE	1.	17.	1.	1.	0.	0.	2.	0.	1.	1.	0.
36	RUMEX	9.	0.	18.	20.	15.	10.	18.	17.	31.	31.	48.
37	SAXIFRAGACEAE	0.	0.	2.	1.	0.	0.	0.	0.	2.	0.	1.
38	SCROPHULARIACEAE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
39	SUCCISA	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.
40	THALICTRUM	0.	14.	3.	2.	8.	0.	8.	1.	1.	0.	1.
41	UMBELLIFERAE	3.	5.	1.	3.	4.	0.	0.	0.	0.	0.	1.
42	URTICA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
43	VALERIANA	0.	0.	0.	0.	0.	0.	1.	0.	0.	0.	1.
44	VICIA	0.	0.	0.	0.	0.	0.	0.	0.	1.	0.	0.
45	VIOLA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
46	HYDROCOTYLE	0.	0.	0.	1.	0.	2.	0.	0.	0.	0.	0.
47	MYRIOPHYLLUM ALTERNIFLORUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
48	MYRIOPHYLLUM SPP	0.	0.	0.	0.	1.	0.	3.	0.	0.	1.	0.
49	MENYANTHES	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
50	NUPHAR	0.	0.	0.	0.	0.	0.	0.	0.	1.	0.	0.

NO.	TYPE	SAMPLE DEPTH (CM.) 636	640	650	656	660	668	680	684	690	696	708
51	POTOMAGETON	0.	0.	0.	0.	1.	0.	0.	0.	0.	0.	4.
52	TYPHA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
53	PTERIDOPHYTA UNDIFF	3.	5.	0.	0.	2.	1.	2.	5.	1.	4.	42.
54	SORBUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
55	ULMUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
56	TILIA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
57	QUERCUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
58	ALNUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
59	FAGUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
60	FRAXINUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
61	HEDERA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
62	ILEX	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
63	POLYGONUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
64	NYMPHAEA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

BROXMOUTH - LOWER DIAGRAM. ANALYSED BY A J ALEXANDER.

COUNTS OF POLLEN AND SPORES

NO.	TYPE	SAMPLE DEPTH (CM.) 492	494	496	502	508	516	522	524	530	536	540	546	550	556
1	BETULA	48.	51.	67.	66.	48.	24.	47.	42.	18.	16.	34.	33.	27.	17.
2	PINUS	20.	29.	17.	12.	19.	31.	15.	14.	19.	19.	33.	19.	21.	34.
3	SALIX	5.	8.	5.	6.	4.	3.	6.	12.	5.	5.	18.	51.	23.	12.
4	CORYLUS	8.	4.	1.	0.	0.	0.	3.	0.	1.	0.	0.	0.	0.	0.
5	PRUNUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
6	JUNIPERUS	15.	0.	21.	11.	7.	7.	3.	1.	1.	4.	4.	5.	19.	9.
7	HIPPOPHAE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
8	EMPETRUM	35.	42.	33.	21.	25.	24.	16.	19.	0.	0.	37.	26.	25.	17.
9	ERICACEAE	0.	1.	1.	0.	4.	0.	2.	0.	0.	0.	0.	0.	2.	0.
10	GRAMINEAE	292.	314.	245.	303.	295.	306.	295.	283.	306.	169.	175.	154.	148.	101.
11	CYPERACEAE	39.	37.	38.	44.	32.	47.	43.	54.	88.	55.	69.	93.	78.	91.
12	ARTEMISIA	1.	1.	2.	3.	7.	2.	4.	8.	1.	10.	10.	16.	6.	5.
13	CAMPANULACEAE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
14	CARYOPHYLLACEAE	0.	0.	1.	1.	3.	1.	2.	4.	0.	0.	13.	9.	4.	16.
15	CHENOPODIACEAE	0.	1.	0.	0.	0.	0.	2.	1.	0.	0.	3.	4.	0.	0.
16	COMPOSITAE - TUBULIFLORAE	2.	1.	0.	0.	2.	4.	5.	3.	0.	0.	1.	2.	4.	2.
17	COMPOSITAE - LIGULIFLORAE	0.	0.	0.	1.	0.	0.	2.	1.	1.	4.	0.	0.	1.	1.
18	CRUCIFERAE	2.	1.	0.	0.	1.	0.	1.	1.	1.	2.	1.	4.	5.	5.
19	DROSERA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
20	DRYAS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
21	EPILOBIUM	2.	4.	3.	5.	2.	3.	1.	5.	8.	1.	1.	0.	0.	0.
22	FILIPENDULA	16.	24.	8.	13.	9.	7.	8.	8.	3.	0.	9.	8.	12.	1.
23	GALIUM	1.	6.	6.	1.	7.	5.	12.	6.	12.	8.	9.	2.	4.	1.
24	GENTIANA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
25	GERANIUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
26	HELIANTHEMUM	0.	1.	0.	0.	1.	0.	0.	0.	0.	0.	5.	7.	4.	7.
27	LABIATAE	0.	0.	0.	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.
28	LEGUMINOSAE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
29	PLANTAGO LANCEOLATA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
30	PLANTAGO SPP.(MAJOR)	0.	0.	0.	0.	0.	0.	0.	2.	1.	0.	2.	1.	0.	1.
31	POLYGONUM	0.	0.	2.	0.	0.	0.	0.	0.	1.	0.	0.	0.	0.	0.
32	POTENTILLA	1.	1.	0.	0.	0.	0.	0.	0.	1.	0.	0.	0.	0.	1.
33	PRIMULA	1.	0.	0.	0.	0.	0.	0.	0.	0.	1.	1.	0.	0.	0.
34	RANUNCULACEAE	1.	1.	2.	0.	7.	2.	7.	6.	9.	5.	0.	2.	4.	1.
35	ROSACEAE	1.	0.	0.	0.	1.	2.	2.	0.	1.	0.	0.	1.	1.	2.
36	RUMEX	8.	3.	9.	9.	20.	30.	24.	28.	31.	62.	67.	58.	123.	101.
37	SAXIFRAGACEAE	0.	0.	0.	0.	2.	0.	0.	0.	2.	0.	0.	2.	0.	0.
38	SCROPHULARIACEAE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
39	SUCCISA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
40	THALICTRUM	1.	0.	3.	3.	0.	2.	0.	4.	1.	8.	12.	7.	8.	4.
41	UMBELLIFERAE	2.	3.	1.	1.	0.	0.	0.	0.	0.	1.	0.	0.	0.	0.
42	URTICA	0.	0.	0.	0.	0.	0.	1.	0.	0.	0.	0.	0.	0.	0.
43	VALERIANA	0.	0.	0.	0.	1.	0.	2.	1.	0.	0.	0.	0.	0.	0.
44	VICIA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
45	VIOLA	1.	0.	0.	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.
46	HYDROCOTYLE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.
47	MYRIOPHYLUM ALTERNIFLORUM	1.	0.	0.	2.	0.	0.	2.	2.	0.	0.	0.	0.	0.	0.
48	MYRIOPHYLUM SPP.	0.	0.	0.	0.	3.	1.	0.	0.	0.	1.	0.	1.	0.	0.
49	MENYANTHES	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
50	NUPHAR	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

NO.	TYPE	SAMPLE DEPTH (CM.) 492	494	496	502	508	516	522	524	530	536	540	546	550	556
51	POTAMOGETON	1.	2.	18.	6.	33.	1.	3.	1.	3.	36.	0.	0.	2.	0.
52	TYPHA	0.	0.	0.	1.	6.	14.	10.	12.	12.	2.	0.	0.	0.	0.
53	PTERIDOPHYTA	10.	9.	31.	14.	33.	20.	5.	5.	3.	3.	6.	11.	3.	6.

NO.	TYPE	SAMPLE DEPTH (CM.) 560	566	570	576	582	588	590	593	596	599	602	607	609	610
1	BETULA	27.	37.	60.	65.	45.	33.	62.	27.	18.	21.	13.	10.	55.	14.
2	PINUS	0.	10.	6.	8.	4.	3.	7.	3.	11.	5.	8.	3.	7.	2.
3	SALIX	3.	2.	4.	7.	2.	0.	4.	3.	5.	3.	4.	4.	5.	6.
4	CORYLUS	0.	0.	2.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
5	PRUNUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
6	JUNIPERUS	9.	27.	40.	63.	46.	39.	31.	20.	36.	20.	17.	28.	14.	22.
7	HIPPOPHAE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
8	EMPETRUM	24.	37.	46.	72.	46.	26.	54.	34.	25.	15.	12.	10.	5.	4.
9	ERICACEAE	0.	0.	0.	0.	0.	0.	1.	0.	0.	0.	0.	0.	0.	0.
10	GRAMINEAE	255.	287.	226.	197.	260.	162.	214.	153.	290.	186.	205.	172.	231.	175.
11	CYPERACEAE	79.	44.	47.	37.	61.	16.	70.	34.	57.	37.	94.	51.	96.	67.
12	ARTEMISIA	1.	1.	6.	0.	3.	1.	1.	2.	3.	5.	3.	0.	2.	3.
13	CAMPANULACEAE	0.	0.	0.	0.	0.	0.	2.	0.	2.	1.	0.	1.	0.	0.
14	CARYOPHYLLACEAE	2.	0.	0.	0.	0.	0.	1.	0.	2.	1.	0.	0.	0.	0.
15	CHENOPODIACEAE	1.	0.	0.	0.	0.	0.	0.	0.	2.	1.	1.	0.	0.	1.
16	COMPOSITAE - TUBULIFLORAE	4.	1.	0.	0.	1.	1.	0.	0.	0.	0.	0.	0.	4.	1.
17	COMPOSITAE - LIGULIFLORAE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
18	CRUCIFERAE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
19	DROSERA	0.	0.	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
20	DRYAS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.	0.
21	EPILOBIUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.	0.	0.	0.	0.
22	FILIPENDULA	8.	25.	26.	29.	9.	14.	1.	4.	3.	8.	3.	7.	6.	0.
23	GALIUM	10.	7.	5.	2.	2.	1.	2.	2.	7.	4.	3.	6.	14.	4.
24	GENTIANA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
25	GERANIUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
26	HELIANTHEMUM	9.	13.	8.	3.	0.	5.	13.	3.	6.	3.	7.	1.	11.	3.
27	LABIATAE	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.	0.	0.	0.
28	LEGUMINOSAE	0.	0.	1.	0.	0.	0.	0.	0.	0.	0.	1.	0.	0.	0.
29	PLANTAGO LANCEOLATA	0.	0.	0.	0.	0.	0.	1.	0.	0.	0.	0.	0.	0.	0.
30	PLANTAGO SPP.(MAJOR)	1.	0.	2.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
31	POLYGONUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
32	POTENTILLA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
33	PRIMULA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
34	RANUNCULACEAE	0.	0.	3.	1.	3.	1.	1.	1.	2.	1.	2.	2.	5.	0.
35	ROSACEAE	0.	0.	4.	2.	0.	1.	1.	0.	0.	0.	2.	0.	0.	1.
36	RUMEX	47.	10.	10.	6.	8.	9.	31.	21.	38.	9.	27.	13.	52.	21.
37	SAXIFRAGACEAE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.	0.	1.	0.
38	SCROPHULARIACEAE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
39	SUCCISA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
40	THALICTRUM	3.	1.	0.	4.	3.	0.	0.	1.	2.	2.	3.	2.	4.	1.
41	UMBELLIFERAE	0.	0.	4.	1.	1.	1.	0.	0.	0.	0.	1.	0.	0.	1.
42	URTICA	0.	0.	0.	1.	0.	0.	0.	0.	4.	0.	0.	0.	0.	0.
43	VALERIANA	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.	0.	0.	0.	0.
44	VICIA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
45	VIOLA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
46	HYDROCOTYLE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
47	MYRIOPHYLUM ALTERNIFLORUM	0.	8.	0.	8.	5.	0.	2.	1.	0.	1.	0.	0.	0.	0.
48	MYRIOPHYLUM SPP.	1.	2.	0.	4.	1.	0.	4.	0.	0.	0.	0.	0.	0.	0.
49	MENYANTHES	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
50	NUPHAR	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

NO.	TYPE	SAMPLE DEPTH (CM.) 560	566	570	576	582	588	590	593	596	599	602	607	609	610
51	POTAMOGETON	0.	0.	0.	0.	0.	0.	0.	0.	2.	1.	0.	1.	1.	0.
52	TYPHA	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
53	PTERIDOPHYTA	0.	3.	5.	3.	9.	2.	16.	2.	5.	5.	5.	3.	3.	0.

NO.	TYPE	SAMPLE DEPTH (CM.) 612	615	617	620	624	626	628	632	636	642	644	646	650	654
1	BETULA	15.	41.	38.	59.	25.	49.	25.	40.	49.	30.	27.	27.	38.	17.
2	PINUS	5.	8.	8.	13.	3.	3.	1.	4.	11.	14.	2.	3.	0.	1.
3	SALIX	4.	5.	5.	8.	4.	4.	4.	4.	5.	5.	3.	14.	1.	8.
4	CORYLUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
5	PRUNUS	0.	0.	0.	0.	0.	1.	0.	0.	1.	0.	0.	0.	0.	0.
6	JUNIPERUS	18.	64.	18.	112.	106.	45.	58.	74.	23.	69.	54.	76.	35.	79.
7	HIPPOPHAE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
8	EMPETRUM	5.	18.	4.	36.	16.	33.	17.	19.	23.	17.	18.	24.	0.	7.
9	ERICACEAE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
10	GRAMINEAE	163.	276.	176.	212.	120.	261.	155.	143.	307.	159.	149.	283.	317.	279.
11	CYPERACEAE	56.	45.	25.	37.	25.	55.	21.	31.	33.	28.	29.	39.	33.	51.
12	ARTEMISIA	4.	0.	0.	2.	0.	1.	1.	1.	4.	0.	2.	2.	0.	6.
13	CAMPANULACEAE	0.	0.	1.	0.	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.
14	CARYOPHYLLACEAE	0.	1.	0.	0.	1.	0.	2.	0.	2.	0.	0.	1.	0.	2.
15	CHENOPODIACEAE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
16	COMPOSITAE - TUBULIFLORAE	1.	0.	0.	0.	0.	0.	0.	0.	3.	0.	2.	1.	2.	0.
17	COMPOSITAE - LIGULIFLORAE	0.	0.	0.	0.	0.	0.	0.	0.	1.	0.	0.	0.	0.	0.
18	CRUCIFERAE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
19	DROSERA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
20	DRYAS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
21	EPILOBIUM	0.	0.	0.	0.	0.	1.	0.	1.	2.	1.	0.	0.	0.	0.
22	FILIPENDULA	5.	9.	7.	8.	4.	3.	5.	4.	1.	7.	4.	2.	1.	0.
23	GALIUM	5.	5.	7.	3.	3.	4.	1.	5.	3.	2.	2.	3.	7.	16.
24	GENTIANA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
25	GERANIUM	0.	0.	0.	0.	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.
26	HELIANTHEMUM	3.	9.	4.	7.	1.	7.	1.	8.	8.	3.	6.	4.	8.	9.
27	LABIATAE	0.	0.	0.	0.	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.
28	LEGUMINOSAE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
29	PLANTAGO LANCEOLATA	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
30	PLANTAGO SPP.(MAJOR)	0.	1.	0.	1.	0.	0.	1.	1.	0.	0.	0.	5.	2.	0.
31	POLYGONUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
32	POTENTILLA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
33	PRIMULA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
34	RANUNCULACEAE	3.	1.	0.	1.	0.	3.	1.	1.	0.	1.	0.	2.	0.	0.
35	ROSACEAE	1.	2.	2.	1.	1.	0.	0.	0.	0.	0.	1.	1.	17.	1.
36	RUMEX	29.	7.	11.	7.	6.	19.	9.	5.	15.	13.	3.	9.	0.	18.
37	SAXIFRAGACEAE	0.	1.	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	2.
38	SCROPHULARIACEAE	0.	0.	0.	0.	0.	0.	0.	0.	1.	0.	0.	0.	0.	0.
39	SUCCISA	0.	0.	1.	0.	0.	0.	0.	0.	1.	0.	0.	0.	1.	0.
40	THALICTRUM	1.	8.	5.	3.	1.	5.	1.	1.	5.	4.	0.	0.	14.	3.
41	UMBELLIFERAE	1.	1.	0.	4.	0.	2.	0.	2.	4.	0.	3.	3.	5.	1.
42	URTICA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
43	VALERIANA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
44	VICIA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
45	VIOLA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
46	HYDROCOTYLE	0.	0.	0.	0.	1.	0.	0.	0.	0.	1.	0.	0.	0.	0.
47	MYRIOPHYLUM ALTERNIFLORUM	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
48	MYRIOPHYLUM SPP.	0.	0.	1.	0.	1.	0.	0.	0.	0.	1.	0.	0.	0.	0.
49	MENYANTHES	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
50	NUPHAR	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

NO.	TYPE	SAMPLE DEPTH (CM.) 612	615	617	620	624	626	628	632	636	642	644	646	650	654
51	POTAMOGETON	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
52	TYPHA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
53	PTERIDOPHYTA	2.	8.	0.	6.	0.	1.	0.	2.	6.	0.	2.	3.	5.	0.

NO.	TYPE	SAMPLE DEPTH (CM.) 656	659	662	666	670	673	675	677	680	682	684	687	690	693
1	BETULA	26.	68.	3.	33.	14.	15.	32.	30.	0.	16.	40.	24.	78.	49.
2	PINUS	1.	7.	4.	5.	6.	2.	1.	0.	34.	9.	2.	33.	2.	4.
3	SALIX	2.	2.	3.	3.	6.	4.	2.	3.	5.	6.	10.	5.	4.	16.
4	CORYLUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
5	PRUNUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
6	JUNIPERUS	41.	62.	25.	18.	45.	3.	10.	7.	1.	7.	12.	0.	0.	0.
7	HIPPOPHAE	0.	0.	0.	0.	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.
8	EMPETRUM	5.	8.	2.	25.	7.	1.	4.	3.	2.	3.	13.	11.	6.	2.
9	ERICACEAE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
10	GRAMINEAE	174.	266.	208.	241.	175.	97.	160.	171.	170.	211.	157.	170.	138.	114.
11	CYPERACEAE	39.	46.	46.	38.	31.	29.	50.	40.	41.	34.	28.	30.	20.	25.
12	ARTEMISIA	5.	4.	2.	2.	6.	3.	4.	0.	4.	4.	3.	0.	0.	2.
13	CAMPANULACEAE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
14	CARYOPHYLLACEAE	1.	0.	0.	0.	0.	0.	0.	1.	1.	4.	5.	1.	2.	3.
15	CHENOPODIACEAE	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.	0.
16	COMPOSITAE - TUBULIFLORAE	0.	0.	1.	2.	1.	1.	0.	0.	1.	3.	0.	6.	2.	2.
17	COMPOSITAE - LIGULIFLORAE	0.	0.	0.	0.	0.	1.	1.	0.	0.	0.	0.	0.	0.	0.
18	CRUCIFERAE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.
19	DROSERA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
20	DRYAS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
21	EPILOBIUM	0.	1.	0.	2.	0.	1.	1.	0.	2.	1.	3.	5.	5.	2.
22	FILIPENDULA	1.	0.	1.	1.	0.	0.	0.	0.	0.	1.	0.	0.	0.	0.
23	GALIUM	1.	1.	2.	3.	4.	9.	2.	13.	7.	6.	8.	6.	5.	11.
24	GENTIANA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
25	GERANIUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
26	HELIANTHEMUM	1.	9.	1.	9.	2.	1.	0.	1.	0.	0.	3.	0.	0.	0.
27	LABIATAE	0.	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
28	LEGUMINOSAE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
29	PLANTAGO LANCEOLATA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
30	PLANTAGO SPP.(MAJOR)	0.	0.	0.	0.	1.	14.	0.	1.	0.	2.	2.	2.	0.	1.
31	POLYGONUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
32	POTENTILLA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
33	PRIMULA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
34	RANUNCULACEAE	0.	0.	1.	1.	0.	0.	1.	1.	0.	2.	1.	2.	0.	1.
35	ROSACEAE	0.	1.	1.	0.	0.	0.	2.	0.	2.	1.	0.	0.	1.	0.
36	RUMEX	3.	20.	4.	15.	9.	10.	15.	9.	18.	67.	17.	16.	31.	16.
37	SAXIFRAGACEAE	0.	1.	1.	0.	0.	0.	1.	0.	0.	0.	0.	0.	2.	3.
38	SCROPHULARIACEAE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
39	SUCCISA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
40	THALICTRUM	1.	2.	3.	8.	3.	0.	13.	10.	8.	1.	1.	1.	1.	0.
41	UMBELLIFERAE	1.	3.	0.	4.	0.	0.	1.	0.	0.	1.	0.	0.	0.	0.
42	URTICA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
43	VALERIANA	0.	0.	0.	0.	0.	0.	0.	0.	1.	0.	0.	0.	0.	0.
44	VICIA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.	0.
45	VIOLA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
46	HYDROCOTYLE	0.	1.	0.	0.	0.	2.	0.	0.	0.	0.	0.	0.	0.	0.
47	MYRIOPHYLUM ALTERNIFLORUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
48	MYRIOPHYLUM SPP.	0.	0.	0.	1.	0.	0.	0.	0.	3.	0.	0.	1.	0.	1.
49	MENYANTHES	0.	0.	1.	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.
50	NUPHAR	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.	0.

NO.	TYPE	SAMPLE DEPTH (CM.) 656	659	662	666	670	673	675	677	680	682	684	687	690	693
51	POTAMOGETON	0.	0.	0.	1.	0.	0.	1.	0.	0.	0.	0.	0.	0.	0.
52	TYPHA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
53	PTERIDOPHYTA	0.	0.	1.	2.	0.	1.	1.	4.	2.	2.	5.	4.	1.	5.

NO.	TYPE	SAMPLE DEPTH (CM.) 696	708
1	BETULA	39.	46.
2	PINUS	7.	8.
3	SALIX	18.	20.
4	CORYLUS	0.	0.
5	PRUNUS	0.	0.
6	JUNIPERUS	0.	0.
7	HIPPOPHAE	0.	0.
8	EMPETRUM	1.	1.
9	ERICACEAE	0.	0.
10	GRAMINEAE	160.	330.
11	CYPERACEAE	20.	16.
12	ARTEMISIA	1.	6.
13	CAMPANULACEAE	0.	0.
14	CARYOPHYLLACEAE	1.	3.
15	CHENOPODIACEAE	3.	1.
16	COMPOSITAE - TUBULIFLORAE	5.	10.
17	COMPOSITAE - LIGULIFLORAE	0.	5.
18	CRUCIFERAE	2.	0.
19	DROSERA	0.	1.
20	DRYAS	0.	1.
21	EPILOBIUM	5.	6.
22	FILIPENDULA	0.	0.
23	GALIUM	0.	1.
24	GENTIANA	3.	0.
25	GERANIUM	0.	0.
26	HELIANTHEMUM	1.	0.
27	LABIATAE	2.	0.
28	LEGUMINOSAE	0.	0.
29	PLANTAGO LANCEOLATA	1.	0.
30	PLANTAGO SPP.(MAJOR)	0.	0.
31	POLYGONUM	0.	0.
32	POTENTILLA	0.	0.
33	PRIMULA	0.	0.
34	RANUNCULACEAE	0.	0.
35	ROSACEAE	1.	0.
36	RUMEX	31.	48.
37	SAXIFRAGACEAE	0.	1.
38	SCROPHULARIACEAE	0.	0.
39	SUCCISA	0.	0.
40	THALICTRUM	0.	1.
41	UMBELLIFERAE	0.	1.
42	URTICA	0.	0.
43	VALERIANA	0.	1.
44	VICIA	0.	0.
45	VIOLA	0.	0.
46	HYDROCOTYLE	0.	0.
47	MYRIOPHYLUM ALTERNIFLORUM	0.	0.
48	MYRIOPHYLUM SPP.	1.	0.
49	MENYANTHES	0.	0.
50	NUPHAR	0.	0.

NO.	TYPE	SAMPLE DEPTH (CM.) 696	708
51	POTAMOGETON	0.	4.
52	TYPHA	0.	0.
53	PTERIDOPHYTA	4.	42.

BALGONE HOUSE. ANALYSED BY A J ALEXANDER, 1980.

COUNTS OF POLLEN AND SPORES

NO.	TYPE	SAMPLE DEPTH (CM.) 265	275	285	295	305	315	325	335	345	355	365	375	385	395
1	BETULA	7.	3.	3.	4.	8.	12.	0.	6.	14.	9.	5.	11.	7.	11.
2	PINUS	16.	14.	9.	10.	17.	19.	8.	13.	22.	22.	11.	11.	6.	8.
3	ULMUS	30.	31.	31.	52.	42.	56.	22.	56.	40.	33.	28.	40.	17.	27.
4	QUERCUS	47.	68.	34.	69.	79.	88.	34.	88.	75.	85.	59.	97.	34.	95.
5	ALNUS	191.	842.	368.	915.	1824.	806.	388.	779.	918.	1048.	1122.	1229.	378.	930.
6	FAGUS	0.	0.	0.	0.	0.	0.	1.	0.	0.	0.	0.	0.	0.	0.
7	TILIA	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.	1.
8	CORYLUS	43.	26.	55.	132.	128.	94.	34.	86.	109.	116.	139.	116.	63.	128.
9	SALIX	4.	2.	0.	0.	4.	0.	2.	2.	3.	2.	2.	4.	0.	6.
10	JUNIPERUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
11	HEDERA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.	0.	0.	2.
12	ERICACEAE	0.	0.	0.	0.	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.
13	CALLUNA	0.	1.	0.	0.	0.	0.	1.	0.	0.	0.	0.	0.	0.	0.
14	EMPETRUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
15	GRAMINEAE	1.	4.	12.	9.	6.	6.	11.	11.	14.	12.	26.	8.	2.	7.
16	CYPERACEAE	332.	115.	10.	9.	8.	4.	12.	28.	8.	8.	3.	10.	0.	9.
17	ARTEMISIA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
18	ARMERIA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
19	CARYOPHYLLACEAE	2.	0.	3.	1.	0.	0.	0.	1.	1.	0.	0.	0.	0.	0.
20	CHENOPODIACEAE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
21	COMPOSITAE - TUBULIFLORAE	0.	0.	0.	1.	0.	0.	0.	0.	1.	0.	0.	0.	0.	2.
22	COMPOSITAE - LIGULIFLORAE	0.	0.	0.	0.	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.
23	DR[illegible]S	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
24	CRUCIFERAE	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
25	EPILOBIUM	6.	0.	4.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
26	FILIPENDULA	19.	0.	2.	3.	11.	6.	4.	2.	5.	11.	10.	2.	0.	3.
27	HELIANTHEMUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
28	LABIATAE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.	0.	0.
29	LEGUMINOSAE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
30	PLANTAGO LANCEOLATA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
31	PLANTAGO SPP	0.	0.	0.	0.	0.	0.	0.	1.	0.	0.	0.	0.	0.	0.
32	POLYGONUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
33	POTENTILLA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
34	RANUNCULACEAE	1.	0.	1.	3.	1.	3.	3.	1.	1.	2.	1.	0.	0.	1.
35	ROSACEAE	0.	0.	0.	0.	0.	2.	0.	0.	1.	1.	0.	1.	1.	0.
36	RUMEX	0.	0.	0.	1.	0.	0.	0.	0.	0.	0.	4.	0.	0.	1.
37	SAXIFRAGA OPPOSITIFOLIA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
38	SUCCISA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
39	UMBELLIFERAE	0.	0.	0.	5.	1.	0.	0.	0.	0.	1.	2.	0.	2.	0.
40	VALERIANA	0.	0.	0.	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.
41	GALIUM	2.	0.	0.	0.	0.	0.	0.	0.	1.	0.	0.	1.	0.	0.
42	THALICTRUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
43	HYDROCOTYLE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
44	MENYANTHES	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.	0.	0.
45	MYRIOPHYLLUM ALTERNIFLORUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
46	MYRIOPHYLLUM SPICATUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.	0.	0.
47	NYMPHAEA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.
48	POTAMOGETON	1.	0.	0.	0.	1.	0.	2.	0.	0.	1.	0.	3.	0.	0.
49	SPARGANIUM	0.	0.	2.	0.	0.	0.	0.	0.	0.	0.	0.	1.	1.	0.
50	TYPHA	7.	4.	0.	16.	0.	2.	0.	12.	3.	3.	0.	24.	0.	2.

NO.	TYPE	SAMPLE DEPTH (CM.) 265	275	285	295	305	315	325	335	345	355	365	375	385	395
51	NUPHAR	0.	1.	0.	0.	1.	0.	0.	0.	0.	0.	0.	1.	0.	2.
52	PTERIDOPHYTA UNDIFF	200.	200.	93.	96.	147.	116.	56.	109.	56.	72.	87.	74.	15.	49.
53	SELAGINELLA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
54	SEDUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
55	DRYOPTERIS TYPE	6.	14.	7.	1.	2.	1.	2.	0.	3.	1.	2.	1.	0.	0.
56	THELYPTERIS TYPE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
57	POLYPODIUM	33.	48.	25.	156.	26.	34.	6.	41.	17.	18.	14.	15.	8.	9.
58	SPHAGNUM	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.	0.	1.
59	CALTHA	0.	1.	0.	1.	1.	1.	0.	0.	0.	0.	0.	2.	0.	1.
60	FRAXINUS	0.	0.	0.	0.	3.	0.	0.	3.	1.	0.	0.	0.	0.	0.
61	CARBONIFEROUS SPORES	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
62	CAMPANULA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.	0.	0.
63	ANAGALLIS ARVENSIS TYPE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.
64	UNIDENTIFIED / INDETERMINATE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.
65	LONICERA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
66	CF. ACER	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
67	EQUISETUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
68	SORBUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
69	VIBURNUM OPULUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
70	PAPAVERACEAE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
71	PARNASSIA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
72	LYSIMACHIA VULGARIS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
73	DROSERA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
74	CF GENTIANA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
75	URTICA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
76	SAXIFRAGA GRANULATA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
77	SAXIFRAGA AZCIDES	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
78	RUBUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
79	LYCOPODIUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
80	MENTHA TYPE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
81	POLEMONIUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
82	SAXIFRAGA STELLARIS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
83	GYPSOPHILA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
84	VICIA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
85	ONOBRYCHIS TYPE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
86	SOLANUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
87	CONVOLVULACEAE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

NO.	TYPE	SAMPLE DEPTH (CM.) 405	410	420	430	440	450	460	465	470	480	490	500	505	510
1	BETULA	21.	30.	51.	42.	75.	67.	54.	96.	37.	45.	91.	113.	84.	107.
2	PINUS	16.	19.	29.	23.	39.	32.	35.	43.	58.	62.	58.	49.	41.	44.
3	ULMUS	14.	11.	6.	8.	16.	9.	16.	15.	24.	19.	17.	24.	30.	22.
4	QUERCUS	57.	68.	64.	43.	88.	59.	68.	73.	104.	127.	104.	80.	91.	74.
5	ALNUS	353.	281.	297.	126.	5.	26.	4.	5.	0.	3.	3.	2.	0.	3.
6	FAGUS	0.	1.	0.	0.	2.	0.	0.	0.	0.	0.	1.	0.	0.	0.
7	TILIA	0.	0.	1.	0.	0.	0.	0.	0.	1.	0.	0.	0.	0.	0.
8	CORYLUS	152.	113.	107.	139.	200.	223.	282.	332.	353.	384.	199.	220.	231.	194.
9	SALIX	1.	12.	8.	10.	13.	8.	8.	1.	3.	4.	4.	0.	5.	1.
10	JUNIPERUS	0.	0.	0.	0.	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.
11	HEDERA	0.	1.	0.	0.	0.	1.	1.	0.	1.	2.	0.	4.	1.	1.
12	ERICACEAE	0.	0.	0.	0.	0.	0.	0.	2.	0.	0.	0.	0.	0.	0.
13	CALLUNA	0.	0.	0.	0.	1.	1.	0.	0.	0.	0.	1.	0.	0.	0.
14	EMPETRUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.	0.	0.	0.
15	GRAMINEAE	9.	6.	5.	5.	11.	12.	7.	3.	4.	1.	2.	5.	5.	2.
16	CYPERACEAE	23.	27.	24.	29.	37.	72.	95.	47.	47.	21.	19.	26.	14.	34.
17	ARTEMISIA	0.	0.	0.	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	1.
18	ARMERIA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
19	CARYOPHYLLACEAE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
20	CHENOPODIACEAE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
21	COMPOSITAE - TUBULIFLORAE	0.	1.	0.	3.	13.	2.	4.	0.	1.	2.	0.	0.	2.	2.
22	COMPOSITAE - LIGULIFLORAE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
23	DRYAS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
24	CRUCIFERAE	0.	0.	0.	0.	1.	0.	0.	0.	0.	0.	3.	0.	0.	0.
25	EPILOBIUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
26	FILIPENDULA	4.	8.	5.	9.	14.	12.	16.	1.	16.	9.	6.	3.	7.	7.
27	HELIANTHEMUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
28	LABIATAE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
29	LEGUMINOSAE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
30	PLANTAGO LANCEOLATA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
31	PLANTAGO SPP	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.
32	POLYGONUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
33	POTENTILLA	0.	0.	2.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
34	RANUNCULACEAE	0.	1.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.	0.
35	ROSACEAE	0.	0.	0.	1.	2.	3.	1.	3.	0.	5.	0.	0.	2.	0.
36	RUMEX	0.	0.	0.	0.	0.	0.	0.	2.	0.	1.	0.	1.	0.	0.
37	SAXIFRAGA OPPOSITIFOLIA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
38	SUCCISA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
39	UMBELLIFERAE	0.	0.	2.	1.	0.	1.	1.	0.	0.	2.	0.	2.	0.	1.
40	VALERIANA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
41	GALIUM	0.	0.	0.	0.	0.	0.	0.	1.	0.	0.	0.	0.	0.	0.
42	THALICTRUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
43	HYDROCOTYLE	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
44	MENYANTHES	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
45	MYRIOPHYLLUM ALTERNIFLORUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
46	MYRIOPHYLLUM SPICATUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.	0.	0.	0.
47	NYMPHAEA	0.	0.	0.	0.	0.	0.	0.	2.	1.	7.	5.	8.	3.	3.
48	POTAMOGETON	1.	1.	0.	3.	1.	2.	0.	0.	1.	1.	1.	0.	0.	0.
49	SPARGANIUM	0.	0.	0.	0.	2.	0.	1.	0.	1.	0.	0.	0.	0.	0.
50	TYPHA	1.	1.	2.	2.	0.	2.	0.	0.	0.	0.	0.	0.	0.	0.

NO.	TYPE	SAMPLE DEPTH (CM.) 405	410	420	430	440	450	460	465	470	480	490	500	505	510
51	NUPHAR	3.	0.	0.	3.	2.	1.	3.	0.	0.	0.	1.	0.	0.	0.
52	PTERIDOPHYTA UNDIFF	43.	38.	30.	39.	59.	73.	48.	25.	47.	29.	5.	31.	39.	32.
53	SELAGINELLA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
54	SEDUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
55	DRYOPTERIS TYPE	0.	0.	0.	1.	1.	0.	0.	0.	0.	0.	1.	0.	0.	0.
56	THELYPTERIS TYPE	0.	0.	0.	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.
57	POLYPODIUM	6.	3.	7.	5.	4.	4.	3.	8.	5.	3.	1.	1.	2.	6.
58	SPHAGNUM	0.	0.	0.	0.	0.	0.	0.	1.	0.	0.	0.	0.	0.	0.
59	CALTHA	0.	0.	0.	0.	0.	0.	1.	0.	0.	0.	0.	0.	0.	0.
60	FRAXINUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
61	CARBONIFEROUS SPORES	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
62	CAMPANULA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
63	ANAGALLIS ARVENSIS TYPE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
64	UNIDENTIFIED / INDETERMINATE	0.	0.	0.	0.	2.	0.	1.	1.	0.	0.	1.	1.	0.	0.
65	LONICERA	0.	1.	0.	0.	0.	0.	1.	0.	0.	0.	0.	0.	0.	0.
66	CF. ACER	0.	0.	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
67	EQUISETUM	0.	0.	0.	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.
68	SORBUS	0.	0.	0.	0.	0.	0.	0.	0.	1.	0.	0.	0.	0.	0.
69	VIBURNUM OPULUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
70	PAPAVERACEAE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
71	PARNASSIA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
72	LYSIMACHIA VULGARIS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
73	DROSERA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
74	CF GENTIANA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
75	URTICA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
76	SAXIFRAGA GRANULATA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
77	SAXIFRAGA AZOIDES	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
78	RUBUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
79	LYCOPODIUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
80	MENTHA TYPE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
81	POLEMONIUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
82	SAXIFRAGA STELLARIS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
83	GYPSOPHILA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
84	VICIA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
85	ONOBRYCHIS TYPE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
86	SOLANUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
87	CONVOLVULACEAE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

		SAMPLE DEPTH (CM.)													
NO.	TYPE	520	530	540	550	560	570	580	590	595	605	615	625	635	645
1	BETULA	90.	105.	73.	154.	165.	130.	56.	115.	134.	71.	168.	243.	274.	250.
2	PINUS	38.	37.	39.	60.	81.	80.	33.	74.	80.	15.	12.	29.	27.	35.
3	ULMUS	34.	33.	31.	14.	10.	3.	2.	13.	2.	3.	3.	0.	2.	0.
4	QUERCUS	91.	63.	51.	7.	13.	5.	1.	2.	0.	1.	1.	3.	1.	0.
5	ALNUS	3.	0.	0.	0.	0.	0.	0.	0.	1.	2.	0.	0.	0.	0.
6	FAGUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
7	TILIA	0.	0.	2.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
8	CORYLUS	303.	213.	541.	621.	799.	843.	373.	1345.	2239.	384.	264.	157.	49.	3.
9	SALIX	4.	6.	5.	24.	21.	21.	20.	35.	23.	16.	23.	23.	38.	56.
10	JUNIPERUS	0.	0.	0.	0.	0.	0.	0.	0.	1.	0.	0.	1.	3.	7.
11	HEDERA	0.	0.	7.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
12	ERICACEAE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.
13	CALLUNA	2.	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
14	EMPETRUM	0.	0.	1.	0.	0.	2.	1.	0.	0.	0.	0.	1.	0.	0.
15	GRAMINEAE	6.	1.	1.	8.	3.	5.	3.	4.	9.	3.	7.	15.	52.	55.
16	CYPERACEAE	19.	23.	34.	18.	8.	44.	13.	40.	31.	12.	20.	28.	49.	32.
17	ARTEMISIA	1.	0.	0.	0.	0.	0.	0.	1.	0.	0.	0.	0.	0.	0.
18	ARMERIA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
19	CARYOPHYLLACEAE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
20	CHENOPODIACEAE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
21	COMPOSITAE - TUBULIFLORAE	3.	0.	2.	1.	1.	1.	0.	1.	0.	0.	0.	0.	0.	0.
22	COMPOSITAE - LIGULIFLORAE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
23	DRYAS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
24	CRUCIFERAE	0.	1.	0.	0.	1.	0.	0.	1.	0.	0.	1.	0.	2.	0.
25	EPILOBIUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
26	FILIPENDULA	9.	15.	3.	1.	0.	3.	2.	1.	4.	1.	6.	3.	8.	59.
27	HELIANTHEMUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
28	LABIATAE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
29	LEGUMINOSAE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
30	PLANTAGO LANCEOLATA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
31	PLANTAGO SPP	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
32	POLYGONUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
33	POTENTILLA	0.	0.	0.	0.	0.	1.	0.	0.	0.	0.	0.	0.	0.	2.
34	RANUNCULACEAE	0.	1.	1.	0.	0.	0.	0.	0.	1.	0.	0.	1.	0.	2.
35	ROSACEAE	0.	1.	0.	9.	5.	11.	1.	8.	13.	2.	1.	2.	4.	0.
36	RUMEX	0.	0.	0.	0.	0.	0.	0.	2.	2.	0.	1.	0.	0.	0.
37	SAXIFRAGA OPPOSITIFOLIA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
38	SUCCISA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
39	UMBELLIFERAE	1.	0.	0.	0.	1.	0.	0.	0.	1.	0.	0.	0.	2.	1.
40	VALERIANA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.
41	GALIUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
42	THALICTRUM	0.	0.	0.	0.	0.	1.	0.	0.	0.	0.	1.	0.	0.	0.
43	HYDROCOTYLE	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
44	MENYANTHES	0.	0.	0.	0.	0.	0.	0.	1.	0.	0.	0.	0.	0.	0.
45	MYRIOPHYLLUM ALTERNIFLORUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	4.
46	MYRIOPHYLLUM SPICATUM	0.	0.	0.	0.	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.
47	NYMPHAEA	3.	0.	1.	1.	0.	3.	0.	1.	1.	3.	0.	0.	2.	1.
48	POTAMOGETON	0.	0.	0.	0.	1.	1.	0.	0.	0.	0.	0.	3.	0.	2.
49	SPARGANIUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
50	TYPHA	3.	0.	2.	1.	1.	0.	0.	0.	0.	0.	0.	0.	1.	3.

NO.	TYPE	SAMPLE DEPTH (CM.) 520	530	540	550	560	570	580	590	595	605	615	625	635	645
51	NUPHAR	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
52	PTERIDOPHYTA UNDIFF	24.	22.	47.	30.	25.	19.	4.	6.	8.	7.	8.	21.	48.	160.
53	SELAGINELLA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
54	SEDUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
55	DRYOPTERIS TYPE	0.	4.	1.	4.	1.	6.	0.	0.	0.	0.	1.	1.	0.	2.
56	THELYPTERIS TYPE	0.	0.	3.	0.	1.	1.	0.	0.	0.	0.	0.	0.	0.	0.
57	POLYPODIUM	6.	3.	3.	2.	4.	1.	0.	2.	2.	1.	0.	0.	1.	2.
58	SPHAGNUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.	0.	0.	0.
59	CALTHA	0.	0.	0.	1.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.
60	FRAXINUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
61	CARBONIFEROUS SPORES	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
62	CAMPANULA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
63	ANAGALLIS ARVENSIS TYPE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
64	UNIDENTIFIED / INDETERMINATE	0.	2.	0.	0.	2.	0.	0.	0.	0.	0.	0.	1.	2.	0.
65	LONICERA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
66	CF. ACER	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
67	EQUISETUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
68	SORBUS	0.	0.	0.	3.	2.	0.	0.	0.	0.	0.	0.	0.	0.	0.
69	VIBURNUM OPULUS	0.	0.	1.	2.	2.	1.	0.	0.	0.	0.	0.	0.	0.	0.
70	PAPAVERACEAE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
71	PARNASSIA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
72	LYSIMACHIA VULGARIS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
73	DROSERA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
74	CF GENTIANA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
75	URTICA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
76	SAXIFRAGA GRANULATA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
77	SAXIFRAGA AZOIDES	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
78	RUBUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
79	LYCOPODIUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
80	MENTHA TYPE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
81	POLEMONIUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
82	SAXIFRAGA STELLARIS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
83	GYPSOPHILA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
84	VICIA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
85	ONOBRYCHIS TYPE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
86	SOLANUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
87	CONVOLVULACEAE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

NO.	TYPE	SAMPLE DEPTH (CM.) 650	655	660	665	670	675	680	685	690	695	700	710	720	725
1	BETULA	204.	176.	47.	67.	61.	44.	24.	14.	5.	13.	10.	13.	5.	5.
2	PINUS	27.	14.	27.	16.	21.	15.	20.	5.	28.	5.	14.	11.	0.	8.
3	ULMUS	0.	0.	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
4	QUERCUS	0.	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
5	ALNUS	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
6	FAGUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
7	TILIA	0.	0.	0.	0.	0.	0.	0.	1.	0.	0.	0.	0.	0.	1.
8	CORYLUS	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
9	SALIX	65.	56.	4.	16.	5.	6.	3.	14.	13.	20.	21.	22.	12.	8.
10	JUNIPERUS	52.	69.	4.	21.	3.	1.	2.	0.	2.	0.	2.	0.	0.	0.
11	HEDERA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
12	ERICACEAE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
13	CALLUNA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
14	EMPETRUM	2.	4.	19.	18.	16.	3.	0.	0.	1.	0.	1.	0.	0.	1.
15	GRAMINEAE	59.	74.	302.	175.	302.	285.	299.	79.	51.	69.	70.	63.	31.	31.
16	CYPERACEAE	22.	27.	46.	94.	56.	85.	87.	124.	135.	89.	92.	81.	59.	55.
17	ARTEMISIA	0.	0.	0.	2.	0.	2.	3.	12.	15.	46.	33.	50.	29.	48.
18	ARMERIA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
19	CARYOPHYLLACEAE	1.	1.	1.	0.	1.	0.	4.	14.	13.	22.	36.	14.	9.	7.
20	CHENOPODIACEAE	0.	0.	0.	0.	0.	0.	0.	0.	1.	2.	0.	0.	0.	0.
21	COMPOSITAE - TUBULIFLORAE	1.	0.	1.	0.	3.	2.	5.	1.	0.	0.	0.	1.	0.	0.
22	COMPOSITAE - LIGULIFLORAE	0.	0.	5.	0.	3.	6.	0.	0.	0.	0.	0.	0.	1.	0.
23	DRYAS	0.	0.	0.	0.	1.	0.	0.	1.	0.	0.	0.	1.	0.	0.
24	CRUCIFERAE	0.	0.	0.	0.	2.	0.	1.	3.	7.	3.	6.	6.	6.	7.
25	EPILOBIUM	0.	0.	4.	1.	2.	2.	1.	0.	0.	0.	0.	0.	0.	0.
26	FILIPENDULA	66.	78.	6.	63.	4.	1.	2.	1.	1.	0.	2.	2.	0.	1.
27	HELIANTHEMUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.	0.	0.	0.	0.
28	LABIATAE	0.	0.	1.	0.	1.	0.	2.	0.	0.	0.	0.	0.	0.	0.
29	LEGUMINOSAE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.	0.	0.
30	PLANTAGO LANCEOLATA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
31	PLANTAGO SPP	0.	0.	0.	0.	1.	3.	2.	0.	0.	0.	1.	0.	0.	0.
32	POLYGONUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
33	POTENTILLA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
34	RANUNCULACEAE	2.	0.	11.	2.	8.	8.	1.	10.	1.	2.	1.	1.	0.	0.
35	ROSACEAE	0.	0.	1.	1.	0.	2.	0.	1.	0.	4.	0.	0.	0.	1.
36	RUMEX	4.	10.	21.	14.	16.	24.	36.	16.	8.	17.	16.	23.	2.	12.
37	SAXIFRAGA OPPOSITIFOLIA	0.	0.	0.	0.	0.	0.	0.	1.	1.	1.	0.	0.	0.	0.
38	SUCCISA	0.	0.	0.	0.	0.	0.	0.	0.	1.	0.	0.	0.	0.	0.
39	UMBELLIFERAE	6.	1.	0.	3.	1.	0.	1.	0.	0.	0.	0.	0.	0.	0.
40	VALERIANA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.
41	GALIUM	0.	0.	5.	5.	5.	6.	4.	0.	0.	0.	0.	2.	0.	0.
42	THALICTRUM	4.	0.	1.	0.	0.	1.	2.	2.	17.	17.	6.	10.	9.	8.
43	HYDROCOTYLE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
44	MENYANTHES	0.	0.	5.	0.	0.	0.	0.	0.	3.	1.	0.	0.	0.	0.
45	MYRIOPHYLLUM ALTERNIFLORUM	2.	0.	6.	4.	7.	75.	287.	17.	0.	0.	0.	0.	0.	0.
46	MYRIOPHYLLUM SPICATUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
47	NYMPHAEA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
48	POTAMOGETON	2.	5.	3.	13.	2.	3.	0.	0.	0.	0.	0.	0.	1.	0.
49	SPARGANIUM	0.	0.	2.	0.	2.	3.	0.	0.	0.	0.	0.	0.	0.	0.
50	TYPHA	6.	2.	3.	1.	2.	7.	0.	0.	0.	0.	0.	0.	0.	0.

NO.	TYPE	SAMPLE DEPTH (CM.) 650	655	660	665	670	675	680	685	690	695	700	710	720	725
51	NUPHAR	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
52	PTERIDOPHYTA UNDIFF	105.	131.	20.	26.	19.	4.	8.	2.	5.	4.	6.	16.	2.	7.
53	SELAGINELLA	0.	0.	0.	0.	0.	0.	0.	2.	1.	1.	7.	1.	6.	2.
54	SEDUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
55	DRYOPTERIS TYPE	19.	78.	30.	22.	33.	0.	1.	0.	1.	0.	1.	0.	0.	0.
56	THELYPTERIS TYPE	2.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
57	POLYPODIUM	3.	4.	6.	1.	4.	1.	0.	0.	0.	1.	0.	0.	0.	2.
58	SPHAGNUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
59	CALTHA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
60	FRAXINUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
61	CARBONIFEROUS SPORES	0.	0.	28.	1.	20.	24.	26.	41.	131.	50.	73.	71.	222.	256.
62	CAMPANULA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
63	ANAGALLIS ARVENSIS TYPE	0.	0.	0.	0.	1.	0.	0.	2.	1.	0.	4.	4.	1.	0.
64	UNIDENTIFIED / INDETERMINATE	0.	2.	4.	0.	1.	0.	0.	6.	7.	6.	7.	0.	2.	1.
65	LONICERA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
66	CF. ACER	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
67	EQUISETUM	1.	1.	0.	2.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
68	SORBUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
69	VIBURNUM OPULUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
70	PAPAVERACEAE	0.	0.	0.	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.
71	PARNASSIA	0.	0.	0.	0.	0.	0.	0.	0.	1.	2.	0.	2.	0.	0.
72	LYSIMACHIA VULGARIS	0.	0.	0.	0.	0.	0.	0.	0.	0.	3.	0.	0.	0.	0.
73	DROSERA	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.	0.	0.	0.	0.
74	CF GENTIANA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	4.	0.	0.
75	URTICA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.	0.
76	SAXIFRAGA GRANULATA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
77	SAXIFRAGA AZOIDES	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
78	RUBUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
79	LYCOPODIUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
80	MENTHA TYPE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
81	POLEMONIUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
82	SAXIFRAGA STELLARIS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
83	GYPSOPHILA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
84	VICIA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
85	ONOBRYCHIS TYPE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
86	SOLANUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
87	CONVOLVULACEAE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

NO.	TYPE	SAMPLE DEPTH (CM.) 730	740	755	757	759	761	763	765	767	769	770	771	772	773
1	BETULA	7.	8.	15.	29.	41.	56.	55.	52.	53.	47.	25.	39.	25.	49.
2	PINUS	11.	12.	11.	16.	8.	7.	9.	3.	12.	17.	3.	12.	14.	9.
3	ULMUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
4	QUERCUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
5	ALNUS	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
6	FAGUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
7	TILIA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.	0.	0.	0.
8	CORYLUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
9	SALIX	33.	20.	2.	7.	3.	1.	1.	2.	2.	6.	6.	5.	10.	9.
10	JUNIPERUS	4.	0.	4.	35.	43.	82.	38.	78.	25.	16.	19.	25.	6.	14.
11	HEDERA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
12	ERICACEAE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
13	CALLUNA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
14	EMPETRUM	0.	3.	12.	17.	24.	22.	34.	49.	28.	20.	17.	18.	6.	6.
15	GRAMINEAE	40.	124.	111.	209.	231.	242.	249.	191.	245.	265.	302.	242.	296.	257.
16	CYPERACEAE	129.	70.	85.	129.	68.	31.	29.	39.	72.	71.	84.	96.	88.	108.
17	ARTEMISIA	31.	13.	11.	4.	1.	1.	4.	1.	2.	3.	3.	7.	2.	2.
18	ARMERIA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
19	CARYOPHYLLACEAE	7.	9.	11.	4.	1.	0.	0.	4.	1.	2.	0.	0.	0.	2.
20	CHENOPODIACEAE	0.	4.	0.	0.	0.	0.	1.	0.	0.	1.	0.	0.	0.	0.
21	COMPOSITAE - TUBULIFLORAE	0.	0.	4.	2.	1.	1.	1.	2.	3.	3.	1.	0.	3.	3.
22	COMPOSITAE - LIGULIFLORAE	0.	0.	3.	0.	1.	0.	0.	3.	4.	8.	1.	2.	1.	0.
23	DRYAS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.	0.	0.	0.
24	CRUCIFERAE	18.	4.	20.	0.	0.	0.	1.	0.	0.	0.	0.	0.	0.	0.
25	EPILOBIUM	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
26	FILIPENDULA	2.	1.	9.	23.	38.	38.	70.	65.	24.	22.	6.	16.	5.	9.
27	HELIANTHEMUM	0.	0.	1.	2.	5.	3.	5.	9.	4.	4.	4.	2.	4.	2.
28	LABIATAE	0.	0.	0.	0.	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.
29	LEGUMINOSAE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
30	PLANTAGO LANCEOLATA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
31	PLANTAGO SPP	0.	0.	0.	0.	0.	0.	0.	0.	1.	0.	0.	1.	0.	0.
32	POLYGONUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
33	POTENTILLA	1.	0.	0.	0.	0.	0.	1.	0.	0.	0.	0.	0.	0.	2.
34	RANUNCULACEAE	4.	1.	1.	2.	2.	3.	2.	2.	8.	3.	2.	3.	3.	3.
35	ROSACEAE	0.	1.	1.	0.	0.	1.	0.	0.	0.	0.	0.	0.	0.	1.
36	RUMEX	10.	29.	17.	25.	18.	12.	5.	5.	20.	15.	14.	41.	32.	30.
37	SAXIFRAGA OPPOSITIFOLIA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
38	SUCCISA	0.	0.	0.	0.	0.	0.	0.	1.	0.	0.	0.	0.	0.	0.
39	UMBELLIFERAE	0.	0.	0.	2.	4.	3.	3.	3.	4.	2.	1.	1.	0.	1.
40	VALERIANA	0.	0.	0.	0.	1.	0.	0.	0.	0.	1.	1.	0.	1.	0.
41	GALIUM	0.	1.	0.	2.	6.	1.	0.	5.	5.	4.	5.	3.	7.	3.
42	THALICTRUM	9.	8.	3.	3.	4.	1.	2.	0.	3.	2.	2.	5.	0.	5.
43	HYDROCOTYLE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.	0.	0.	0.
44	MENYANTHES	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
45	MYRIOPHYLLUM ALTERNIFLORUM	0.	0.	2.	1.	2.	3.	0.	4.	4.	1.	1.	1.	2.	0.
46	MYRIOPHYLLUM SPICATUM	0.	0.	0.	0.	0.	0.	0.	1.	1.	0.	0.	0.	0.	0.
47	NYMPHAEA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
48	POTAMOGETON	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.	1.	0.	0.	0.
49	SPARGANIUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
50	TYPHA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

NO.	TYPE	SAMPLE DEPTH (CM.) 730	740	755	757	759	761	763	765	767	769	770	771	772	773
51	NUPHAR	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
52	PTERIDOPHYTA UNDIFF	23.	2.	13.	3.	6.	4.	2.	10.	8.	16.	13.	11.	17.	7.
53	SELAGINELLA	16.	9.	3.	2.	3.	3.	2.	2.	9.	10.	9.	8.	3.	7.
54	SEDUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
55	DRYOPTERIS TYPE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
56	THELYPTERIS TYPE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
57	POLYPODIUM	2.	0.	1.	1.	1.	0.	1.	0.	0.	3.	1.	0.	0.	1.
58	SPHAGNUM	0.	0.	2.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
59	CALTHA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
60	FRAXINUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
61	CARBONIFEROUS SPORES	114.	86.	11.	4.	3.	1.	0.	0.	16.	9.	31.	13.	26.	3.
62	CAMPANULA	0.	0.	0.	0.	0.	0.	0.	1.	2.	0.	0.	0.	0.	0.
63	ANAGALLIS ARVENSIS TYPE	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
64	UNIDENTIFIED / INDETERMINATE	0.	0.	1.	1.	1.	1.	1.	1.	0.	0.	0.	0.	0.	0.
65	LONICERA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
66	CF. ACER	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
67	EQUISETUM	0.	0.	0.	0.	0.	0.	0.	1.	0.	0.	0.	0.	0.	0.
68	SORBUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
69	VIBURNUM OPULUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
70	PAPAVERACEAE	0.	1.	1.	0.	0.	0.	0.	0.	1.	0.	0.	0.	0.	0.
71	PARNASSIA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
72	LYSIMACHIA VULGARIS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
73	DROSERA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
74	CF GENTIANA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
75	URTICA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
76	SAXIFRAGA GRANULATA	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
77	SAXIFRAGA AZOIDES	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
78	RUBUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	2.
79	LYCOPODIUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
80	MENTHA TYPE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
81	POLEMONIUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
82	SAXIFRAGA STELLARIS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
83	GYPSOPHILA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
84	VICIA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
85	ONOBRYCHIS TYPE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
86	SOLANUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
87	CONVOLVULACEAE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

NO.	TYPE	SAMPLE DEPTH (CM.) 774	775	777	779	781	782	784	786	788	790	792	794	796	798
1	BETULA	46.	33.	38.	39.	56.	77.	37.	55.	53.	82.	50.	68.	77.	45.
2	PINUS	18.	10.	6.	11.	8.	7.	4.	1.	3.	2.	3.	6.	2.	6.
3	ULMUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
4	QUERCUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
5	ALNUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
6	FAGUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
7	TILIA	0.	0.	2.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
8	CORYLUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
9	SALIX	15.	19.	6.	3.	3.	2.	4.	6.	4.	7.	5.	4.	9.	5.
10	JUNIPERUS	8.	14.	23.	34.	47.	39.	89.	89.	72.	89.	100.	75.	91.	56.
11	HEDERA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
12	ERICACEAE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
13	CALLUNA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
14	EMPETRUM	6.	10.	9.	17.	15.	26.	17.	16.	28.	27.	21.	22.	17.	21.
15	GRAMINEAE	236.	246.	264.	227.	239.	205.	209.	225.	213.	197.	220.	224.	218.	262.
16	CYPERACEAE	110.	107.	107.	103.	68.	55.	53.	44.	45.	48.	29.	41.	44.	55.
17	ARTEMISIA	6.	11.	0.	0.	0.	0.	0.	1.	4.	0.	6.	4.	2.	5.
18	ARMERIA	0.	0.	0.	4.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
19	CARYOPHYLLACEAE	0.	0.	2.	1.	0.	0.	1.	0.	1.	1.	0.	0.	0.	0.
20	CHENOPODIACEAE	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.	0.	0.
21	COMPOSITAE - TUBULIFLORAE	7.	0.	2.	2.	1.	1.	0.	3.	3.	0.	1.	0.	1.	2.
22	COMPOSITAE - LIGULIFLORAE	2.	1.	2.	1.	0.	1.	0.	1.	1.	1.	2.	0.	0.	1.
23	DRYAS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
24	CRUCIFERAE	2.	0.	1.	1.	0.	0.	0.	0.	0.	0.	1.	1.	0.	0.
25	EPILOBIUM	0.	0.	1.	0.	0.	0.	0.	2.	0.	1.	0.	0.	0.	1.
26	FILIPENDULA	4.	5.	20.	19.	37.	72.	53.	42.	33.	18.	29.	15.	8.	5.
27	HELIANTHEMUM	2.	1.	1.	2.	8.	10.	9.	8.	7.	5.	3.	7.	4.	13.
28	LABIATAE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	2.	0.
29	LEGUMINOSAE	0.	0.	0.	0.	0.	0.	1.	0.	0.	0.	0.	0.	0.	0.
30	PLANTAGO LANCEOLATA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
31	PLANTAGO SPP	0.	0.	0.	0.	0.	0.	0.	0.	1.	0.	3.	0.	0.	0.
32	POLYGONUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
33	POTENTILLA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.	1.	1.
34	RANUNCULACEAE	1.	3.	2.	4.	2.	3.	6.	3.	5.	4.	3.	4.	3.	3.
35	ROSACEAE	0.	0.	0.	1.	0.	0.	0.	1.	1.	0.	2.	0.	0.	0.
36	RUMEX	43.	49.	32.	21.	7.	4.	12.	2.	13.	16.	10.	11.	6.	11.
37	SAXIFRAGA OPPOSITIFOLIA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
38	SUCCISA	0.	0.	0.	1.	0.	2.	0.	0.	0.	1.	0.	1.	0.	2.
39	UMBELLIFERAE	0.	2.	2.	0.	4.	0.	1.	3.	6.	5.	2.	5.	2.	3.
40	VALERIANA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
41	GALIUM	1.	6.	8.	6.	3.	0.	1.	2.	4.	4.	6.	4.	4.	4.
42	THALICTRUM	0.	2.	4.	3.	3.	1.	7.	4.	8.	1.	5.	5.	4.	9.
43	HYDROCOTYLE	0.	0.	0.	0.	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.
44	MENYANTHES	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
45	MYRIOPHYLLUM ALTERNIFLORUM	2.	1.	1.	1.	0.	1.	0.	1.	2.	1.	1.	1.	1.	6.
46	MYRIOPHYLLUM SPICATUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
47	NYMPHAEA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
48	POTAMOGETON	0.	2.	0.	0.	0.	0.	0.	0.	2.	1.	0.	2.	0.	0.
49	SPARGANIUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
50	TYPHA	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.	0.	0.	0.	0.

NO.	TYPE	SAMPLE DEPTH (CM.) 774	775	777	779	781	782	784	786	788	790	792	794	796	798
51	NUPHAR	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
52	PTERIDOPHYTA UNDIFF	5.	18.	12.	16.	19.	20.	17.	16.	15.	5.	18.	17.	9.	15.
53	SELAGINELLA	3.	6.	4.	9.	2.	2.	1.	0.	1.	0.	2.	0.	4.	3.
54	SEDUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
55	DRYOPTERIS TYPE	0.	0.	0.	1.	1.	1.	0.	1.	1.	2.	1.	6.	2.	0.
56	THELYPTERIS TYPE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
57	POLYPODIUM	1.	0.	1.	1.	0.	1.	0.	0.	0.	0.	0.	0.	1.	0.
58	SPHAGNUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
59	CALTHA	0.	0.	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
60	FRAXINUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
61	CARBONIFEROUS SPORES	23.	16.	19.	26.	14.	0.	1.	1.	1.	1.	1.	0.	0.	0.
62	CAMPANULA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
63	ANAGALLIS ARVENSIS TYPE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.	0.
64	UNIDENTIFIED / INDETERMINATE	0.	0.	0.	0.	0.	3.	0.	0.	1.	1.	1.	2.	0.	2.
65	LONICERA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
66	CF. ACER	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
67	EQUISETUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
68	SORBUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
69	VIBURNUM OPULUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
70	PAPAVERACEAE	0.	1.	0.	0.	0.	0.	1.	0.	1.	0.	0.	0.	0.	0.
71	PARNASSIA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
72	LYSIMACHIA VULGARIS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
73	DROSERA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
74	CF GENTIANA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
75	URTICA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
76	SAXIFRAGA GRANULATA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
77	SAXIFRAGA AZOIDES	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
78	RUBUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
79	LYCOPODIUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.	0.	0.	1.
80	MENTHA TYPE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
81	POLEMONIUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
82	SAXIFRAGA STELLARIS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
83	GYPSOPHILA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
84	VICIA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
85	ONOBRYCHIS TYPE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
86	SOLANUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
87	CONVOLVULACEAE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

NO.	TYPE	SAMPLE DEPTH (CM.) 800	802	804	806	808	810	812	814	816	818	820	822	824	826
1	BETULA	62.	45.	43.	37.	29.	47.	51.	33.	50.	67.	29.	74.	30.	44.
2	PINUS	3.	6.	6.	4.	9.	6.	2.	3.	3.	1.	0.	5.	1.	6.
3	ULMUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
4	QUERCUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
5	ALNUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
6	FAGUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
7	TILIA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
8	CORYLUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
9	SALIX	7.	8.	6.	6.	4.	6.	5.	3.	3.	8.	4.	12.	13.	17.
10	JUNIPERUS	41.	51.	38.	34.	38.	15.	11.	17.	10.	19.	4.	2.	9.	4.
11	HEDERA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
12	ERICACEAE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.	0.
13	CALLUNA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
14	EMPETRUM	26.	13.	17.	10.	14.	14.	19.	14.	9.	15.	3.	1.	4.	2.
15	GRAMINEAE	267.	285.	290.	308.	305.	298.	415.	306.	298.	233.	171.	280.	251.	237.
16	CYPERACEAE	47.	34.	44.	57.	69.	77.	50.	51.	66.	77.	45.	51.	64.	64.
17	ARTEMISIA	2.	3.	6.	2.	5.	3.	9.	3.	3.	4.	2.	5.	11.	10.
18	ARMERIA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
19	CARYOPHYLLACEAE	1.	1.	0.	1.	2.	1.	4.	1.	1.	0.	1.	3.	7.	5.
20	CHENOPODIACEAE	0.	0.	0.	0.	0.	2.	0.	1.	0.	1.	0.	0.	1.	0.
21	COMPOSITAE - TUBULIFLORAE	0.	1.	1.	0.	0.	2.	0.	2.	2.	1.	3.	4.	6.	7.
22	COMPOSITAE - LIGULIFLORAE	1.	1.	1.	1.	3.	0.	0.	1.	0.	3.	0.	1.	2.	2.
23	DRYAS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
24	CRUCIFERAE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	2.	1.	2.
25	EPILOBIUM	1.	2.	2.	0.	0.	0.	0.	0.	2.	2.	2.	4.	3.	0.
26	FILIPENDULA	10.	2.	0.	1.	1.	2.	1.	3.	0.	0.	1.	3.	1.	0.
27	HELIANTHEMUM	8.	8.	3.	9.	4.	5.	1.	2.	1.	1.	0.	2.	1.	1.
28	LABIATAE	0.	0.	0.	0.	1.	1.	0.	0.	0.	0.	0.	1.	0.	0.
29	LEGUMINOSAE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
30	PLANTAGO LANCEOLATA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
31	PLANTAGO SPP	3.	2.	2.	1.	0.	0.	1.	1.	1.	0.	3.	1.	3.	2.
32	POLYGONUM	0.	0.	0.	0.	0.	0.	1.	0.	0.	1.	0.	0.	0.	0.
33	POTENTILLA	0.	2.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
34	RANUNCULACEAE	3.	6.	4.	4.	2.	5.	5.	0.	2.	4.	1.	7.	3.	1.
35	ROSACEAE	1.	1.	3.	3.	2.	2.	1.	2.	1.	0.	0.	1.	0.	2.
36	RUMEX	5.	13.	20.	13.	11.	15.	23.	13.	20.	28.	20.	34.	48.	79.
37	SAXIFRAGA OPPOSITIFOLIA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
38	SUCCISA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.	0.
39	UMBELLIFERAE	3.	3.	1.	2.	3.	5.	4.	3.	2.	1.	0.	0.	0.	0.
40	VALERIANA	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.	0.	0.	0.	0.
41	GALIUM	8.	2.	6.	6.	7.	8.	8.	10.	8.	13.	11.	18.	17.	11.
42	THALICTRUM	14.	11.	11.	14.	10.	9.	19.	15.	20.	29.	8.	10.	6.	10.
43	HYDROCOTYLE	0.	3.	3.	1.	1.	2.	0.	0.	0.	0.	0.	0.	0.	0.
44	MENYANTHES	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
45	MYRIOPHYLLUM ALTERNIFLORUM	1.	1.	0.	0.	0.	4.	0.	0.	0.	0.	1.	2.	2.	3.
46	MYRIOPHYLLUM SPICATUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
47	NYMPHAEA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
48	POTAMOGETON	0.	0.	0.	0.	1.	0.	1.	0.	0.	0.	1.	0.	0.	2.
49	SPARGANIUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
50	TYPHA	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

NO.	TYPE	SAMPLE DEPTH (CM.) 800	802	804	806	808	810	812	814	816	818	820	822	824	826
51	NUPHAR	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
52	PTERIDOPHYTA UNDIFF	8.	15.	11.	10.	11.	9.	8.	6.	5.	1.	2.	11.	6.	9.
53	SELAGINELLA	1.	1.	2.	1.	1.	0.	2.	1.	0.	0.	1.	2.	0.	1.
54	SEDUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
55	DRYOPTERIS TYPE	3.	0.	1.	1.	0.	0.	0.	1.	1.	0.	0.	0.	0.	0.
56	THELYPTERIS TYPE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
57	POLYPODIUM	0.	0.	0.	1.	0.	0.	0.	0.	0.	0.	0.	5.	4.	2.
58	SPHAGNUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
59	CALTHA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
60	FRAXINUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
61	CARBONIFEROUS SPORES	0.	0.	4.	1.	0.	0.	0.	6.	0.	6.	0.	5.	6.	3.
62	CAMPANULA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
63	ANAGALLIS ARVENSIS TYPE	0.	1.	1.	0.	0.	0.	0.	0.	0.	0.	0.	1.	0.	0.
64	UNIDENTIFIED / INDETERMINATE	0.	0.	0.	0.	0.	1.	0.	1.	0.	1.	1.	2.	0.	3.
65	LONICERA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
66	CF. ACER	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
67	EQUISETUM	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	2.	0.	1.	0.
68	SORBUS	0.	0.	0.	0.	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.
69	VIBURNUM OPULUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
70	PAPAVERACEAE	1.	0.	0.	0.	0.	1.	0.	0.	1.	0.	0.	0.	1.	0.
71	PARNASSIA	0.	0.	0.	0.	1.	0.	0.	0.	0.	0.	0.	0.	1.	0.
72	LYSIMACHIA VULGARIS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
73	DROSERA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
74	CF GENTIANA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
75	URTICA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
76	SAXIFRAGA GRANULATA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
77	SAXIFRAGA AZOIDES	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
78	RUBUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
79	LYCOPODIUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
80	MENTHA TYPE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.	1.	0.	0.
81	POLEMONIUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
82	SAXIFRAGA STELLARIS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.
83	GYPSOPHILA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
84	VICIA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
85	ONOBRYCHIS TYPE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
86	SOLANUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
87	CONVOLVULACEAE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

NO.	TYPE	SAMPLE DEPTH (CM.) 828	830	832	834	836	838	840
1	BETULA	31.	37.	74.	168.	118.	68.	76.
2	PINUS	4.	4.	28.	8.	3.	4.	4.
3	ULMUS	0.	0.	0.	0.	0.	0.	0.
4	QUERCUS	0.	0.	0.	0.	0.	0.	0.
5	ALNUS	0.	0.	0.	0.	0.	0.	0.
6	FAGUS	0.	0.	0.	0.	0.	0.	0.
7	TILIA	0.	0.	0.	0.	0.	0.	0.
8	CORYLUS	0.	0.	0.	0.	0.	0.	0.
9	SALIX	3.	3.	15.	8.	7.	11.	20.
10	JUNIPERUS	2.	4.	2.	10.	1.	2.	0.
11	HEDERA	0.	0.	0.	0.	0.	0.	0.
12	ERICACEAE	0.	0.	0.	0.	0.	0.	0.
13	CALLUNA	0.	0.	0.	0.	0.	0.	0.
14	EMPETRUM	2.	6.	9.	6.	5.	3.	1.
15	GRAMINEAE	282.	194.	261.	207.	99.	107.	133.
16	CYPERACEAE	47.	33.	59.	34.	44.	34.	24.
17	ARTEMISIA	10.	2.	9.	7.	0.	5.	10.
18	ARMERIA	0.	0.	0.	0.	0.	0.	0.
19	CARYOPHYLLACEAE	11.	1.	2.	2.	3.	1.	1.
20	CHENOPODIACEAE	0.	3.	0.	1.	1.	0.	0.
21	COMPOSITAE - TUBULIFLORAE	8.	0.	5.	7.	2.	3.	1.
22	COMPOSITAE - LIGULIFLORAE	0.	0.	1.	2.	1.	1.	0.
23	DRYAS	0.	0.	0.	0.	0.	0.	0.
24	CRUCIFERAE	0.	0.	0.	1.	1.	0.	0.
25	EPILOBIUM	1.	0.	1.	1.	2.	1.	3.
26	FILIPENDULA	1.	0.	0.	0.	0.	0.	0.
27	HELIANTHEMUM	0.	1.	0.	0.	0.	1.	0.
28	LABIATAE	0.	0.	0.	0.	0.	1.	0.
29	LEGUMINOSAE	0.	0.	0.	0.	0.	0.	0.
30	PLANTAGO LANCEOLATA	0.	0.	0.	0.	0.	0.	0.
31	PLANTAGO SPP	1.	0.	1.	2.	0.	2.	1.
32	POLYGONUM	0.	0.	0.	0.	0.	0.	0.
33	POTENTILLA	1.	0.	0.	0.	0.	0.	0.
34	RANUNCULACEAE	3.	3.	1.	2.	2.	2.	0.
35	ROSACEAE	7.	0.	1.	0.	1.	1.	2.
36	RUMEX	83.	13.	20.	37.	14.	19.	15.
37	SAXIFRAGA OPPOSITIFOLIA	0.	0.	0.	0.	0.	1.	0.
38	SUCCISA	1.	0.	0.	0.	0.	0.	0.
39	UMBELLIFERAE	0.	0.	0.	0.	0.	1.	1.
40	VALERIANA	0.	0.	1.	0.	0.	0.	0.
41	GALIUM	8.	2.	14.	8.	7.	18.	5.
42	THALICTRUM	1.	1.	7.	3.	1.	3.	0.
43	HYDROCOTYLE	0.	0.	2.	0.	0.	0.	0.
44	MENYANTHES	0.	0.	0.	0.	0.	0.	0.
45	MYRIOPHYLLUM ALTERNIFLORUM	0.	0.	0.	1.	1.	0.	1.
46	MYRIOPHYLLUM SPICATUM	0.	0.	0.	3.	0.	1.	0.
47	NYMPHAEA	0.	0.	0.	0.	0.	0.	0.
48	POTAMOGETON	0.	0.	0.	0.	1.	0.	0.
49	SPARGANIUM	0.	0.	0.	0.	0.	0.	0.
50	TYPHA	0.	0.	0.	0.	0.	0.	0.

NO.	TYPE	SAMPLE DEPTH (CM.) 828	830	832	834	836	838	840
51	NUPHAR	0.	0.	0.	0.	0.	0.	0.
52	PTERIDOPHYTA UNDIFF	12.	2.	6.	12.	7.	9.	6.
53	SELAGINELLA	1.	0.	0.	0.	5.	0.	0.
54	SEDUM	0.	0.	0.	0.	0.	0.	0.
55	DRYOPTERIS TYPE	0.	2.	0.	0.	0.	0.	1.
56	THELYPTERIS TYPE	0.	1.	0.	0.	0.	0.	2.
57	POLYPODIUM	5.	1.	5.	4.	6.	9.	4.
58	SPHAGNUM	0.	0.	0.	0.	0.	0.	0.
59	CALTHA	0.	0.	0.	0.	0.	0.	0.
60	FRAXINUS	0.	0.	0.	0.	0.	0.	0.
61	CARBONIFEROUS SPORES	5.	0.	7.	8.	3.	6.	9.
62	CAMPANULA	0.	0.	0.	0.	0.	0.	0.
63	ANAGALLIS ARVENSIS TYPE	1.	0.	1.	0.	1.	0.	0.
64	UNIDENTIFIED / INDETERMINATE	0.	0.	1.	0.	0.	1.	0.
65	LONICERA	0.	0.	0.	0.	0.	0.	0.
66	CF. ACER	0.	0.	0.	0.	0.	0.	0.
67	EQUISETUM	1.	0.	0.	0.	0.	0.	1.
68	SORBUS	0.	0.	0.	0.	0.	0.	0.
69	VIBURNUM OPULUS	0.	0.	0.	0.	0.	0.	0.
70	PAPAVERACEAE	1.	0.	0.	0.	1.	0.	0.
71	PARNASSIA	0.	0.	0.	0.	0.	0.	1.
72	LYSIMACHIA VULGARIS	0.	0.	0.	0.	0.	0.	0.
73	DROSERA	0.	0.	0.	0.	0.	0.	0.
74	CF GENTIANA	1.	0.	0.	0.	1.	0.	0.
75	URTICA	0.	0.	0.	0.	0.	0.	0.
76	SAXIFRAGA GRANULATA	0.	0.	0.	0.	1.	0.	0.
77	SAXIFRAGA AZOIDES	0.	0.	0.	0.	0.	0.	0.
78	RUBUS	0.	0.	0.	0.	0.	0.	0.
79	LYCOPODIUM	0.	0.	0.	0.	0.	0.	0.
80	MENTHA TYPE	0.	0.	0.	0.	0.	0.	0.
81	POLEMONIUM	0.	0.	0.	0.	0.	1.	0.
82	SAXIFRAGA STELLARIS	1.	0.	0.	0.	0.	0.	0.
83	GYPSOPHILA	1.	0.	0.	0.	0.	0.	0.
84	VICIA	0.	0.	1.	0.	0.	0.	0.
85	ONOBRYCHIS TYPE	0.	0.	3.	0.	0.	0.	0.
86	SOLANUM	0.	0.	2.	0.	0.	0.	0.
87	CONVOLVULACEAE	0.	0.	0.	0.	0.	1.	0.

CORSTORPHINE SITE. ANALYSED BY DR.W.W.NEWEY, 1967.

COUNTS OF POLLEN AND SPORES

NO.	TYPE	SAMPLE DEPTH (CM.) 85	95	105	115	125	135	145	155	175	185	195	205	215	225
1	BETULA	1.	3.	3.	0.	0.	2.	8.	5.	1.	0.	0.	6.	2.	1.
2	GRAMINEAE	3.	13.	10.	5.	1.	2.	23.	36.	37.	0.	12.	71.	101.	33.
3	CYPERACEAE	4.	65.	37.	39.	2.	4.	70.	116.	78.	0.	7.	136.	52.	72.
4	DERIVED CARBONIFEROUS SPORES	11.	79.	82.	149.	10.	22.	152.	360.	115.	0.	60.	0.	259.	181.
5	PINUS	0.	1.	2.	2.	0.	0.	4.	3.	1.	0.	1.	2.	1.	0.
6	CORYLUS	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
7	SALIX	0.	5.	1.	6.	0.	0.	10.	10.	6.	0.	1.	6.	7.	5.
8	CALLUNA	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
9	EMPETRUM	0.	3.	0.	0.	0.	0.	0.	2.	0.	0.	0.	2.	3.	2.
10	EPHEDERA	0.	1.	0.	0.	0.	0.	0.	2.	1.	0.	0.	3.	0.	1.
11	ARTEMISIA	0.	1.	0.	1.	0.	0.	1.	0.	1.	0.	0.	2.	2.	2.
12	CARYOPHYLLACEAE	0.	3.	4.	2.	0.	0.	5.	1.	3.	0.	1.	1.	0.	3.
13	FILIPENDULA	0.	1.	0.	0.	0.	0.	1.	0.	0.	0.	0.	2.	2.	1.
14	UMBELLIFERAE	0.	2.	0.	0.	0.	0.	1.	4.	0.	0.	0.	0.	2.	1.
15	NYMPHAEA	0.	1.	0.	0.	0.	0.	0.	0.	1.	0.	0.	0.	0.	0.
16	POTOMAGETON	0.	2.	0.	0.	0.	0.	0.	1.	2.	0.	0.	0.	0.	1.
17	FILICALES	0.	3.	0.	0.	0.	0.	0.	1.	0.	0.	1.	3.	2.	0.
18	LYCOPODIUM	0.	2.	1.	3.	0.	0.	2.	5.	1.	0.	1.	2.	7.	3.
19	SELAGINELLA	0.	2.	3.	2.	0.	1.	7.	7.	5.	0.	0.	11.	6.	4.
20	THALICTRUM	0.	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	2.	0.
21	SPARGANIUM	0.	0.	1.	1.	0.	0.	5.	0.	0.	1.	0.	0.	0.	0.
22	SPHAGNUM	0.	0.	0.	1.	0.	1.	0.	0.	0.	0.	1.	0.	0.	1.
23	COMPOSITAE	0.	2.	0.	0.	0.	0.	2.	1.	3.	0.	0.	1.	4.	3.
24	EPILOBIUM	0.	0.	0.	0.	0.	0.	1.	0.	1.	0.	0.	0.	1.	0.
25	GALIUM	0.	0.	0.	0.	0.	0.	2.	0.	1.	0.	0.	0.	0.	0.
26	URTICA	0.	0.	0.	0.	0.	0.	1.	2.	0.	0.	2.	7.	1.	2.
27	MYRIOPHYLUM ALTERNIFLORUM	0.	0.	0.	0.	0.	0.	3.	0.	0.	0.	0.	3.	2.	0.
28	POLYPODIUM	0.	0.	0.	0.	0.	0.	2.	2.	0.	0.	0.	0.	3.	1.
29	HELIANTHEMUM	0.	0.	0.	0.	0.	0.	0.	0.	2.	0.	0.	0.	4.	3.
30	QUERCUS	0.	0.	0.	0.	0.	0.	0.	0.	1.	0.	0.	0.	0.	0.
31	SUCCISA PRATENSIS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.	0.	0.
32	MYRIOPHYLUM HETERO	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
33	RUMEX	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.	0.	0.
34	RANUNCULACEAE(CALTHA)	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
35	JUNIPERUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.	0.	0.
36	VIOLA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
37	POLYGONUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
38	BETULA NANA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	4.	0.
39	VALERIANA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
40	CHENOPODIACEAE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
41	HIPPOPHAE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
42	SANGUISORBA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
43	LYSIMACHIA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
44	CAMPANULA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
45	POTENTILLA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
46	SAXIFRAGA	0.	0.	0.	0.	0.	0.	0.	0.	1.	0.	0.	0.	0.	0.
47	ERICACEAE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	2.	0.	0.
48	LABIATAE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
49	NUPHAR	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
50	ALNUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

NO.	TYPE	SAMPLE DEPTH (CM.)													
		85	95	105	115	125	135	145	155	175	185	195	205	215	225
51	CENTAUREA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
52	CHAMAENERION	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
53	DRYAS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
54	PLANTAGO	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.	0.	0.	0.

NO.	TYPE	SAMPLE DEPTH (CM.) 235	245	255	265	275	285	295	305	315	325	335	345	355	365
1	BETULA	3.	1.	1.	5.	3.	4.	3.	4.	0.	5.	63.	14.	67.	36.
2	GRAMINEAE	62.	63.	64.	54.	44.	13.	32.	27.	34.	49.	153.	111.	146.	190.
3	CYPERACEAE	99.	100.	117.	96.	54.	59.	101.	72.	40.	55.	61.	74.	62.	54.
4	DERIVED CARBONIFEROUS SPORES	114.	144.	113.	175.	105.	103.	97.	66.	30.	0.	26.	44.	34.	26.
5	PINUS	6.	1.	2.	2.	0.	3.	3.	0.	2.	3.	1.	0.	3.	3.
6	CORYLUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
7	SALIX	11.	5.	7.	14.	4.	7.	13.	7.	7.	4.	7.	6.	6.	8.
8	CALLUNA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
9	EMPETRUM	1.	2.	0.	4.	0.	0.	0.	0.	0.	1.	13.	7.	40.	14.
10	EPHEDERA	0.	1.	1.	1.	1.	0.	4.	0.	0.	0.	0.	0.	2.	0.
11	ARTEMISIA	1.	0.	0.	1.	1.	1.	5.	2.	2.	2.	3.	0.	4.	0.
12	CARYOPHYLLACEAE	2.	4.	0.	11.	0.	4.	5.	2.	0.	0.	0.	1.	3.	2.
13	FILIPENDULA	4.	1.	1.	5.	0.	2.	9.	4.	0.	3.	36.	19.	70.	30.
14	UMBELLIFERAE	0.	1.	1.	1.	1.	1.	0.	0.	0.	0.	2.	0.	4.	0.
15	NYMPHAEA	0.	0.	1.	0.	0.	0.	1.	0.	0.	0.	0.	0.	0.	0.
16	POTOMAGETON	1.	0.	1.	4.	1.	0.	0.	0.	0.	0.	3.	7.	0.	11.
17	FILICALES	3.	0.	0.	0.	1.	1.	3.	3.	2.	2.	1.	0.	0.	1.
18	LYCOPODIUM	0.	0.	0.	0.	0.	0.	1.	1.	0.	0.	1.	0.	0.	0.
19	SELAGINELLA	13.	13.	14.	4.	2.	7.	13.	19.	8.	12.	1.	2.	9.	1.
20	THALICTRUM	0.	0.	0.	1.	0.	0.	1.	0.	0.	2.	1.	3.	4.	3.
21	SPARGANIUM	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
22	SPHAGNUM	0.	0.	0.	0.	0.	1.	0.	0.	2.	0.	1.	1.	0.	1.
23	COMPOSITAE	2.	0.	3.	4.	1.	0.	0.	0.	0.	2.	0.	1.	1.	2.
24	EPILOBIUM	0.	0.	0.	1.	0.	0.	0.	0.	0.	0.	1.	0.	0.	0.
25	GALIUM	2.	1.	0.	0.	0.	0.	2.	0.	0.	0.	1.	1.	1.	0.
26	URTICA	7.	1.	6.	1.	4.	1.	2.	0.	0.	0.	3.	1.	2.	0.
27	MYRIOPHYLUM ALTERNIFLORUM	1.	1.	0.	2.	2.	1.	4.	0.	0.	1.	2.	2.	7.	4.
28	POLYPODIUM	4.	1.	2.	4.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
29	HELIANTHEMUM	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	4.	2.
30	QUERCUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
31	SUCCISA PRATENSIS	0.	0.	0.	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.
32	MYRIOPHYLUM HETERO	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	2.	1.
33	RUMEX	0.	0.	0.	1.	2.	1.	1.	0.	0.	0.	0.	2.	4.	2.
34	RANUNCULACEAE(CALTHA)	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
35	JUNIPERUS	0.	1.	0.	1.	1.	1.	2.	2.	5.	0.	10.	8.	6.	6.
36	VIOLA	0.	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
37	POLYGONUM	0.	0.	0.	0.	0.	2.	0.	0.	0.	0.	0.	0.	1.	2.
38	BETULA NANA	0.	0.	0.	0.	0.	3.	2.	3.	0.	0.	0.	10.	4.	0.
39	VALERIANA	0.	0.	0.	0.	0.	0.	1.	0.	0.	2.	0.	0.	0.	0.
40	CHENOPODIACEAE	0.	0.	1.	1.	0.	0.	1.	0.	0.	1.	0.	1.	0.	1.
41	HIPPOPHAE	0.	0.	0.	0.	0.	0.	0.	1.	0.	0.	0.	0.	2.	0.
42	SANGUISORBA	0.	0.	0.	0.	0.	0.	0.	1.	0.	0.	0.	0.	0.	0.
43	LYSIMACHIA	0.	0.	0.	0.	0.	0.	0.	1.	0.	0.	0.	0.	0.	0.
44	CAMPANULA	0.	0.	0.	0.	0.	0.	0.	1.	0.	0.	0.	0.	0.	0.
45	POTENTILLA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	2.	0.
46	SAXIFRAGA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.	0.
47	ERICACEAE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	2.	0.	0.	0.
48	LABIATAE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.
49	NUPHAR	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
50	ALNUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

NO.	TYPE	SAMPLE DEPTH (CM.) 235	245	255	265	275	285	295	305	315	325	335	345	355	365
51	CENTAUREA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
52	CHAMAENERION	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
53	DRYAS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
54	PLANTAGO	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

NO.	TYPE	SAMPLE DEPTH (CM.) 375	385	405	415	425	435	445	455	465	475	485	495	505	515
1	BETULA	20.	16.	27.	26.	25.	20.	30.	11.	9.	9.	21.	58.	39.	16.
2	GRAMINEAE	163.	112.	167.	162.	260.	151.	134.	84.	48.	70.	109.	123.	150.	61.
3	CYPERACEAE	43.	65.	58.	163.	67.	64.	100.	59.	46.	89.	37.	47.	41.	38.
4	DERIVED CARBONIFEROUS SPORES	24.	40.	23.	44.	67.	39.	129.	75.	87.	119.	94.	87.	120.	188.
5	PINUS	2.	3.	3.	2.	1.	2.	3.	0.	3.	4.	4.	0.	1.	0.
6	CORYLUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
7	SALIX	1.	7.	3.	9.	9.	7.	13.	10.	6.	10.	15.	20.	7.	16.
8	CALLUNA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
9	EMPETRUM	15.	11.	21.	5.	10.	9.	9.	1.	0.	2.	2.	3.	2.	3.
10	EPHEDERA	0.	1.	1.	0.	0.	1.	4.	0.	1.	1.	3.	1.	0.	0.
11	ARTEMISIA	0.	0.	1.	3.	1.	3.	10.	2.	23.	1.	2.	5.	2.	4.
12	CARYOPHYLLACEAE	1.	1.	0.	0.	5.	2.	3.	3.	0.	0.	2.	0.	1.	0.
13	FILIPENDULA	1.	15.	4.	3.	2.	9.	12.	3.	12.	5.	11.	4.	0.	3.
14	UMBELLIFERAE	3.	5.	2.	3.	2.	2.	0.	0.	0.	1.	0.	0.	1.	0.
15	NYMPHAEA	1.	0.	1.	0.	1.	0.	0.	0.	0.	0.	0.	1.	0.	0.
16	POTOMAGETON	5.	10.	2.	1.	2.	0.	8.	2.	0.	0.	3.	0.	0.	0.
17	FILICALES	0.	1.	0.	2.	1.	1.	5.	0.	0.	2.	1.	0.	1.	0.
18	LYCOPODIUM	0.	0.	0.	0.	2.	1.	5.	0.	0.	3.	0.	0.	0.	0.
19	SELAGINELLA	0.	3.	0.	1.	1.	4.	5.	1.	0.	13.	1.	0.	2.	0.
20	THALICTRUM	3.	5.	1.	0.	14.	11.	5.	3.	2.	2.	1.	1.	1.	0.
21	SPARGANIUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	3.
22	SPHAGNUM	0.	0.	0.	0.	0.	0.	1.	0.	0.	0.	1.	0.	0.	0.
23	COMPOSITAE	2.	1.	2.	1.	1.	1.	5.	2.	0.	1.	0.	2.	2.	4.
24	EPILOBIUM	0.	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
25	GALIUM	2.	2.	1.	5.	3.	5.	13.	5.	5.	4.	14.	7.	7.	2.
26	URTICA	0.	0.	0.	2.	1.	0.	0.	0.	3.	2.	3.	1.	3.	6.
27	MYRIOPHYLUM ALTERNIFLORUM	4.	5.	4.	2.	6.	7.	4.	5.	6.	4.	3.	5.	12.	24.
28	POLYPODIUM	0.	4.	12.	12.	1.	1.	0.	0.	0.	0.	0.	0.	1.	0.
29	HELIANTHEMUM	1.	0.	1.	0.	0.	0.	0.	0.	1.	1.	1.	1.	0.	0.
30	QUERCUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
31	SUCCISA PRATENSIS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
32	MYRIOPHYLUM HETERO	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
33	RUMEX	1.	3.	2.	3.	5.	2.	5.	7.	6.	4.	6.	14.	5.	1.
34	RANUNCULACEAE(CALTHA)	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
35	JUNIPERUS	10.	1.	10.	9.	6.	1.	1.	0.	0.	3.	1.	0.	2.	0.
36	VIOLA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
37	POLYGONUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
38	BETULA NANA	0.	1.	1.	2.	2.	1.	4.	2.	0.	8.	10.	4.	7.	7.
39	VALERIANA	0.	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
40	CHENOPODIACEAE	0.	0.	0.	2.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.
41	HIPPOPHAE	0.	0.	1.	0.	1.	0.	0.	0.	0.	0.	0.	1.	0.	0.
42	SANGUISORBA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.	0.	0.
43	LYSIMACHIA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
44	CAMPANULA	2.	0.	0.	0.	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.
45	POTENTILLA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
46	SAXIFRAGA	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.	0.	0.	0.	0.
47	ERICACEAE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
48	LABIATAE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
49	NUPHAR	0.	0.	0.	0.	0.	0.	0.	0.	1.	0.	0.	0.	0.	0.
50	ALNUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.	0.	0.	0.	0.

NO.	TYPE	SAMPLE DEPTH (CM.)													
		375	385	405	415	425	435	445	455	465	475	485	495	505	515
51	CENTAUREA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.	0.
52	CHAMAENERION	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.	0.
53	DRYAS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
54	PLANTAGO	0.	0.	1.	2.	0.	2.	2.	0.	0.	0.	0.	0.	1.	0.

NO.	TYPE	SAMPLE DEPTH (CM.) 525	535	545	555	565	585
1	BETULA	20.	21.	9.	0.	0.	1.
2	GRAMINEAE	42.	46.	32.	25.	4.	30.
3	CYPERACEAE	19.	37.	23.	4.	5.	13.
4	DERIVED CARBONIFEROUS SPORES	61.	112.	93.	59.	65.	267.
5	PINUS	1.	1.	1.	0.	0.	5.
6	CORYLUS	0.	0.	1.	0.	0.	0.
7	SALIX	13.	37.	4.	2.	0.	1.
8	CALLUNA	0.	0.	0.	0.	0.	1.
9	EMPETRUM	0.	1.	0.	0.	0.	0.
10	EPHEDERA	0.	1.	1.	0.	0.	0.
11	ARTEMISIA	2.	1.	0.	0.	0.	1.
12	CARYOPHYLLACEAE	0.	0.	0.	0.	0.	1.
13	FILIPENDULA	5.	0.	2.	0.	0.	1.
14	UMBELLIFERAE	0.	0.	2.	0.	0.	1.
15	NYMPHAEA	0.	0.	0.	0.	0.	0.
16	POTOMAGETON	1.	2.	1.	0.	0.	0.
17	FILICALES	0.	0.	1.	3.	0.	0.
18	LYCOPODIUM	0.	0.	0.	0.	0.	0.
19	SELAGINELLA	0.	1.	0.	0.	0.	2.
20	THALICTRUM	0.	1.	0.	0.	0.	0.
21	SPARGANIUM	1.	0.	0.	0.	0.	0.
22	SPHAGNUM	0.	0.	0.	0.	0.	1.
23	COMPOSITAE	1.	4.	0.	1.	1.	1.
24	EPILOBIUM	0.	0.	0.	0.	0.	0.
25	GALIUM	5.	0.	0.	2.	0.	0.
26	URTICA	2.	3.	1.	2.	1.	3.
27	MYRIOPHYLUM ALTERNIFLORUM	7.	2.	1.	0.	0.	1.
28	POLYPODIUM	0.	0.	1.	0.	0.	0.
29	HELIANTHEMUM	0.	0.	3.	1.	0.	0.
30	QUERCUS	0.	0.	0.	0.	0.	0.
31	SUCCISA PRATENSIS	0.	0.	0.	0.	0.	2.
32	MYRIOPHYLUM HETERO	0.	0.	0.	0.	0.	0.
33	RUMEX	0.	2.	6.	3.	0.	0.
34	RANUNCULACEAE(CALTHA)	0.	0.	0.	0.	0.	0.
35	JUNIPERUS	1.	0.	0.	0.	0.	0.
36	VIOLA	0.	0.	0.	0.	0.	0.
37	POLYGONUM	0.	0.	0.	0.	0.	0.
38	BETULA NANA	5.	10.	4.	0.	0.	0.
39	VALERIANA	0.	0.	0.	0.	0.	0.
40	CHENOPODIACEAE	0.	0.	1.	0.	0.	0.
41	HIPPOPHAE	0.	0.	0.	0.	0.	1.
42	SANGUISORBA	0.	0.	0.	0.	0.	0.
43	LYSIMACHIA	0.	0.	0.	0.	0.	0.
44	CAMPANULA	0.	0.	0.	0.	0.	0.
45	POTENTILLA	0.	0.	0.	0.	0.	0.
46	SAXIFRAGA	0.	0.	0.	0.	0.	0.
47	ERICACEAE	0.	0.	0.	0.	0.	0.
48	LABIATAE	0.	0.	0.	0.	0.	0.
49	NUPHAR	0.	0.	0.	0.	0.	0.
50	ALNUS	0.	0.	0.	0.	0.	0.

NO.	TYPE	SAMPLE DEPTH (CM.) 525	535	545	555	565	585
51	CENTAUREA	0.	0.	0.	1.	0.	0.
52	CHAMAENERION	0.	0.	0.	0.	0.	0.
53	DRYAS	0.	0.	0.	1.	0.	0.
54	PLANTAGO	0.	1.	0.	0.	0.	0.

CORSTORPHINE SITE. ANALYSED BY A J ALEXANDER, 1982/83

COUNTS OF POLLEN AND SPORES

NO.	TYPE	SAMPLE DEPTH (CM.) 205	210	215	220	230	235	240	245	270	290	325	345	380	385
1	BETULA	4.	8.	1.	3.	4.	2.	15.	0.	1.	2.	1.	1.	10.	37.
2	GRAMINEAE	24.	12.	8.	8.	7.	5.	15.	10.	7.	10.	1.	3.	13.	106.
3	CYPERACEAE	55.	56.	30.	16.	33.	32.	68.	60.	18.	48.	7.	22.	34.	90.
4	DERIVED CARBONIFEROUS SPORES	331.	330.	300.	324.	376.	287.	249.	138.	151.	162.	82.	105.	125.	198.
5	PINUS	4.	2.	8.	6.	3.	5.	9.	1.	3.	0.	0.	0.	2.	11.
6	CORYLUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
7	SALIX	2.	0.	3.	1.	0.	0.	4.	6.	1.	1.	0.	1.	0.	4.
8	CALLUNA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
9	EMPETRUM	2.	0.	0.	1.	0.	0.	0.	0.	0.	0.	0.	1.	0.	14.
10	EPHEDERA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
11	ARTEMISIA	2.	0.	0.	2.	0.	0.	1.	2.	0.	1.	0.	0.	1.	4.
12	CARYOPHYLLACEAE	1.	3.	9.	4.	5.	7.	16.	6.	5.	8.	2.	4.	3.	3.
13	FILIPENDULA	1.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	2.	8.
14	UMBELLIFERAE	0.	0.	0.	0.	0.	0.	1.	0.	0.	0.	0.	0.	0.	1.
15	NYMPHAEA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
16	POTOMAGETON	0.	0.	0.	0.	0.	0.	1.	0.	0.	0.	0.	0.	0.	2.
17	FILICALES	2.	4.	1.	2.	0.	0.	2.	3.	0.	3.	3.	4.	4.	8.
18	LYCOPODIUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
19	SELAGINELLA	5.	2.	10.	11.	7.	13.	19.	22.	7.	14.	5.	18.	20.	7.
20	THALICTRUM	2.	0.	1.	3.	0.	1.	0.	0.	1.	0.	0.	1.	0.	2.
21	SPARGANIUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
22	SPHAGNUM	0.	0.	0.	0.	0.	0.	0.	1.	0.	0.	0.	0.	0.	0.
23	COMPOSITAE - TARAXACUM	0.	3.	0.	0.	0.	0.	3.	2.	1.	1.	1.	1.	3.	1.
24	EPILOBIUM	0.	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
25	GALIUM	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.	0.	1.
26	URTICA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
27	MYRIOPHYLUM ALTERNIFLORUM	0.	1.	0.	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.
28	POLYPODIUM VULGARE	0.	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
29	HELIANTHEMUM	1.	0.	0.	0.	0.	0.	0.	0.	0.	1.	0.	0.	0.	1.
30	ROSACEAE	1.	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.
31	SUCCISA PRATENSIS	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.	0.	0.	0.	0.
32	MYRIOPHYLUM HETERO	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
33	RUMEX	0.	0.	1.	2.	1.	0.	6.	0.	2.	2.	0.	1.	0.	22.
34	RANUNCULACEAE	0.	0.	0.	1.	0.	0.	0.	0.	0.	1.	0.	0.	0.	3.
35	JUNIPERUS	0.	2.	0.	0.	0.	0.	1.	0.	0.	0.	0.	0.	0.	3.
36	VIOLA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
37	POLYGONUM	0.	0.	0.	0.	0.	0.	2.	0.	0.	0.	0.	0.	0.	0.
38	BETULA NANA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
39	VALERIANA	0.	0.	1.	1.	0.	0.	0.	1.	0.	3.	0.	0.	0.	0.
40	CHEONOPODIACEAE	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
41	HIPPOPHAE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
42	SANGUISORBA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
43	LYSIMACHIA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
44	CAMPANULA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
45	POTENTILLA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
46	SAXIFRAGA - UNDIFF	0.	0.	0.	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.
47	ERICACEAE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
48	LABIATAE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
49	NUPHAR	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
50	ALNUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

NO.	TYPE	SAMPLE DEPTH (CM.) 205	210	215	220	230	235	240	245	270	290	325	345	380	385
51	SEDUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
52	LINUM CARTHARTICUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
53	DRYAS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
54	PLANTAGO	0.	0.	1.	0.	0.	0.	1.	0.	0.	0.	0.	0.	0.	1.
55	SAXIFRAGA STELLARIS	2.	1.	0.	0.	0.	2.	0.	0.	0.	0.	0.	0.	0.	0.
56	PARNASSIA PALUSTRIS	1.	0.	1.	0.	0.	0.	1.	0.	0.	0.	0.	0.	0.	0.
57	CRYPTOGAMA	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
58	COMPOSITAE - LIGULIFLORAE	0.	0.	1.	0.	1.	0.	3.	3.	1.	0.	0.	0.	0.	2.
59	SAXIFRAGA GRANULATA	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
60	CRUCIFERAE	0.	0.	5.	5.	3.	8.	3.	3.	2.	0.	1.	1.	1.	0.
61	ANAGALLIS	0.	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
62	EQUISETUM	0.	0.	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
63	SAXIFRAGA AZOIDES	0.	0.	0.	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.
64	TYPHA	0.	0.	0.	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.
65	SCROPHULARIACEAE	0.	0.	0.	0.	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.
66	ARMERIA	0.	0.	0.	0.	0.	0.	2.	0.	0.	0.	0.	0.	0.	0.
67	SAMBUCUS	0.	0.	0.	0.	0.	0.	0.	1.	0.	0.	0.	0.	0.	0.
68	SAXIFRAGA OPPOSITIFOLIA	0.	0.	0.	0.	0.	0.	0.	1.	0.	0.	0.	0.	0.	0.
69	VICIA	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.	0.	0.	0.	0.
70	MENYANTHES	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.	0.	0.
71	ULMUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
72	CARPINUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.	0.	0.
73	COMPOSITAE - CIRSIUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
74	HYDROCOTYLE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
75	TILIA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
76	COMPOSITAE - BELLIS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
77	UNIDENTIFIED - INDETERMINATE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.	0.	0.

NO.	TYPE	SAMPLE DEPTH (CM.) 390	395	400	405	412	418	422	427	433	438	443	448	453	458
1	BETULA	52.	58.	43.	44.	17.	24.	32.	30.	24.	20.	35.	23.	24.	25.
2	GRAMINEAE	128.	131.	98.	153.	172.	195.	177.	168.	154.	189.	139.	192.	159.	181.
3	CYPERACEAE	47.	30.	29.	38.	44.	26.	41.	52.	99.	51.	63.	30.	68.	53.
4	DERIVED CARBONIFEROUS SPORES	33.	8.	6.	8.	47.	14.	28.	14.	28.	27.	15.	12.	16.	15.
5	PINUS	3.	6.	1.	4.	1.	4.	4.	0.	0.	5.	1.	0.	1.	1.
6	CORYLUS	0.	0.	0.	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.
7	SALIX	3.	4.	3.	3.	1.	3.	1.	1.	5.	2.	3.	2.	0.	2.
8	CALLUNA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
9	EMPETRUM	16.	11.	26.	26.	21.	26.	8.	21.	8.	12.	13.	25.	17.	16.
10	EPHEDERA	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.	0.	0.	0.	0.
11	ARTEMISIA	0.	0.	1.	1.	0.	1.	0.	1.	0.	3.	2.	3.	2.	1.
12	CARYOPHYLLACEAE	1.	0.	1.	0.	0.	0.	1.	0.	0.	1.	0.	2.	0.	1.
13	FILIPENDULA	16.	20.	48.	18.	1.	3.	1.	1.	0.	2.	1.	0.	0.	0.
14	UMBELLIFERAE	0.	0.	3.	2.	1.	1.	0.	0.	0.	4.	0.	1.	2.	1.
15	NYMPHAEA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
16	POTOMAGETON	1.	1.	2.	4.	5.	4.	3.	3.	34.	5.	2.	0.	1.	0.
17	FILICALES	7.	4.	5.	19.	1.	1.	1.	4.	0.	0.	1.	1.	5.	3.
18	LYCOPODIUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
19	SELAGINELLA	1.	2.	0.	0.	0.	0.	2.	1.	1.	0.	0.	0.	0.	0.
20	THALICTRUM	0.	1.	1.	0.	1.	0.	6.	0.	2.	1.	3.	3.	7.	7.
21	SPARGANIUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
22	SPHAGNUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
23	COMPOSITAE - TARAXACUM	2.	0.	0.	2.	1.	0.	2.	1.	0.	0.	0.	0.	1.	0.
24	EPILOBIUM	0.	0.	0.	0.	1.	0.	1.	0.	0.	0.	0.	0.	0.	0.
25	GALIUM	1.	1.	0.	1.	2.	2.	2.	2.	4.	1.	2.	7.	5.	11.
26	URTICA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
27	MYRIOPHYLUM ALTERNIFLORUM	0.	0.	1.	1.	5.	0.	0.	1.	2.	0.	2.	1.	0.	0.
28	POLYPODIUM VULGARE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
29	HELIANTHEMUM	0.	2.	2.	1.	3.	3.	3.	3.	0.	1.	2.	4.	0.	2.
30	ROSACEAE	1.	0.	0.	1.	0.	2.	0.	2.	0.	0.	1.	0.	1.	0.
31	SUCCISA PRATENSIS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
32	MYRIOPHYLUM HETERO	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.	0.	0.	0.	0.
33	RUMEX	5.	11.	5.	7.	6.	4.	10.	10.	7.	11.	10.	11.	15.	12.
34	RANUNCULACEAE	1.	1.	1.	2.	0.	0.	0.	0.	0.	1.	2.	2.	1.	1.
35	JUNIPERUS	43.	43.	39.	15.	26.	5.	16.	18.	4.	18.	21.	8.	4.	8.
36	VIOLA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
37	POLYGONUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
38	BETULA NANA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
39	VALERIANA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
40	CHENOPODIACEAE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
41	HIPPOPHAE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
42	SANGUISORBA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
43	LYSIMACHIA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
44	CAMPANULA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
45	POTENTILLA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
46	SAXIFRAGA - UNDIFF	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
47	ERICACEAE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
48	LABIATAE	0.	0.	0.	0.	0.	0.	0.	1.	0.	0.	0.	0.	0.	0.
49	NUPHAR	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
50	ALNUS	0.	0.	0.	0.	1.	0.	0.	1.	0.	0.	0.	0.	0.	0.

NO.	TYPE	SAMPLE DEPTH (CM.) 390	395	400	405	412	418	422	427	433	438	443	448	453	458
51	SEDUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
52	LINUM CARTHARTICUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
53	DRYAS	0.	0.	0.	0.	1.	0.	0.	0.	0.	0.	1.	0.	0.	0.
54	PLANTAGO	1.	0.	2.	1.	0.	0.	0.	0.	1.	0.	0.	0.	0.	1.
55	SAXIFRAGA STELLARIS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
56	PARNASSIA PALUSTRIS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
57	CRYPTOGAMA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
58	COMPOSITAE - LIGULIFLORAE	1.	0.	1.	1.	0.	0.	0.	0.	1.	0.	0.	0.	0.	0.
59	SAXIFRAGA GRANULATA	0.	0.	0.	0.	0.	1.	1.	0.	1.	0.	1.	0.	0.	1.
60	CRUCIFERAE	0.	1.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
61	ANAGALLIS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
62	EQUISETUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
63	SAXIFRAGA AZOIDES	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.
64	TYPHA	0.	0.	0.	1.	0.	0.	0.	0.	0.	1.	0.	0.	0.	0.
65	SCROPHULARIACEAE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
66	ARMERIA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
67	SAMBUCUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
68	SAXIFRAGA OPPOSITIFOLIA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
69	VICIA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
70	MENYANTHES	1.	0.	0.	0.	0.	0.	1.	0.	1.	0.	0.	1.	0.	0.
71	ULMUS	0.	1.	0.	0.	1.	0.	0.	0.	0.	1.	0.	0.	0.	0.
72	CARPINUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
73	COMPOSITAE - CIRSIUM	0.	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
74	HYDROCOTYLE	0.	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
75	TILIA	0.	0.	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
76	COMPOSITAE - BELLIS	0.	0.	0.	0.	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.
77	UNIDENTIFIED - INDETERMINATE	0.	0.	0.	0.	0.	0.	1.	0.	0.	0.	0.	0.	0.	0.

NO.	TYPE	SAMPLE DEPTH (CM.) 463	480	485	490	495	500	505	510	515	520	525	540	550	560
1	BETULA	45.	40.	55.	63.	18.	37.	8.	39.	41.	61.	43.	91.	64.	86.
2	GRAMINEAE	167.	137.	66.	125.	60.	97.	21.	115.	115.	129.	135.	87.	122.	88.
3	CYPERACEAE	58.	82.	32.	50.	33.	61.	18.	55.	70.	59.	48.	44.	73.	59.
4	DERIVED CARBONIFEROUS SPORES	38.	56.	28.	130.	118.	439.	92.	367.	180.	110.	66.	152.	177.	317.
5	PINUS	1.	1.	3.	2.	1.	4.	1.	1.	5.	3.	2.	4.	1.	1.
6	CORYLUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
7	SALIX	1.	1.	2.	3.	1.	9.	0.	6.	3.	3.	3.	8.	4.	9.
8	CALLUNA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
9	EMPETRUM	12.	3.	1.	0.	0.	5.	1.	3.	6.	12.	3.	14.	3.	1.
10	EPHEDERA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
11	ARTEMISIA	1.	2.	5.	7.	3.	3.	1.	3.	1.	4.	6.	1.	4.	4.
12	CARYOPHYLLACEAE	0.	2.	0.	0.	1.	6.	1.	10.	1.	1.	0.	1.	2.	4.
13	FILIPENDULA	1.	0.	0.	1.	0.	0.	0.	1.	3.	0.	0.	1.	1.	0.
14	UMBELLIFERAE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
15	NYMPHAEA	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.	0.	0.	0.	0.
16	POTOMAGETON	0.	3.	0.	0.	1.	0.	1.	0.	0.	0.	0.	0.	0.	0.
17	FILICALES	0.	9.	0.	0.	1.	6.	4.	1.	0.	0.	5.	0.	3.	5.
18	LYCOPODIUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
19	SELAGINELLA	0.	2.	0.	0.	0.	1.	3.	0.	0.	0.	0.	0.	2.	0.
20	THALICTRUM	4.	6.	1.	5.	0.	2.	0.	0.	1.	1.	0.	0.	1.	1.
21	SPARGANIUM	1.	0.	0.	0.	0.	2.	0.	0.	0.	0.	0.	1.	5.	8.
22	SPHAGNUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
23	COMPOSITAE - TARAXACUM	0.	1.	0.	3.	1.	0.	2.	0.	0.	0.	0.	0.	1.	0.
24	EPILOBIUM	0.	1.	0.	0.	0.	0.	0.	0.	0.	1.	0.	2.	0.	2.
25	GALIUM	0.	14.	4.	4.	2.	1.	0.	3.	0.	4.	7.	9.	8.	11.
26	URTICA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
27	MYRIOPHYLUM ALTERNIFLORUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.	0.	1.	2.	0.
28	POLYPODIUM VULGARE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.	1.	1.
29	HE[redacted]ANTHEMUM	0.	0.	0.	1.	0.	1.	0.	0.	0.	0.	1.	1.	0.	0.
30	ROSACEAE	0.	1.	0.	1.	0.	1.	0.	0.	1.	0.	0.	0.	0.	0.
31	SUCCISA PRATENSIS	0.	0.	0.	0.	1.	0.	0.	0.	1.	0.	1.	0.	0.	0.
32	MYRIOPHYLUM HETERO	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
33	RUMEX	5.	10.	15.	29.	7.	89.	2.	61.	11.	9.	13.	27.	14.	29.
34	RANUNCULACEAE	1.	1.	0.	3.	0.	2.	0.	2.	1.	1.	0.	0.	1.	0.
35	JUNIPERUS	10.	12.	4.	4.	1.	2.	0.	3.	3.	8.	5.	9.	4.	7.
36	VIOLA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
37	POLYGONUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
38	BETULA NANA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
39	VALERIANA	0.	0.	0.	0.	0.	0.	0.	0.	1.	0.	0.	0.	0.	0.
40	CHEONOPODIACEAE	1.	1.	0.	0.	1.	0.	0.	1.	1.	0.	0.	0.	0.	0.
41	HIPPOPHAE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
42	SANGUISORBA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
43	LYSIMACHIA	0.	0.	0.	0.	0.	0.	0.	0.	1.	0.	0.	0.	0.	0.
44	CAMPANULA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
45	POTENTILLA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
46	SAXIFRAGA - UNDIFF	0.	0.	0.	0.	0.	0.	0.	0.	1.	0.	0.	0.	0.	0.
47	ERICACEAE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
48	LABIATAE	0.	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
49	NUPHAR	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
50	ALNUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

NO.	TYPE	SAMPLE DEPTH (CM.) 463	480	485	490	495	500	505	510	515	520	525	540	550	560
51	SEDUM	0.	1.	0.	0.	0.	0.	0.	1.	0.	0.	0.	0.	0.	0.
52	LINUM CARTHARTICUM	0.	0.	0.	0.	0.	0.	0.	1.	0.	0.	0.	0.	0.	0.
53	DRYAS	0.	0.	0.	1.	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.
54	PLANTAGO	0.	0.	0.	2.	0.	0.	0.	2.	0.	3.	2.	5.	1.	0.
55	SAXIFRAGA STELLARIS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
56	PARNASSIA PALUSTRIS	0.	0.	2.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
57	CRYPTOGAMA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
58	COMPOSITAE - LIGULIFLORAE	1.	0.	0.	0.	0.	0.	0.	2.	1.	0.	3.	2.	0.	0.
59	SAXIFRAGA GRANULATA	0.	0.	0.	0.	0.	2.	0.	1.	0.	0.	0.	0.	0.	1.
60	CRUCIFERAE	0.	0.	1.	0.	0.	1.	0.	3.	0.	0.	0.	0.	0.	0.
61	ANAGALLIS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
62	EQUISETUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
63	SAXIFRAGA AZOIDES	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
64	TYPHA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
65	SCROPHULARIACEAE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
66	ARMERIA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
67	SAMBUCUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
68	SAXIFRAGA OPPOSITIFOLIA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
69	VICIA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
70	MENYANTHES	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
71	ULMUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
72	CARPINUS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
73	COMPOSITAE - CIRSIUM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
74	HYDROCOTYLE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
75	TILIA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
76	COMPOSITAE - BELLIS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
77	UNIDENTIFIED - INDETERMINATE	0.	0.	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	1.	3.

NO.	TYPE	SAMPLE DEPTH (CM.) 570	580	595	600	610	625	635	655
1	BETULA	74.	73.	34.	44.	8.	6.	59.	1.
2	GRAMINEAE	96.	110.	155.	27.	31.	2.	101.	1.
3	CYPERACEAE	64.	63.	49.	37.	23.	1.	44.	3.
4	DERIVED CARBONIFEROUS SPORES	439.	409.	22.	309.	390.	253.	250.	193.
5	PINUS	4.	1.	5.	3.	8.	1.	2.	0.
6	CORYLUS	0.	0.	0.	0.	0.	0.	0.	0.
7	SALIX	13.	16.	2.	6.	4.	3.	22.	0.
8	CALLUNA	0.	0.	0.	0.	0.	0.	0.	0.
9	EMPETRUM	3.	1.	14.	0.	0.	0.	1.	0.
10	EPHEDERA	0.	0.	0.	0.	0.	0.	0.	0.
11	ARTEMISIA	5.	1.	0.	0.	0.	1.	6.	0.
12	CARYOPHYLLACEAE	1.	0.	0.	1.	0.	0.	0.	0.
13	FILIPENDULA	0.	0.	10.	0.	0.	1.	0.	0.
14	UMBELLIFERAE	0.	0.	0.	0.	0.	0.	0.	0.
15	NYMPHAEA	0.	0.	0.	1.	0.	0.	0.	0.
16	POTOMAGETON	0.	0.	1.	0.	0.	0.	0.	0.
17	FILICALES	2.	1.	0.	1.	0.	0.	12.	1.
18	LYCOPODIUM	0.	0.	0.	0.	0.	0.	0.	0.
19	SELAGINELLA	0.	0.	0.	0.	0.	0.	0.	0.
20	THALICTRUM	0.	1.	6.	0.	0.	0.	1.	0.
21	SPARGANIUM	3.	0.	1.	0.	0.	0.	0.	0.
22	SPHAGNUM	0.	0.	0.	0.	0.	0.	0.	0.
23	COMPOSITAE - TARAXACUM	1.	2.	0.	0.	1.	2.	1.	0.
24	EPILOBIUM	1.	2.	0.	0.	1.	1.	2.	0.
25	GALIUM	4.	2.	3.	0.	0.	0.	1.	0.
26	URTICA	1.	0.	0.	0.	0.	0.	0.	0.
27	MYRIOPHYLUM ALTERNIFLORUM	0.	0.	0.	0.	0.	0.	0.	0.
28	POLYPODIUM VULGARE	2.	1.	0.	1.	1.	0.	0.	0.
29	HELIANTHEMUM	1.	0.	1.	1.	0.	0.	0.	0.
30	[illegible]ACEAE	0.	0.	0.	1.	0.	0.	0.	0.
31	SUCCISA PRATENSIS	0.	0.	0.	0.	0.	0.	0.	0.
32	MYRIOPHYLUM HETERO	0.	0.	0.	0.	0.	0.	0.	0.
33	RUMEX	17.	20.	7.	5.	15.	1.	24.	3.
34	RANUNCULACEAE	1.	0.	1.	0.	0.	0.	0.	0.
35	JUNIPERUS	2.	0.	19.	0.	0.	0.	0.	0.
36	VIOLA	0.	0.	0.	0.	0.	0.	0.	0.
37	POLYGONUM	0.	2.	0.	0.	0.	0.	1.	0.
38	BETULA NANA	0.	0.	0.	0.	0.	0.	0.	0.
39	VALERIANA	0.	0.	0.	0.	0.	0.	0.	0.
40	CHEONOPODIACEAE	0.	0.	0.	0.	0.	0.	0.	0.
41	HIPPOPHAE	0.	0.	0.	2.	0.	0.	0.	0.
42	SANGUISORBA	0.	0.	0.	0.	0.	0.	0.	0.
43	LYSIMACHIA	0.	0.	0.	0.	0.	0.	0.	0.
44	CAMPANULA	0.	0.	0.	0.	0.	0.	0.	0.
45	POTENTILLA	0.	0.	0.	0.	0.	0.	0.	0.
46	SAXIFRAGA - UNDIFF	0.	0.	0.	1.	0.	0.	0.	0.
47	ERICACEAE	0.	0.	0.	0.	0.	0.	0.	0.
48	LABIATAE	0.	0.	0.	0.	0.	0.	0.	0.
49	NUPHAR	0.	0.	0.	0.	0.	0.	0.	0.
50	ALNUS	0.	0.	0.	0.	0.	0.	0.	0.

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                                                                     S A M P L E   D E P T H   ( C M .)
 NO.            TYPE                                   570   580   595   600   610   625   635   655
  51  SEDUM                                             1.    1.    0.    0.    0.    0.    0.    0.
  52  LINUM CARTHARTICUM                                0.    0.    0.    0.    0.    0.    0.    0.
  53  DRYAS                                             0.    0.    1.    0.    0.    0.    0.    0.
  54  PLANTAGO                                          0.    1.    0.    0.    0.    0.    0.    0.
  55  SAXIFRAGA STELLARIS                               0.    0.    0.    0.    0.    0.    0.    0.
  56  PARNASSIA PALUSTRIS                               0.    0.    0.    1.    0.    0.    0.    0.
  57  CRYPTOGAMA                                        0.    0.    0.    0.    0.    0.    0.    0.
  58  COMPOSITAE - LIGULIFLORAE                         3.    1.    0.    0.    1.    1.    1.    0.
  59  SAXIFRAGA GRANULATA                               0.    0.    0.    0.    0.    0.    0.    0.
  60  CRUCIFERAE                                        0.    0.    0.    0.    0.    0.    0.    0.
  61  ANAGALLIS                                         0.    0.    0.    0.    0.    0.    0.    0.
  62  EQUISETUM                                         0.    0.    0.    0.    0.    0.    0.    0.
  63  SAXIFRAGA AZOIDES                                 0.    0.    0.    0.    0.    0.    0.    0.
  64  TYPHA                                             2.    3.    0.    0.    3.    0.    0.    0.
  65  SCROPHULARIACEAE                                  0.    0.    0.    0.    0.    0.    0.    0.
  66  ARMERIA                                           0.    0.    0.    0.    0.    0.    0.    0.
  67  SAMBUCUS                                          0.    0.    0.    2.    0.    0.    0.    0.
  68  SAXIFRAGA OPPOSITIFOLIA                           0.    0.    0.    0.    0.    0.    0.    0.
  69  VICIA                                             0.    0.    0.    0.    0.    0.    0.    0.
  70  MENYANTHES                                        0.    0.    0.    0.    0.    0.    0.    0.
  71  ULMUS                                             0.    0.    0.    0.    0.    0.    0.    0.
  72  CARPINUS                                          0.    0.    0.    0.    0.    0.    0.    0.
  73  COMPOSITAE - CIRSIUM                              0.    0.    0.    0.    0.    0.    0.    0.
  74  HYDROCOTYLE                                       0.    1.    0.    0.    0.    0.    0.    0.
  75  TILIA                                             0.    0.    0.    0.    0.    0.    0.    0.
  76  COMPOSITAE - BELLIS                               0.    0.    0.    0.    0.    0.    0.    0.
  77  UNIDENTIFIED - INDETERMINATE                      0.    0.    0.    1.    1.    0.    1.    0.
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110212 EJJA26.APP4 39K LISTED LOCAL LPO                                                                9 PAGES PRINTED

***EMAS 2972 EMAS*** EJJA29 A.ALEXANDER         HIGH_SCHOOL_YARDS          END 09/07/84 12.13.22 EJJA29 ***EMAS 2972 EMAS***
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***EMAS 2972 EMAS*** EJJA29 A.ALEXANDER         HIGH_SCHOOL_YARDS          END 09/07/84 12.13.22 EJJA29 ***EMAS 2972 EMAS***
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Appendix 2

Listings of results from ZONATION programs for the following sites:

(a) Broxmouth - (i) complete core
(ii) upper core
(iii) lower core (MK I)
(iv) lower core (MK II)

(b) Balgone House - (i) complete core
(ii) lower core

(c) Corstorphine (WWN)

(d) Corstorphine (AJA)

BROXMOUTH - COMPLETE CORE

1RESULTS OF SPLITINF

INF CONTENT	PERCENT OF TOTAL	MARKERS
71.458405		
25.159531	35.21	43
18.708374	26.18	22 43
13.753625	19.25	22 40 43
12.541508	17.55	7 22 40 43
11.515728	16.12	7 22 25 40 43
10.546021	14.76	7 22 25 40 43 58
9.218813	12.90	7 22 25 40 43 52 58
8.106264	11.34	7 22 25 40 43 52 58 75
7.655777	10.71	7 22 25 40 43 52 58 63 75
7.207656	10.09	7 17 22 25 40 43 52 58 63 75
6.483107	9.07	7 17 20 22 25 40 43 52 58 63 75
6.155962	8.61	7 17 20 22 25 40 43 52 58 63 75 78
5.850855	8.19	7 17 20 22 25 40 43 52 58 63 66 75 78
5.583504	7.81	7 17 20 22 25 40 43 48 52 58 63 66 75 78
5.328121	7.46	7 17 20 22 24 25 40 43 48 52 58 63 66 75 78
5.097685	7.13	7 9 17 20 22 24 25 40 43 48 52 58 63 66 75 78
4.920537	6.89	7 9 17 20 22 24 25 40 43 48 52 58 63 66 75 78 79
4.743826	6.64	7 9 17 20 22 24 25 40 43 48 52 53 58 63 66 75 78 79
4.546021	6.36	7 9 17 20 22 24 25 40 43 48 52 53 57 58 63 66 75 78 79
4.373708	6.12	7 9 17 20 22 24 25 40 41 43 48 52 53 57 58 63 66 75 78 79

OFURTHER SPLITS ARE

0.149105	0.21	76 78 77
0.143295	0.20	67 75 68
0.136880	0.19	1 7 5
0.135939	0.19	59 63 62
0.131341	0.18	21 22 21
0.131064	0.18	54 57 55
0.127066	0.18	26 40 29
0.123467	0.17	49 52 51
0.121805	0.17	10 17 12
0.107207	0.15	64 66 65
0.105060	0.15	44 48 45
0.076045	0.11	80 81 80
0.065069	0.09	18 20 19
0.056731	0.08	8 9 8
0.052175	0.07	23 24 23
0.027831	0.04	42 43 42

1RESULTS OF SPLITLSQ

UNWEIGHTED LEAST SQUARES ANALYSIS

SUM OF SQUARES	PERCENT OF TOTAL	MARKERS
16.758408		
4.925597	29.39	41
3.563869	21.27	24 41
*** INVESTIGATE 8 7 IN GROUP 1 - 24		
CONTENTS ARE 0.5749 0.5754		
2.467978	14.73	24 41 43
1.778095	10.61	24 40 41 43
1.638327	9.78	8 24 40 41 43
1.493510	8.91	8 17 24 40 41 43
1.401989	8.37	8 17 24 40 41 43 65
1.202332	7.17	8 17 24 40 41 43 52 65
1.034628	6.17	8 17 24 40 41 43 52 57 65
0.971633	5.80	8 17 24 25 40 41 43 52 57 65

0.860883	5.14	8	17	22	24	25	40	41	43	52	57	65	77							
0.750239	4.48	8	17	20	22	24	25	40	41	43	52	57	65	77						
0.710325	4.24	8	17	20	21	22	24	25	40	41	43	52	57	65	77					
0.673522	4.02	8	17	20	21	22	24	25	40	41	43	52	57	65	75	77				
0.639046	3.81	8	17	20	21	22	24	25	40	41	43	52	55	57	65	75	77			
0.607215	3.62	8	17	20	21	22	24	25	40	41	43	52	55	57	65	66	75	77		
0.578845	3.45	8	17	20	21	22	24	25	40	41	43	52	55	57	65	66	68	75	77	
0.552561	3.30	8	17	20	21	22	24	25	29	40	41	43	52	55	57	65	66	68	75	77
0.526667	3.14	8	17	20	21	22	24	25	29	40	41	43	52	55	57	63	65	66	68	75	77

FURTHER SPLITS ARE

0.029186	0.17	58	63	59
0.024080	0.14	9	17	12
0.022855	0.14	53	55	53
0.022747	0.14	78	81	79
0.022021	0.13	44	52	48
0.018497	0.11	1	8	4
0.015334	0.09	67	68	67
0.010882	0.06	64	65	64
0.008660	0.05	76	77	76
0.007529	0.04	18	20	19
0.006653	0.04	69	75	69
0.006493	0.04	23	24	23
0.004866	0.03	56	57	56
0.003083	0.02	30	40	39
0.001919	0.01	42	43	42
0.001689	0.01	26	29	28

BROXMOUTH - UPPER CORE

1RESULTS OF SPLITINF

INF CONTENT	PERCENT OF TOTAL	MARKERS
17.794601		
10.976401	61.68	22
5.995197	33.69	22 40
4.766460	26.79	7 22 40
3.926182	22.06	7 22 24 40
3.352801	18.84	7 17 22 24 40
2.623272	14.74	7 17 20 22 24 40
2.274938	12.78	7 9 17 20 22 24 40
2.092743	11.76	7 9 17 20 22 24 29 40
1.930300	10.85	7 9 17 20 22 24 29 40 41
1.794356	10.08	5 7 9 17 20 22 24 29 40 41
1.659328	9.32	5 6 7 9 17 20 22 24 29 40 41
1.525206	8.57	5 6 7 9 17 20 21 22 24 29 40 41
1.437927	8.08	5 6 7 9 17 20 21 22 24 29 38 40 41
1.351621	7.60	5 6 7 9 17 19 20 21 22 24 29 38 40 41
1.272883	7.15	5 6 7 9 14 17 19 20 21 22 24 29 38 40 41
1.050001	5.90	5 6 7 9 14 15 17 19 20 21 22 24 29 38 40 41
0.945688	5.31	5 6 7 9 12 14 15 17 19 20 21 22 24 29 38 40 41
0.866194	4.87	5 6 7 9 12 13 14 15 17 19 20 21 22 24 29 38 40 41
0.803449	4.52	5 6 7 8 9 12 13 14 15 17 19 20 21 22 24 29 38 40 41
0.742356	4.17	4 5 6 7 8 9 12 13 14 15 17 19 20 21 22 24 29 38 40 41
OFURTHER SPLITS ARE		
0.061746	0.35	1 4 1
0.058526	0.33	23 24 23
0.051959	0.29	10 12 11
0.043722	0.25	30 38 34
0.039856	0.22	18 19 18
0.039299	0.22	16 17 16
0.028808	0.16	25 29 25
0.028116	0.16	42 43 42
0.023747	0.13	39 40 39

1RESULTS OF SPLITLSQ

UNWEIGHTED LEAST SQUARES ANALYSIS

SUM OF SQUARES	PERCENT OF TOTAL	MARKERS
3.941387		
2.437967	61.86	40
0.750892	19.05	24 40
0.605439	15.36	7 24 40
0.450866	11.44	7 17 24 40
0.407230	10.33	7 17 22 24 40
0.302598	7.68	7 17 20 22 24 40
0.261629	6.64	7 17 20 22 24 29 40
0.225089	5.71	7 17 20 21 22 24 29 40
0.191449	4.86	7 9 17 20 21 22 24 29 40
0.174177	4.42	4 7 9 17 20 21 22 24 29 40
0.157136	3.99	4 7 9 17 20 21 22 24 29 40 41
0.140806	3.57	4 7 9 14 17 20 21 22 24 29 40 41
0.112111	2.84	4 7 9 14 15 17 20 21 22 24 29 40 41
0.089742	2.28	4 7 9 12 14 15 17 20 21 22 24 29 40 41
0.078411	1.99	4 7 9 12 13 14 15 17 20 21 22 24 29 40 41
0.070745	1.79	4 7 9 12 13 14 15 17 19 20 21 22 24 29 40 41
0.064110	1.63	4 7 9 12 13 14 15 17 19 20 21 22 23 24 29 40 41
0.058172	1.48	4 5 7 9 12 13 14 15 17 19 20 21 22 23 24 29 40 41
0.052401	1.33	4 5 6 7 9 12 13 14 15 17 19 20 21 22 23 24 29 40 41

0.047178	1.20	3	4	5	6	7	9	12	13	14	15	17	19	20	21	22	23	24	29	40	41

FURTHER SPLITS ARE

0.004934	0.13	18	19	18
0.003952	0.10	25	29	26
0.003658	0.09	10	12	11
0.003451	0.09	8	9	8
0.003162	0.08	30	40	37
0.003013	0.08	16	17	16
0.002069	0.05	1	3	1
0.001746	0.04	42	43	42

BROXMOUTH - LOWER CORE MKI

1RESULTS OF SPLITINF

INF CONTENT	PERCENT OF TOTAL	MARKERS
8.199604		
7.196563	87.77	15
5.862312	71.50	9 15
4.678869	57.06	9 15 32
4.257452	51.92	9 15 20 32
3.867790	47.17	9 15 20 32 35
3.493713	42.61	9 15 20 23 32 35
3.201579	39.05	5 9 15 20 23 32 35
2.979323	36.33	5 9 10 15 20 23 32 35
2.747233	33.50	5 9 10 14 15 20 23 32 35
2.546099	31.05	5 9 10 14 15 20 23 32 35 36
2.371413	28.92	5 9 10 14 15 20 23 32 34 35 36
2.217975	27.05	5 9 10 14 15 20 23 32 33 34 35 36
2.067224	25.21	5 9 10 14 15 20 23 25 32 33 34 35 36
1.925813	23.49	5 9 10 14 15 19 20 23 25 32 33 34 35 36
1.786176	21.78	5 8 9 10 14 15 19 20 23 25 32 33 34 35 36
1.648930	20.11	5 8 9 10 12 14 15 19 20 23 25 32 33 34 35 36
1.533216	18.70	5 8 9 10 12 14 15 19 20 22 23 25 32 33 34 35 36
1.437150	17.53	2 5 8 9 10 12 14 15 19 20 22 23 25 32 33 34 35 36
1.343563	16.39	2 5 8 9 10 12 14 15 19 20 22 23 25 28 32 33 34 35 36
1.141651	13.92	2 5 8 9 10 12 14 15 19 20 22 23 25 28 29 32 33 34 35 36

0FURTHER SPLITS ARE

0.127238	1.55	30 32 31
0.086714	1.06	37 38 37
0.083122	1.01	16 19 16
0.080563	0.98	26 28 27
0.071951	0.88	3 5 4
0.064424	0.79	6 8 6
0.063176	0.77	13 14 13
0.060714	0.74	11 12 11
0.058350	0.71	24 25 24
0.056136	0.68	21 22 21
0.052031	0.63	1 2 1

1RESULTS OF SPLITLSQ

UNWEIGHTED LEAST SQUARES ANALYSIS

SUM OF SQUARES	PERCENT OF TOTAL	MARKERS
0.885995		
0.788803	89.03	9
0.509504	57.51	9 14
0.437458	49.37	9 14 26
0.383063	43.24	9 14 26 34
0.351444	39.67	9 12 14 26 34
0.323340	36.49	9 12 14 26 32 34
0.299821	33.84	9 12 14 23 26 32 34
0.271005	30.59	9 12 14 21 23 26 32 34
0.248059	28.00	9 12 14 21 23 26 32 34 36
0.226377	25.55	9 10 12 14 21 23 26 32 34 36
0.207711	23.44	5 9 10 12 14 21 23 26 32 34 36
0.190287	21.48	5 9 10 12 14 16 21 23 26 32 34 36
0.166049	18.74	5 9 10 12 14 16 20 21 23 26 32 34 36
0.152620	17.23	5 9 10 12 14 16 20 21 23 26 32 34 35 36
0.143676	16.22	5 9 10 12 14 16 20 21 23 26 32 33 34 35 36
0.134789	15.21	5 8 9 10 12 14 16 20 21 23 26 32 33 34 35 36

0.117408	13.25	5	8	9	10	12	14	15	16	18	20	21	23	26	32	33	34	35	36	
0.109891	12.40	5	8	9	10	12	14	15	16	18	19	20	21	23	26	32	33	34	35	36
0.102504	11.57	5	8	9	10	12	14	15	16	18	19	20	21	23	25	26	32	33	34	35	36

FURTHER SPLITS ARE

0.014555	1.64	24	25	24
0.007110	0.80	27	32	29
0.006959	0.79	37	38	37
0.006778	0.77	22	23	22
0.006406	0.72	1	5	2
0.005766	0.65	11	12	11
0.004817	0.54	17	18	17
0.004800	0.54	13	14	13
0.002972	0.34	6	8	6

BROXMOUTH - LOWER DIAGRAM - MKII

1RESULTS OF SPLITINF

INF CONTENT	PERCENT OF TOTAL	MARKERS
12.262391		
10.741844	87.60	47
8.688743	70.86	15 47
7.354492	59.98	9 15 47
6.637370	54.13	9 15 29 47
6.019834	49.09	9 15 22 29 47
5.499301	44.85	9 15 22 29 47 54
5.119602	41.75	9 15 22 29 40 47 54
4.827468	39.37	5 9 15 22 29 40 47 54
4.599926	37.51	5 9 15 22 29 40 41 47 54
4.377670	35.70	5 9 10 15 22 29 40 41 47 54
4.145580	33.81	5 9 10 14 15 22 29 40 41 47 54
3.928294	32.04	5 9 10 14 15 22 29 40 41 47 54 56
3.715276	30.30	5 9 10 14 15 22 29 40 41 47 51 54 56
3.546589	28.92	5 9 10 14 15 22 29 40 41 47 50 51 54 56
3.379275	27.56	5 9 10 14 15 20 22 29 40 41 47 50 51 54 56
3.214663	26.22	5 9 10 14 15 20 22 29 31 40 41 47 50 51 54 56
3.069870	25.03	5 9 10 14 15 20 22 29 31 40 41 47 50 51 52 54 56
2.927762	23.88	5 9 10 14 15 20 22 29 31 33 40 41 47 50 51 52 54 56
2.788125	22.74	5 8 9 10 14 15 20 22 29 31 33 40 41 47 50 51 52 54 56
2.650879	21.62	5 8 9 10 12 14 15 20 22 29 31 33 40 41 47 50 51 52 54 56

0FURTHER SPLITS ARE

0.132324	1.08	23 29 26
0.111694	0.91	42 47 44
0.106159	0.87	53 54 53
0.098476	0.80	48 50 48
0.096066	0.78	1 5 2
0.092774	0.76	55 56 55
0.086714	0.71	57 58 57
0.075654	0.62	16 20 16
0.067872	0.55	30 31 30
0.064424	0.53	6 8 6
0.063658	0.52	34 40 38
0.063176	0.52	13 14 13
0.060714	0.50	11 12 11
0.055420	0.45	32 33 32
0.046143	0.38	21 22 21

1RESULTS OF SPLITLSQ

UNWEIGHTED LEAST SQUARES ANALYSIS

SUM OF SQUARES	PERCENT OF TOTAL	MARKERS
1.294358		
1.190792	92.00	29
1.030636	79.63	29 47
0.872660	67.42	9 29 47
0.671719	51.90	9 14 29 47
0.605790	46.80	9 14 29 39 47
0.551942	42.64	9 14 22 29 39 47
0.508013	39.25	9 14 22 29 39 47 54
0.473103	36.55	9 14 22 29 39 47 54 56
0.441484	34.11	9 12 14 22 29 39 47 54 56
0.414020	31.99	9 12 14 22 29 31 39 47 54 56
0.372529	28.78	9 12 14 22 29 31 33 39 47 54 56

*** INVESTIGATE 37 34 IN GROUP 34 - 39

CONTENTS ARE 0.0460 0.0461

0.348944	26.96	9 12 14 16 22 29 31 33 39 47 54 56

0.327263	25.28	9	10	12	14	16	22	29	31	33	39	47	54	56							
0.308597	23.84	5	9	10	12	14	16	22	29	31	33	39	47	54	56						
0.291410	22.51	5	9	10	12	14	16	22	24	29	31	33	39	47	54	56					
0.278626	21.53	5	9	10	12	14	16	22	24	29	31	33	39	47	51	54	56				
0.264272	20.42	5	9	10	12	14	16	22	24	29	31	33	39	47	51	52	54	56			
0.250228	19.33	5	9	10	12	14	16	22	24	29	31	33	39	47	50	51	52	54	56		
0.239839	18.53	5	9	10	12	14	16	18	22	24	29	31	33	39	47	50	51	52	54	56	
0.229717	17.75	5	9	10	12	14	16	18	20	22	24	29	31	33	39	47	50	51	52	54	56

FURTHER SPLITS ARE

0.008888	0.69	6	9	8
0.008882	0.69	15	16	15
0.008604	0.66	40	47	44
0.008553	0.66	32	33	32
0.007269	0.56	53	54	53
0.006959	0.54	57	58	57
0.006707	0.52	34	39	37
0.006406	0.49	1	5	2
0.006064	0.47	55	56	55
0.005766	0.45	11	12	11
0.004817	0.37	17	18	17
0.004800	0.37	13	14	13
0.004616	0.36	25	29	26
0.004558	0.35	30	31	30
0.004212	0.33	21	22	21
0.003917	0.30	19	20	19
0.002428	0.19	48	50	48
0.001894	0.15	23	24	23

BALGONE HOUSE - COMPLETE

1RESULTS OF SPLITINF

INF CONTENT	PERCENT OF TOTAL	MARKERS
128.124802		
57.023804	44.51	41
37.260284	29.08	18 41
29.266144	22.84	18 41 58
23.626221	18.44	18 41 49 58
20.873947	16.29	18 41 44 49 58
18.457855	14.41	18 31 41 44 49 58
16.042877	12.52	18 31 41 44 49 58 89
14.386079	11.23	18 31 39 41 44 49 58 89
13.055989	10.19	1 18 31 39 41 44 49 58 89
11.880438	9.27	1 14 18 31 39 41 44 49 58 89
10.839028	8.46	1 14 18 31 39 41 44 49 58 75 89
9.990246	7.80	1 14 18 31 39 41 44 49 58 75 89 101
9.217507	7.19	1 14 18 31 39 41 44 47 49 58 75 89 101
8.630525	6.74	1 14 18 31 39 41 44 47 49 58 75 83 89 101
8.081871	6.31	1 14 18 31 39 41 44 47 49 58 65 75 83 89 101
7.620554	5.95	1 14 18 31 39 41 44 47 49 58 60 65 75 83 89 101
7.193283	5.61	1 14 18 31 39 41 44 47 49 54 58 60 65 75 83 89 101
6.742504	5.26	1 14 18 31 39 41 44 47 49 54 56 58 60 65 75 83 89 101
6.370562	4.97	1 14 18 21 31 39 41 44 47 49 54 56 58 60 65 75 83 89 101
6.098773	4.76	1 14 18 21 31 39 41 44 47 49 54 56 58 60 65 75 83 89 95 101

*** INVESTIGATE 93 92 IN GROUP 90 - 95
CONTENTS ARE 0.1710 0.1711
0FURTHER SPLITS ARE

0.266323	0.21	2 14 2
0.264240	0.21	32 39 38
0.264102	0.21	50 54 50
0.221613	0.17	57 58 57
0.190439	0.15	66 75 73
0.157307	0.12	40 41 40
0.151269	0.12	96 101 99
0.145177	0.11	22 31 30
0.143546	0.11	76 83 78
0.135888	0.11	61 65 64
0.126020	0.10	42 44 42
0.124791	0.10	48 49 48
0.123240	0.10	15 18 17
0.112424	0.09	45 47 45
0.095339	0.07	102 105 103
0.094807	0.07	59 60 59
0.093114	0.07	84 89 86
0.078519	0.06	90 95 93
0.062462	0.05	19 21 19
0.031419	0.02	55 56 55

1RESULTS OF SPLITLSQ

UNWEIGHTED LEAST SQUARES ANALYSIS

SUM OF SQUARES	PERCENT OF TOTAL	MARKERS
22.921616		
12.488813	54.48	40

*** INVESTIGATE 58 59 IN GROUP 41 - 105
CONTENTS ARE 3.1550 3.1557

6.215885	27.12	17 40
4.937254	21.54	17 40 58
4.093454	17.86	17 40 49 58

3.445260	15.03	17	40	44	49	58														
2.936366	12.81	17	30	40	44	49	58													
2.583749	11.27	17	30	38	40	44	49	58												
2.240333	9.77	1	17	30	38	40	44	49	58											
2.000579	8.73	1	17	30	38	40	44	49	58	101										
1.770952	7.73	1	17	30	38	40	44	49	58	84	101									
1.607925	7.01	1	14	17	30	38	40	44	49	58	84	101								
1.470619	6.42	1	14	17	30	38	40	44	49	54	58	84	101							
1.319742	5.76	1	14	17	30	38	40	44	49	54	56	58	84	101						
1.204028	5.25	1	14	17	30	38	40	44	49	54	56	58	75	84	101					
1.098141	4.79	1	14	17	30	38	40	44	48	49	54	56	58	75	84	101				
0.997643	4.35	1	14	17	18	30	38	40	44	48	49	54	56	58	75	84	101			
0.943451	4.12	1	14	17	18	30	38	40	41	44	48	49	54	56	58	75	84	101		
0.896143	3.91	1	14	17	18	30	38	40	41	44	48	49	54	56	58	64	75	84	101	
0.821460	3.58	1	14	17	18	30	38	40	41	44	48	49	54	56	58	60	64	75	84	101
0.778303	3.40	1	14	17	18	24	30	38	40	41	44	48	49	54	56	58	60	64	75	84 101

FURTHER SPLITS ARE

0.047031	0.21	19	24	21
0.042500	0.19	57	58	57
0.039916	0.17	85	101	93
0.036436	0.16	2	14	3
0.034666	0.15	39	40	39
0.028363	0.12	50	54	51
0.026026	0.11	31	38	33
0.017537	0.08	76	84	76
0.016566	0.07	102	105	103
0.016563	0.07	45	48	47
0.013491	0.06	42	44	42
0.013061	0.06	61	64	63
0.012693	0.06	65	75	73
0.006945	0.03	25	30	25
0.005064	0.02	59	60	59
0.003601	0.02	15	17	15
0.001560	0.01	55	56	55

BALGONE HOUSE - LATEGLACIAL

1RESULTS OF SPLITINF

INF CONTENT	PERCENT OF TOTAL	MARKERS
33.844650		
24.664413	72.88	19
17.429306	51.50	5 19
13.572413	40.10	5 10 19
11.081404	32.74	5 10 19 50
9.963939	29.44	5 10 19 37 50
8.921488	26.36	2 5 10 19 37 50
8.088772	23.90	2 5 10 19 37 50 62

*** INVESTIGATE 55 56 IN GROUP 51 - 62

CONTENTS ARE 0.6783 0.6783

7.325715	21.65	2 5 8 10 19 37 50 62
6.869103	20.30	2 5 8 10 11 19 37 50 62
6.416592	18.96	2 5 8 10 11 19 37 44 50 62
5.972181	17.65	2 5 8 10 11 19 25 37 44 50 62
5.436172	16.06	2 5 8 10 11 19 21 25 37 44 50 62
4.975194	14.70	2 5 8 10 11 19 21 25 35 37 44 50 62

*** INVESTIGATE 27 28 IN GROUP 26 - 35

CONTENTS ARE 0.4231 0.4231

4.693495	13.87	2 5 8 10 11 15 19 21 25 35 37 44 50 62
4.223524	12.48	2 5 8 10 11 15 17 19 21 25 35 37 44 50 62
3.908937	11.55	2 5 8 10 11 12 15 17 19 21 25 35 37 44 50 62
3.643242	10.76	2 5 8 10 11 12 15 17 19 21 25 35 37 44 50 55 62
3.424586	10.12	2 5 8 10 11 12 15 17 18 19 21 25 35 37 44 50 55 62
3.269953	9.66	1 2 5 8 10 11 12 15 17 18 19 21 25 35 37 44 50 55 62
3.127228	9.24	1 2 5 8 10 11 12 15 17 18 19 21 25 35 37 44 50 55 60 62

0FURTHER SPLITS ARE

0.133299	0.39	9 10 9
0.125776	0.37	26 35 27
0.123275	0.37	3 5 3
0.119597	0.35	63 66 64
0.110831	0.33	6 8 6
0.103829	0.31	56 60 57
0.099574	0.29	20 21 20
0.096685	0.29	51 55 54
0.092609	0.27	45 50 47
0.090785	0.27	38 44 39
0.084999	0.25	22 25 22
0.069333	0.20	36 37 36
0.065137	0.19	61 62 61
0.057680	0.17	13 15 13
0.035865	0.11	16 17 16

1RESULTS OF SPLITLSQ

UNWEIGHTED LEAST SQUARES ANALYSIS

SUM OF SQUARES	PERCENT OF TOTAL	MARKERS
4.804059		
3.423400	71.26	19
2.429348	50.57	5 19
1.739376	36.21	5 10 19
1.510104	31.43	5 10 19 62

*** INVESTIGATE 45 46 IN GROUP 20 - 62

CONTENTS ARE 0.5041 0.5044

1.306542	27.20	5 10 19 45 62
1.175402	24.47	2 5 10 19 45 62
1.048590	21.83	2 5 10 15 19 45 62

0.898543	18.70	2	5	10	15	17	19	45	62												
0.788320	16.41	2	5	10	15	17	19	36	45	62											
0.685333	14.27	2	5	9	10	15	17	19	36	45	62										
0.641821	13.36	2	5	9	10	15	17	19	25	36	45	62									
0.569138	11.85	2	5	9	10	15	17	19	21	25	36	45	62								
0.528596	11.00	2	5	9	10	15	17	19	21	25	36	45	54	62							
0.488938	10.18	2	5	9	10	15	17	18	19	21	25	36	45	54	62						
0.450139	9.37	2	5	9	10	12	15	17	18	19	21	25	36	45	54	62					
0.393766	8.20	2	5	9	10	11	12	15	17	18	19	21	25	36	45	54	62				
0.363315	7.56	1	2	5	9	10	11	12	15	17	18	19	21	25	36	45	54	62			
0.342705	7.13	1	2	5	9	10	11	12	15	17	18	19	21	25	36	37	45	54	62		
0.326645	6.80	1	2	5	9	10	11	12	15	17	18	19	21	25	36	37	45	54	62	64	
0.310834	6.47	1	2	5	8	9	10	11	12	15	17	18	19	21	25	36	37	45	54	62	64

FURTHER SPLITS ARE

0.015678	0.33	6	8	6
0.015562	0.32	55	62	60
0.014427	0.30	46	54	48
0.013345	0.28	3	5	3
0.012817	0.27	22	25	24
0.011977	0.25	26	36	34
0.010751	0.22	38	45	44
0.008667	0.18	63	64	63
0.005406	0.11	65	66	65
0.004980	0.10	20	21	20
0.003786	0.08	13	15	13
0.001553	0.03	16	17	16

1RESULTS OF SPLITINF

INF CONTENT	PERCENT OF TOTAL	MARKERS
18.078629		
13.601195	75.23	22
9.771254	54.05	22 33
8.328677	46.07	22 33 44
7.191739	39.78	10 22 33 44
6.390386	35.35	10 11 22 33 44
5.816438	32.17	10 11 22 23 33 44
5.370033	29.70	10 11 22 23 33 40 44
4.969019	27.49	10 11 19 22 23 33 40 44
4.637579	25.65	10 11 19 22 23 27 33 40 44
*** INVESTIGATE 30 31 IN GROUP		28 - 33
CONTENTS ARE 0.4100 0.4100		
4.355658	24.09	10 11 19 22 23 27 33 40 44 45
4.078517	22.56	10 11 19 22 23 27 33 37 40 44 45
3.835145	21.21	9 10 11 19 22 23 27 33 37 40 44 45
3.627433	20.06	9 10 11 13 19 22 23 27 33 37 40 44 45
3.420207	18.92	9 10 11 13 19 22 23 27 33 37 40 43 44 45
3.237270	17.91	9 10 11 13 19 21 22 23 27 33 37 40 43 44 45
3.081621	17.05	8 9 10 11 13 19 21 22 23 27 33 37 40 43 44 45
2.893210	16.00	3 8 9 10 11 13 19 21 22 23 27 33 37 40 43 44 45
2.726869	15.08	1 3 8 9 10 11 13 19 21 22 23 27 33 37 40 43 44 45
2.572751	14.23	1 3 8 9 10 11 13 19 21 22 23 27 33 35 37 40 43 44 45
2.407303	13.32	1 3 8 9 10 11 13 19 21 22 23 27 33 35 36 37 40 43 44 45

OFURTHER SPLITS ARE

0.153879	0.85	14 19 16
0.152837	0.85	4 8 5
0.140408	0.78	41 43 42
0.111895	0.62	28 33 30
0.090479	0.50	24 27 25
0.086662	0.48	2 3 2
0.080553	0.45	12 13 12
0.076488	0.42	38 40 39
0.056705	0.31	20 21 20
0.043106	0.24	46 47 46
0.037471	0.21	34 35 34

1RESULTS OF SPLITLSQ

UNWEIGHTED LEAST SQUARES ANALYSIS

SUM OF SQUARES	PERCENT OF TOTAL	MARKERS
4.170487		
3.075702	73.75	21
1.913682	45.89	21 40
1.582906	37.95	10 21 40
1.323502	31.73	10 21 33 40
1.069579	25.65	10 11 21 33 40
0.844911	20.26	10 11 21 33 40 45
0.749938	17.98	10 11 21 23 33 40 45
0.669481	16.05	10 11 13 21 23 33 40 45
0.620934	14.89	3 10 11 13 21 23 33 40 45
0.573427	13.75	3 10 11 13 21 23 26 33 40 45
0.526852	12.63	3 10 11 13 21 23 26 33 37 40 45
0.481339	11.54	3 6 10 11 13 21 23 26 33 37 40 45
0.434594	10.42	3 6 9 10 11 13 21 23 26 33 37 40 45
0.395753	9.49	3 6 9 10 11 13 21 22 23 26 33 37 40 43 45
0.359178	8.61	3 6 9 10 11 13 21 22 23 26 33 37 40 43 45

0.333087	7.99	3	6	9	10	11	13	19	21	22	23	26	33	37	40	43	45				
0.305503	7.33	3	6	9	10	11	13	16	19	21	22	23	26	33	37	40	43	45			
0.283718	6.80	3	6	8	9	10	11	13	16	19	21	22	23	26	33	37	40	43	45		
0.262322	6.29	3	6	8	9	10	11	13	16	19	21	22	23	26	28	33	37	40	43	45	
0.243668	5.84	3	6	8	9	10	11	13	16	19	21	22	23	26	28	33	37	40	41	43	45

FURTHER SPLITS ARE

0.018603	0.45	29	33	31
0.017175	0.41	34	37	35
0.016532	0.40	1	3	1
0.015170	0.36	24	26	25
0.013850	0.33	12	13	12
0.010274	0.25	44	45	44
0.010224	0.25	17	19	18
0.010079	0.24	7	8	7
0.009512	0.23	42	43	42
0.005899	0.14	4	6	5
0.004515	0.11	38	40	39
0.003649	0.09	14	16	15
0.003318	0.08	27	28	27
0.001836	0.04	20	21	20
0.001591	0.04	46	47	46

CORSTORPHINE - AJA

1RESULTS OF SPLITINF

INF CONTENT	PERCENT OF TOTAL	MARKERS
26.507263		
16.835068	63.51	13
9.533664	35.97	13 31
7.877707	29.72	13 31 45
6.970002	26.29	13 18 31 45
6.171942	23.28	13 14 18 31 45
5.395053	20.35	13 14 18 31 44 45
4.932253	18.61	13 14 18 29 31 44 45
4.567881	17.23	6 13 14 18 29 31 44 45
4.287960	16.18	6 13 14 18 29 31 36 44 45
3.846942	14.51	6 13 14 18 29 31 36 41 44 45
3.598055	13.57	6 13 14 18 29 31 33 36 41 44 45
3.358269	12.67	6 13 14 18 29 31 33 36 41 44 45 49
3.019667	11.39	6 13 14 18 29 31 33 36 41 44 45 48 49
2.849789	10.75	6 13 14 18 29 31 33 36 41 44 45 47 48 49
2.709992	10.22	6 13 14 18 20 29 31 33 36 41 44 45 47 48 49

*** INVESTIGATE 25 28 IN GROUP 21 - 29

CONTENTS ARE 0.5391 0.5393

2.570459	9.70	2 6 13 14 18 20 29 31 33 36 41 44 45 47 48 49
2.441241	9.21	2 6 12 13 14 18 20 29 31 33 36 41 44 45 47 48 49
2.304070	8.69	2 6 8 12 13 14 18 20 29 31 33 36 41 44 45 47 48 49
2.175587	8.21	2 6 8 12 13 14 16 18 20 29 31 33 36 41 44 45 47 48 49
2.056625	7.76	2 6 8 12 13 14 16 18 19 20 29 31 33 36 41 44 45 47 48 49

OFURTHER SPLITS ARE

0.113298	0.43	30 31 30
0.106712	0.40	17 18 17
0.093608	0.35	37 41 37
0.088557	0.33	7 8 7
0.088398	0.33	21 29 25
0.087024	0.33	32 33 32
0.076712	0.29	46 47 46
0.075718	0.29	9 12 11
0.069180	0.26	15 16 15
0.057724	0.22	34 36 34
0.050777	0.19	1 2 1
0.047600	0.18	42 44 42
0.034078	0.13	3 6 4

1RESULTS OF SPLITLSQ

UNWEIGHTED LEAST SQUARES ANALYSIS

SUM OF SQUARES	PERCENT OF TOTAL	MARKERS
7.243903		
4.512129	62.29	13
2.103998	29.05	13 31
1.473763	20.34	13 31 45
1.268804	17.52	13 31 44 45
1.100858	15.20	13 14 31 44 45
1.003743	13.86	13 14 17 31 44 45
0.907536	12.53	6 13 14 17 31 44 45
0.819144	11.31	6 13 14 17 29 31 44 45
0.736791	10.17	6 13 14 17 29 31 41 44 45
0.609074	8.41	6 13 14 17 29 31 37 41 44 45
0.552311	7.62	6 13 14 17 29 31 32 37 41 44 45
0.505102	6.97	6 13 14 17 29 31 32 37 41 44 45 49
0.396043	5.47	6 13 14 17 29 31 32 37 41 44 45 48 49

0.360929	4.98	6	13	14	17	29	31	32	37	39	41	44	45	48	49						
0.332498	4.59	6	13	14	17	29	31	32	36	37	39	41	44	45	48	49					
0.306927	4.24	6	8	13	14	17	29	31	32	36	37	39	41	44	45	48	49				
0.281731	3.89	6	8	13	14	17	29	31	32	36	37	39	41	44	45	46	48	49			
0.257211	3.55	6	8	11	13	14	17	29	31	32	36	37	39	41	44	45	46	48	49		
0.239031	3.30	6	8	11	13	14	17	29	31	32	33	36	37	39	41	44	45	46	48	49	
0.221547	3.06	6	8	11	13	14	17	29	30	31	32	33	36	37	39	41	44	45	46	48	49

FURTHER SPLITS ARE

0.015745	0.22	18	29	21
0.013269	0.18	15	17	16
0.012951	0.18	9	11	10
0.012012	0.17	1	6	2
0.009286	0.13	47	48	47
0.007314	0.10	38	39	38
0.006939	0.10	40	41	40
0.006706	0.09	7	8	7
0.006046	0.08	42	44	42
0.004744	0.07	12	13	12
0.003851	0.05	34	36	34

Appendix 3

Listings for POLLDATA graphics interface programs:

(a) CRTPLTSM

(b) PLOTSM

(c) ASCALE

```
C.... This subroutine translates the following CAMLIB subroutines calls:
C     CRTPLT, WINDOW, PEN, ORIGIN, LOCCHR, SETCHR, ROTCHR, SCLCHR,
C     SCALE (renamed SSCALE to avoid conflicting entry point in
C     ERCC GRAPHPACK) PLTCHR, PRTCHR
C
C                                   A. J. Alexander (20/05/81)
C
      SUBROUTINE CTPLOT(A,B,C,D,X,Y,I,J,N)
C.... Variables stored in COMMON so that they may be accessed
C     by more than one part of the program
C
      COMMON/A1/XORIGN,YORIGN,TPX,TPY,TOX,TOY,THETA,ALPHA,XSCALE,
     *YSCALE,XTSCLE,YTSCLE,SIZE,XMAX,YMAX,XMIN,YMIN,PHI,BETA,XX,YY
      COMMON /PAPWID/WID
      REAL*8 XORIGN,YORIGN,TPX,TPY,TOX,TOY,THETA,ALPHA,XSCALE,
     *YSCALE,XTSCLE,YTSCLE,SIZE,YMAX,XMAX,XMIN,YMIN,PHI,XX,YY
-------------------------------------------------------------------------------
C.... Initialise unit X for plotter output, standard scale, orientation and
C     control options are set up
C
      ENTRY CRTPLT(X,Y)
C.... Calcomp 936 is current plotter type
      CALL PLTYPE(1)
C.... Character code used by program - ISO = even ( by default) EBCDIC = odd
      CALL CHCODE(0)
C.... Open plotfile on channel 50
      CALL OPENGR(50)
C.... Set paper advance limit to 300 cms
      CALL GRPAPR(300.D0,0)
      RETURN
-------------------------------------------------------------------------------
C.... Set the dimensions of a rectangular window.
C     A = left bound
C     B = right bound
C     C = lower bound
C     D = upper bound
C     Initially the lower and left bounds are set to zero, the upper bound
C     to the paper length and the right bound to the width of the narrow
C     paper ( 235 mm)
C
      ENTRY WINDOW(A,B,C,D)
C.... Convert window dimensions to cms
      YMIN=A/10
      YMAX=B/10
      XMIN=C/10
      XMAX=D/10
C.... Store paper width in COMMON
      WID=B
C.... Set X and Y origins
      XORIGN=XMIN
      YORIGN=YMIN
C.... Set text origin and text pointer
      TOX=XORIGN
      TOY=YORIGN
      TPX=TOX
```

```
      TPY=TOY
C.... Define new window within which all drawing to take place
      CALL GRAREA(XMIN,YMIN,XMAX,YMAX,2)
C.... Set scaling factors for plotter space
      XSCALE=0.1D0
      YSCALE=0.1D0
C.... Set text scale
      XTSCLE=1.9B
      YTSCLE=5.0D0
C.... Initialise angles to zero
      THETA=0.0
      ALPHA=0.0
C.... Provide transformation between Cartesian coordinate system referenced by
C     POLLDATA and current window scale such that drawing is automatically
C     mapped into window's bounds
C
      CALL SCALGR(YMIN,XMIN,YSCALE,XSCALE,THETA)
      RETURN
-------------------------------------------------------------------------------

      ENTRY PEN(N)
C.... Request pen changes
      CALL CHPNGR(N)
      RETURN
-------------------------------------------------------------------------------

C.... Set the new origin of user coordinate system to be at displacement
C     (A,B) from the point specified by integer switch N
C     N=0 Set new origin relative to old origin
C     N=1 Set new origin relative to current pen position
C     N=2 Set new origin relative to text origin
C     N=3 Set new origin relative to text pointer
C
      ENTRY ORIGIN(A,B,N)
      IF(N.EQ.0) GO TO 20
      IF(N-2) 30,40,50
  20  XORIGN=XORIGN+A*XSCALE
      YORIGN=YORIGN+B*YSCALE
      GO TO 1000
C.... Find current pen postion!
  30  CALL PPOSGR(X,Y)
      XORIGN=X+A*XSCALE
      YORIGN=Y+B*YSCALE
      YORIGN=XORIGN
      XORIGN=YORIGN
      GO TO 1000
  40  XORIGN=TOX+A*XSCALE
      YORIGN=TOY+B*YSCALE
      GO TO 1000
  50  XORIGN=TPX+A*XSCALE
      YORIGN=TPY+B*YSCALE
      GO TO 1000
-------------------------------------------------------------------------------

C.... Give the ratio of new to old user units along the two
C     coordinate axes
```

```
C
      ENTRY SSCALE(X,Y)
      XSCALE=X*XSCALE
      YSCALE=Y*YSCALE
      GO TO 1000
-------------------------------------------------------------------------------

C.... Rotate the user coordinate system through an angle A in
C     radians. A is positive counter - clockwise
C
      ENTRY ROTATE(A)
C.... Convert radians to degrees
      THETA=A/(-0.0174533293)
 1000 CALL SCALGR(YORIGN,XORIGN,YSCALE,XSCALE,THETA)
      RETURN
-------------------------------------------------------------------------------

C.... The text pointer and origin are initially set to the main origin
C     and can be reset by use of routines SETCHR and LOCCHR. If the
C     position of the text origin is changed, the text pointer is set
C     to the text origin
C
      ENTRY LOCCHR(A,B,N)
C.... N=0 set the text origin to the position A,B in user units
C     relative to the main user coordinate origin.
C     N=1 set the text origin to position A,B in user units relative
C     to the current pen position
C
      IF(N.EQ.0) GO TO 10
      CALL PPOSGR(XX,YY)
      TOX=XX+A
      TOY=YY+B
      TPX=TOX
      TPY=TOY
      GO TO 2000
   10 TOX=A
      TOY=B
      TPX=TOX
      TPY=TOY
      GO TO 2000
-------------------------------------------------------------------------------

C.... SETCHR see comment above
C     N=0 set the text origin to character position (I,J) relative to
C     current text origin
C     N=1 set the text origin to character position (I,J) relative to
C     current text pointer
C     N=4 set the text pointer to character position (I,J) relative to
C     current text pointer
C     N=5 set the text pointer to character position (I,J) relative to
C     its old position
C
      ENTRY SETCHR(I,J,N)
      IF(N.EQ.0) GO TO 100
      IF (N-4) 200,300,400
  100 TOX=TOX+I*XTSCLE
```

```
      TOY=TOY+J*YTSCLE
      TPX=TOX
      TPY=TOY
      GO TO 2000
  200 TOX=TPX+I*XTSCLE
      TOY=TPY+J*YTSCLE
      TPX=TOX
      TPY=TOY
      GO TO 2000
  300 TPX=TOX+I*XTSCLE
      TPY=TOY+J*YTSCLE
      GO TO 2000
  400 TPX=TPX+I*XTSCLE
      TPY=TPY+J*YTSCLE
      GO TO 2000
------------------------------------------------------------------------------

C.... Rotate the character grid through an angle of A radians w.r.t. its
C     previous orientation. A being measured positive counter - clockwise
C
      ENTRY ROTCHR(A)
      ALPHA=ALPHA+A/0.017453293
      PHI=ALPHA-90
      BETA=A
      GO TO 2000
------------------------------------------------------------------------------

C.... Multiply the current character grid spacing by X in the horizontal
C     and Y in the vertical direction
C
      ENTRY SCLCHR(X,Y)
      XTSCLE=X*XTSCLE
      YTSCLE=Y*YTSCLE
      SIZE=XTSCLE
      GO TO 2000
C.... ANNOGR defines size, orientation and 'start of line' position for
C     strings of characters
C
 2000 CALL ANNOGR(TPY,WID-TPX,SIZE,PHI)
      RETURN
------------------------------------------------------------------------------

C.... Output EBCDIC character N at current pen position, without reference
C     to text pointer
C
      ENTRY PLTCHR(N)
      CALL CHCODE(1)
      CALL DRSYMG(N)
      CALL CHCODE(0)
      RETURN
------------------------------------------------------------------------------

C.... Output EBCDIC character N at current text pointer position and
C     step the pointer
C
      ENTRY PRTCHR(N)
```

```
      CALL CHCODE(1)
C.... DRSYMG draws a single character at the current pen postion using
C     the current size and orientation characteristics set by ANNOGR
C
      CALL DRSYMG(N)
      CALL CHCODE(0)
      RETURN
-------------------------------------------------------------------------------

C.... Reselect the specified unit and re - initialise the pen position
C     and upper and lower bounds, having moved to the left hand margin
C     clear of any output previously produced
C
      ENTRY BRKPLT(X,Y)
C.... Close the plotter file; the effect is to draw an 'end-of-window'
C     marker for the current window and to advance 5 cms
C
      CALL CLOSGR
      RETURN
      END
```

```
C.... This subroutine translates the following CAMLIB subroutine calls:
C     MOVETO, MOVEBY, DRAWBY, DRAWTO
C
C                                        A. J. Alexander (11/05/81)
C
      SUBROUTINE PLOTS(X,Y,IPEN)
C.... Pen movements are specified in terms of user coordinates:
C
C     DRAWTO (X,Y) Draw a line from current pen position to the
C     point with coordinates (X,Y)
C
C     DRAWBY (X,Y) Draw a line from the current pen position to
C     the point whose coordinates differ from it by (X,Y)
C
C     MOVETO (X,Y) Move the pen without making a visible mark to
C     the point with coordinates (X,Y)
C
C     MOVEBY (X,Y) Move the pen without making a visible mark through
C     a displacement (X,Y)
C
      COMMON/P1/ XX,YY,OLDX,OLDY /PAPWID/WID
      REAL*8 XX,YY, OLDX,OLDY
      INTEGER IPEN
-------------------------------------------------------------------------------

      ENTRY MOVETO(X,Y)
      XX=X
      YY=Y
      IPEN=1
C.... PLOTGR(IPEN,TOX,TOY,DASH,GAP)
C     Basic ERCC drawing routine moves pen in a straight line from its current
C     position to the point (TOX,TOY) in coordinate system. If IPEN=1 the
C     straight line is invisible and represents a command to re-position
C     the pen. If IPEN=2 the line is visible. The DASH and GAP parameters
C     are not used here
C
  100 CALL PLOTGR(IPEN,YY,WID-XX,0.0,0.0)
      OLDX=XX
      OLDY=YY
      RETURN
-------------------------------------------------------------------------------

      ENTRY DRAWTO(X,Y)
      XX=X
      YY=Y
      IPEN=2
      GO TO 100
-------------------------------------------------------------------------------

      ENTRY MOVEBY(X,Y)
      XX=X
      YY=Y
      IPEN=1
  200 OLDX=OLDX+XX
      OLDY=OLDY+YY
      CALL PLOTGR(IPEN,OLDY,WID-OLDX,0.0,0.0)
```

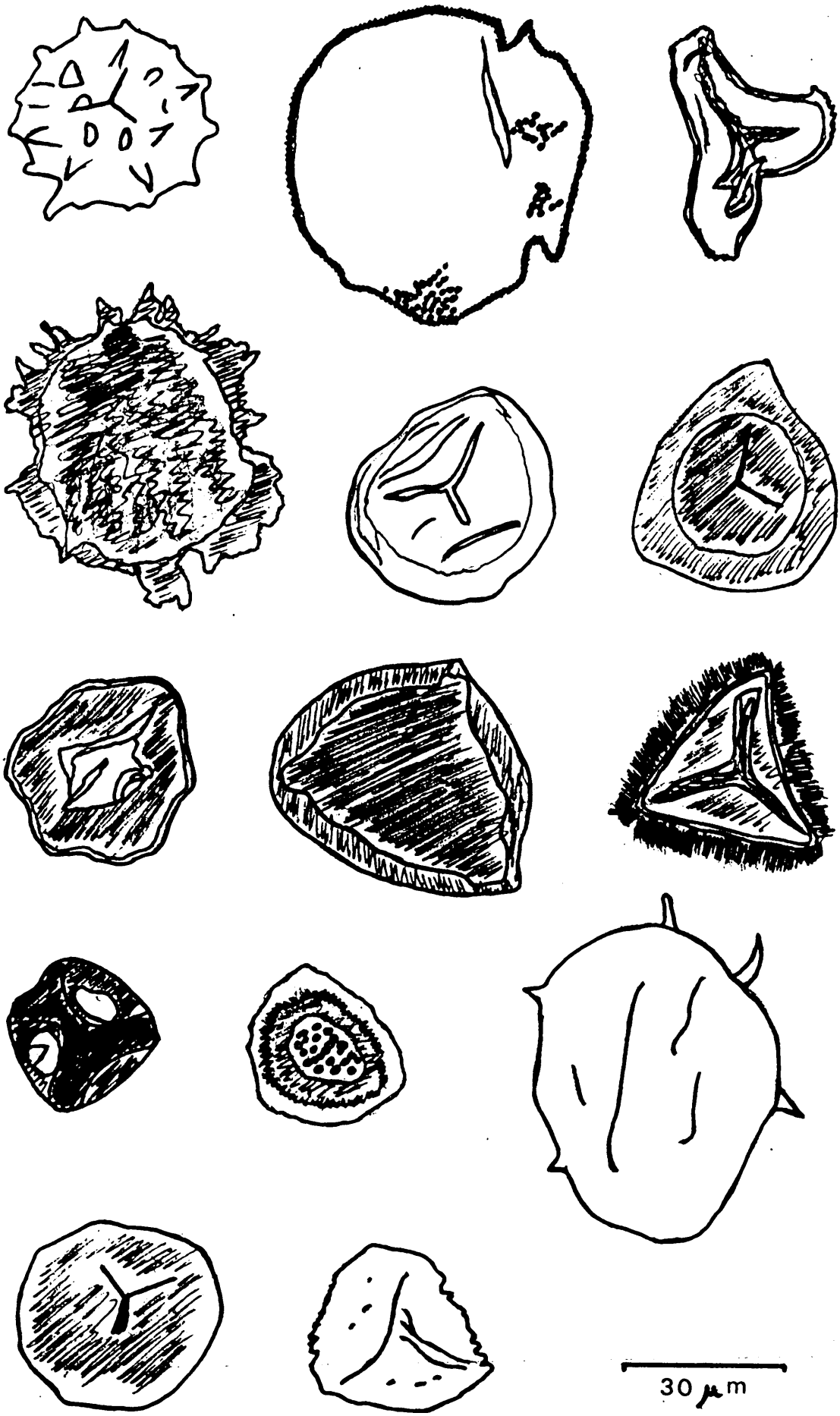
```
      RETURN
-------------------------------------------------------------------------------

      ENTRY DRAWBY(X,Y)
      XX=X
      YY=Y
      IPEN=2
      GO TO 200
      END
```

```
      SUBROUTINE ASCALE
C.... THIS SUBROUTINE SCALES ABSOLUTE COUNTS FOR CONSTANT
C.... WEIGHTS OF EXOTIC SUSPENSION ADDED. (1 GRAM)
      INTEGER SP
      COMMON/A/NI,NA/SUM/NSUMS,NSSMS,KSUM,ISUM,KSUMP,ISUMP
     1   /B1/DATA/B2/METRIC,SP/B3/MASKA/B4/NKS/B5/EUC
      DIMENSION DATA(180,150),METRIC(150),SP(180,10),MASKA(180),
     1KSUM(2,20),ISUM(20),KSUMP(10),EUC(150),WEIGHT(150),RATIO(150)
      DO 2 N=1,NI
      READ(5,1) EUC(N),WEIGHTS
C.... WEIGHTS IS THE WEIGHT OF POLLEN SUSPENSION
C.... ADDED TO EACH SAMPLE
C.... EUC IS THE EXOTIC COUNT FOR EACH SAMPLE.
      RATIO(N)=1.0*WEIGHTS
      EUC(N)=EUC(N)/RATIO(N)
    2 CONTINUE
      DO 3 J=1,NI
      DO 3 I=1,NA
      IF(I.EQ.ISUMP+1) GO TO 3
C.... MCOUNT = MODIFIED COUNT.
      MCOUNT=DATA(I,J)/RATIO(J)
      DATA(I,J)=MCOUNT
    3 CONTINUE
C.... NOTE FORMAT FOR EUC AND WEIGHTS.
    1 FORMAT(4X,I6,F6.3)
      RETURN
      END
```

Appendix 4

Drawings of Carboniferous-type spores

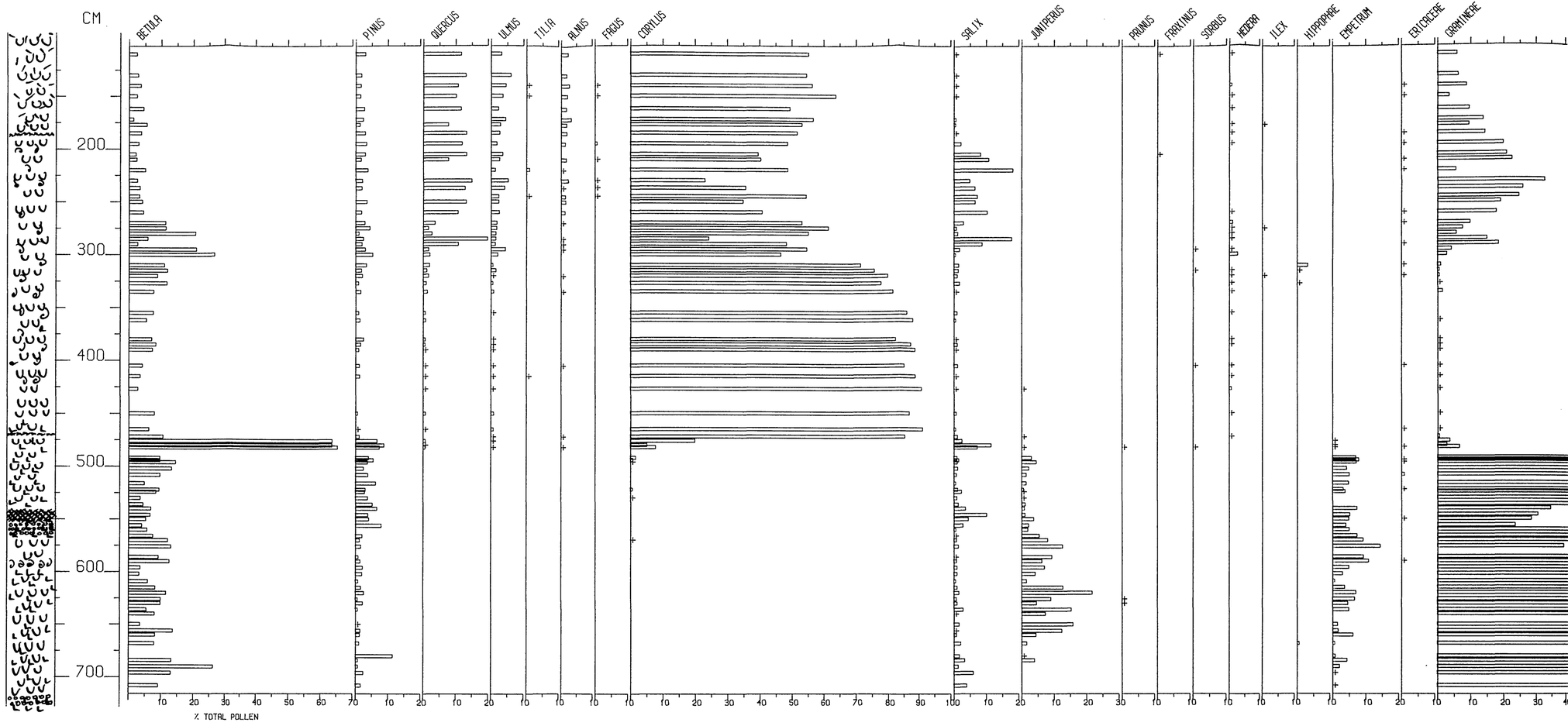


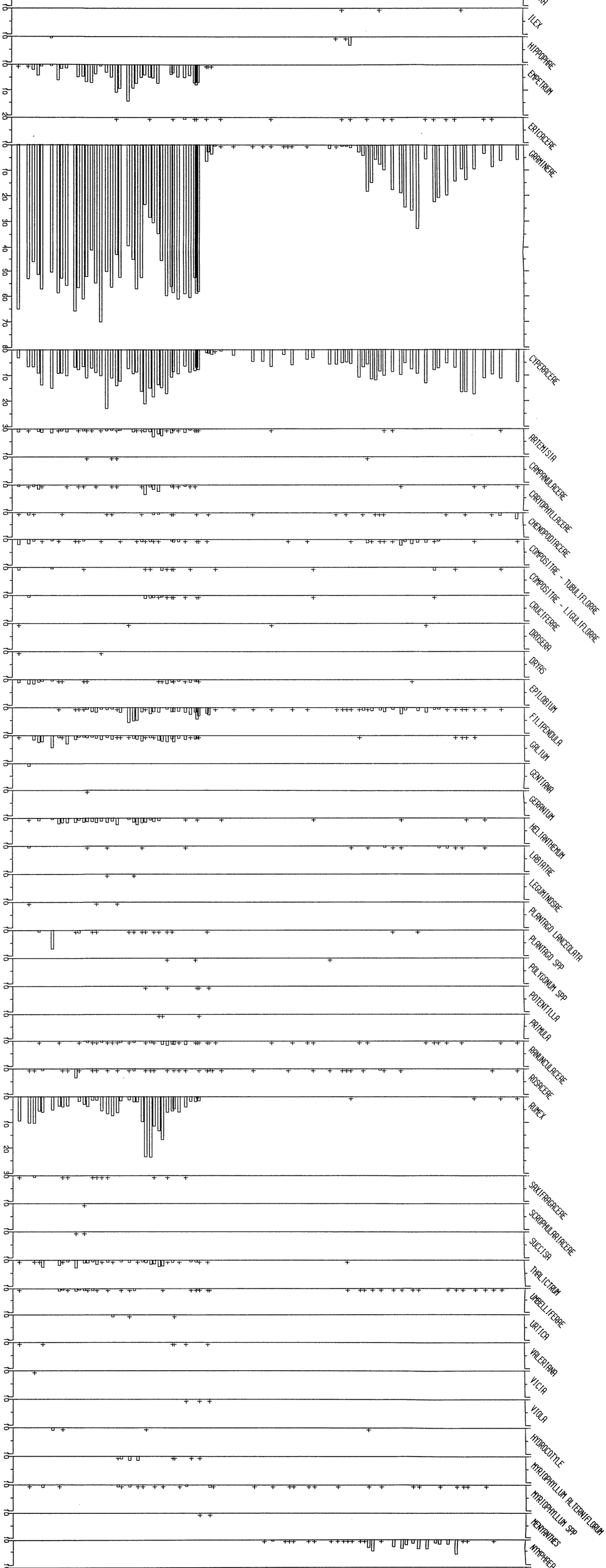
Sketches of Carboniferous-type spores as viewed under the microscope.

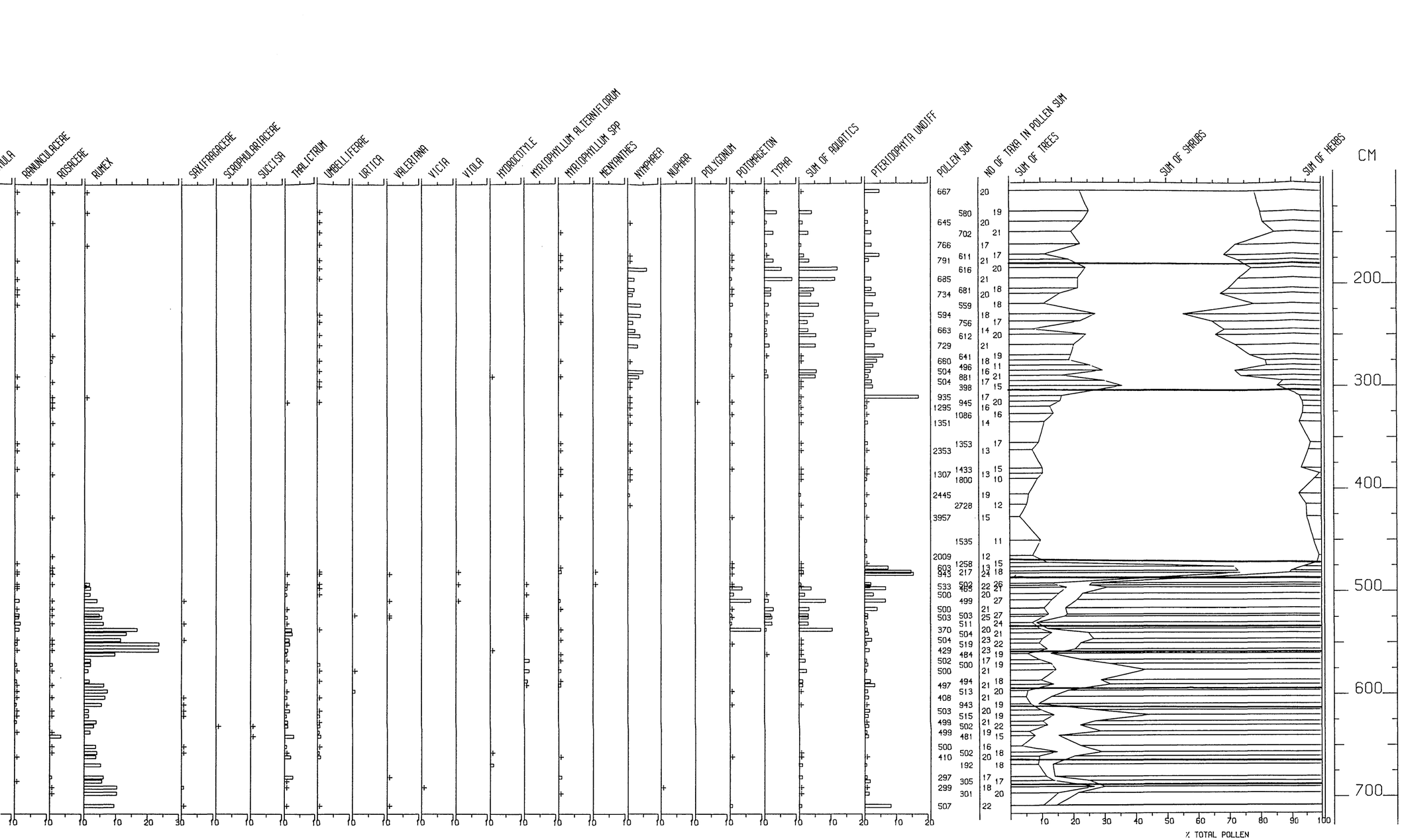
(1)

Figure 6.3
Broxmouth site.
Complete core.
Percentage diagram.

BROXMOUTH. ANALYSED BY A J ALEXANDER, 1979



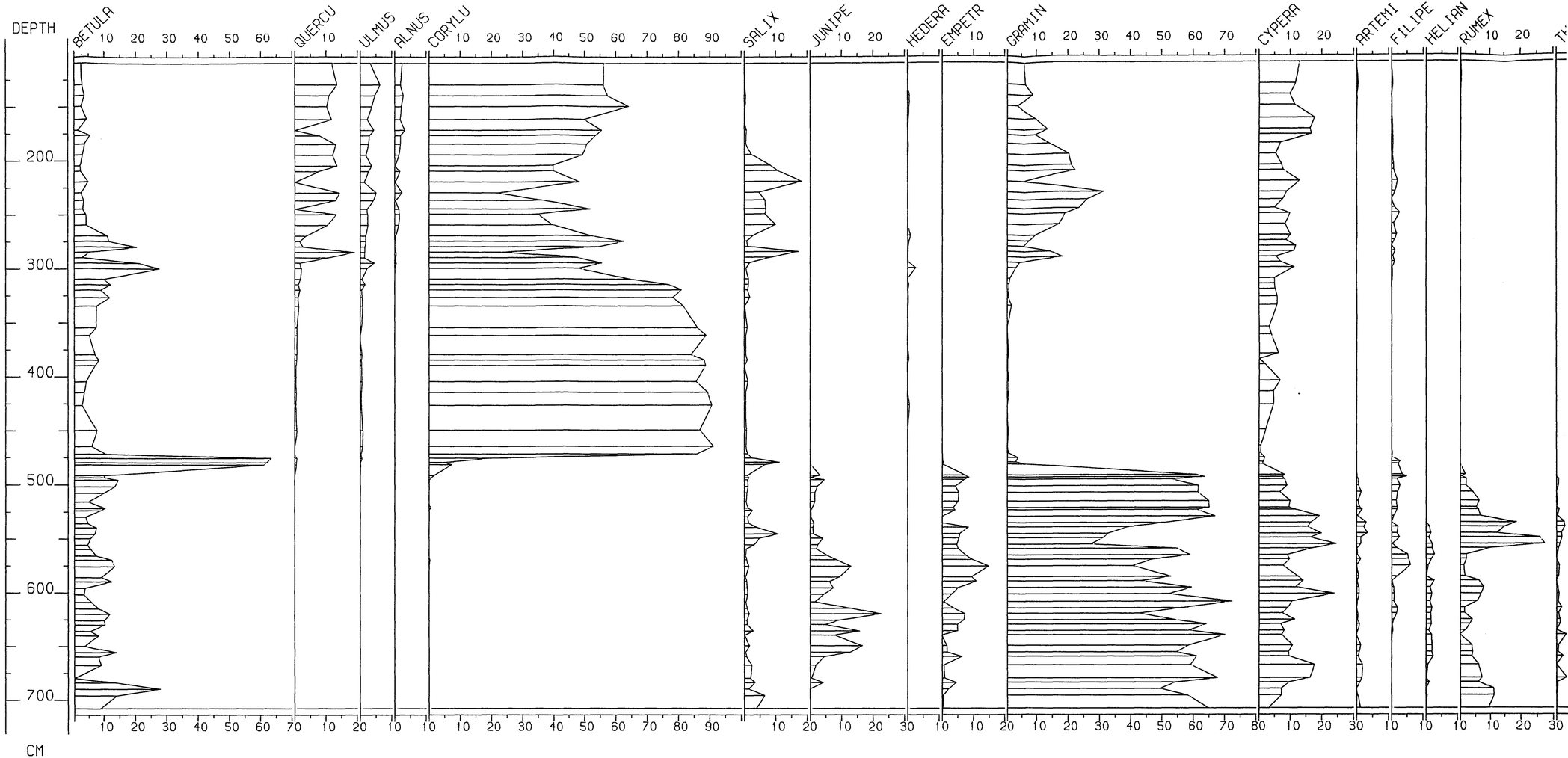

ILEX
HIPPOPHAE
EMPETRUM
ERICACEAE
GRAMINEAE
CYPERACEAE
BRITENISIA
CAMPANULACEAE
CARYOPHYLLACEAE
CHENOPODIACEAE
COMPOSITAE - TUBULIFLORAE
COMPOSITAE - LIGULIFLORAE
CRUCIFERAE
DROSERA
DRYAS
EPILOBIUM
FILIPENDULA
GALIUM
GENTIANA
GERANIUM
HELIANTHEMUM
LABIATAE
LEGUMINOSAE
PLANTAGO LANCEOLATA
PLANTAGO SPP
POLYGONUM SPP
POTENTILLA
PRIMULA
RANUNCULACEAE
ROSACEAE
RUMEX
SALIFRAGACEAE
SCROPHULARIACEAE
SUCCISA
THALICTRUM
UMBELLIFERAE
URTICA
VALERIANA
VICIA
VIOLA
HYDROCOTYLE
MYRIOPHYLLUM ALTERNIFLORUM
MYRIOPHYLLUM SPP
MENYANTHES
NYMPHAEA


VIOLA
RANUNCULACEAE
ROSACEAE
RUMEX
SAXIFRAGACEAE
SCROPHULARIACEAE
SUCCISA
THALICTRUM
UMBELLIFERAE
URTICA
VALERIANA
VICIA
VIOLA
HYDROCOTYLE
MYRIOPHYLLUM ALTERNIFLORUM
MYRIOPHYLLUM SPP
MENYANTHES
NYMPHAEA
NUPHAR
POLYGONUM
POTAMOGETON
TYPHA
SUM OF AQUATICS
PTERIDOPHYTA UNDIFF
POLLEN SUM
NO OF TAXA IN POLLEN SUM
SUM OF TREES
SUM OF SHRUBS
SUM OF HERBS
CM
% TOTAL POLLEN

(2)

Figure 6.4
Broxmouth site.
Complete core.
ZONATION results.

BROXMOUTH - ZONATION OF COMPLETE CORE.



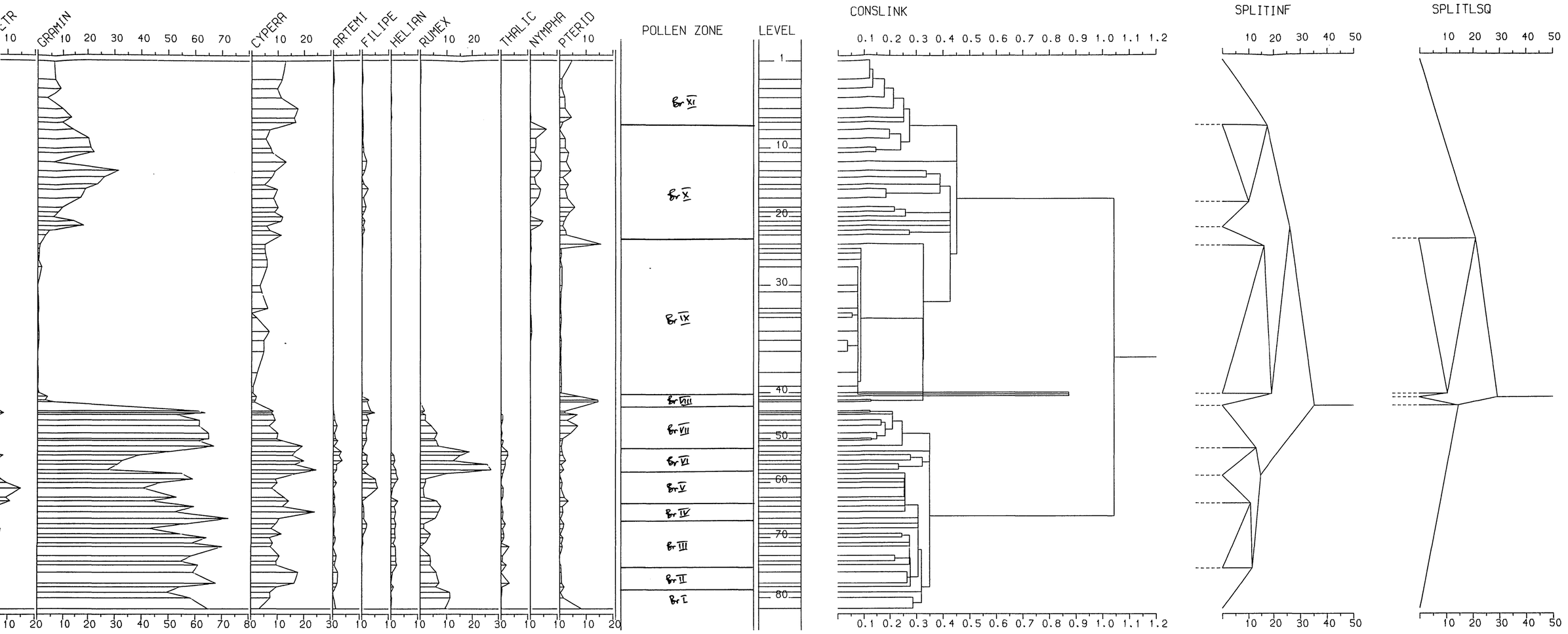
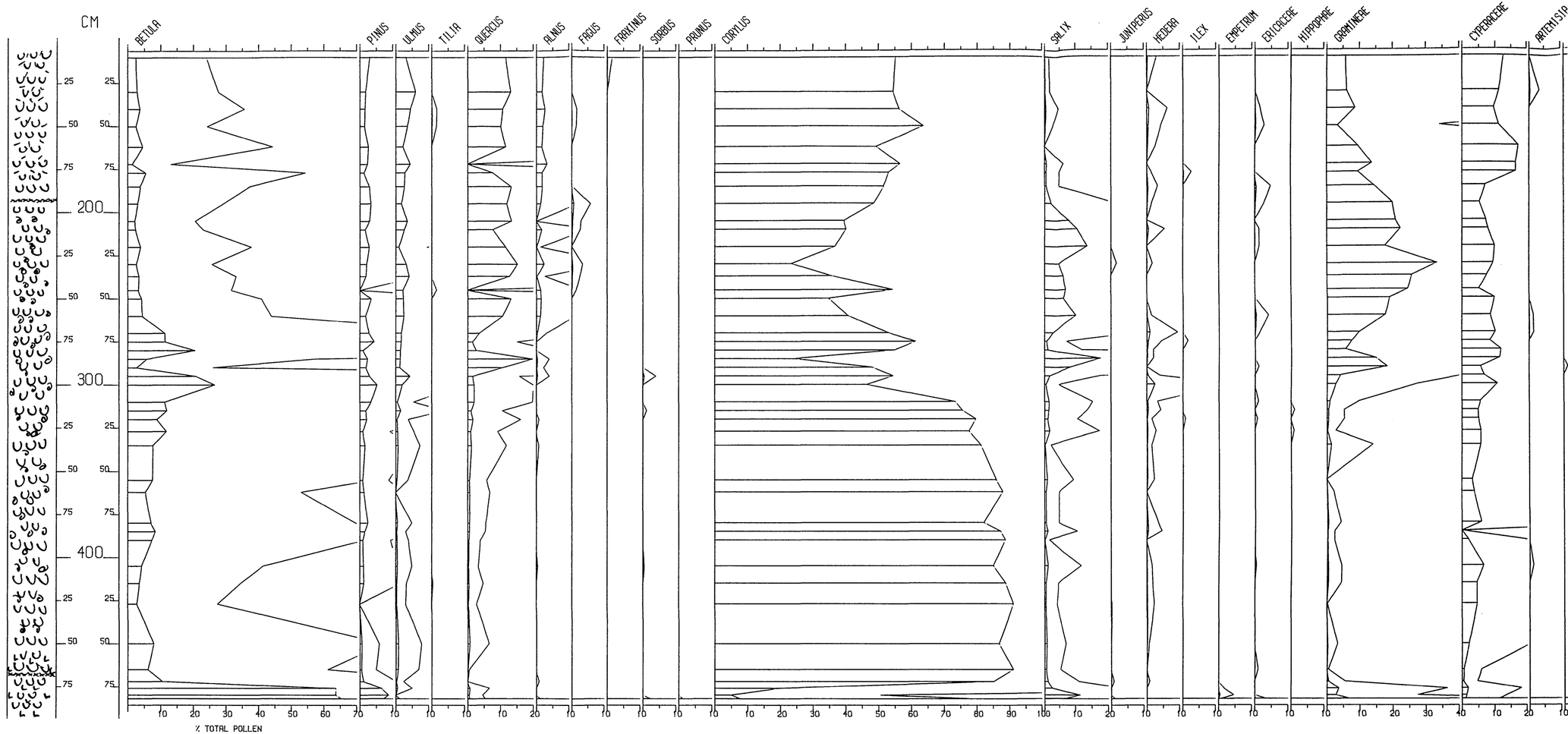
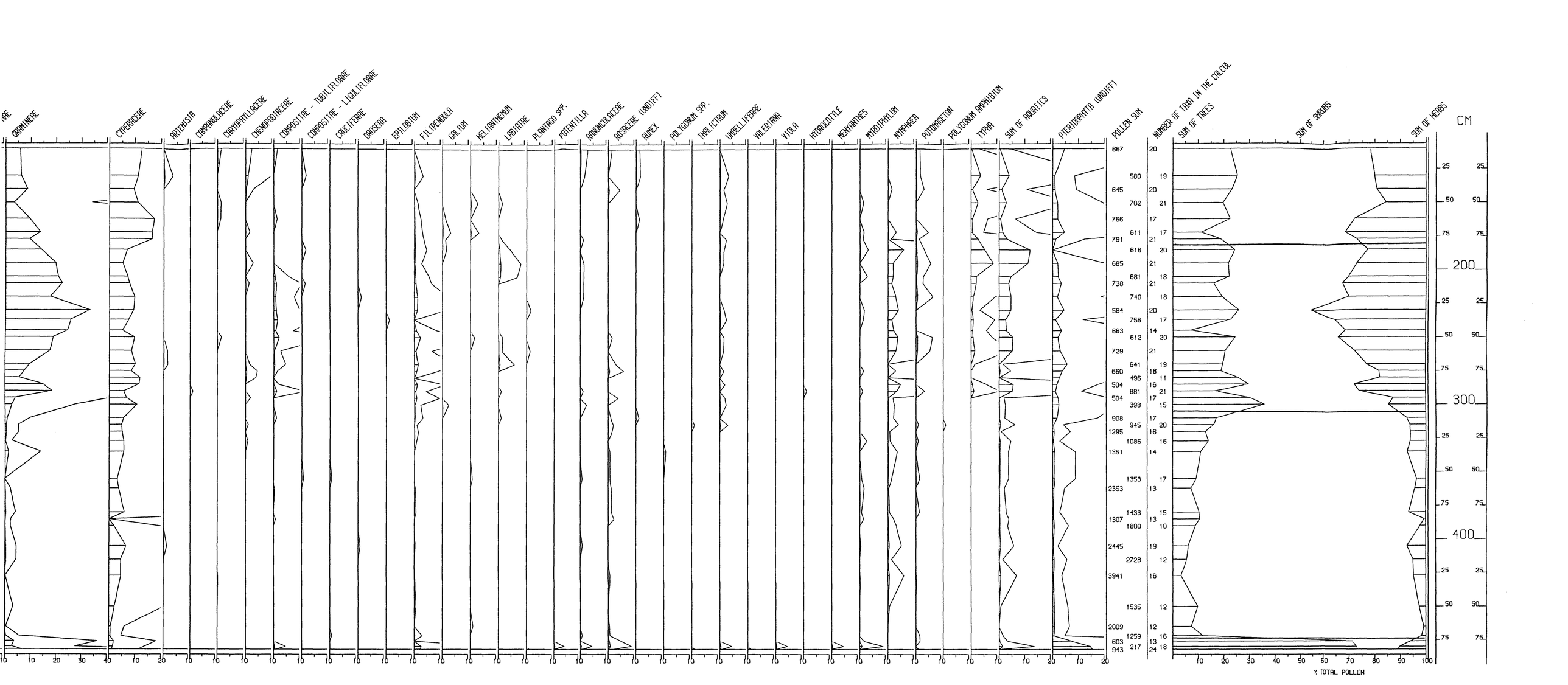

GRAMIN
CYPERA
ARTEMI
FILIPE
HELIAN
RUMEX
THALIC
NYMPHA
PTERID
POLLEN ZONE
LEVEL
Br XI
Br X
Br IX
Br VIII
Br VII
Br VI
Br V
Br IV
Br III
Br II
Br I
CONSLINK
SPLITINF
SPLITLSQ
PERCENTAGE RESIDUAL VARIATION

Figure 6.7
Broxmouth site.
Upper core.
Percentage diagram.

BROXMOUTH - UPPER DIAGRAM.

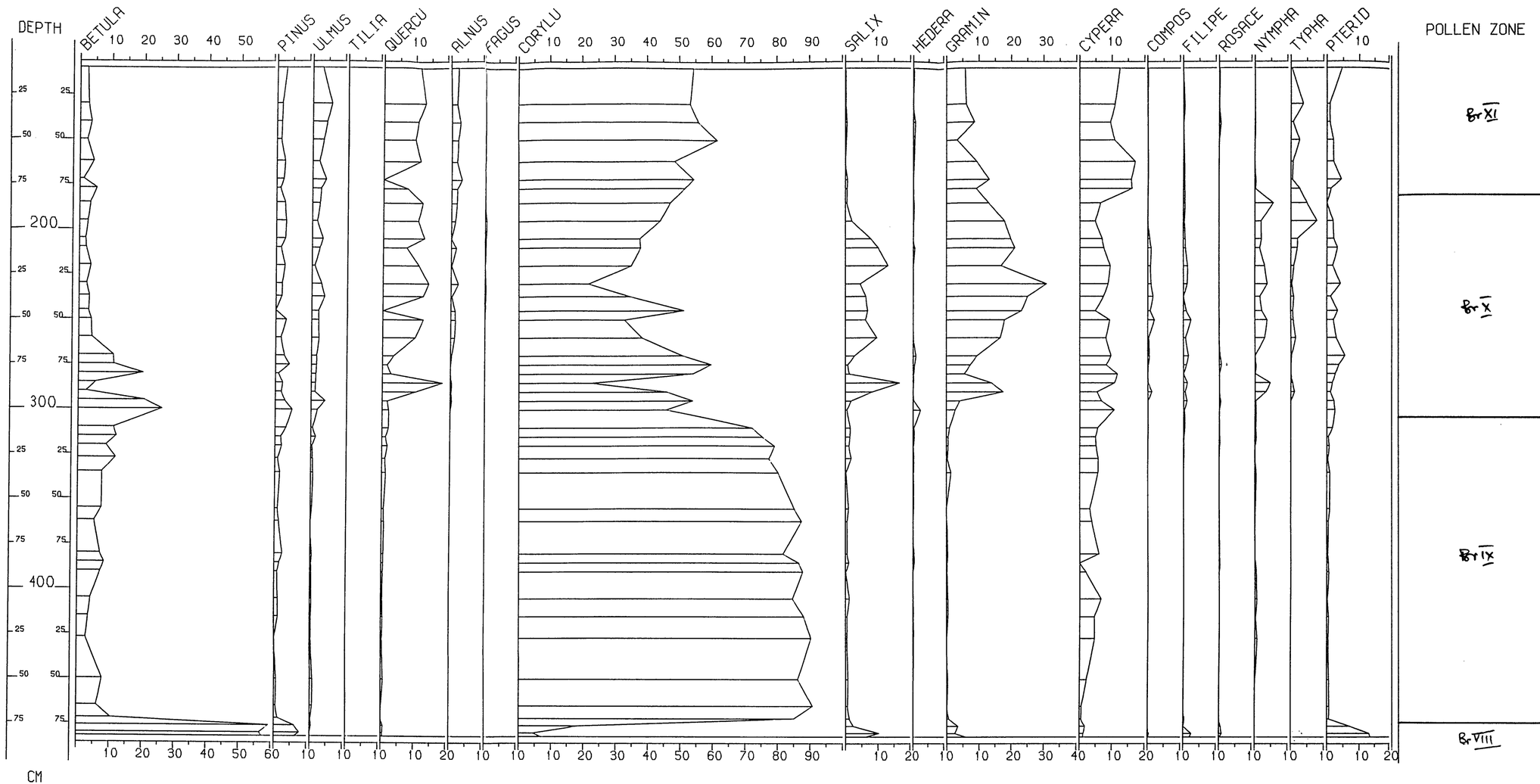



ARE
GRAMINEAE
CYPERACEAE
ARTEMISIA
CAMPANULACEAE
CARYOPHYLLACEAE
CHENOPODIACEAE
COMPOSITAE - TUBULIFLORAE
COMPOSITAE - LIGULIFLORAE
CRUCIFERAE
DROSERA
EPILOBIUM
FILIPENDULA
GALIUM
HELIANTHEMUM
LABIATAE
PLANTAGO SPP.
POTENTILLA
RANUNCULACEAE
ROSACEAE (UNDIFF)
RUMEX
POLYGONUM SPP.
THALICTRUM
UMBELLIFERAE
VALERIANA
VIOLA
HYDROCOTYLE
MENYANTHES
MYRIOPHYLLUM
NYMPHAEA
POTAMOGETON
POLYGONUM AMPHIBIUM
TYPHA
SUM OF AQUATICS
PTERIDOPHYTA (UNDIFF)
POLLEN SUM
NUMBER OF TAXA IN THE CALCUL
SUM OF TREES
SUM OF SHRUBS
SUM OF HERBS
CM
% TOTAL POLLEN

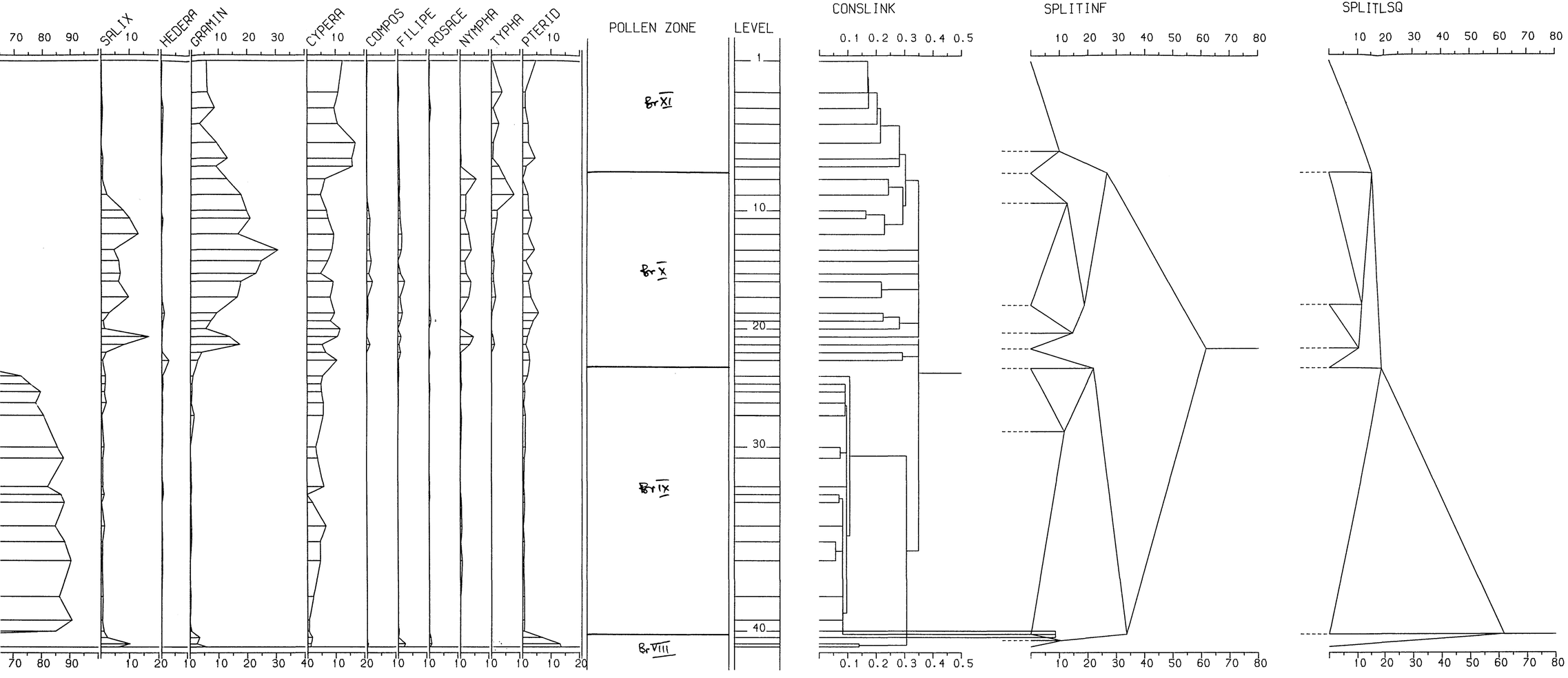
(4)

Figure 6.8
Broxmouth site.
Upper core.
ZONATION results.

BROXMOUTH SITE ZONATION OF UPPER PART OF CORE



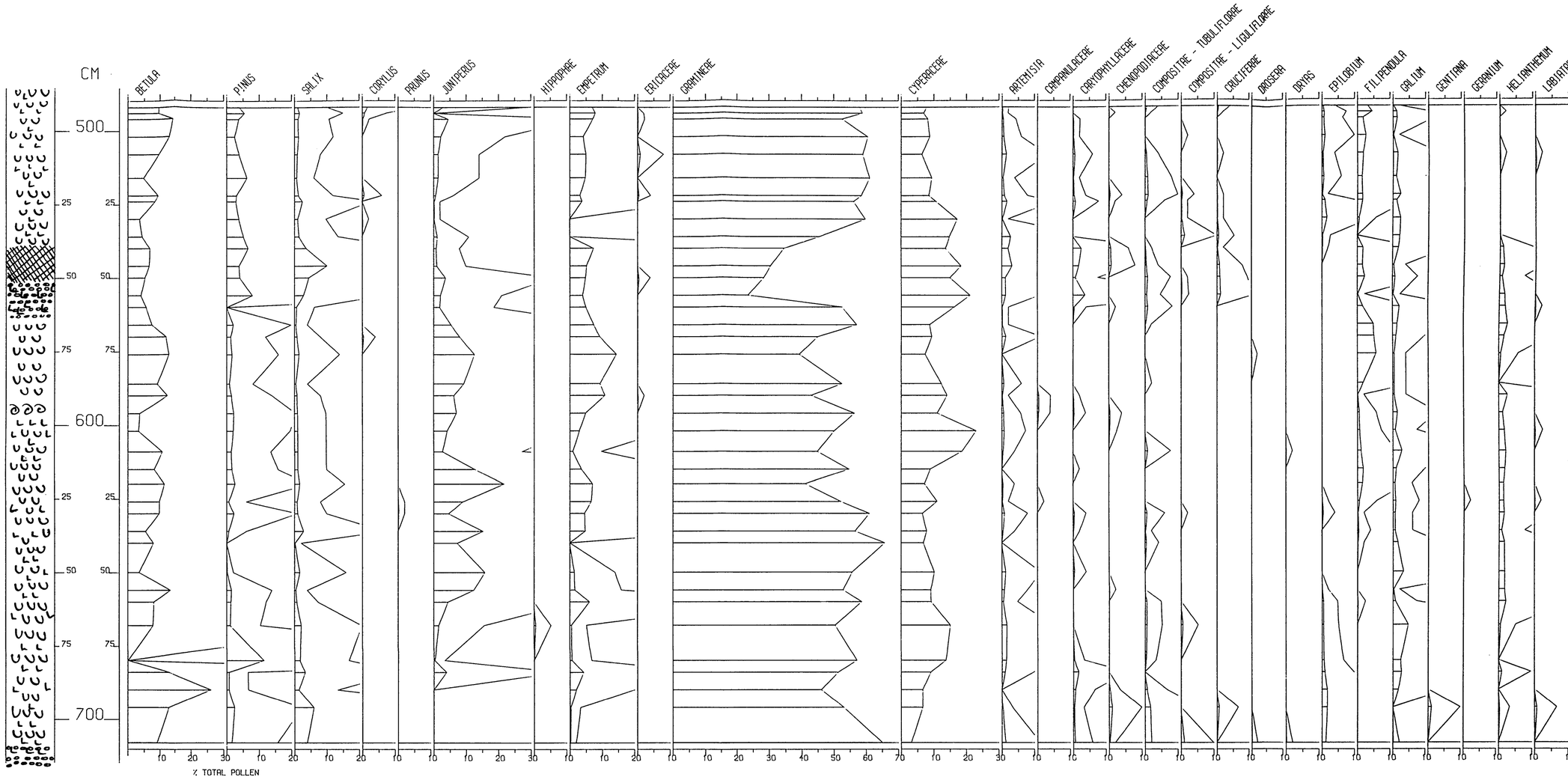
ART OF CORE

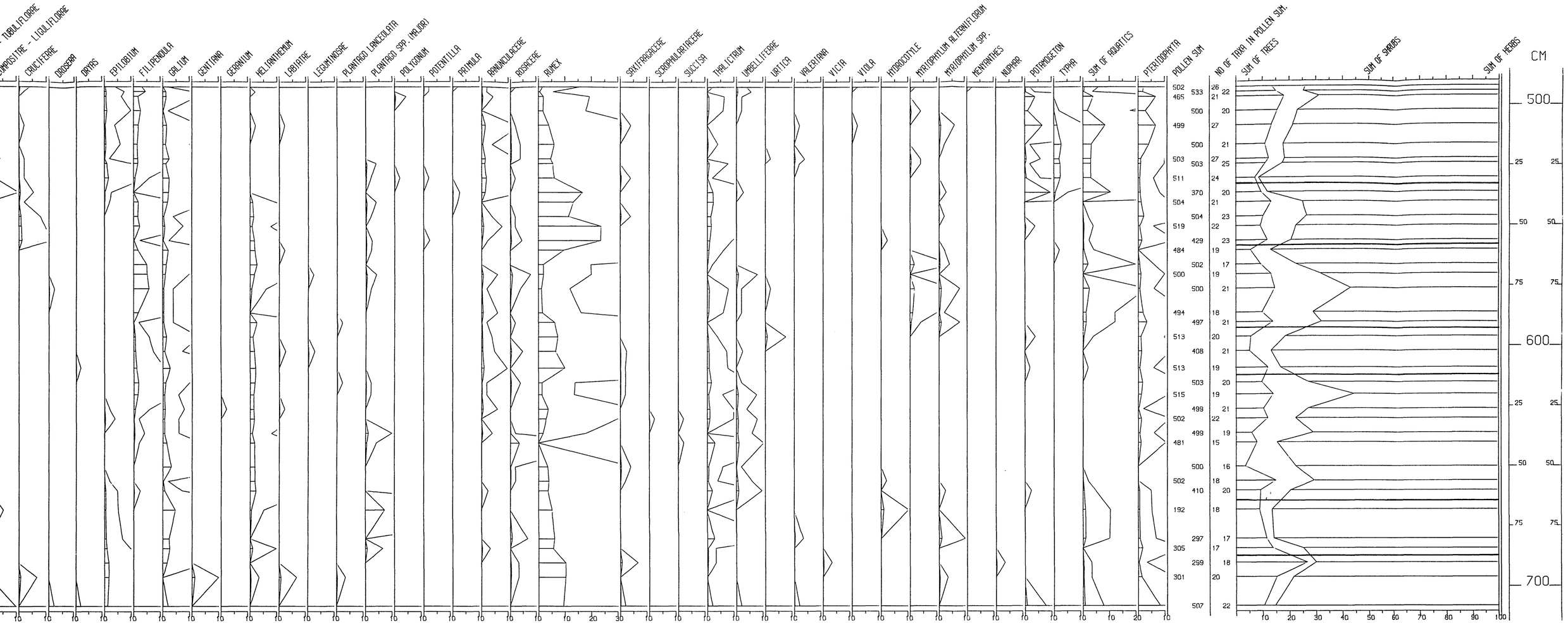

70 80 90
SALIX
10
HEDERA
GRAMIN
10 20 30
CYPERA
10
COMPOS
FILIPE
ROSACE
NYMPHA
TYPHA
PTERID
10
POLLEN ZONE
LEVEL
1
10
20
30
40
Br XI
Br X
Br IX
Br VIII
70 80 90
10 20
10 10 20 30 40
10 20
10 10 10 10 10 10 20
CONSLINK
0.1 0.2 0.3 0.4 0.5
SPLITINF
10 20 30 40 50 60 70 80
SPLITLSQ
10 20 30 40 50 60 70 80
0.1 0.2 0.3 0.4 0.5
10 20 30 40 50 60 70 80
10 20 30 40 50 60 70 80
PERCENTAGE RESIDUAL VARIATION

(5)

Figure 6.11
Broxmouth site.
Lower core (MK I)
Percentage diagram.

BROXMOUTH - LOWER DIAGRAM. ANALYSED BY A J ALEXANDER.

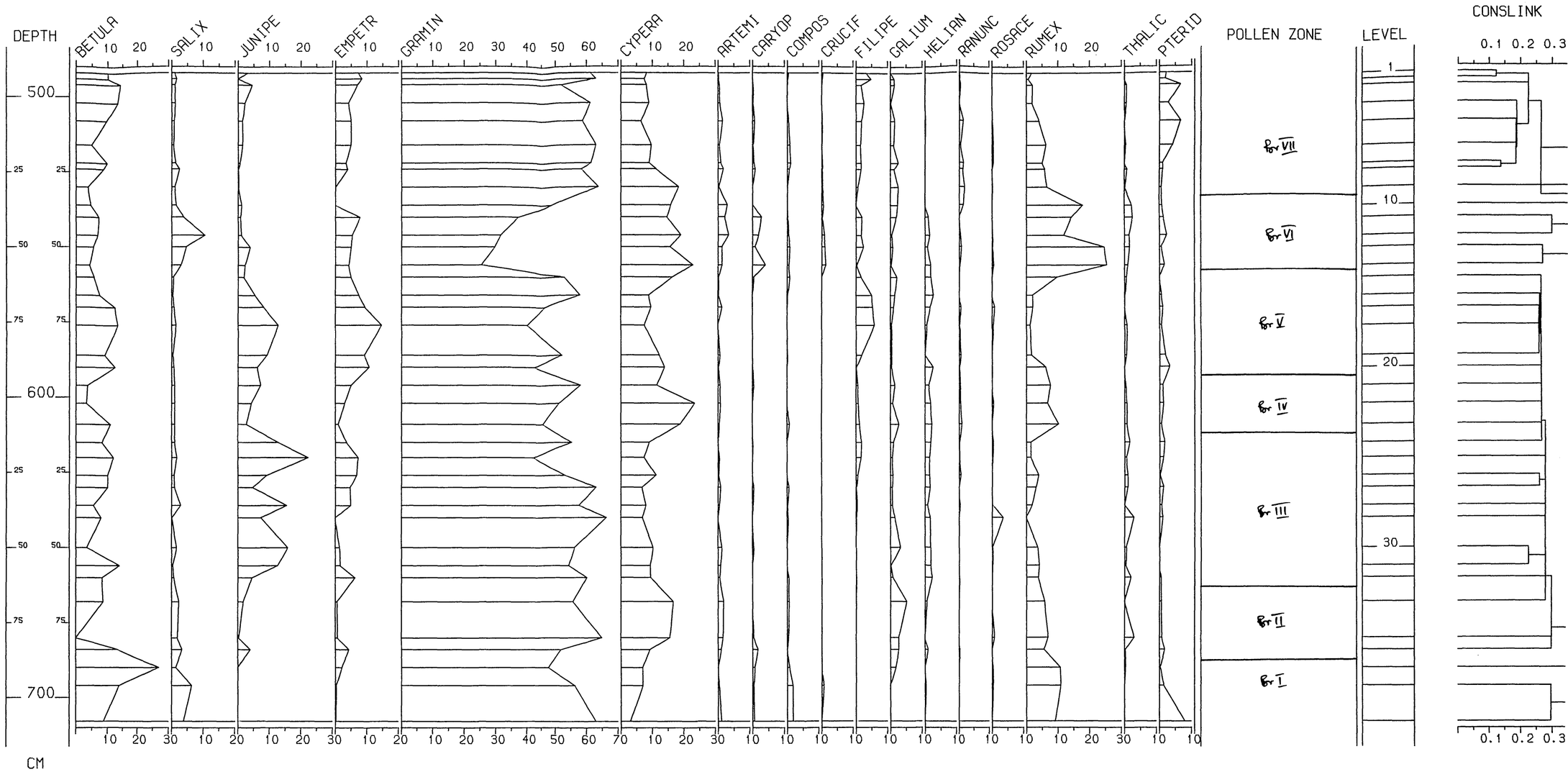


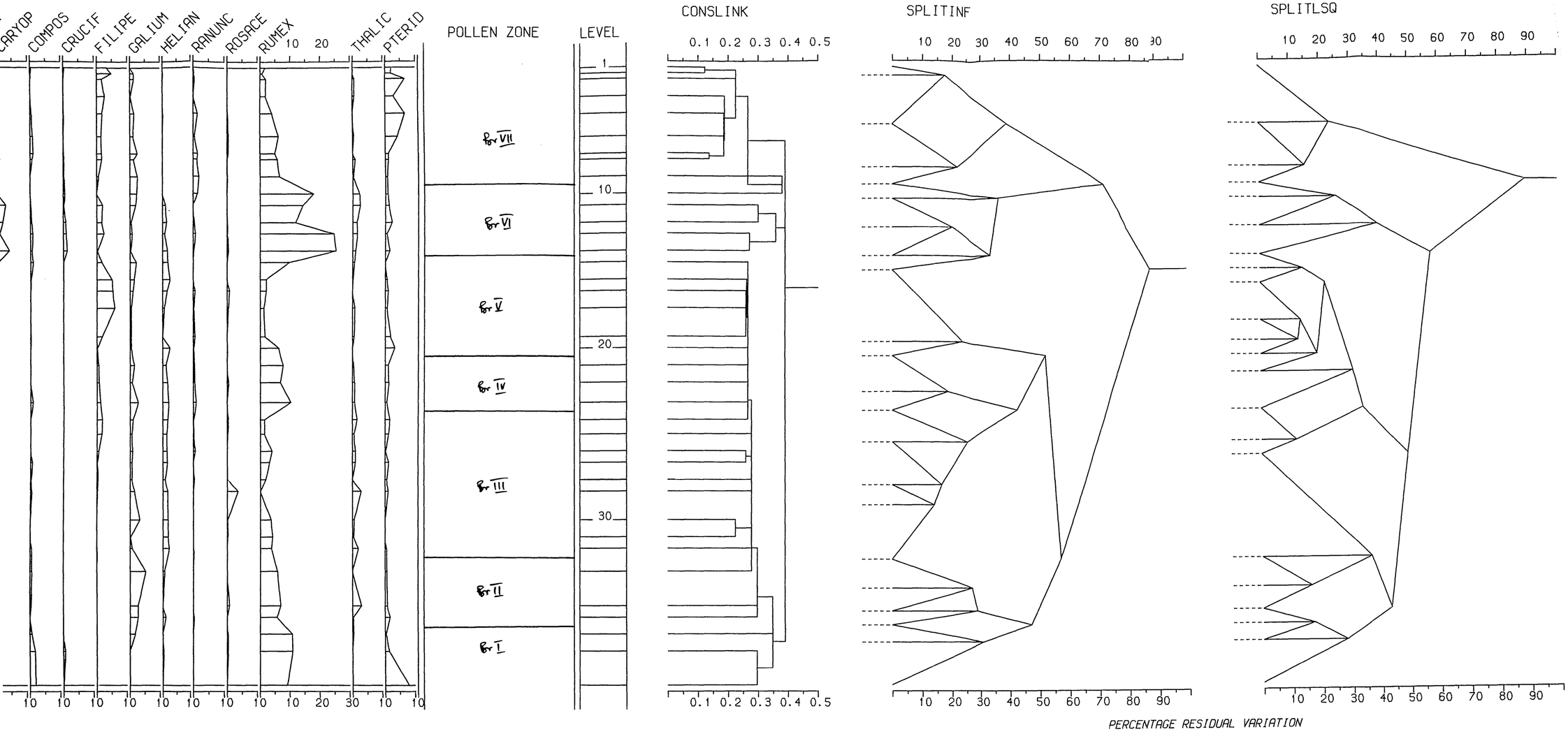

COMPOSITAE - TUBULIFLORAE
COMPOSITAE - LIGULIFLORAE
CRUCIFERAE
DROSERA
DRYAS
EPILOBIUM
FILIPENDULA
GALIUM
GENTIANA
GERANIUM
HELIANTHEMUM
LABIATAE
LEGUMINOSAE
PLANTAGO LANCEOLATA
PLANTAGO SPP. (MAJOR)
POLYGONUM
POTENTILLA
PRIMULA
RANUNCULACEAE
ROSACEAE
RUMEX
SAXIFRAGACEAE
SCROPHULARIACEAE
SUCCISA
THALICTRUM
UMBELLIFERAE
URTICA
VALERIANA
VICIA
VIOLA
HYDROCOTYLE
MYRIOPHYLLUM ALTERNIFLORUM
MYRIOPHYLLUM SPP.
MENYANTHES
NUPHAR
POTAMOGETON
TYPHA
SUM OF AQUATICS
PTERIDOPHYTA
POLLEN SUM
NO OF TRVA IN POLLEN SUM.
SUM OF TREES
SUM OF SHRUBS
SUM OF HERBS
CM
% TOTAL POLLEN

(6)

Figure 6.12
Broxmouth site.
Lower core (MK I)
ZONATION results.

ZONATION OF LOWER BROXMOUTH CORE.



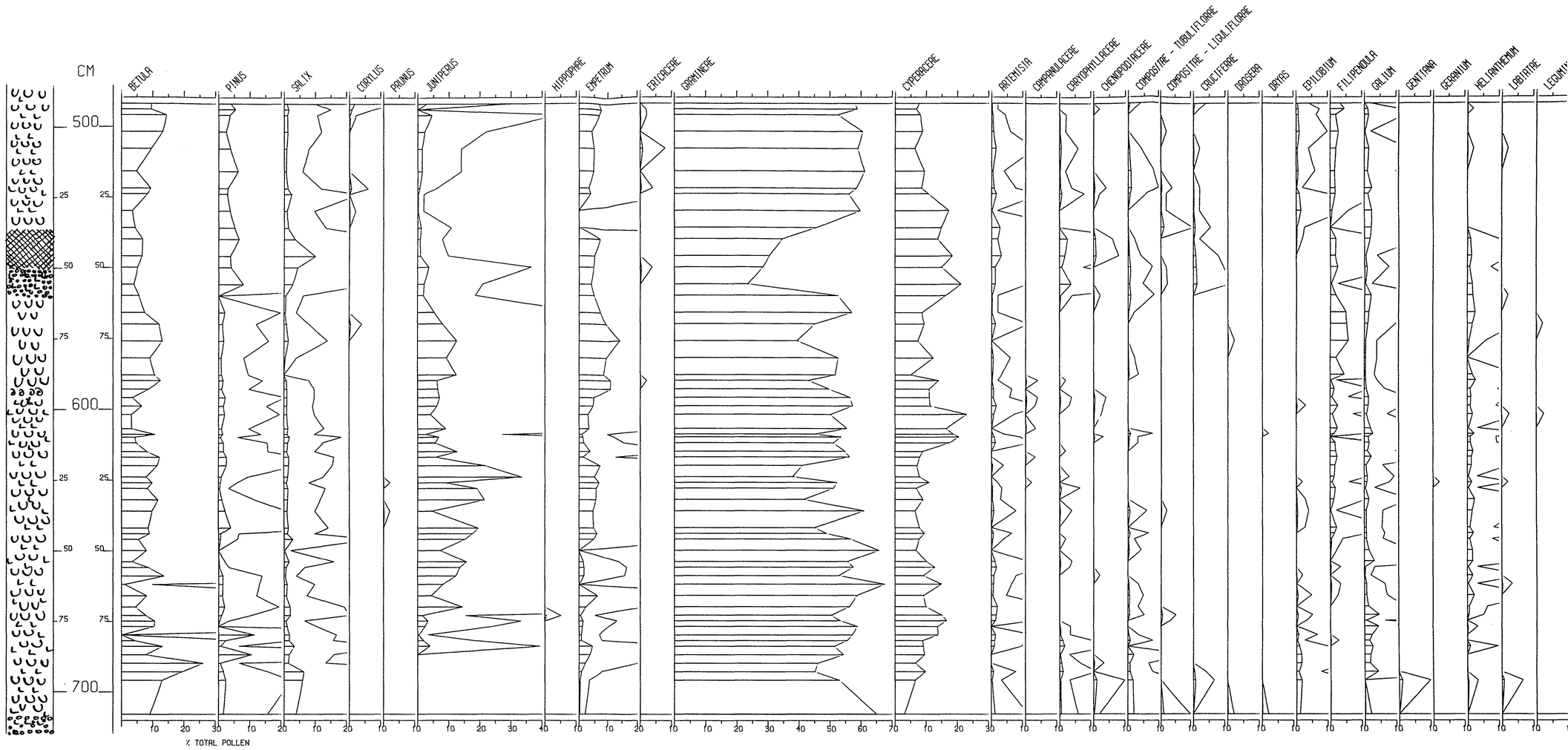

CARYOP
COMPOS
CRUCIF
FILIPE
GALIUM
HELIAN
RANUNC
ROSACE
RUMEX
THALIC
PTERID
10 20
10 10 10 10 10 10 10 10 10 20 30 10 10
POLLEN ZONE
LEVEL
Br VII
Br VI
Br V
Br IV
Br III
Br II
Br I
1
10
20
30
CONSLINK
0.1 0.2 0.3 0.4 0.5
0.1 0.2 0.3 0.4 0.5
SPLITINF
10 20 30 40 50 60 70 80 90
10 20 30 40 50 60 70 80 90
SPLITLSQ
10 20 30 40 50 60 70 80 90
10 20 30 40 50 60 70 80 90
PERCENTAGE RESIDUAL VARIATION

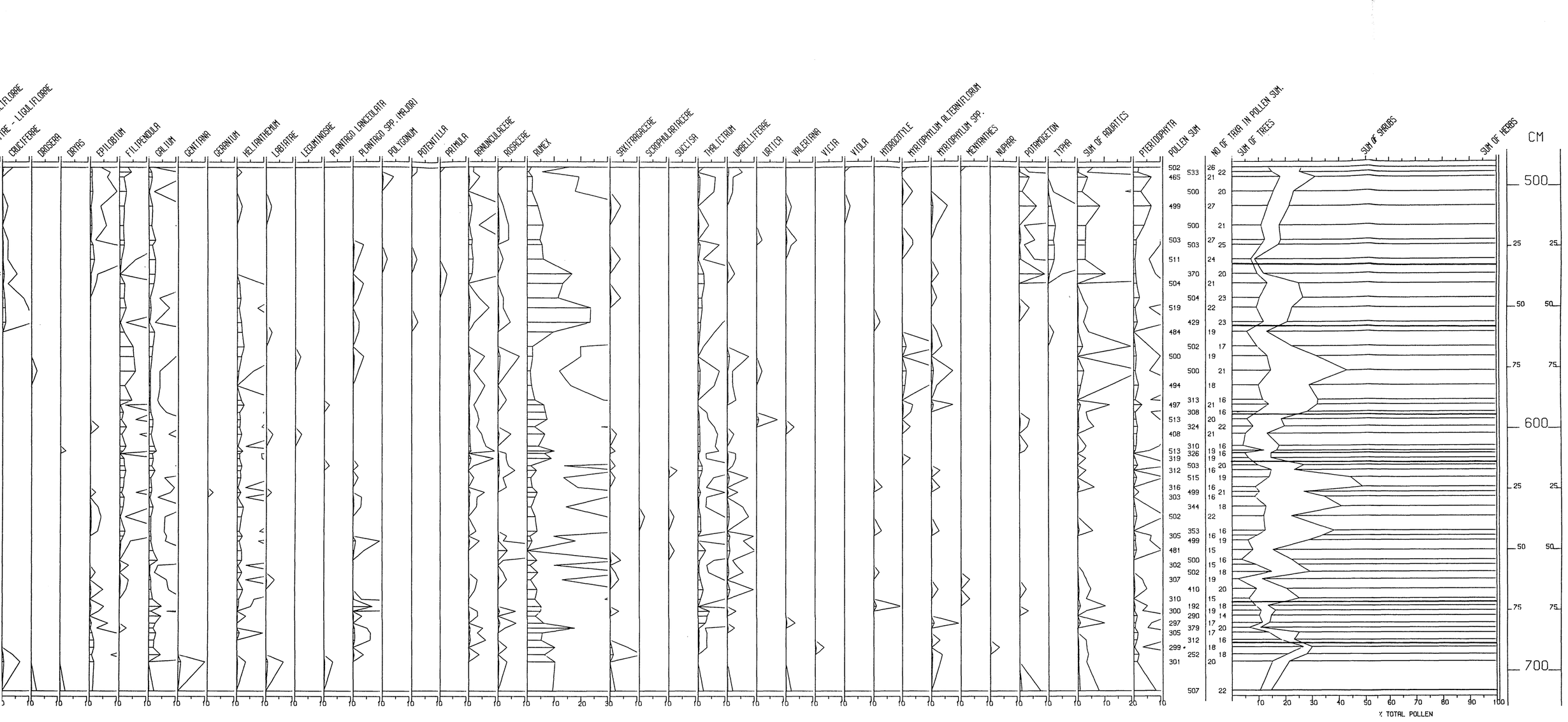
(7)

Figure 6.15
Broxmouth site.
Lower core (MK II)
Percentage diagram.

BROXMOUTH - LOWER DIAGRAM.

ANALYSED BY A J ALEXANDER.




CRUCIFERAE
DROSERA
DRYAS
EPILOBIUM
FILIPENDULA
GALIUM
GENTIANA
GERANIUM
HELIANTHEMUM
LABIATAE
LEGUMINOSAE
PLANTAGO LANCEOLATA
PLANTAGO SPP. (MAJOR)
POLYGONUM
POTENTILLA
PRIMULA
RANUNCULACEAE
ROSACEAE
RUMEX
SAXIFRAGACEAE
SCROPHULARIACEAE
SUCCISA
THALICTRUM
UMBELLIFERAE
URTICA
VALERIANA
VICIA
VIOLA
HYDROCOTYLE
MYRIOPHYLLUM ALTERNIFLORUM
MYRIOPHYLLUM SPP.
MENYANTHES
NUPHAR
POTAMOGETON
TYPHA
SUM OF AQUATICS
PTERIDOPHYTA
POLLEN SUM
NO OF TAXA IN POLLEN SUM.
SUM OF TREES
SUM OF SHRUBS
SUM OF HERBS
CM
% TOTAL POLLEN

(8)

Figure 6.16
Broxmouth site.
Lower core (MK II)
ZONATION results.

BROXMOUTH - LOWER DIAGRAM ZONATION

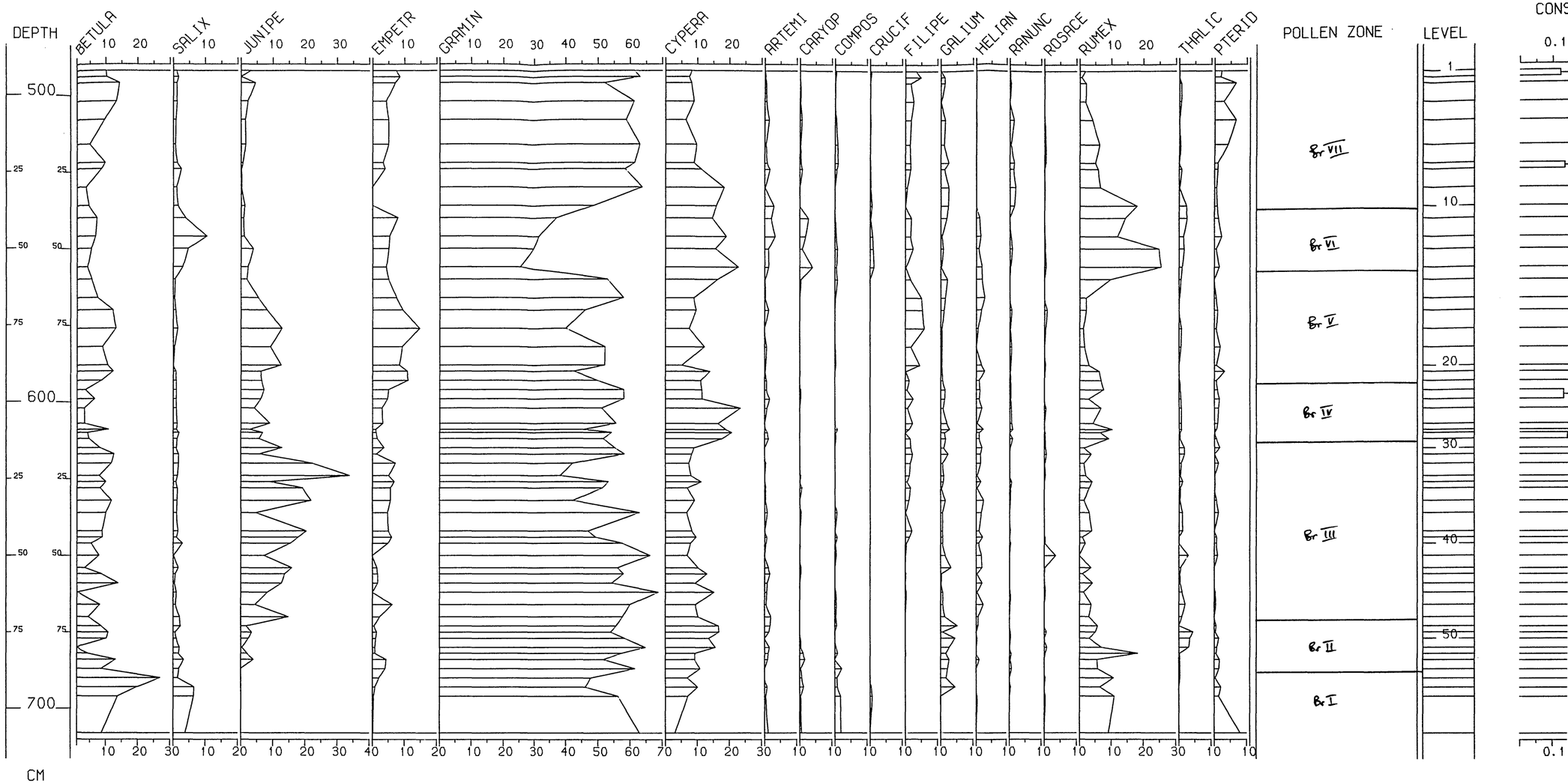
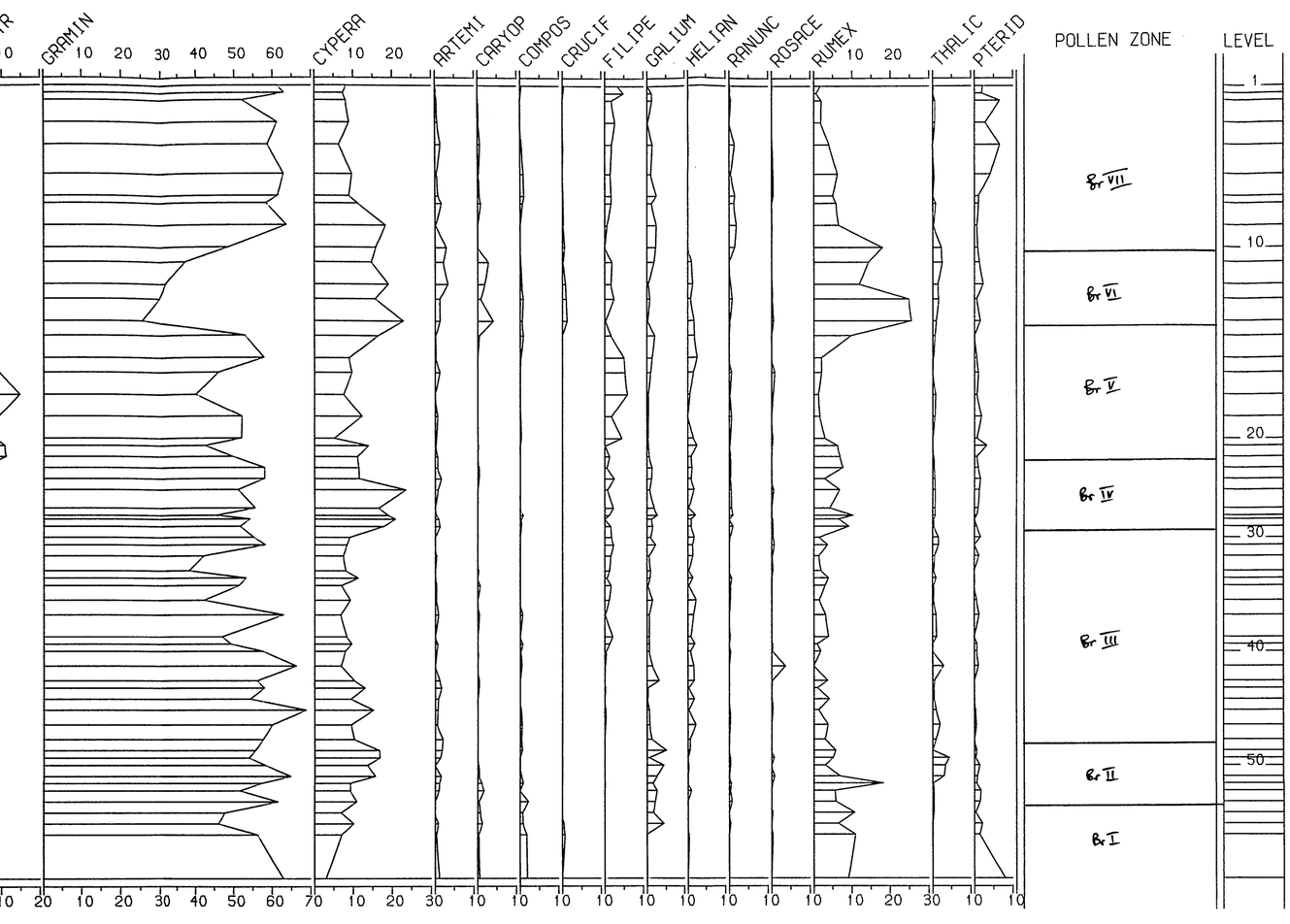
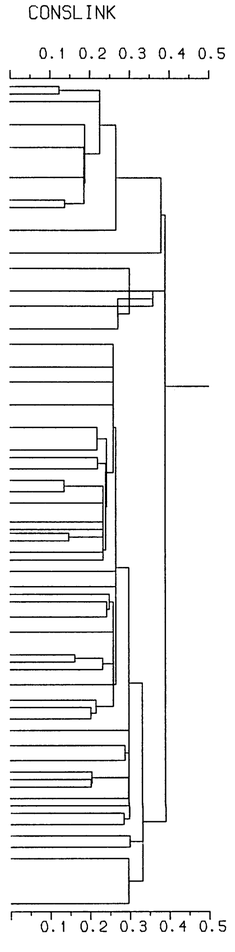
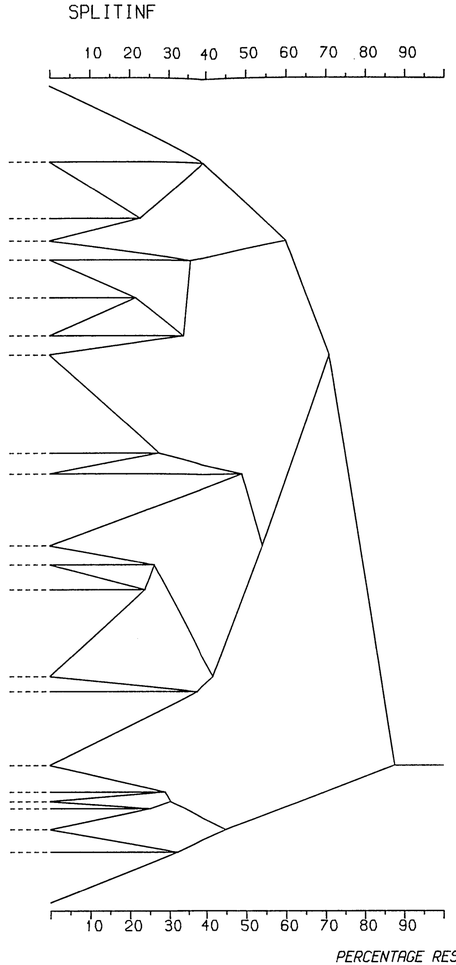
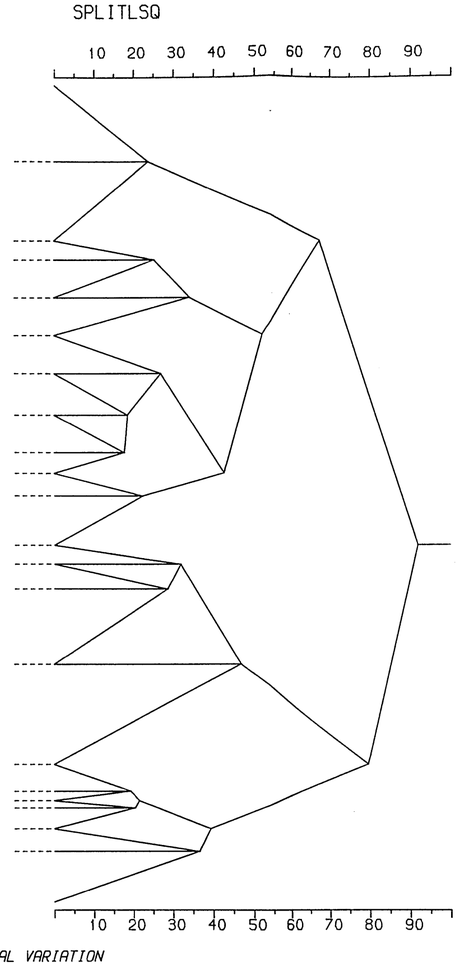


DIAGRAM ZONATION





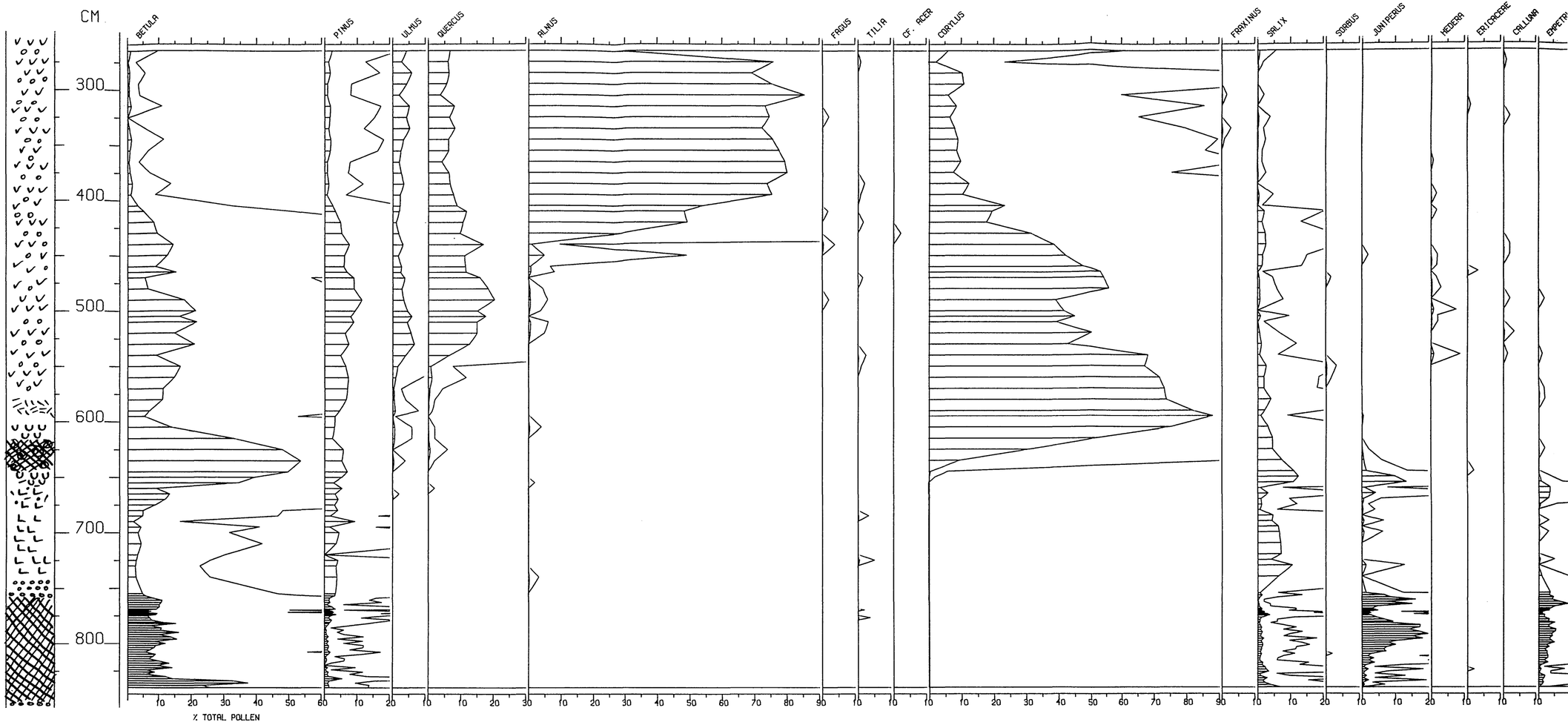


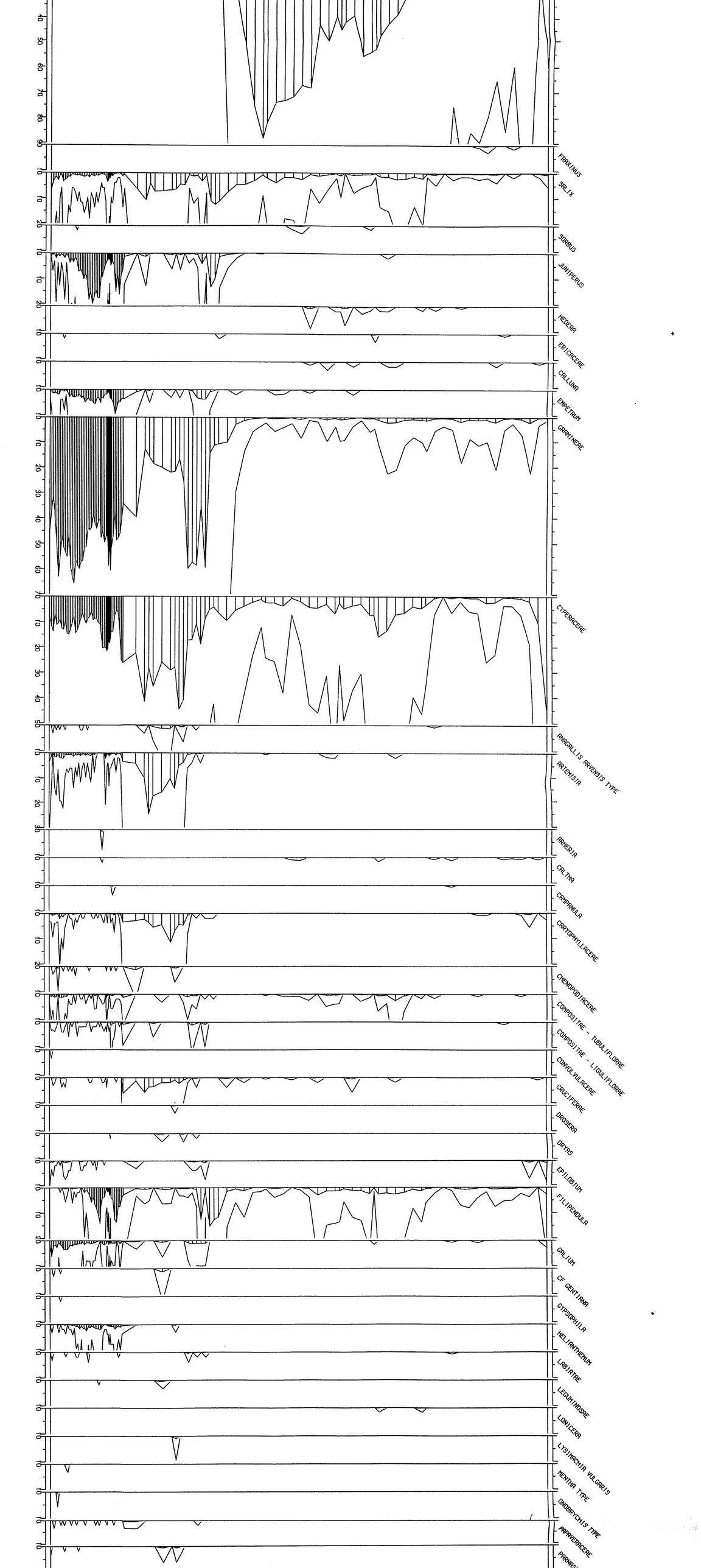


(9)

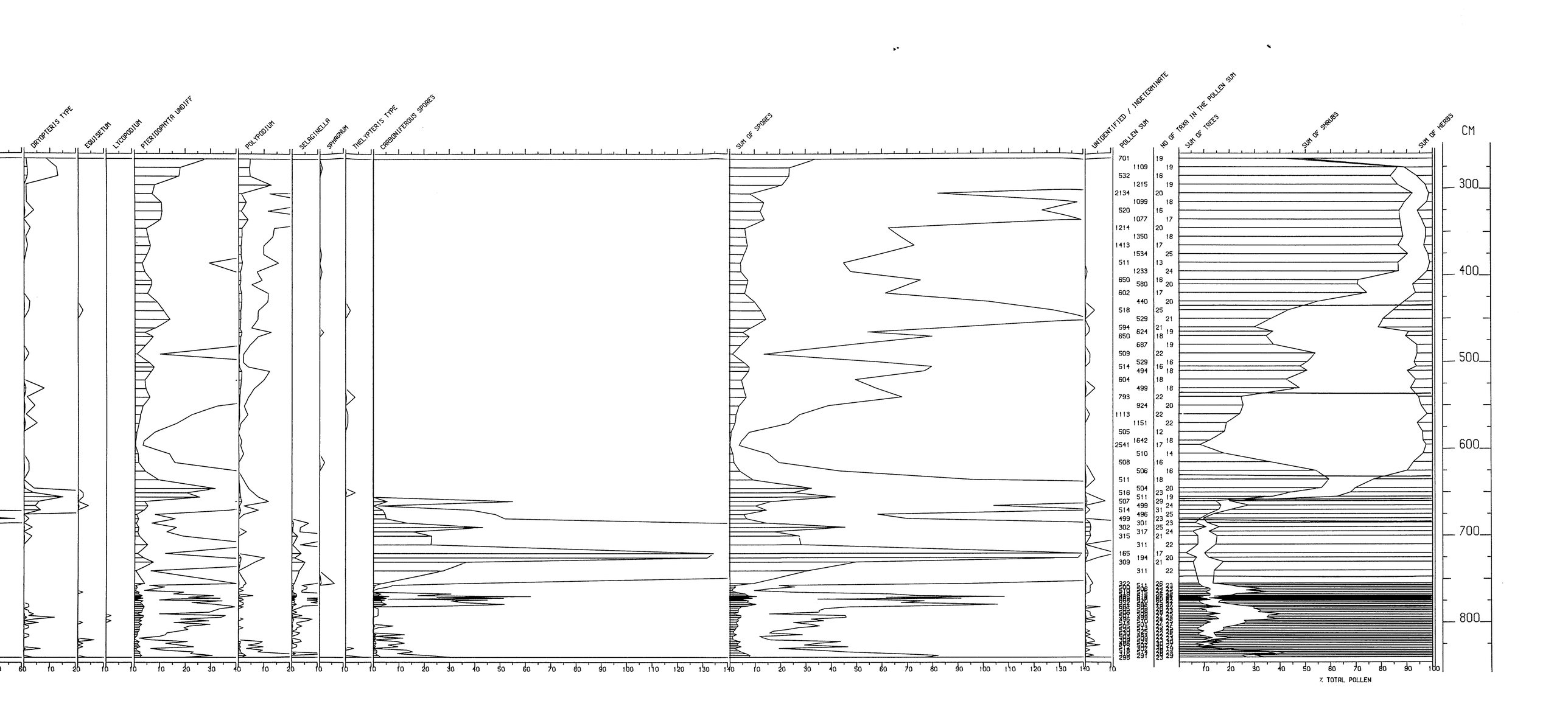
Figure 7.2
Balgone House site.
Complete core.
Percentage diagram.

BALGONE HOUSE. ANALYSED BY A J ALEXANDER, 1980.




FRAXINUS
SALIX
SORBUS
JUNIPERUS
HEDERA
ERICACEAE
CALLUNA
EMPETRUM
GRAMINEAE
CYPERACEAE
RANUNCULUS ARVENSIS TYPE
ARTEMISIA
ARMERIA
CALLUNA
CAMPANULA
CARYOPHYLLACEAE
CHENOPODIACEAE
COMPOSITAE - TUBULIFLORAE
COMPOSITAE - LIGULIFLORAE
CONVOLVULACEAE
CRUCIFERAE
DROSERA
DRYAS
EPILOBIUM
FILIPENDULA
GALIUM
CF GENTIANA
GYPSOPHILA
HELIANTHEMUM
LABIATAE
LEGUMINOSAE
LONICERA
LYSIMACHIA VULGARIS
MENTHA TYPE
ONOBRYCHIS TYPE
PRIMULACEAE
PRUNUS

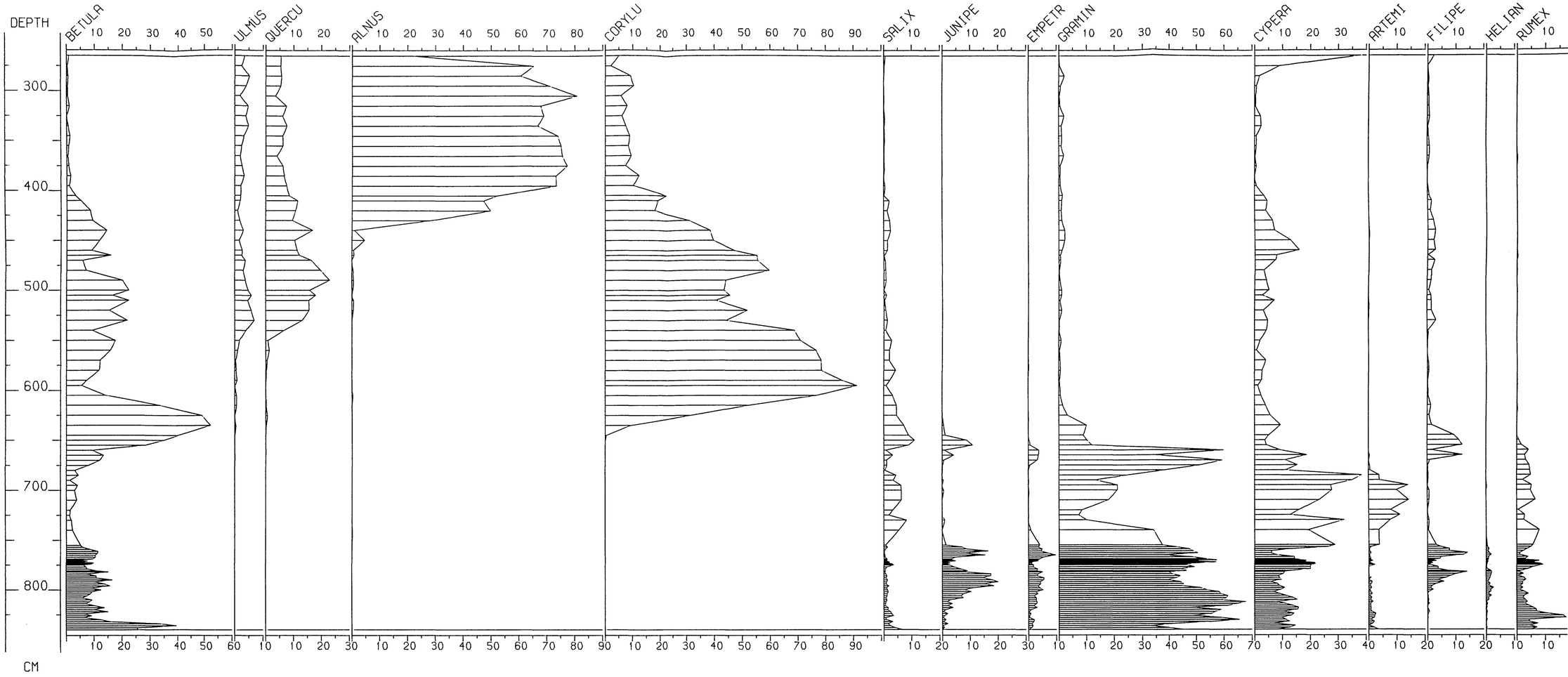
PSOPHILA
HELIANTHEMUM
LABIATAE
LEGUMINOSAE
LONICERA
LYSIMACHIA VULGARIS
MENTHA TYPE
ONOBRYCHIS TYPE
PRIMVERACEAE
PRUNASSIA
PLANTAGO SPP
POLEMONIUM
POLYGONUM
POTENTILLA
RANUNCULACEAE
ROSACEAE
RUBUS
RUMEX
SAXIFRAGA OPPOSITIFOLIA
SAXIFRAGA GRANULATA
SAXIFRAGA AZOIDES
SAXIFRAGA STELLARIS
SOLANUM
SUCCISA
THALICTRUM
VALERIANA
VIBURNUM OPULUS
VICIA
UMBELLIFERAE
URTICA
HYDROCOTILE
MENYANTHES
MYRIOPHYLLUM ALTERNIFLORUM
MYRIOPHYLLUM SPICATUM
NUPHAR
NYMPHAEA
POTAMOGETON
SPARGANIUM
TYPHA
SUM OF AQUATICS
DRYOPTERIS TYPE
EQUISETUM
LYCOPODIUM
PTERIDOPHYTA UNDIFF

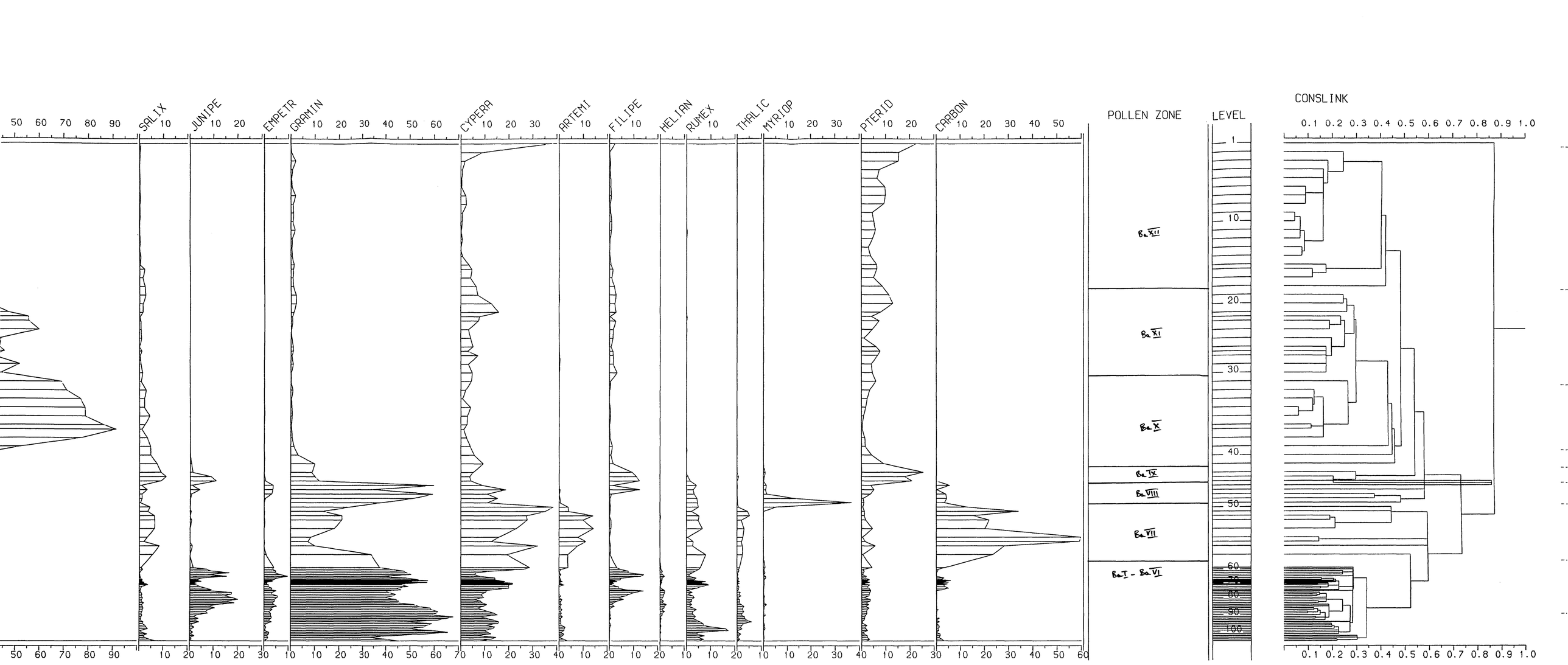

DRYOPTERIS TYPE
EQUISETUM
LYCOPODIUM
PTERIDOPHYTA UNDIFF
POLYPODIUM
SELAGINELLA
SPHAGNUM
THELYPTERIS TYPE
CARBONIFEROUS SPORES
SUM OF SPORES
UNIDENTIFIED / INDETERMINATE
POLLEN SUM
NO OF TAXA IN THE POLLEN SUM
SUM OF TREES
SUM OF SHRUBS
SUM OF HERBS
CM
300
400
500
600
700
800
% TOTAL POLLEN

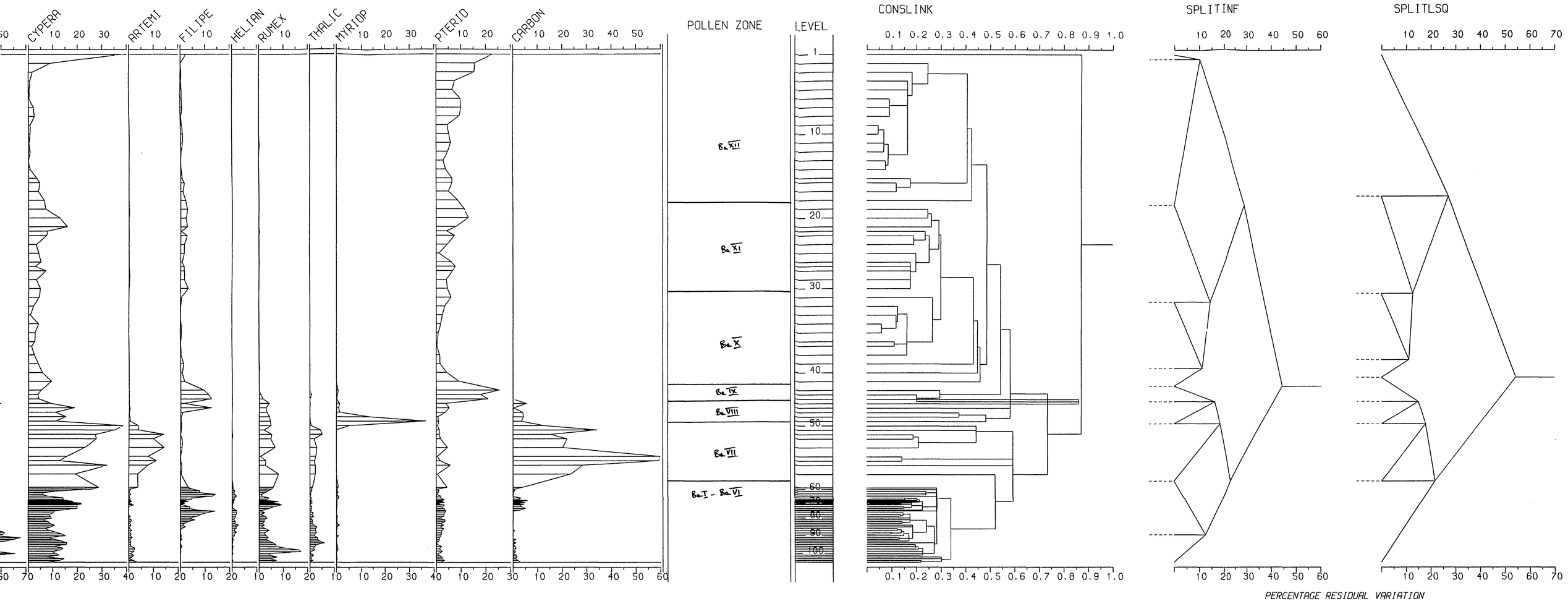
(10)

Figure 7.3
Balgone House site.
Complete core.
ZONATION results.

BALGONE - ZONATION OF COMPLETE DATA SET.




SALIX
JUNIPE
EMPETR
GRAMIN
CYPERA
ARTEMI
FILIPE
HELIAN
RUMEX
THALIC
MYRIOP
PTERID
CARBON
POLLEN ZONE
LEVEL
CONSLINK
Ba XII
Ba XI
Ba X
Ba IX
Ba VIII
Ba VII
Ba I - Ba VI

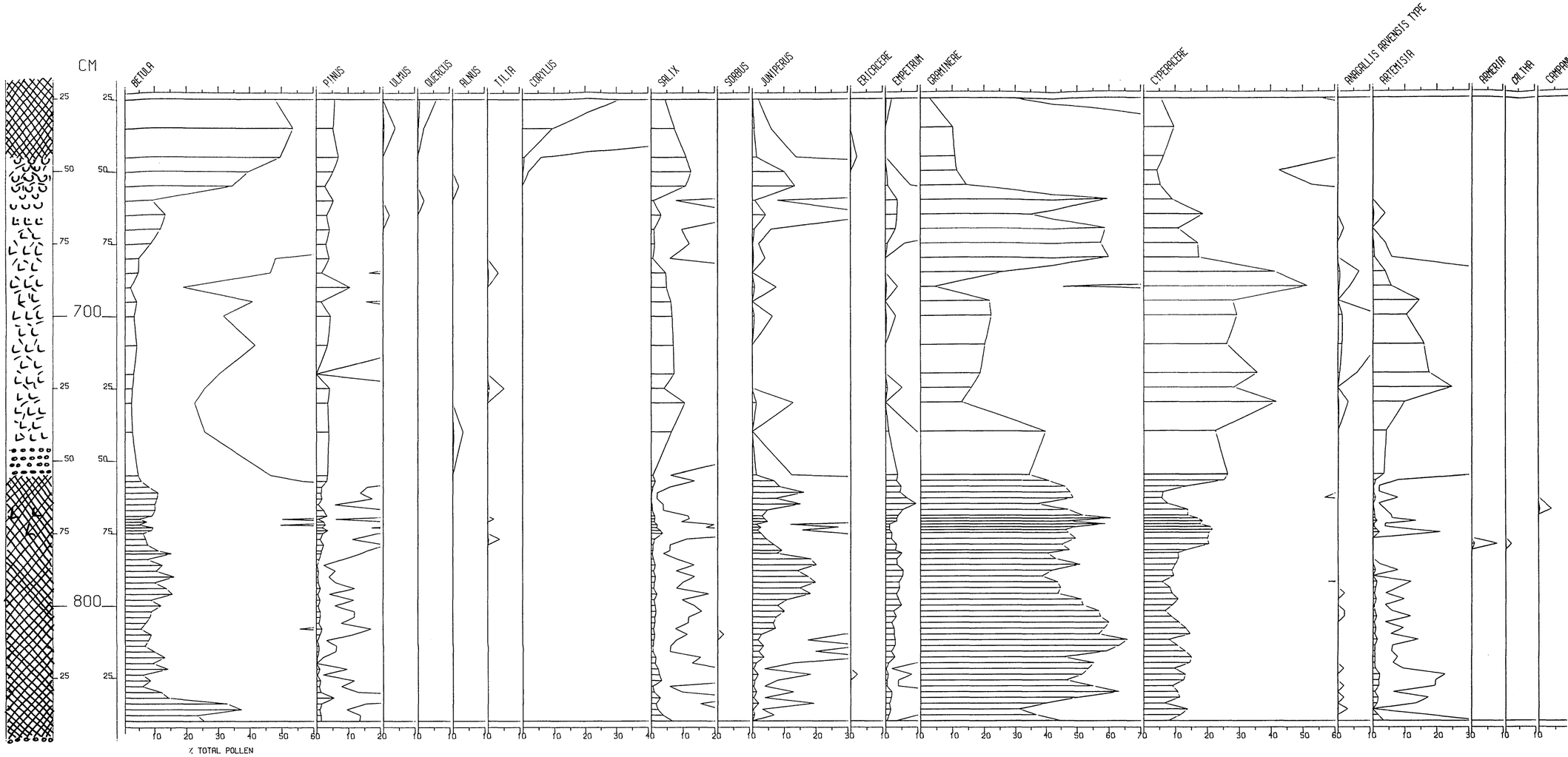

CYPERA
ARTEMI
FILIPE
HELIAN
RUMEX
THALIC
MYRIOP
PTERID
CARBON
POLLEN ZONE
LEVEL
Ba XII
Ba XI
Ba X
Ba IX
Ba VIII
Ba VII
Ba I - Ba VI
CONSLINK
SPLITINF
SPLITLSQ
PERCENTAGE RESIDUAL VARIATION

(11)

Figure 7.6
Balgone House site.
Lower core.
Percentage diagram.

BALGONE HOUSE.

ANALYSED BY A J ALEXANDER, 1980



CYPERACEAE

ANAGALLIS ARVENSIS TYPE

ARTEMISIA

ARMERIA

CALTHA

CAMPANULA

CARYOPHYLLACEAE

CHENOPODIACEAE

COMPOSITAE - TUBULIFLORAE

COMPOSITAE - LIGULIFLORAE

CONVOLVULACEAE

CRUCIFERAE

DROSERA

DRYAS

EPILOBIUM

FILIPENDULA

GALIUM

CF GENTIANA

GYPSOPHILA

HELIANTHEMUM

LABIATAE

LEGUMINOSAE

LYSIMACHIA VULGARIS

MENTHA TYPE

ONOBRYCHIS TYPE

PAPAVERACEAE

PARNASSIA

PLANTAGO SPP

POLEMONIUM

POLYGONUM

POTENTILLA

RANUNCULACEAE

ROSACEAE

RUBUS

RUMEX

SAXIFRAGA OPPOSITIFOLIA

SAXIFRAGA GRANULATA

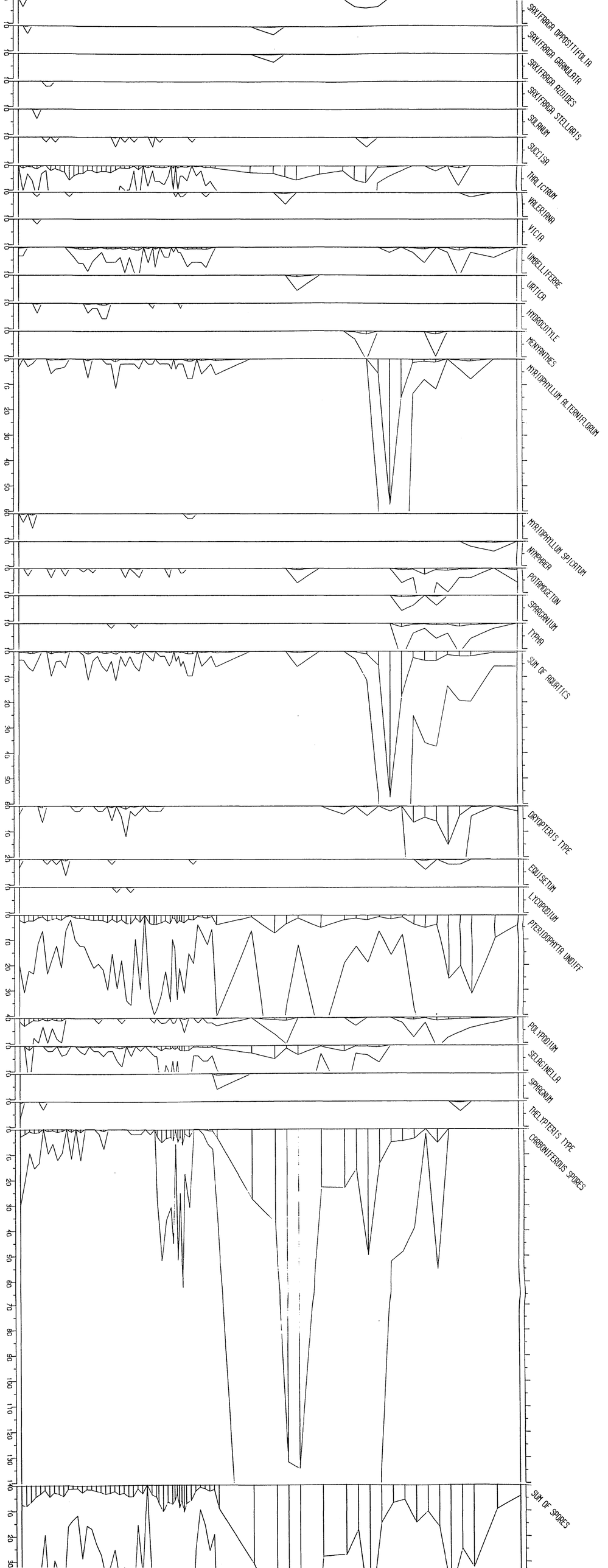
SAXIFRAGA AIZOIDES

SAXIFRAGA STELLARIS

SOLANUM

SUCISA

THALICTRUM


SAXIFRAGA OPPOSITIFOLIA
SAXIFRAGA GRANULATA
SAXIFRAGA RIVULARIS
SAXIFRAGA STELLARIS
SOLANUM
SUCCISA
THALICTRUM
VALERIANA
VICIA
UMBELLIFERAE
URTICA
HYDROCOTYLE
MENYANTHES
MYRIOPHYLLUM ALTERNIFLORUM
MYRIOPHYLLUM SPICATUM
NYMPHAEA
POTAMOGETON
SPARGANIUM
TYPHA
SUM OF AQUATICS
CRYPTERIS TYPE
EQUISETUM
LYCOPODIUM
PTERIDOPHYTA UNDIFF
POLYPODIUM
SELAGINELLA
SPHAGNUM
THELYPTERIS TYPE
CARBONIFEROUS SPORES
SUM OF SPORES

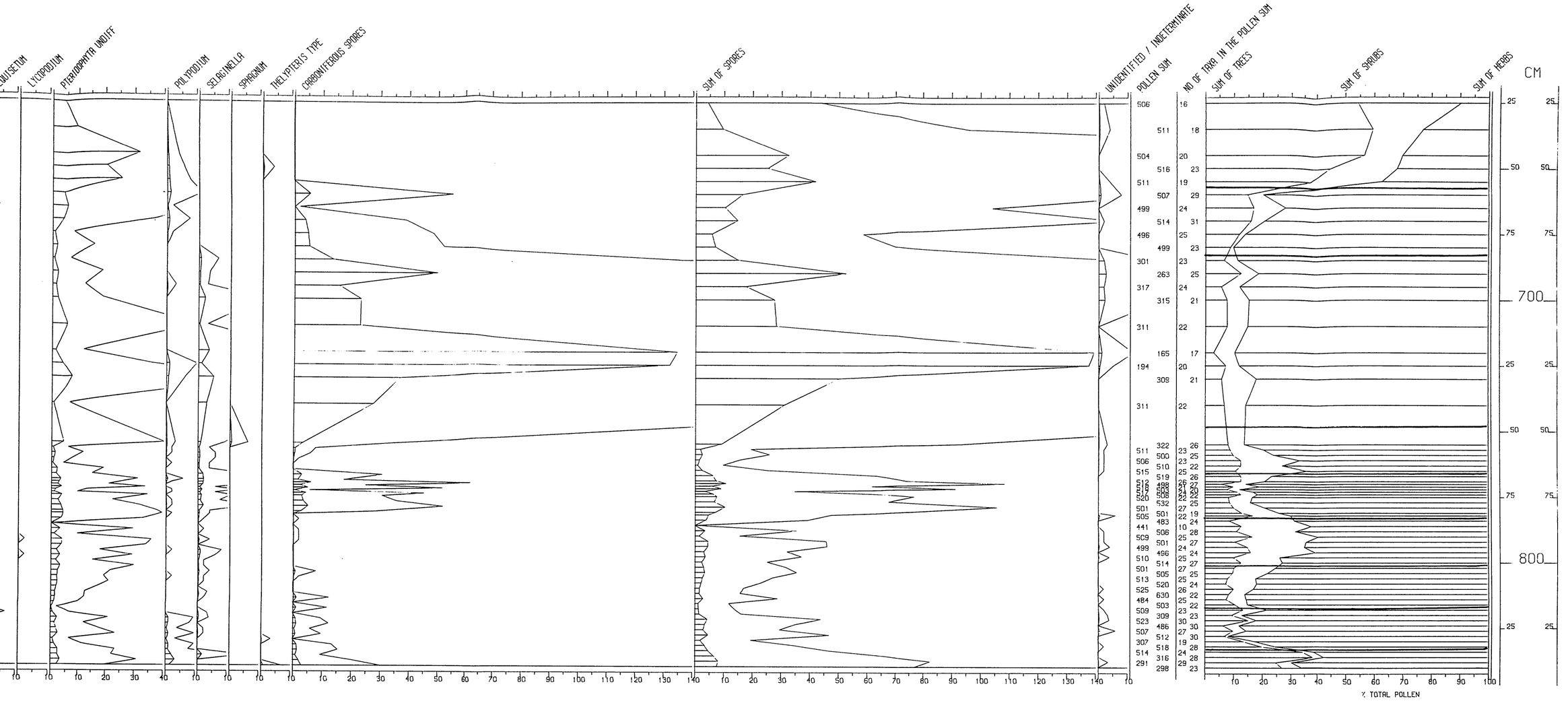
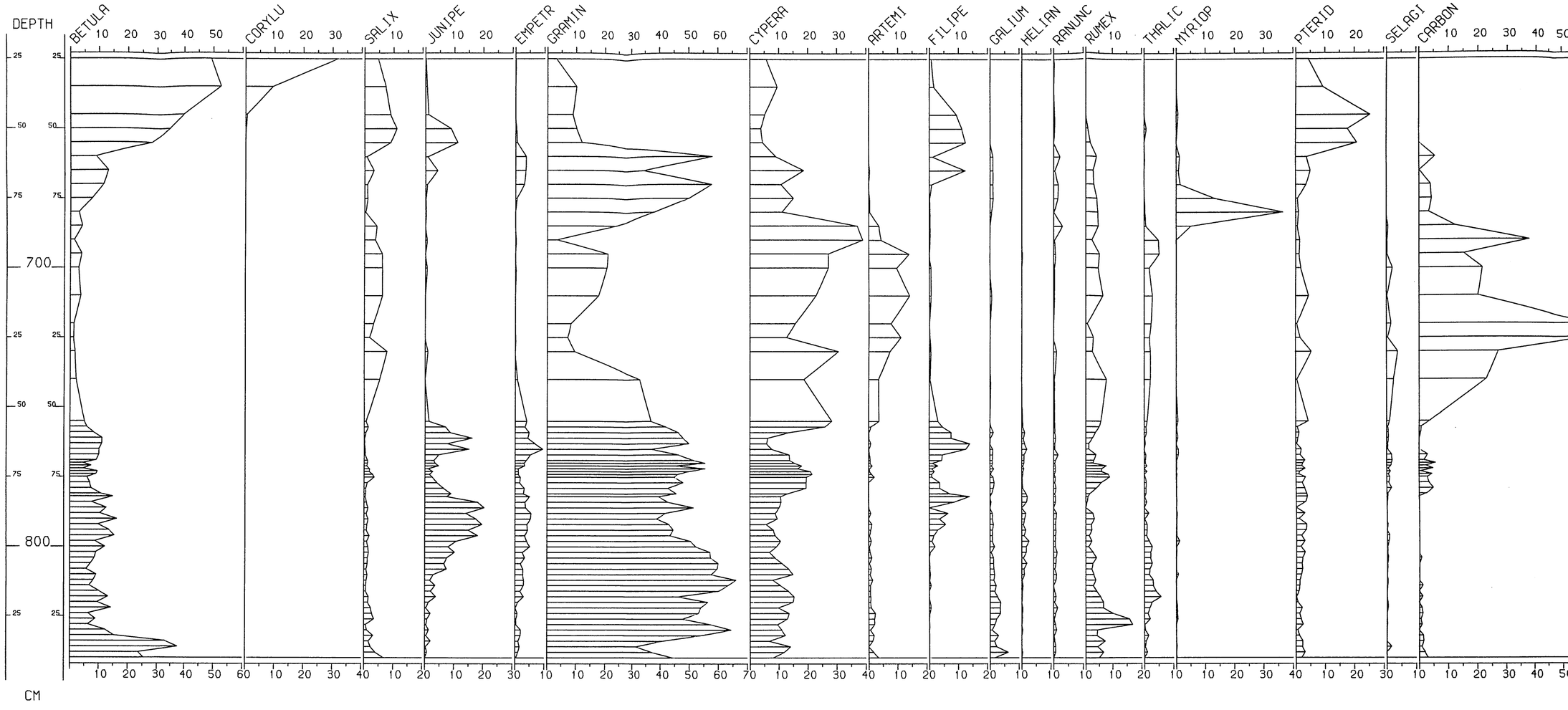
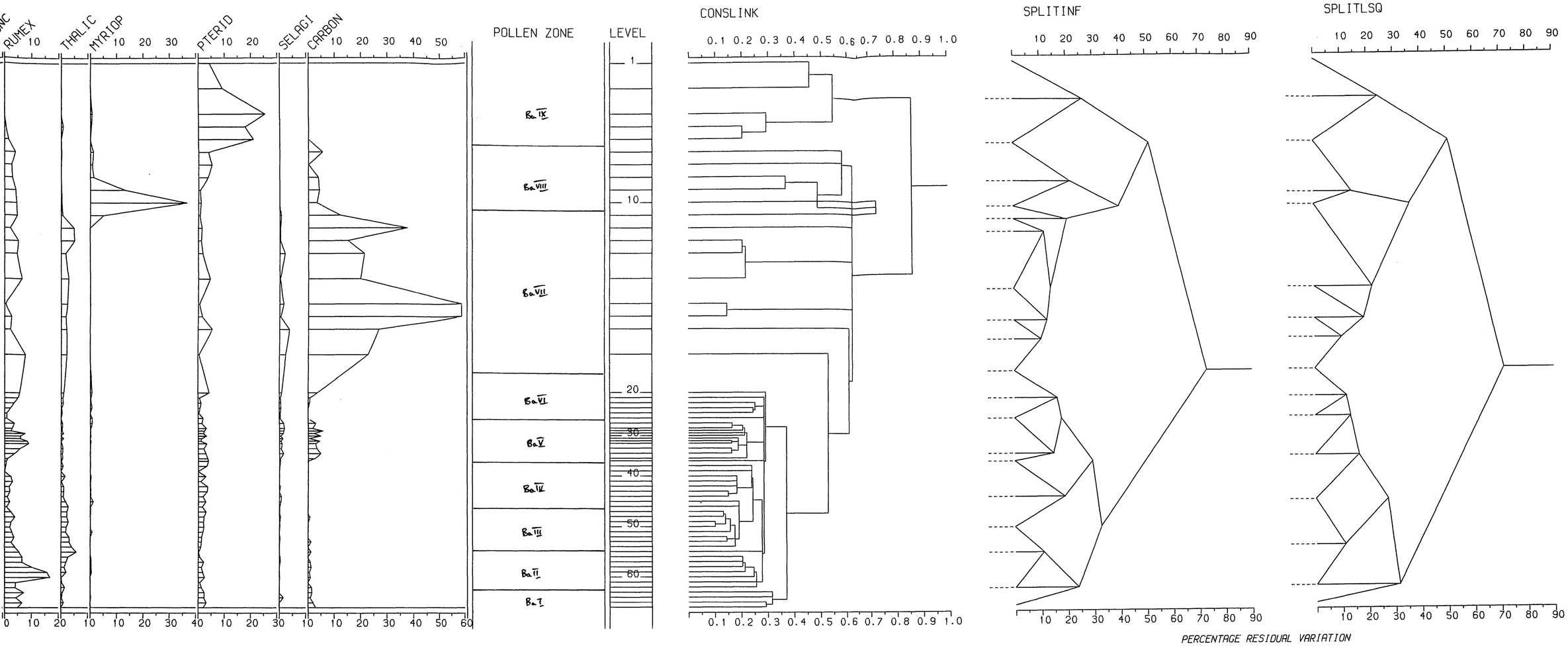

EQUISETUM
LYCOPODIUM
PTERIDOPHYTA UNDIFF
POLYPODIUM
SELAGINELLA
SPHAGNUM
THELYPTERIS TYPE
CARBONIFEROUS SPORES
SUM OF SPORES
UNIDENTIFIED / INDETERMINATE
POLLEN SUM
NO OF TAXA IN THE POLLEN SUM
SUM OF TREES
SUM OF SHRUBS
SUM OF HERBS
CM
% TOTAL POLLEN

Figure 7.7
Balgone House site.
Lower core.
ZONATION results.

BALGONE HOUSE - LATEGLACIAL ZONATION.

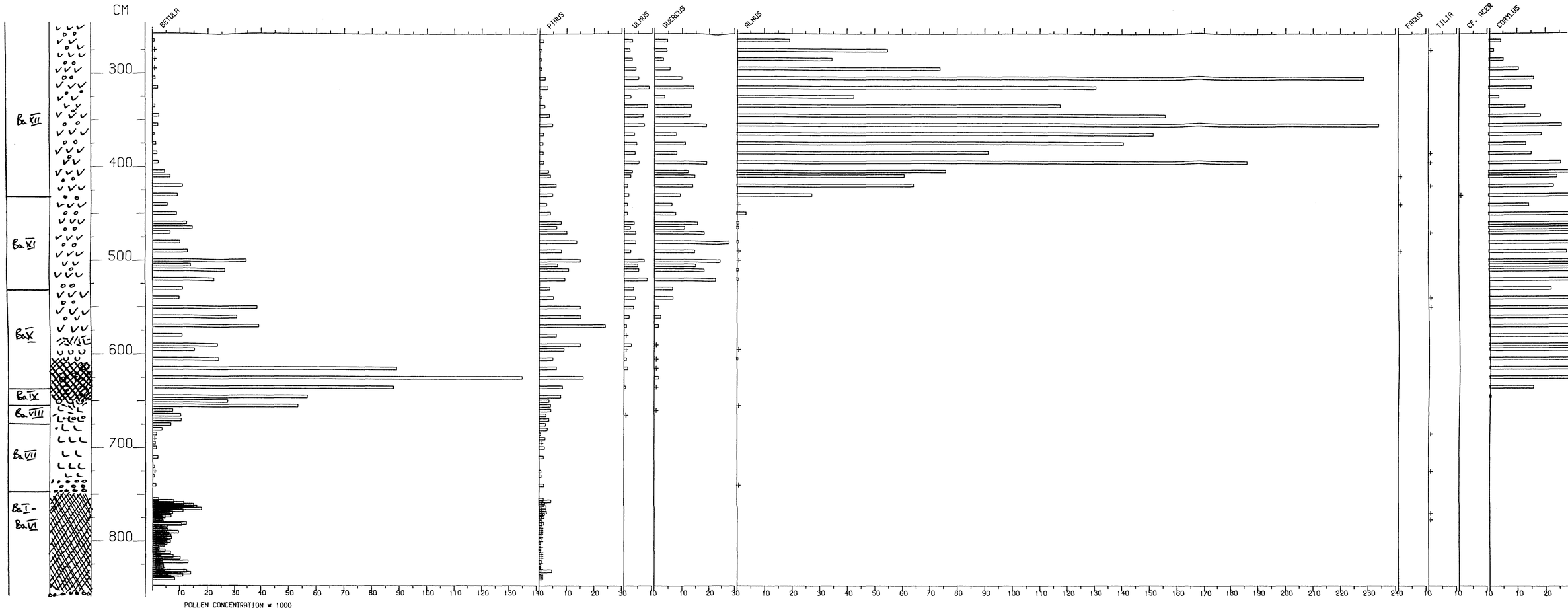


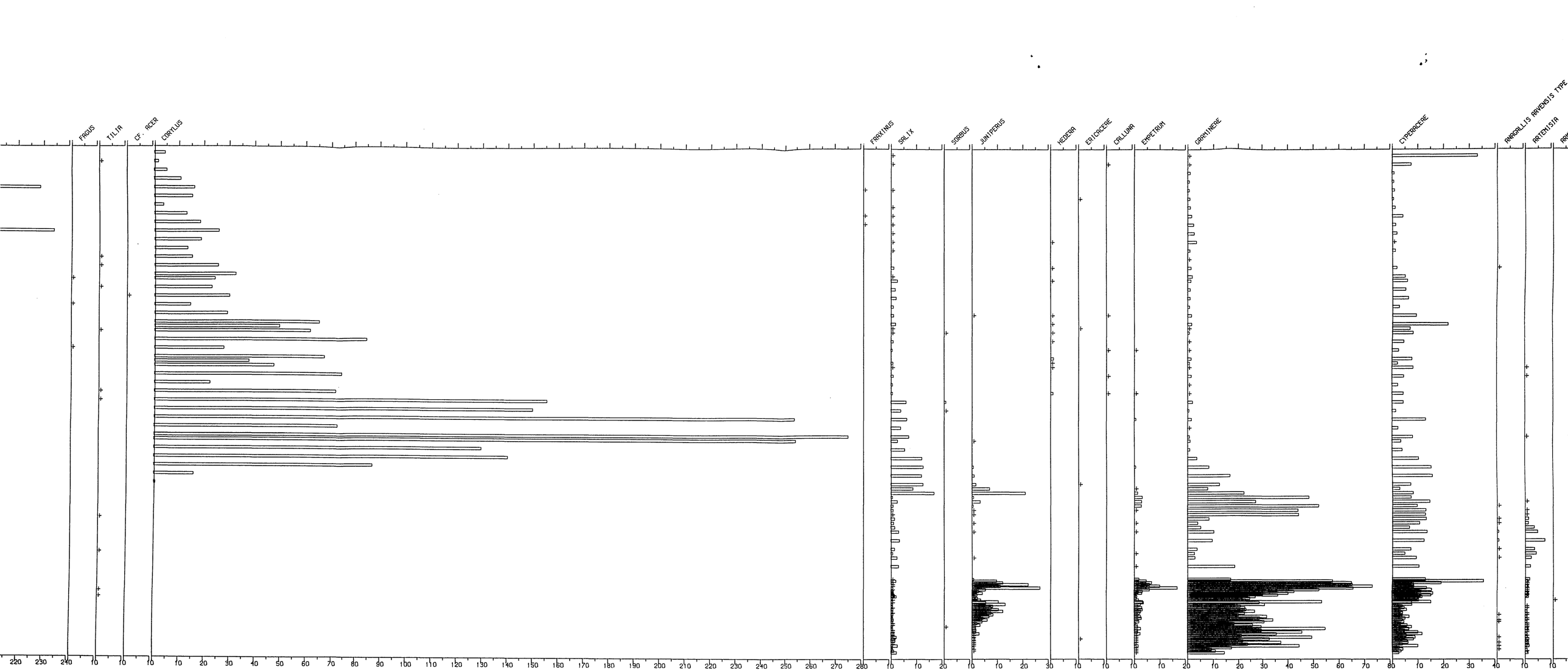

RUMEX
THALIC
MYRIOP
PTERID
SELAGI
CARBON
POLLEN ZONE
LEVEL
Ba IX
Ba VIII
Ba VII
Ba VI
Ba V
Ba IV
Ba III
Ba II
Ba I
CONSLINK
SPLITINF
SPLITLSQ
PERCENTAGE RESIDUAL VARIATION

(13)

Figure 7.11
Balgone House site.
Complete core.
Concentration diagram.

BALGONE HOUSE. ANALYSED BY A J ALEXANDER, 1980.

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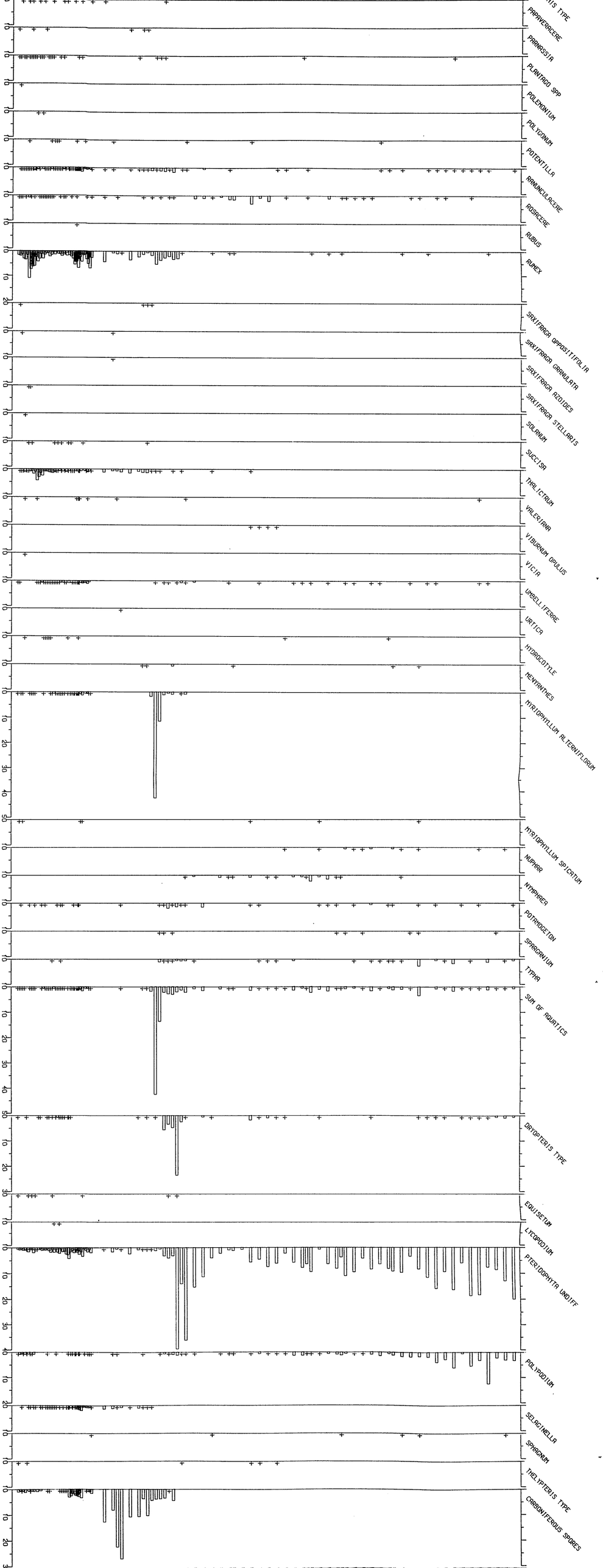
TILIA
CF. ACER
CORYLUS
FRAXINUS
SALIX
SORBUS
JUNIPERUS
HEDERA
ERICACEAE
CALLUNA
EMPETRUM
GRAMINEAE
CYPERACEAE
ANTHEMIS TYPE
ARTEMISIA

HEDERA
ERICACEAE
CALLUNA
EMPETRUM
GRAMINEAE
CYPERACEAE
ANAGALLIS ARVENSIS TYPE
ARTEMISIA
ARMERIA
CALTHA
CAMPANULA
CARYOPHYLLACEAE
CHENOPODIACEAE
COMPOSITAE - TUBULIFLORAE
COMPOSITAE - LIGULIFLORAE
CONVOLVULACEAE
CRUCIFERAE
DROSERA
DRYAS
EPILOBIUM
FILIPENDULA
GALIUM
CF GENTIANA
GYPSOPHILA
HELIANTHEMUM
LABIATAE
LEGUMINOSAE
LONICERA
LYSIMACHIA VULGARIS
MENTHA TYPE
ONOBRYCHIS TYPE
PRIMULACEAE
PARNASSIA
PLANTAGO SPP
POLEMONIUM
POLYGONUM
POTENTILLA
RANUNCULACEAE
ROSACEAE
RUBUS
RUMEX
SAXIFRAGA OPPOSITIFOLIA
SAXIFRAGA GRA
SAX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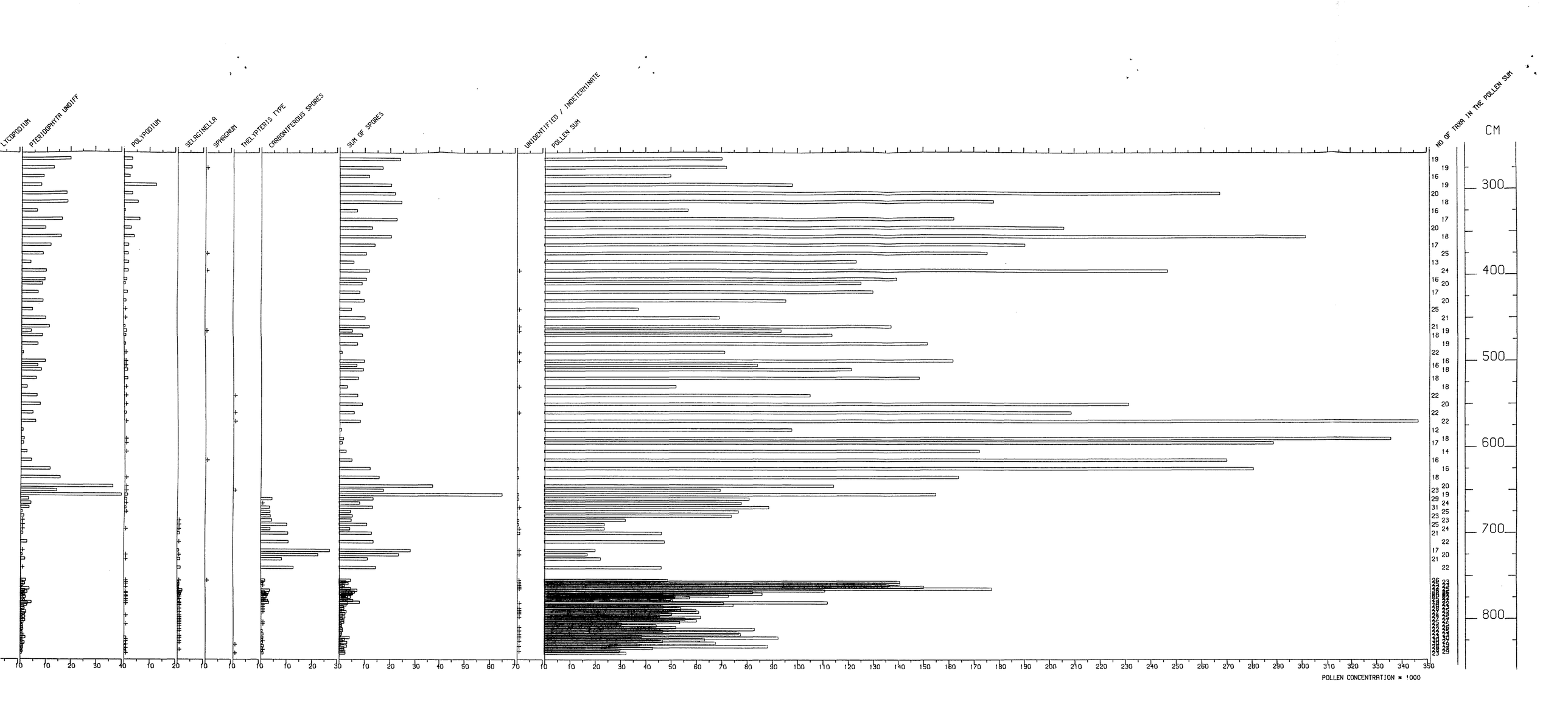
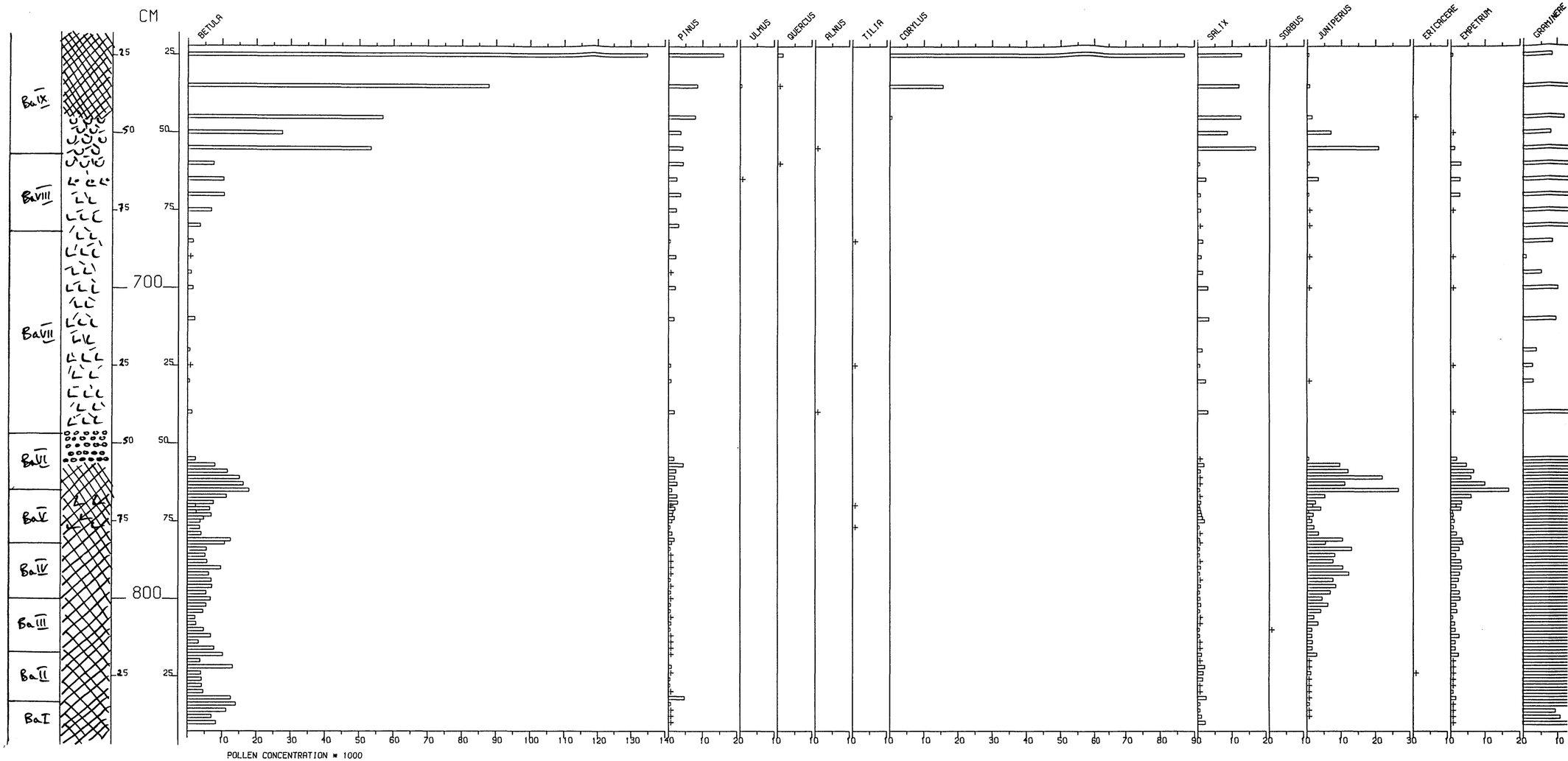
PRIMULA
PLANTAGO SPP
POLEMONIUM
POLYGONUM
POTENTILLA
RANUNCULACEAE
ROSACEAE
RUBUS
RUMEX
SAXIFRAGA OPPOSITIFOLIA
SAXIFRAGA GRANULATA
SAXIFRAGA RIVULARIS
SAXIFRAGA STELLARIS
SOLANUM
SUCCISA
THALICTRUM
VALERIANA
VIBURNUM OPULUS
VICIA
UMBELLIFERAE
URTICA
HYDROCOTYLE
MENYANTHES
MYRIOPHYLLUM ALTERNIFLORUM
MYRIOPHYLLUM SPICATUM
NUPHAR
NYMPHAEA
POTAMOGETON
SPARGANIUM
TYPHA
SUM OF AQUATICS
DRYOPTERIS TYPE
EQUISETUM
LYCOPODIUM
PTERIDOPHYTA UNDIFF
POLYPODIUM
SELAGINELLA
SPHAGNUM
THELYPTERIS TYPE
CARBONIFEROUS SPORES


LYCOPODIUM
PTERIDOPHYTA UNDIFF
POLYPODIUM
SELAGINELLA
SPHAGNUM
THELYPTERIS TYPE
CARBONIFEROUS SPORES
SUM OF SPORES
UNIDENTIFIED / INDETERMINATE
POLLEN SUM
NO OF TAXA IN THE POLLEN SUM
CM
300
400
500
600
700
800
POLLEN CONCENTRATION * 1000

(14)

Figure 7.12
Balgone House site.
Lower core.
Concentration diagram.

BALGONE HOUSE. ANALYSED BY A J ALEXANDER, 1980



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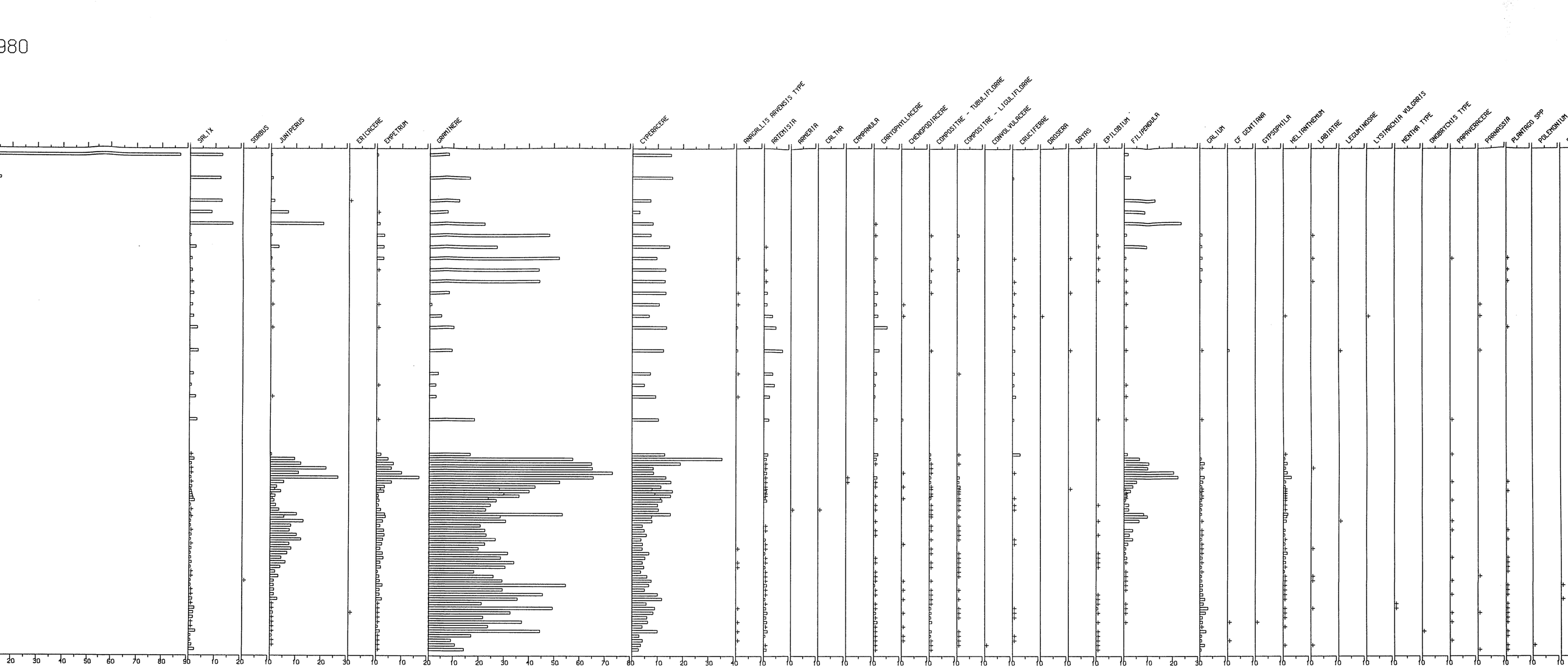
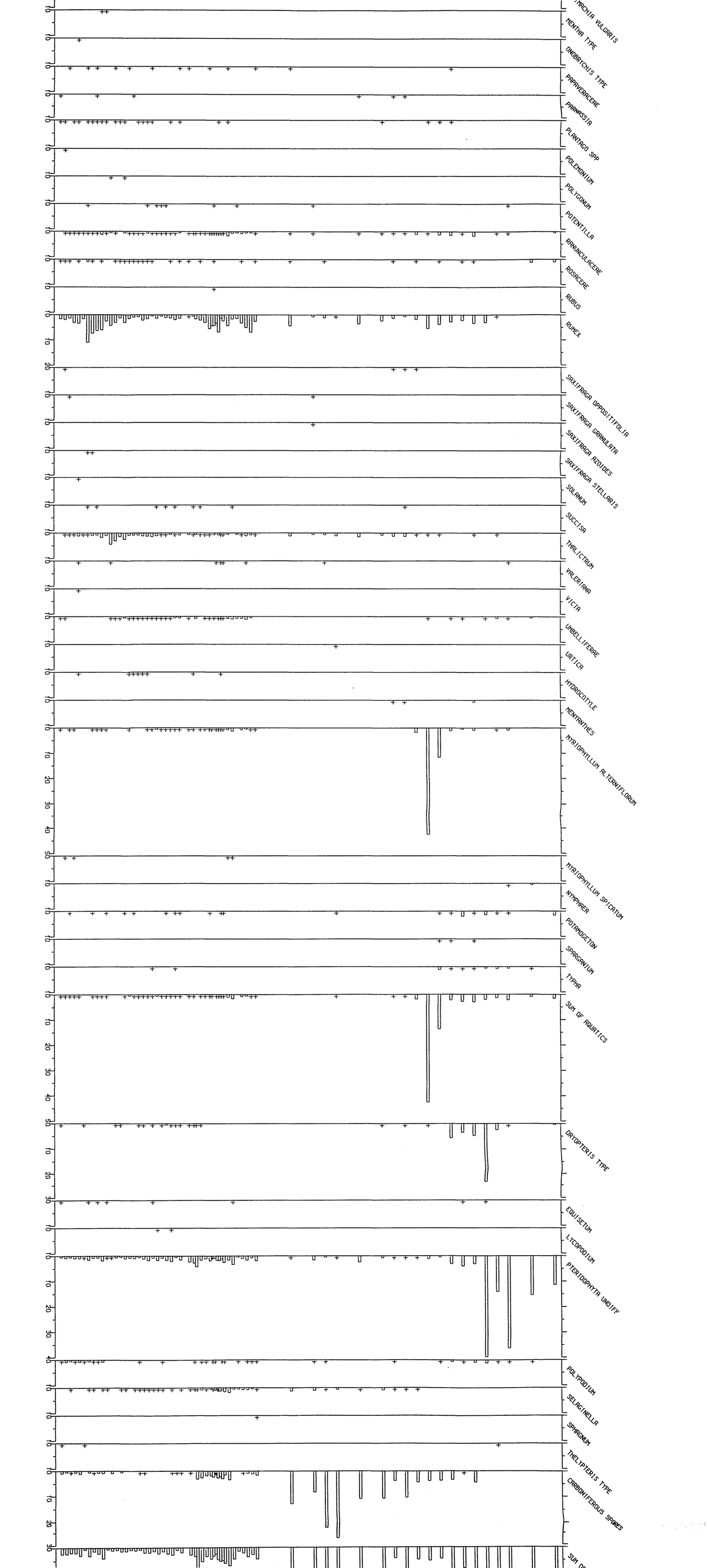
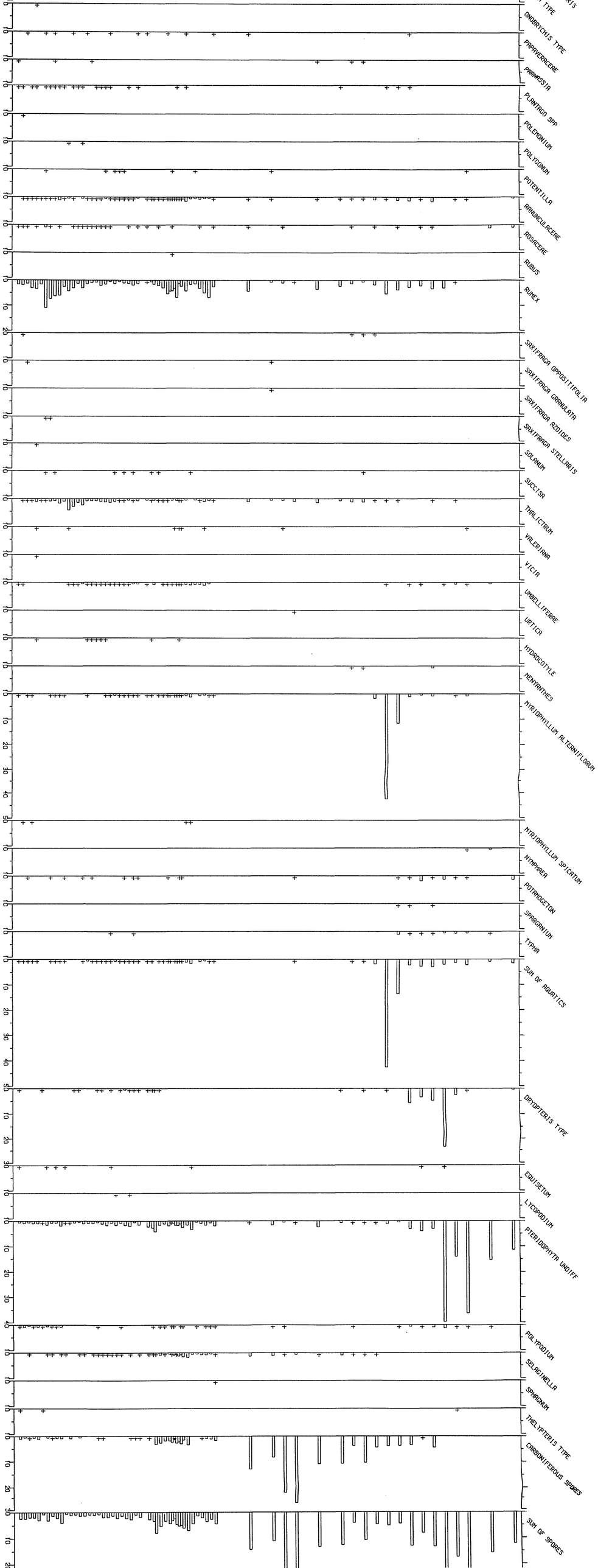

SALIX
SORBUS
JUNIPERUS
ERICACEAE
EMPETRUM
GRAMINEAE
CYPERACEAE
RANUNCULUS ARVENSIS TYPE
ARTEMISIA
ARMERIA
CALTHA
CAMPANULA
CARYOPHYLLACEAE
CHENOPODIACEAE
COMPOSITAE - TUBULIFLORAE
COMPOSITAE - LIGULIFLORAE
CONVOLVULACEAE
CRUCIFERAE
DROSERA
DRYAS
EPILOBIUM
FILIPENDULA
GALIUM
GF GENTIANA
GYPSOPHILA
HELIANTHEMUM
LABIATAE
LEGUMINOSAE
LYSIMACHIA VULGARIS
MENTHA TYPE
ONOBRYCHIS TYPE
PARNASSIA
PLANTAGO SPP
POLEMONIUM


ANCHUSA VULGARIS
MENTHA TYPE
ONOBRYCHIS TYPE
PAPAVERACEAE
PARNASSIA
PLANTAGO SPP
POLEMONIUM
POLYGONUM
POTENTILLA
RANUNCULACEAE
ROSACEAE
RUBUS
RUMEX
SAXIFRAGA OPPOSITIFOLIA
SAXIFRAGA GRANULATA
SAXIFRAGA RIVULARIS
SAXIFRAGA STELLARIS
SOLANUM
SUCCISA
THALICTRUM
VALERIANA
VICIA
UMBELLIFERAE
URTICA
HYDROCOTYLE
MENYANTHES
MYRIOPHYLLUM ALTERNIFLORUM
MYRIOPHYLLUM SPICATUM
NYMPHAEA
POTAMOGETON
SPARGANIUM
TYPHA
SUM OF AQUATICS
DRYOPTERIS TYPE
EQUISETUM
LYCOPODIUM
PTERIDOPHYTA UNDIFF
POLYPODIUM
SELAGINELLA
SPHAGNUM
THELYPTERIS TYPE
CARBONIFEROUS SPORES
SUM OF


ONOBRYCHIS TYPE
PAPAVERACEAE
PAPAVER
PLANTAGO SPP
POLEMONIUM
POLYGONUM
POTENTILLA
RANUNCULACEAE
ROSACEAE
RUBUS
RUMEX
SAXIFRAGA OPPOSITIFOLIA
SAXIFRAGA GRANULATA
SAXIFRAGA AIZOIDES
SAXIFRAGA STELLARIS
SOLANUM
SUCCISA
THALICTRUM
VALERIANA
VICIA
UMBELLIFERAE
URTICA
HYDROCOTYLE
MENYANTHES
MYRIOPHYLLUM ALTERNIFLORUM
MYRIOPHYLLUM SPICATUM
NYMPHAEA
POTAMOGETON
SPARGANIUM
TYPHA
SUM OF AQUATICS
DRYOPTERIS TYPE
EQUISETUM
LYCOPODIUM
PTERIDOPHYTA UNDIFF
POLYPODIUM
SELAGINELLA
SPHAGNUM
THELYPTERIS TYPE
CARBONIFEROUS SPORES
SUM OF SPORES

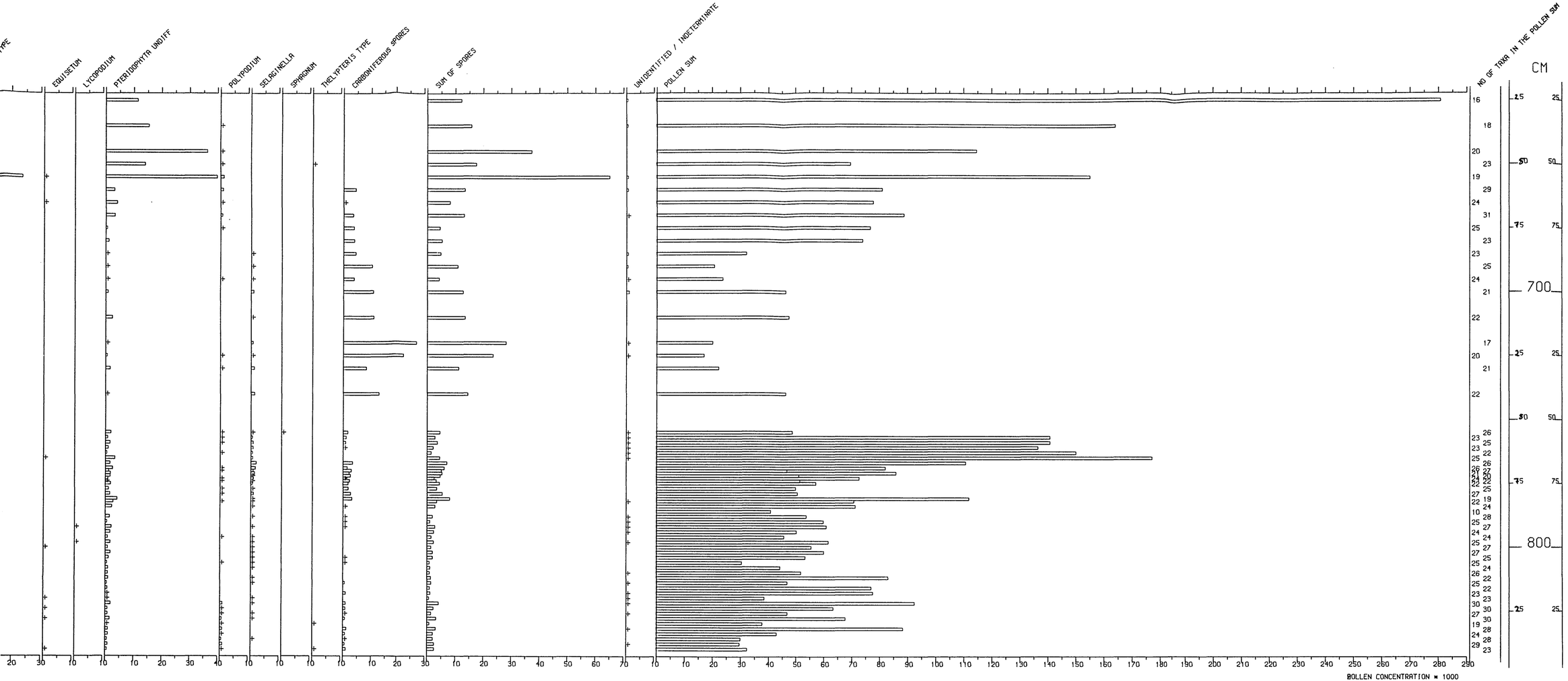
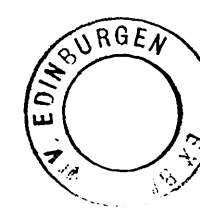
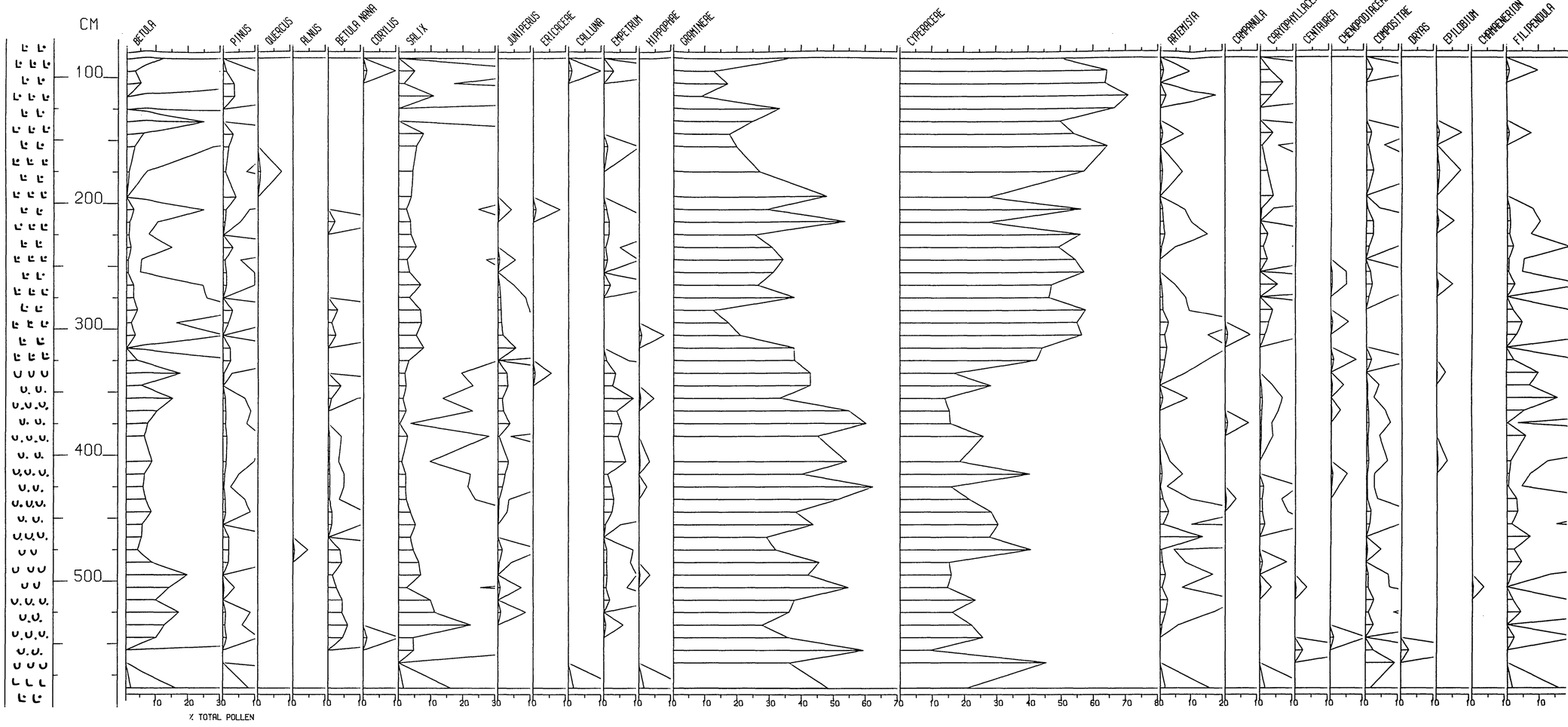
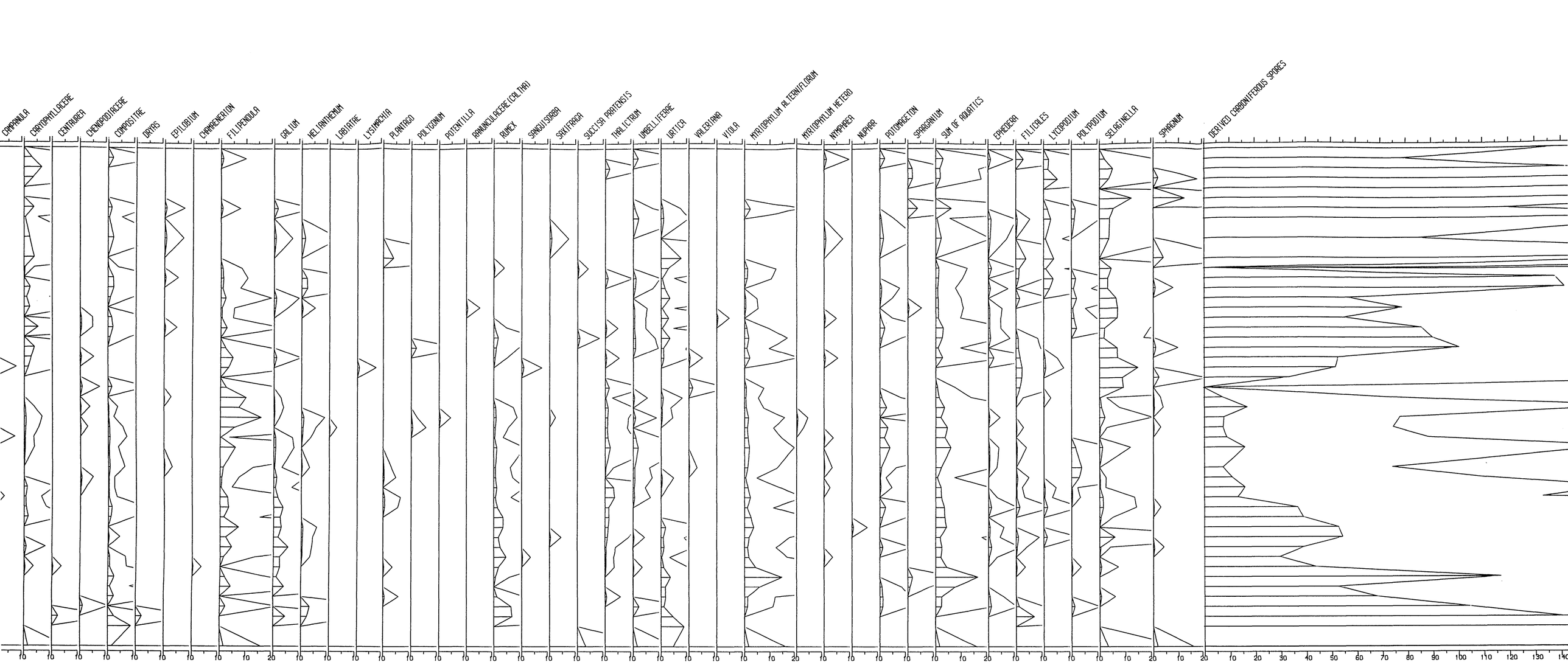

TYPE
EQUISETUM
LYCOPODIUM
PTERIDOPHYTA UNDIFF
POLYPODIUM
SELAGINELLA
SPHAGNUM
THELYPTERIS TYPE
CARBONIFEROUS SPORES
SUM OF SPORES
UNIDENTIFIED / INDETERMINATE
POLLEN SUM
NO OF TAXA IN THE POLLEN SUM
CM
700
800
POLLEN CONCENTRATION * 1000

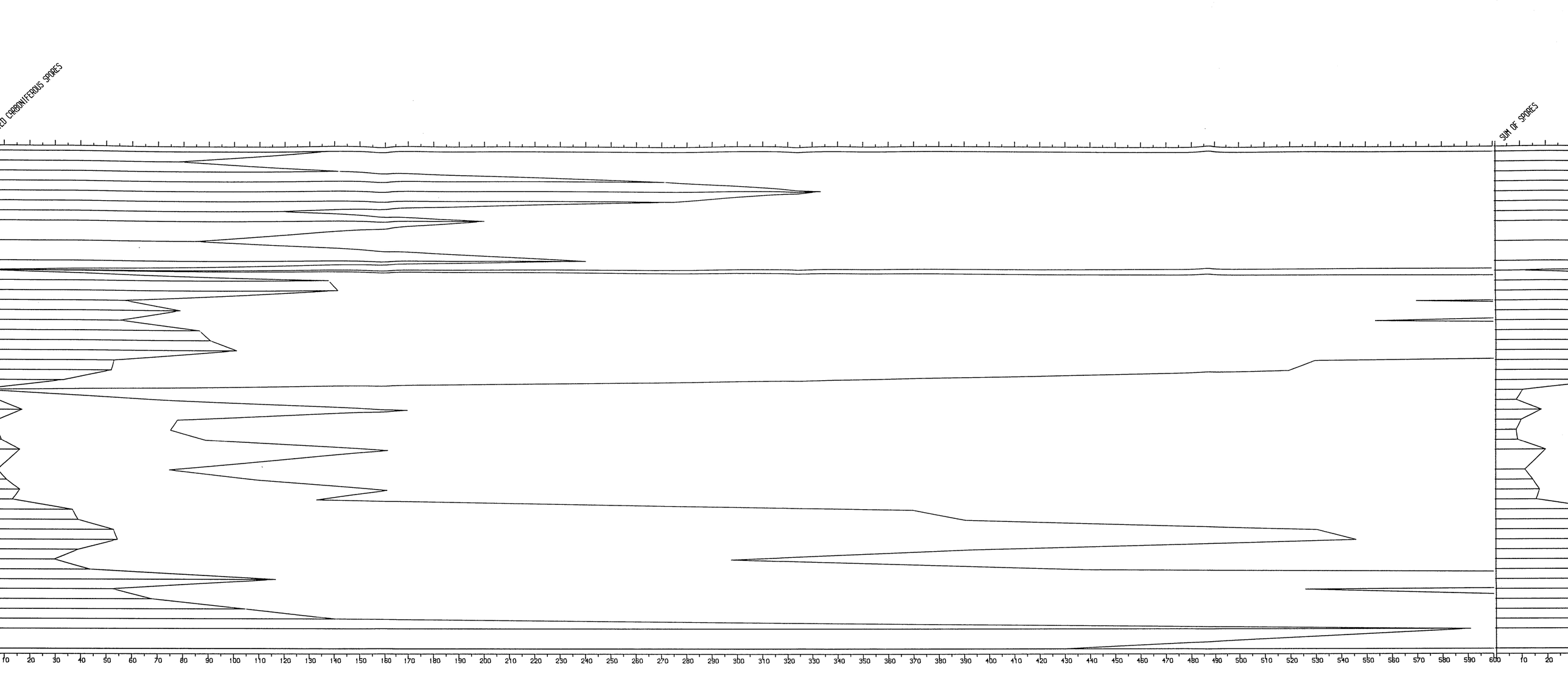
Figure 8.1
Corstorphine site.
Analyst - Dr. Newey
Percentage diagram

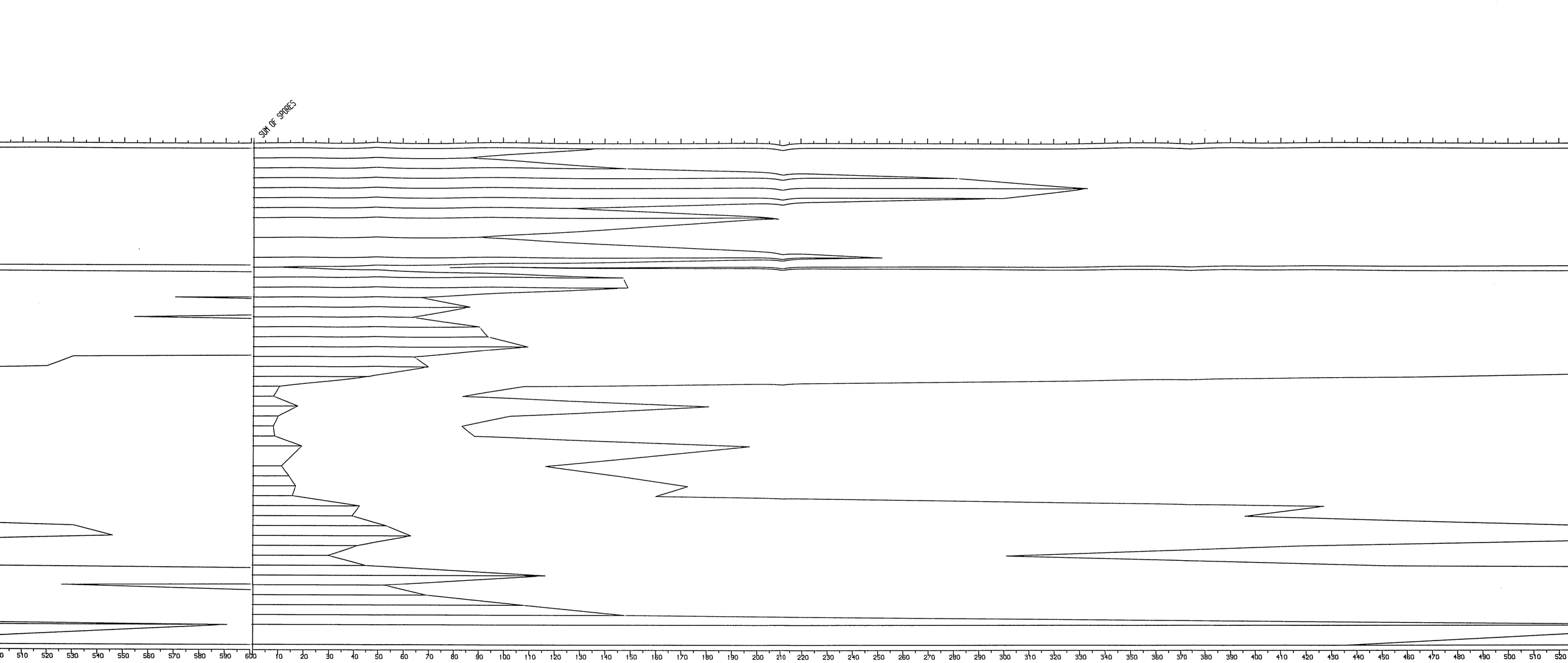


CORSTORPHINE SITE. ANALYSED BY DR. W. W. NEWEY, 1967.




CAMPANULA
CARYOPHYLLACEAE
CENTAUREA
CHENOPODIACEAE
COMPOSITAE
DRYAS
EPILOBIUM
GAMANERION
FILIPENDULA
GALIUM
HELIANTHEMUM
LABIATAE
LYSIMACHIA
PLANTAGO
POLYGONUM
POTENTILLA
RANUNCULACEAE (CALTHA)
RUMEX
SANGUISORBA
SAXIFRAGA
SUCCISA PRATENSIS
THALICTRUM
UMBELLIFERAE
URTICA
VALERIANA
VIOLA
MYRIOPHYLUM ALTERNIFLORUM
MYRIOPHYLUM HETERO
NYMPHAEA
NUPHAR
POTAMOGETON
SPARGANIUM
SUM OF AQUATICS
EPHEDRA
FILICALES
LYCOPODIUM
POLYPODIUM
SELAGINELLA
SPHAGNUM
DERIVED CARBONIFEROUS SPORES
10 10 10 10 10 10 10 10 10 20 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 20 10 20 10 20 10 20 30 40 50 60 70 80 90 100 110 120 130 140


ED CARBONIFEROUS SPORES
SUM OF SPORES
10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200 210 220 230 240 250 260 270 280 290 300 310 320 330 340 350 360 370 380 390 400 410 420 430 440 450 460 470 480 490 500 510 520 530 540 550 560 570 580 590 600
10 20


SUM OF SPORES
0 510 520 530 540 550 560 570 580 590 600 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200 210 220 230 240 250 260 270 280 290 300 310 320 330 340 350 360 370 380 390 400 410 420 430 440 450 460 470 480 490 500 510 520

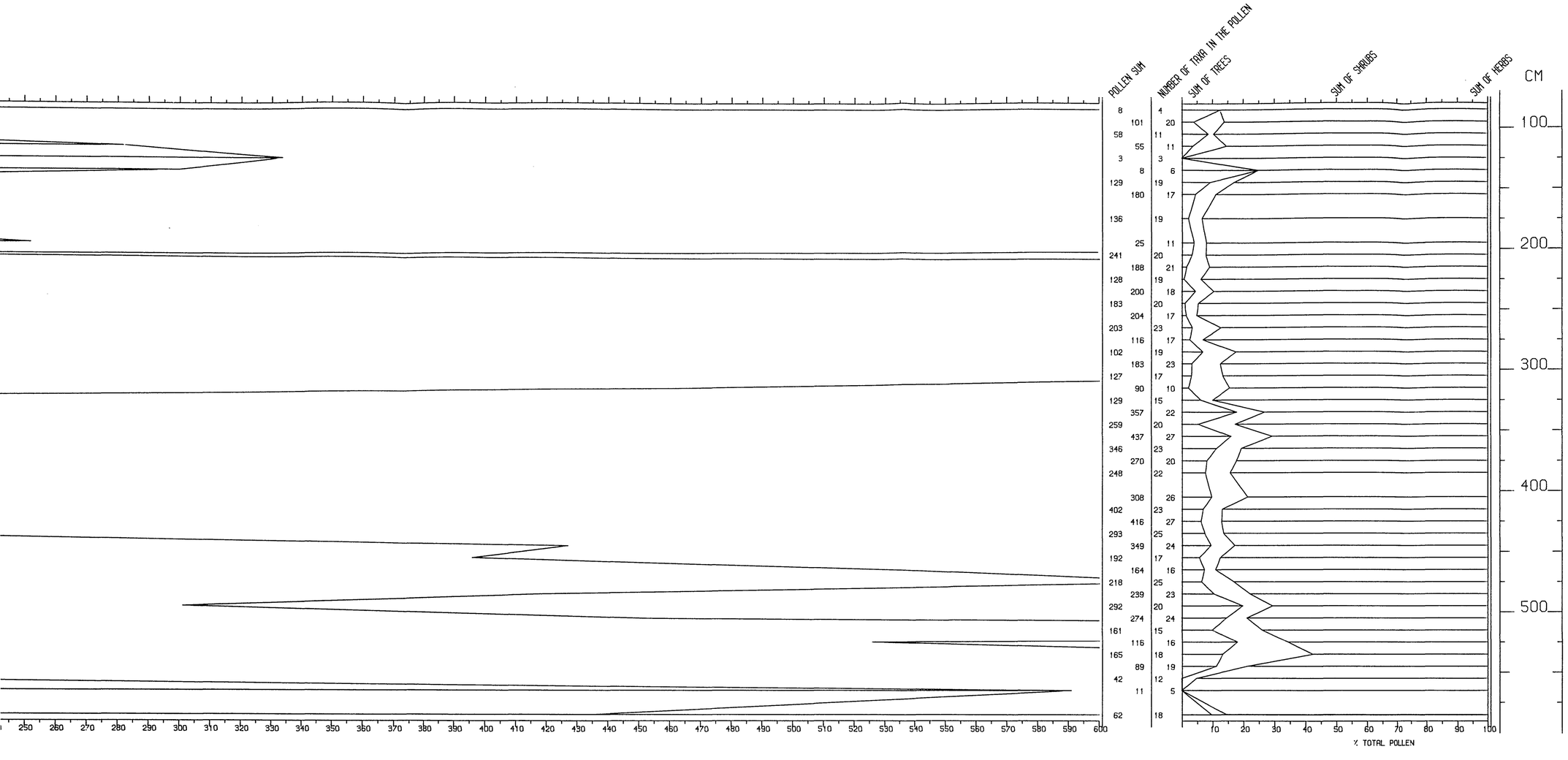
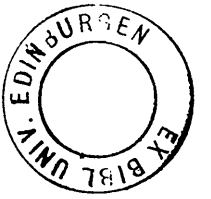
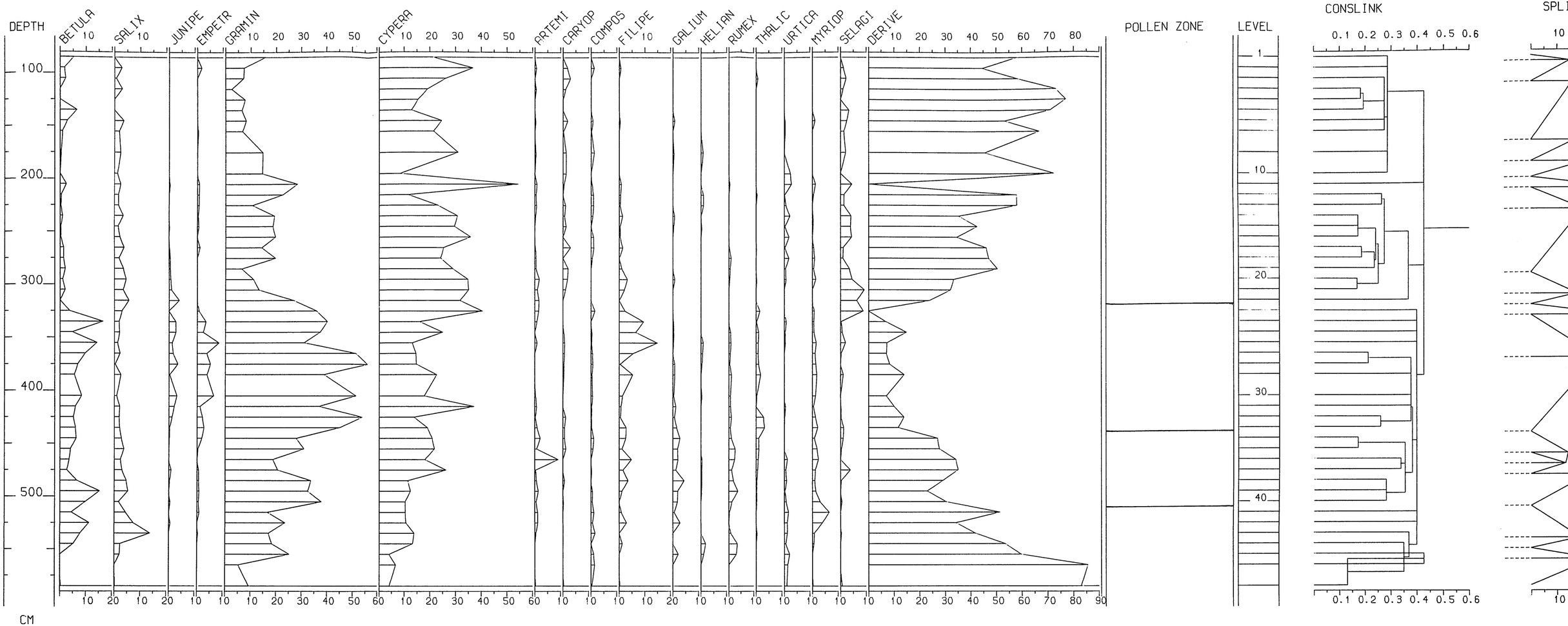

POLLEN SUM
NUMBER OF TAXA IN THE POLLEN
SUM OF TREES
SUM OF SHRUBS
SUM OF HERBS
CM
100
200
300
400
500
% TOTAL POLLEN

Figure 8.2
Corstorphine site.
Analyst - Dr. Newey
ZONATION results.



CORSTORPHINE ZONATION. ANALYSED BY DR. W. W. NEWEY, 1967.



W. NEWEY, 1967.

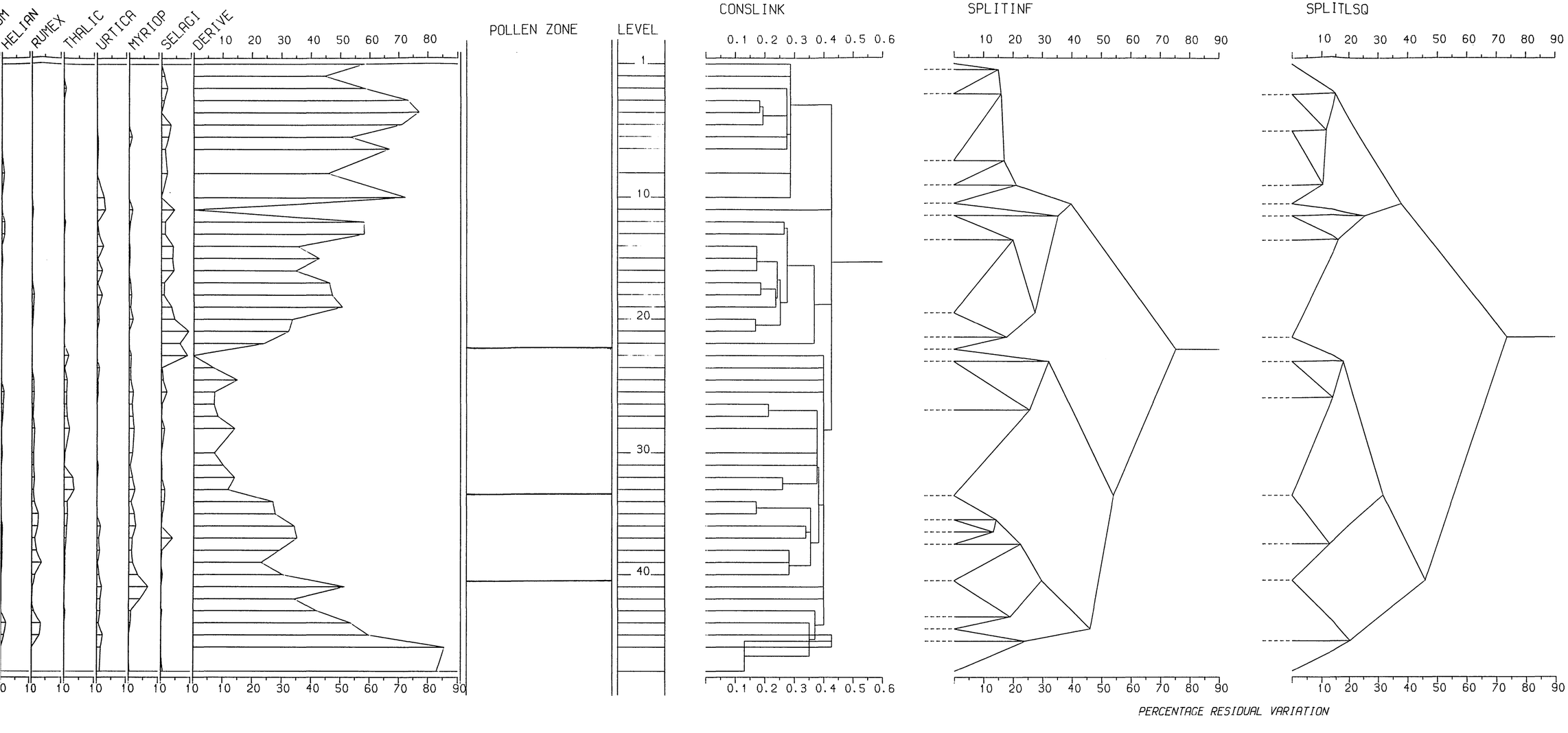
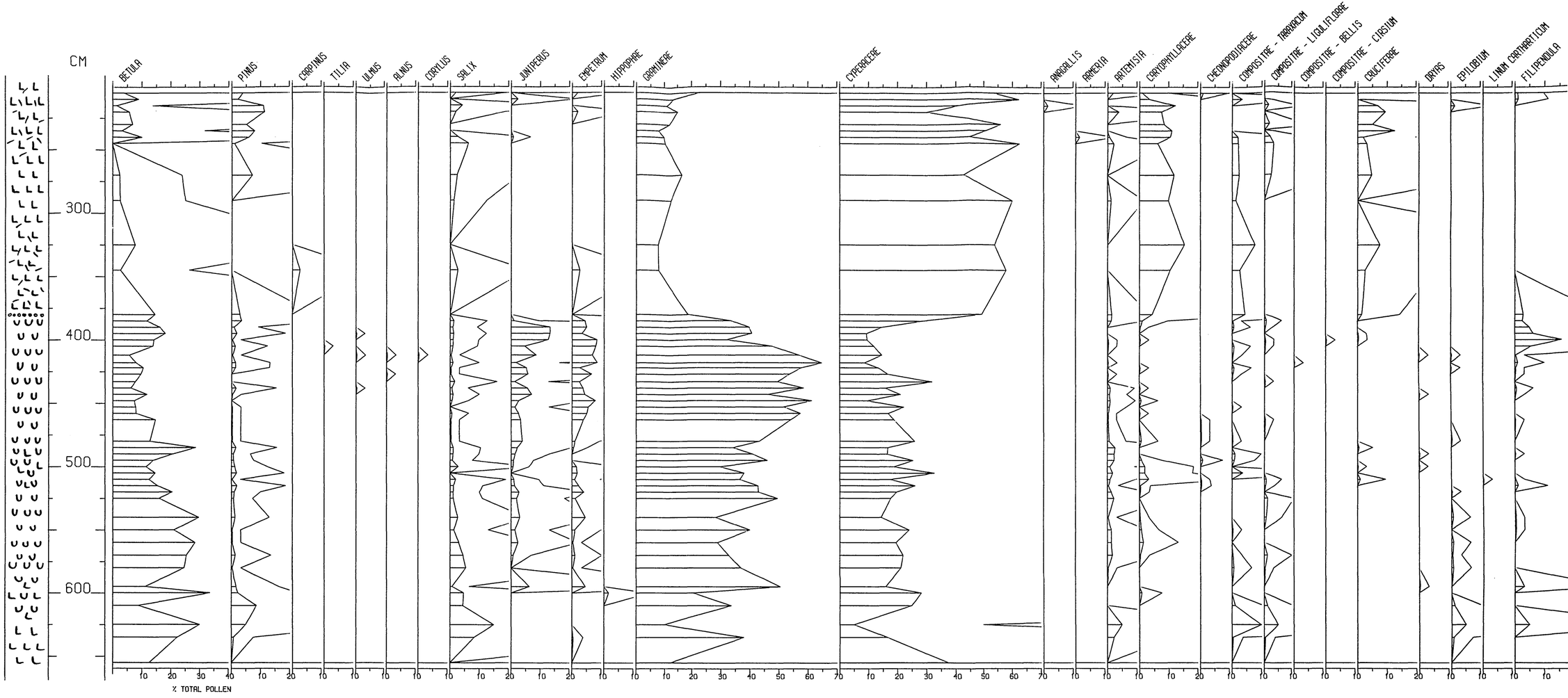
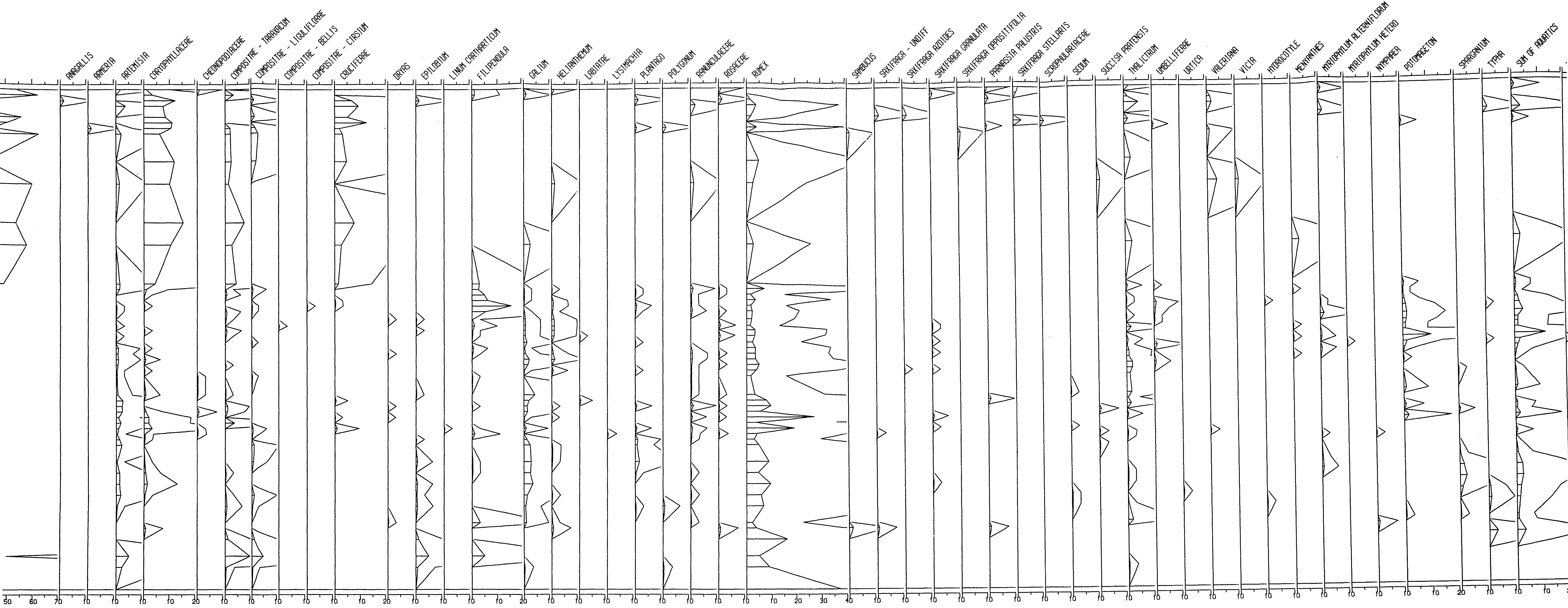

HELIAN
RUMEX
THALIC
URTICA
MYRIOP
SELAGI
DERIVE
POLLEN ZONE
LEVEL
CONSLINK
SPLITINF
SPLITLSQ
PERCENTAGE RESIDUAL VARIATION

Figure 8.5
Corstorphine site.
Analyst - A. Alexander
Percentage diagram

CORSTORPHINE SITE.

ANALYSED BY A J ALEXANDER, 1982/83




ANAGALLIS
ARMERIA
ARTEMISIA
CARYOPHYLLACEAE
CHENOPODIACEAE
COMPOSITAE - TARAXACUM
COMPOSITAE - LIGULIFLORAE
COMPOSITAE - BELLIS
COMPOSITAE - CIRSIUM
CRUCIFERAE
DRYAS
EPILOBIUM
LINUM CARTHARTICUM
FILIPENDULA
GALIUM
HELIANTHEMUM
LABIATAE
LYSIMACHIA
PLANTAGO
POLYGONUM
RANUNCULACEAE
ROSACEAE
RUMEX
SAMBUCUS
SAXIFRAGA - UNDIFF
SAXIFRAGA AIZOIDES
SAXIFRAGA GRANULATA
SAXIFRAGA OPPOSITIFOLIA
PARNASSIA PALUSTRIS
SAXIFRAGA STELLARIS
SCROPHULARIACEAE
SEDUM
SUCCISA PRATENSIS
THALICTRUM
UMBELLIFERAE
URTICA
VALERIANA
VICIA
HYDROCOTYLE
MENYANTHES
MYRIOPHYLLUM ALTERNIFLORUM
MYRIOPHYLLUM HETERO
NYMPHAEA
POTAMOGETON
SPARGANIUM
TYPHA
SUM OF AQUATICS

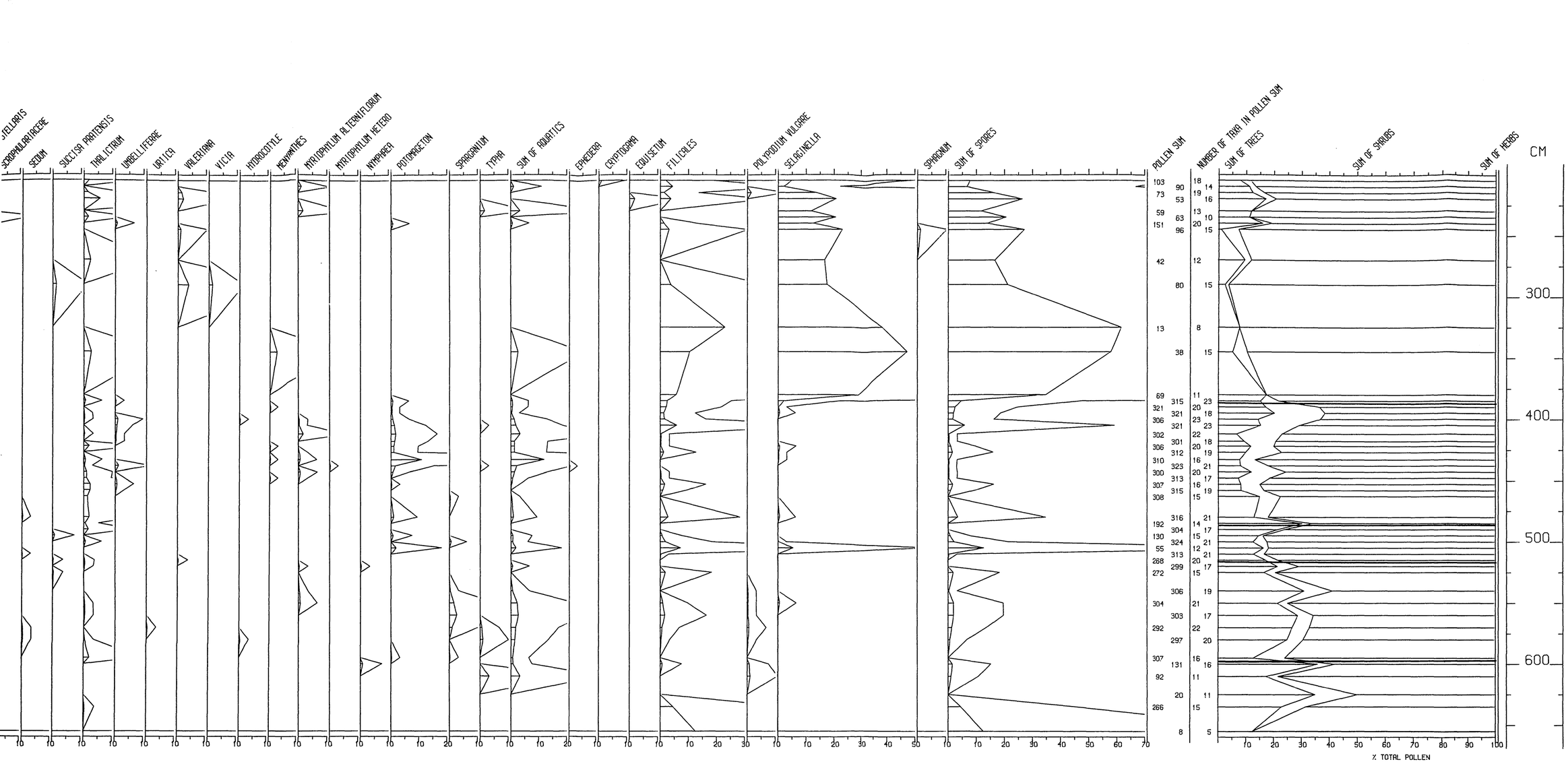
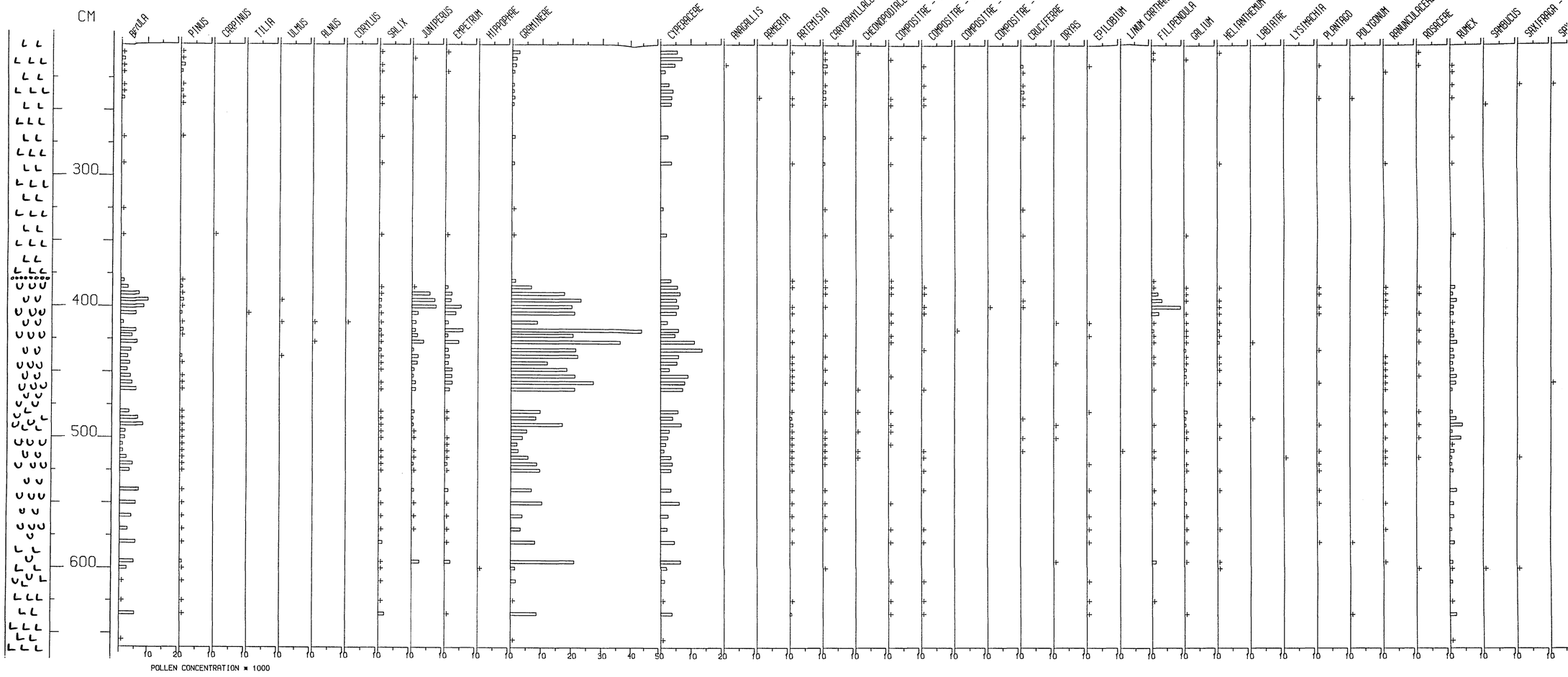

STELLARIS
SCROPHULARIACEAE
SEDUM
SUCCISA PRATENSIS
THALICTRUM
UMBELLIFERAE
URTICA
VALERIANA
VICIA
HYDROCOTYLE
MENYANTHES
MYRIOPHYLUM ALTERNIFLORUM
MYRIOPHYLUM HETERO
NYMPHAEA
POTAMOGETON
SPARGANIUM
TYPHA
SUM OF AQUATICS
EPHEDRA
CRYPTOGAMA
EQUISETUM
FILICALES
POLYPODIUM VULGARE
SELAGINELLA
SPHAGNUM
SUM OF SPORES
POLLEN SUM
NUMBER OF TAXA IN POLLEN SUM
SUM OF TREES
SUM OF SHRUBS
SUM OF HERBS
CM
300
400
500
600
% TOTAL POLLEN

Figure 8.6
Corstorphine site.
Analyst - A. Alexander
Concentration diagram.

CORSTORPHINE SITE. ANALYSED BY A J ALEXANDER, 1982/83

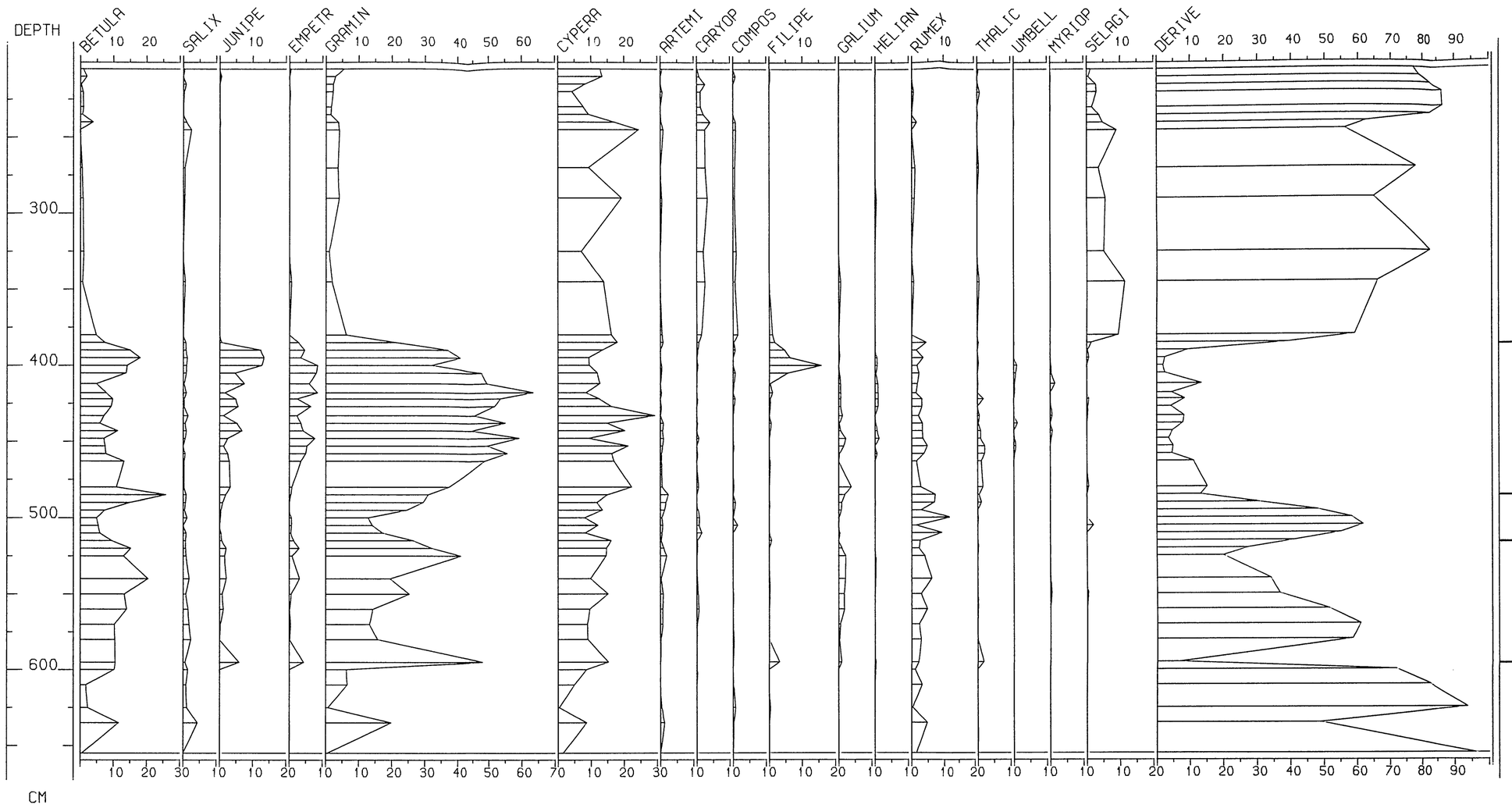


HELIANTHEMUM
LABIATAE
LYSIMACHIA
PLANTAGO
POLYGONUM
RANUNCULACEAE
ROSACEAE
RUMEX
SAMBUCUS
SAXIFRAGA - UNDIFF
SAXIFRAGA AIZOIDES
SAXIFRAGA GRANULATA
SAXIFRAGA OPPOSITIFOLIA
PARNASSIA PALUSTRIS
SAXIFRAGA STELLARIS
SCROPHULARIACEAE
SEDUM
SILICISA PRATENSIS
THALICTRUM
UMBELLIFERAE
URTICA
VALERIANA
VICIA
HYDROCOTYLE
MENTHANTHES
MYRIOPHYLLUM ALTERNIFLORUM
MYRIOPHYLLUM HETERO
NYMPHAEA
POTAMOGETON
SPARGANIUM
TYPHA
SUM OF AQUATICS
EPHEDERA
CRYPTOGRAMA
EQUISETUM
FILICALES
POLYPODIUM VULGARE
SELAGINELLA
SPHAGNUM
SUM OF SPORES
POLLEN SUM
NUMBER OF TREE IN POLLEN SUM
CM
CORE V
CORE IV
CORE III
CORE II
CORE I
300
400
500
600
POLLEN CONCENTRATION * 1000

(19)

Figure 8.8
Corstorphine site.
Analyst - A. Alexander
ZONATION results.

CORSTORPHINE ZONATION. ANALYSED BY A.J. ALEXANDER 1982/83



LEXANDER 1982/83