THE VEGETATIONAL AND ARCHAEOLOGICAL HISTORY OF THE INGLEBOROUGH MASSIF, NORTH YORKSHIRE

Submitted in accordance with the requirements for the degree of Doctor of Philosophy

by

Susan Swales

Department of Plant Sciences
The University of Leeds

September 1987

SUMMARY

The Flandrian vegetational and archaeological history of the Ingleborough Massif was investigated using pollen and macrofossil analysis of peat deposits in conjunction with radiocarbon dating.

A transect was taken across the massif, running north-west to south-east, and peat deposits were sampled at intervals, as close to the transect as possible. This was to give a range of altitude and peat types, as well as sites both near to and far from limestone and known archaeological remains.

Pollen influx (produced by means of an exotic marker grain method) and percentage pollen diagrams were produced for five peat profiles while percentage diagrams only were produced for a further six.

The earliest peat formed in the Arks corrie c. 9240 ± 100 BP and revealed an open countryside with some birch and juniper bushes. *Corylus* migrated into the area and formed a major component of the vegetation near the Arks c. 8730 ± 80 BP. After the arrival of *Quercus* and *Ulmus* trees, *Alnus* appeared in the area c. 7450 ± 80 BP but did not reach high numbers until 6400 ± 70 BP.

Some evidence of possible early Mesolithic activity during this period was found. Small-scale and short-lived clearance of the mixed-oak woodland began c. 5700 BP, due to the activities of either Late Mesolithic or Early Neolithic peoples. A distinctive and long-term clearance phase (lasting c. 500-700 years) took place in the Early Neolithic Period, characterised by high percentages of *Rumex acetosa/acetosella* type pollen with smaller percentages of other ruderal pollen types and occasional cereal grains. The evidence points to both pastoral and arable farming being practised on the well-drained Carboniferous Limestone soils.

After a short tree recovery, widespread clearance was renewed on the massif in the Early Bronze Age, with *Plantago lanceolata* and *Pteridium* the most abundant indicator grains. Extensive areas of the massif were covered by spreading blanket bog in this period.

All peat profiles have been truncated, three end with the Late Bronze Age; the others continue until the Iron Age on end of the Romano-British Period, at which time the massif was almost cleared of woodland. Regrowth occurred at the beginning of the Norman Period, at least at one site. Severe erosion has taken place over the whole of the massif. There is evidence at the Arks site of a "bog-burst" or "gill-brack" having taken place.

CONTENTS

FIGURES, PLATES, TABLES and DIAGRAMS

Diagrams and figures enclosed in pocket

ABBREVIATIONS AND DEFINITIONS

NGR	-	National Grid Reference
MSL	-	Altitude in metres above Mean Sea Level at Newlyn
w/v	-	weight per volume
TLP	-	Total Land Pollen
AP	-	Arboreal Pollen
SP	-	Shrub Pollen
NAP	-	Non-Arboreal Pollen
Ing.	-	Ingleborough
ING	-	Chronozone for Ingleborough
yr	-	year
BP	-	uncalibrated, radiocarbon years before present (1950)
BC	-	uncalibrated, radiocarbon years before Christ
AD	-	calender years Anno Domini
ad	-	uncalibrated, radiocarbon years Anno Domini
OSAN	-	Ordinance Survey Antiquities Number
Ruderal	-	here used (as in Simmons & Innes, 1981) to denote herbs considered to be colonisers of waste or freshly-cleared ground
monocot remains	-	remains of monocotyledonous plants, otherwise unidentified
carr	-	any area of wet/damp woodland
Empirical limit/rise	-	the point at which pollen of the species first becomes consistently present, i.e. for a number of consecutive samples (Smith & Pilcher, 1973)
Rational limit/rise	-	the point at which the pollen curve begins to rise to sustained high values (Smith & Pilcher, 1973).

All latin names of plants have been taken from the Flora of the British Isles, Second Edition, by Clapham et al., 1962.

ACKNOWLEDGEMENTS

I am indebted to Dr. David Bartley for his supervision of this work, for his invaluable advice, guidance and patience, also the Department of Plant Sciences, University of Leeds, for use of research facilities.

I am grateful to Mr. Alan King for supplying information on the archaeology of the Ingleborough Massif and for providing peat samples from his hut circle excavation. I would also like to thank the North Yorkshire County Council, Archaeology Department and the Department of Archaeology, University of Leeds, for allowing me access to maps and Ordinance Survey record cards. Thanks also to Paul Field for preparing wood samples.

As well as Dr. Bartley, many other people were kind enough to brave the elements and help with peat boring expeditions. Grateful thanks to Paul Field, Chris Smith, Joy Bannister, Russell Parry, Allan Hiscutt, Adrian Bavage, Jeff Keen and David Hackett.

Many thanks are due to Joy whose good company made long hours of pollen-counting bearable. I would also like to thank Dr. Winifred Dickinson for her invaluable discussion and advice.

I would like to thank Monica Hale for encouraging and accommodating the writing of this thesis during my employment on the Urban Spaces Scheme.

I am grateful to Susan Leith for her typing of this thesis and copious cups of tea and finally, special thanks to Rus for his company and patience throughout.

Financial support for this work was provided by an award from the Science and Engineering Research Council, and radiocarbon dates were paid for by the Natural Environmental Research Council, and this is gratefully acknowledged.

For Mum and Dad

Plate 1

Ingleborough Hill above the limestone pavement of Southerscales Scars.

1. INTRODUCTION

The Ingleborough Massif, situated in the Yorkshire Dales National Park (NGR, SD 77), is roughly triangular and covers approximately 65km^2. It is bounded to the north-west by the B6255, Ingleton to Hawes Road, to the north-east by the River Ribble and to the south by the Old Road (Ingleton to Clapham) (fig. 1.1). The sides of the massif rise steeply and then flatten out at 350-390m above Mean Sea Level (MSL). Above the plateau rises the ridge consisting of Ingleborough Hill (723m MSL), Simon Fell (640m MSL) and Park Fell (564m MSL), extending south-west to north-east.

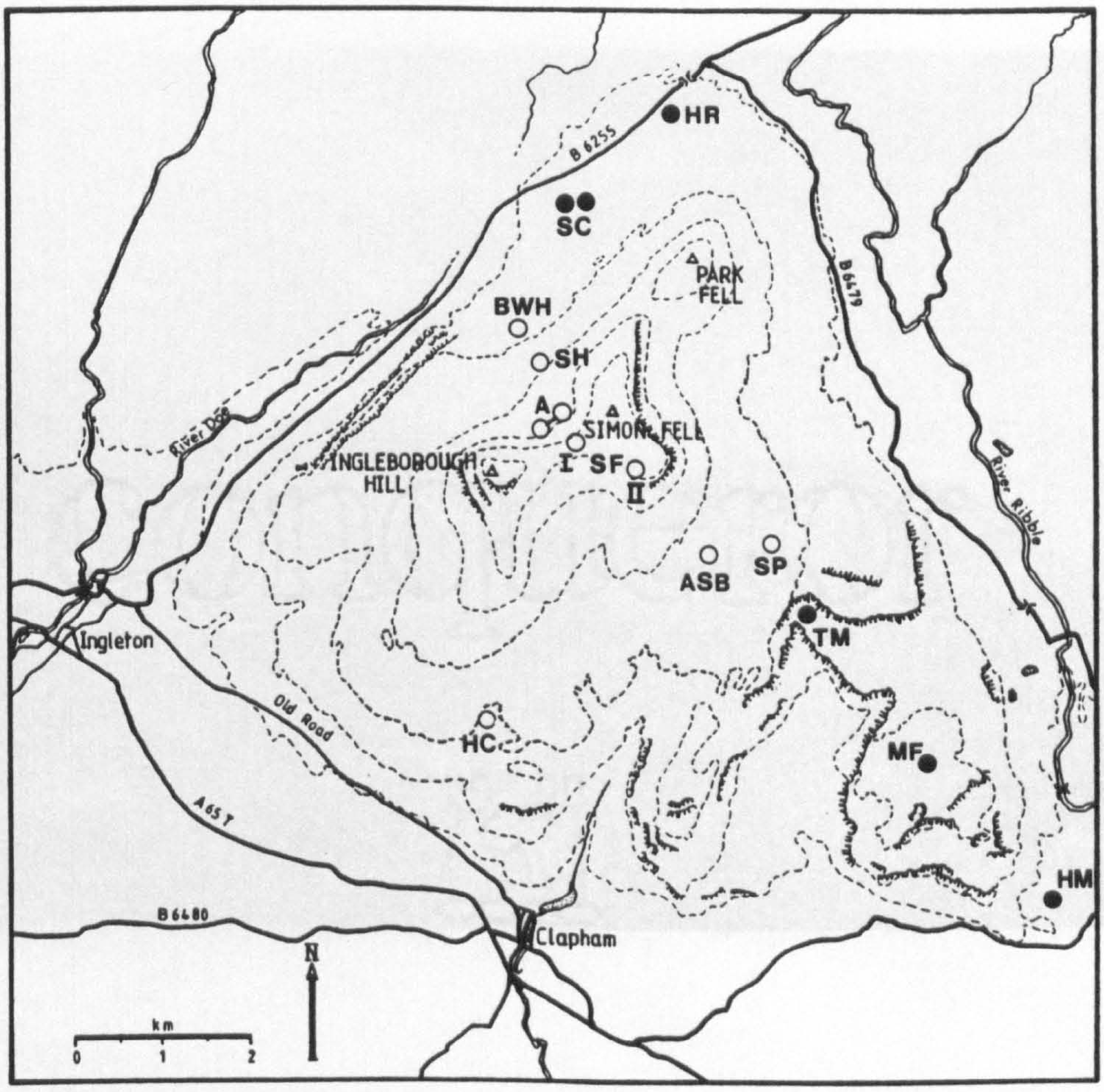
The aim of this investigation was to study the Flandrian vegetational and archaeological history of the massif by carrying out pollen and macrofossil analysis of the peat deposits in conjunction with radiocarbon dating. From the results a broad ecological setting is proposed against which the archaeological remains may be viewed. The nature of the vegetational changes to a certain extent give an insight into the ways man has utilised the land throughout the prehistoric and historic periods.

The Ingleborough Massif is a particularly interesting area to study because of its diverse topography, geology, vegetation and archaeology. Large areas of limestone plateau and most of the hillslopes are covered by peat deposits of various types, and so material is readily available for this kind of investigation.

1.1. Geology

The geological succession forming the massif is shown in fig. 1.2.

Figure 1.1. Map of the Ingleborough Massif showing the location of the transect and sampling sites.



Author's sites

BWH - Braithwaite Wife Hole

SH - Sunset Hole

A - Arks

SF - Simon Fell

ASB - Allotment Shooting Box

SP - Sulber Pot

Gosden, 1965

HR - Howrake Rocks

SC - Scar Close

TM - Thieves Moss

MF - Moughton Fell

HM - Helwith Moss

HC - Hut Circle

Plate 2

Ingleborough Massif from the north-east showing Park Fell (left), Simon Fell (centre) and Ingleborough Hill (right).

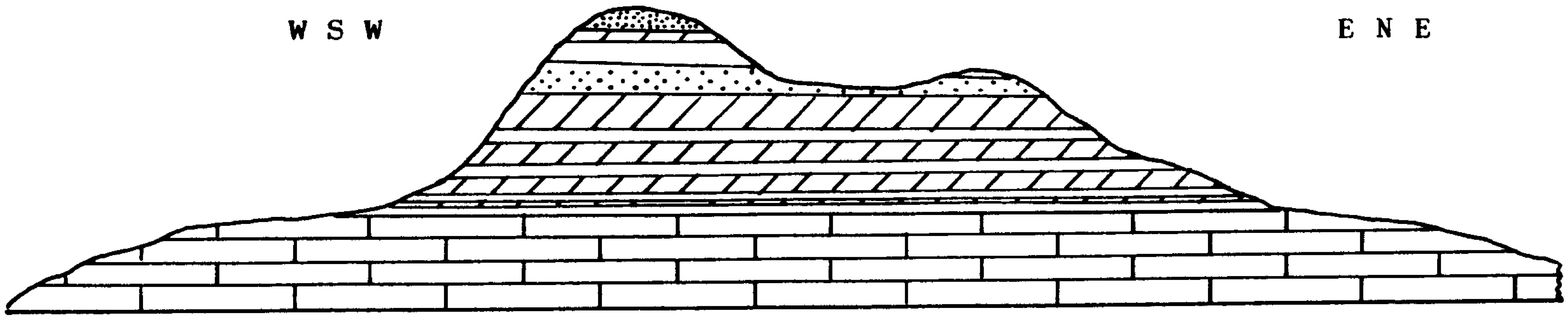
1.1.1. Pre-Glacial

The Ingletonian series consist of greywackes and sub-greywackes strongly folded by a Precambrian orogeny. These rocks are welded together to form a rigid basement called the Askrigg Block, bounded on the south and west by the Craven and Dent fault systems.

Ordovician and Silurian rocks are only present as inliers in the valleys on the southern side of Ingleborough.

Carboniferous rocks dominate the landscape of the area. These strata lie uncomformably on the Ingletonian series and are unfolded but show a gentle tilt of 3-5^{o} to the north-north-east. The Great Scar Limestone bed is 152-183m thick, and the upper eroded surface forms the plateau of the massif. The ridge rising above the plateau is formed from the Yoredale Series. This is the product of rhythmic or cyclic sedimentation and is divided into units, each consisting of a limestone bed overlain by shale, sandstone and then coal. The differential weathering of these strata has given rise to the terraced slopes of Ingleborough. Finally the Yoredale Series is capped by Millstone Grit forming the summit of Ingleborough Hill.

During the Tertiary Period prolonged erosion took place. The summit of Ingleborough and those of the surrounding hills, Whernside, Pen-y-ghent etc. appear to represent an ancient erosion surface at just over 610 m. At present the few tributaries reaching the main rivers from the massif do so over pre-Carboniferous rocks. Dry valleys show that in the past, water flowed over the limestone, indicating a high water-table which has since fallen. (Sweeting, 1950; O'Connor, 1964; Dunham, et al., 1953; Dakyns, et al., 1890.)



limestone

sandstone & shales

Ingletonian series

CARBONIFEROUS

Coal Measures
Millstone Grit
Yoredale Beds
Great Scar Limestone
UNCONFORMITY

SILURIAN

UNCONFORMITY

ORDOVICIAN

UNCONFORMITY

PRECAMBRIAN

Ingletonian Series

Figure 1.2. Diagram showing the geological succession forming the Ingleborough Massif

1.1.2. Glacial

The effects of only one major glaciation can be seen in the Yorkshire Dales. The remnants of deposits from any earlier glaciations appear to have been incorporated into those of the latest, to the extent that they are no longer distinguishable (Raistrick, 1931).

Glacial drift and erratics on the massif consist entirely of local material. Evidence from drumlins, striations and other glacially derived features point to the local development of an ice-mass with its centre of dispersion lying immediately south of Dodd Fell to the north of Ingleborough. From the orientation of these features around Ribblehead the ice appears to have travelled south-south-west. Glaciers travelled south-south-east down Ribblesdale, south-west between Whernside and Ingleborough and south through Crummockdale. Drifts extend up to 610m on Ingleborough and striated surfaces up to 427m on the east side of the mountain. It is possible that the summit of Ingleborough Hill was left ice-free as a nunatak.

The retreat of the valley glaciers left a series of frontal moraines, some of which obstructed drainage forming temporary lakes which filled with clay and silt. Large areas of the massif are now covered by drift and erratics can be seen on many of the limestone pavements.

Manley (1959) suggests that the north face of Ingleborough, in what is now known as The Arks, bore a corrie glacier, as late as the Younger Dryas period (c. 11000 - 10300 BP). He suggests that may have been the southernmost outlier of the post-Allerød glaciation in N. W. England.

1.1.3. Post-Glacial

Large areas of the ground surface of the massif are pock-marked by small cone-shaped depressions or "shake holes". These features are generally found in lines following the outcrop of each Yordale Limestone and on the Great Scar Limestone where there is a cover of glacial drift. These appear to be subsidence cones, formed where runoff from impervious strata above meets the pervious limestone. The water and drift are washed downwards through an open joint in the limestone. The frequency of the shake holes increases rapidly up to an overburden thickness of 1.8 to 2.5m beyond which there is a steady decline in frequency. At 9.0 to 12.2m of overburden they are rare and very large, a good example being Braithwaite Wife Hole (Clayton, 1966).

Small pot-holes may develop (10-20m deep) where wider joints underlie the boulder clay. The major pot-holes, e.g. Gaping Gill and Alum Pot are pre-glacial in origin.

One of the most distinctive features of the Ingleborough landscape is the presence of large areas of limestone pavements formed on the eroded surface of the plateau. The processes shaping the pavements probably began in Pre-Glacial times. Water percolating down through the soil etched the surface of the limestone, dissolving the calcium carbonate and enlarging the joints and bedding partings. Eventually all excess rainfall can be drained away, halting surface runoff. Enlarged openings in the bedrock undermine the stability of the soil/vegetation systems above. If the process continues the overburden is washed underground leaving the bare limestone clints. If the soil is deeper than the plant root zone, the surface vegetation and soils are somewhat insulated from the processes below (Drew, 1982).

Estimates as to the depth of limestone, lost by solution since the last glaciation, have been made. Measurements of the limestone pedestals beneath the Norber erratics and estimates of the rates of chemical erosion for rivers in the area both suggest a figure of 40 to 50cm (Sweeting, 1964 & 1965; Clayton, 1966).

The limestone pavements are still being denuded of vegetation. Because of the inherent instability of the soil and vegetation lying on developing pavement, it seems likely that any stress brought to bear on the system, whether man-made or otherwise, can only have served to accelerate the process.

1.2. Climate

The climate of the Ingleborough massif can be generally described as prevailingly windy, humid and cloudy. Winds are mainly westerly or south-westerly. The upland windspeed at Malham Tarn (395m MSL, 16km due south-east of Ingleborough) is on average 1.5 x that of most lowland stations. This means that for the vegetation, local shelter assumes a greater importance (Manley, 1956).

Rainfall on the limestone uplands is high, as shown in the following table:

Table 1.1. Average annual rainfall for the Craven Area

STATION	NATIONAL GRID REF.	ALTITUDE	AVERAGE ANNUAL RAINFALL
Ribblehead (Station)	SD 766 789	312m	2.00m
Settle (Malham Tarn)	SD 893 672	395m	1.53m
Settle (Great Bridge)	SD 702 589	252m	1.85m

(after Gosden, 1965).

At Malham Tarn the rain fell in measurable amounts on 220 days of the year. The potential evapotranspiration rate is 500mm (Bullock, 1971), hence a very high precipitation/evapotranspiration rate occurs in this area. On average, snow and sleet are recorded on 47 days per year.

On the main limestone plateau the mean annual temperature range is 11.6°C (13.3°C July, 1.7°C January) (Bullock, 1971). Temperatures at 0°C or below ("air frost") at Malham Tarn could be expected on about 90 days of the year. There is a relatively rapid daytime fall in temperature with altitude - a lapse rate of about 2.8°C/305m. Generally in the north of Britain the lapse rate is about 2.2°C/305m.

A further climatic factor is atmospheric pollution. Such pollution, in the form of acid rain, increases weathering potential and lowers the pH of the soils. This, however, will have only been important over the past 200 years.

1.3. Soils and vegetation

The soils of the Ingleborough Massif can be classified into five major groups: calcareous soils (rendzinas), brown earths, podsolised soils, gley soils and organic soils. Most of the soils are acidic because the high precipitation/evapotranspiration ratio ensures intense leaching of bases, not replenished by weathering. Base-rich rendzinas are only found in soils of less than 30cm depth, over pavement clints or on stable limestone screes. Base-rich soils are also found over the Yordale limestone beds and downslope from such outcrops where there is a continual supply of bases in the runoff (Bullock, 1971).

The pavements support a great variety of species. The grykes are colonised by shade or woodland plants such as *Phyllitis scolopendrium*, *Asplenium* spp, *Mercurialis perennis*, *Sanicula europaea* and *Actaea spicata*.

The clints are often bare or colonised only by crustose lichens because of the degree of exposure and water stress. However, herbaceous species do colonise small depressions on their surface if soil has collected there. Some of the pavements bear tree species to a greater or lesser extent, the best example on the massif being Colt Park Wood. It is thought that these communities represent a relict woodland, the main species being Fraxinus excelsior, Sorbus aucuparia and Prunus padus. Larch has been planted on some pavements, e.g. Howrake Rocks. A rich bryophyte flora grows in the shelter provided by the trees. Woodland is rare on the massif but occurs on all rock types. These patches are small and are either plantations or are heavily affected by felling or grazing.

On increasing depth of soil away from the limestone there is a rapid decrease in soil pH and the rendzinas grade into eutrophic brown-earths, oligotrophic brown-earths and peaty gleyed podsols. Wide shallow depressions in the limestone, often drift-filled, bear a species-rich calcareous grassland dominated by Festuca ovina or Sesleria caerulea. As the soil gets deeper these grasslands quickly grade into acidic grasslands where the main cover-formers are Nardus stricta, Juncus squarrosus, Festuca ovina, Molinia caerulea and Polytrichum commune. With increasing wetness the Nardus stricta and Juncus squarrosus communities tend to grade into Molinia grassland or blanket bog. As grazing pressure becomes greater Polytrichum commune increases and may become dominant. On the summit of Ingleborough and on the upper terraces between exposures of gritstone a heavily-grazed, Festuca ovina-dominated grassland occurs. Generally the acid grasslands grade into heath and blanket bog communities.

Various types of blanket bog form communities over extensive areas of the massif, both on the drift and also on the limestone at lower altitudes. Grazing is strongly influential in determining the type of bog present. Sheep are the main grazers although cattle are becoming more important now that extensive drainage schemes are being carried out. Calluna vulgaris and Eriophorum angustifolium tend to be differentially removed by grazing whereas others such as Polytrichum commune and Galium saxatile are encouraged. An increase in the basicity allows a floristically richer community to grow with Drosera rotundifolia, Vaccinium oxycoccos and Narthecium ossifragum etc. When better drainage is present, Molinia caerulea becomes important. In drier and shallower areas Calluna or Empetrum-dominated heaths may occur, but heaths are not generally extensive on Ingleborough.

On the higher slopes of Ingleborough, particularly the summits of Simon Fell and Park Fell, are deep peat deposits, dominated by Eriophorum communities and deeply dissected into haggs. The channels often reach the basal drift.

On the plateau and lower slopes of the south-east corner of the massif, half-buried limestone pavement supporting calcareous grassland, together with mounds of peat dominated by Nardus stricta and Calluna vulgaris, can be seen. Peat can also be found lying directly on limestone pavement, often as isolated "islands" across clints.

There are several other interesting and unusual communities to be found in the area. On Moughton there is a juniper-rich community which is a rare type of natural scrub. The juniper bushes are widely spaced but clumps do occur, and there is a closed ground layer, mainly of bryophytes beneath each bush. Vaccinium myrtillus and Calluna vulgaris are frequent and the rare species Listera cordata is also present. There are records of this vegetation being more widespread on the massif in the past (Cheetham, 1947).

On the cliffs and crags of Ingleborough where grazing animals cannot reach, a sub-alpine flora can be found. Arctic-alpine species present include *Saxifraga oppositifolia*, *S. hypnoides*, *Saussurea alpina* and *Poa alpina*.

A more detailed account of the local bog communities at each sampling site is given in the following site descriptions.

1.4. Archaeology

The archaeology of the Ingleborough massif and the landscape of the Great Scar Limestone in general poses particular problems as far as interpretation and dating are concerned. Prehistoric man seems to have preferred to settle on the limestone because of the well-drained pasture it provided. This has led to centuries of archaeological remains being condensed into a few centimetres of soil, or else lying directly on bare limestone.

Artefacts tend to be poorly preserved because of the heavy rainfall, extended frosts, extremely porous ground and its alkalinity. Most of the people who lived on these highlands were poor, with few possessions. It is usually not possible to make a clear-cut separation between different periods of occupation. In the Highland Zone old populations tended to absorb or mix with newcomers. The inhabitants were restricted to the same basic material of limestone boulders and by the same topography of small scars and hollows, so that similar structures were built over a long period (Raistrick, 1962).

Evidence (section 10.) has been found suggesting that man has been present on the massif since Palaeolithic times (c. 10,000 BC). The caves and slopes of the limestone have yielded artefacts assigned to the Palaeolithic, Mesolithic, Neolithic and Bronze Age

Periods, but in small numbers. Flint of some form is the most common find in all sites, to the end of the Iron Age. Flint is a useful indicator of human presence because the nearest flint-bearing chalk lies across the Vale of York. The frequency of flint and chert in Bronze Age and Iron Age sites, and the rarity of metal objects confirms the impression that these people were living in relative poverty and harsh conditions when compared with their contemporaries in Lowland Britain.

By far the most abundant archaeological remains have been assigned to the Iron Age and Romano-British Periods. The outlines of farmsteads, villages, droveways and field systems together with that of the hillfort on the summit of Ingleborough, can clearly be seen today.

In the Medieval Period the monasteries developed sheep farming on the uplands and the massif is still heavily grazed by sheep and cattle today. The present human population of the massif is very sparse, limited to a few farms near the roadsides.

A detailed description of the archaeological remains is provided in section 10.

1.5. Palaeoecological investigations already carried out in the area

Pollen analytical work has previously been carried out on the massif by Gosden (1965 and 1968) whose main aim was to investigate the karstic features of the plateau from the botanical point of view. The study centred on Scar Close (fig. 1.1), a section of limestone pavement with well-developed clints and grykes, and Scar Close Moss, an adjacent area of glacial drift lying on the limestone shelf, bearing a more or less continuous sheet of wet acid bog. On the exposed pavement there are isolated patches of peat in direct contact with the limestone. The aim of the work was to shed some light on the origins of these peat "islands". The two suggestions put forward were that they were either relics of a once continuous peat cover or else developed independently from a number of centres and are still advancing. Two transects were laid out, crossing from the Moss on to the pavement and four monoliths were dug at intervals from each transect. Additional monoliths for comparison were taken from peat profiles on pavements at Moughton and Howrake Rocks (fig.1.1 and Gosden, 1965). Gosden found that the "islands" of Scar Close and the peat of Scar Close Moss were synchronous and recent, belonging to Godwins Zone VIIb/VIII or the Sub-Boreal to Sub-Atlantic periods. The "islands" are relics of a once continuous sheet and not the result of recolonisation. The series of pollen diagrams from the upper to lower sites showed a progressive truncation from below, this being interpreted as either the gradual spreading of peat on to the pavement from the Moss side, or the result of oxidation of the lower peat layers in contact with the limestone. The peat may have formed on persistant drift which has since been washed into the gryke system, or developed on the limestone itself. Gosden interprets the absence of pebbles of glacial origin beneath the peat as making the latter more likely.

Two raised bogs, Helwith Moss and Thieves Moss (fig.1.1) were also investigated by Gosden to provide additional information and a time scale against which to view the shorter profiles of the pavements. At Thieves Moss, peat accumulation began in Godwins Zone II and continued to early VIIa. Some time after, peat growth stopped and erosion set in. At Helwith Moss, peat growth began in Godwins Zone V and has continued to the present day.

Interesting comparisons can be made between the Scar Close, Moughton and Howrake Rocks sites of Gosden and the sites associated with the limestone plateau of the present investigations. Similarly the deep profiles of the raised bogs provide a useful backdrop against which to compare the blanket peat profiles studied here.

Other sites have been investigated in the Craven area by Pigott and Pigott (1963) and Jones (1977). Pigott and Pigott took a series of borings in Tarn Moss, a raised bog and fen complex on the western side of Malham Tarn. (NGR, SD 886 668; 375m, MSL.)

Analysis of macro-remains and pollen content of the deposits revealed a sequence beginning in Godwins Zone II and continuing to the present, Godwins Zone VIII (radiocarbon dates available). Pigott and Pigott suggest from their results that juniper scrub occupied the limestone upland during the Late-glacial Period. In the Post-glacial Period this was supplanted by hazel scrub, possibly with pine and subsequently oak and elm. Forest destruction apparently began in the Late Neolithic or Early Bronze Age but was accelerated during the Iron Age, Norse and Monastic Periods. The authors suggested that there was no clear evidence pointing to widespread soil erosion accompanying deforestation and the limestone pavements would seem to have lacked a covering of mineral soil since the Last Glaciation.

Jones (1977) studied five sites, White Moss, Eshton Tarn, Threshfield Moor, Linton Mires and Martons Both, in the Craven area. He concentrated on how man affected the vegetation and related this to the archaeological history of the region (section 10).

The above results are examined in detail, later on in the text, where comparisons are made with the Ingleborough diagrams so as to put the local vegetational changes into their regional context.

2. MATERIALS AND METHODS

The size of the massif and the time constraints made a complete coverage of the study area impossible. Sites were therefore selected in order to give as representative a sample as possible, including:

a) a range of altitudes
b) peat growing close to and far from, known concentrations of archaeological sites
c) peat growing both near to, and far from, limestone pavement
d) sites on both the north and south sides of the massif
e) a range of different peat types.

It was decided that a transect running north-west/south-east, across the massif (fig. 2.1.) would best fulfil these criteria as well as the general aims of the project (Section 1). Peat deposits were sampled at intervals, as close to the line of the transect as possible. Three of the sites studied by Gosden (1965), Moughton, Thieves Moss and Helwith Moss, lie, more or less, along the transect if it is extended further in a south-easterly direction. Seven study sites were chosen along the transect: Braithwaite Wife Hole, Sunset Hole, The Arks, Simon Fell I, Simon Fell II, Allotment Shooting Box and Sulber Pot. The Hut Circle was the only site investigated off the transect.

2.1 Collection and storage of samples

Peat for analysis was collected as monoliths (blocks of peat about 15 x 15 x 30cm) or "Russian" cores (50cm long). To enable transport and easy storage, monoliths were supported on hardboard and cores in plastic troughs. Both monoliths and cores were wrapped in polythene to prevent dehydration. Samples of wood for later

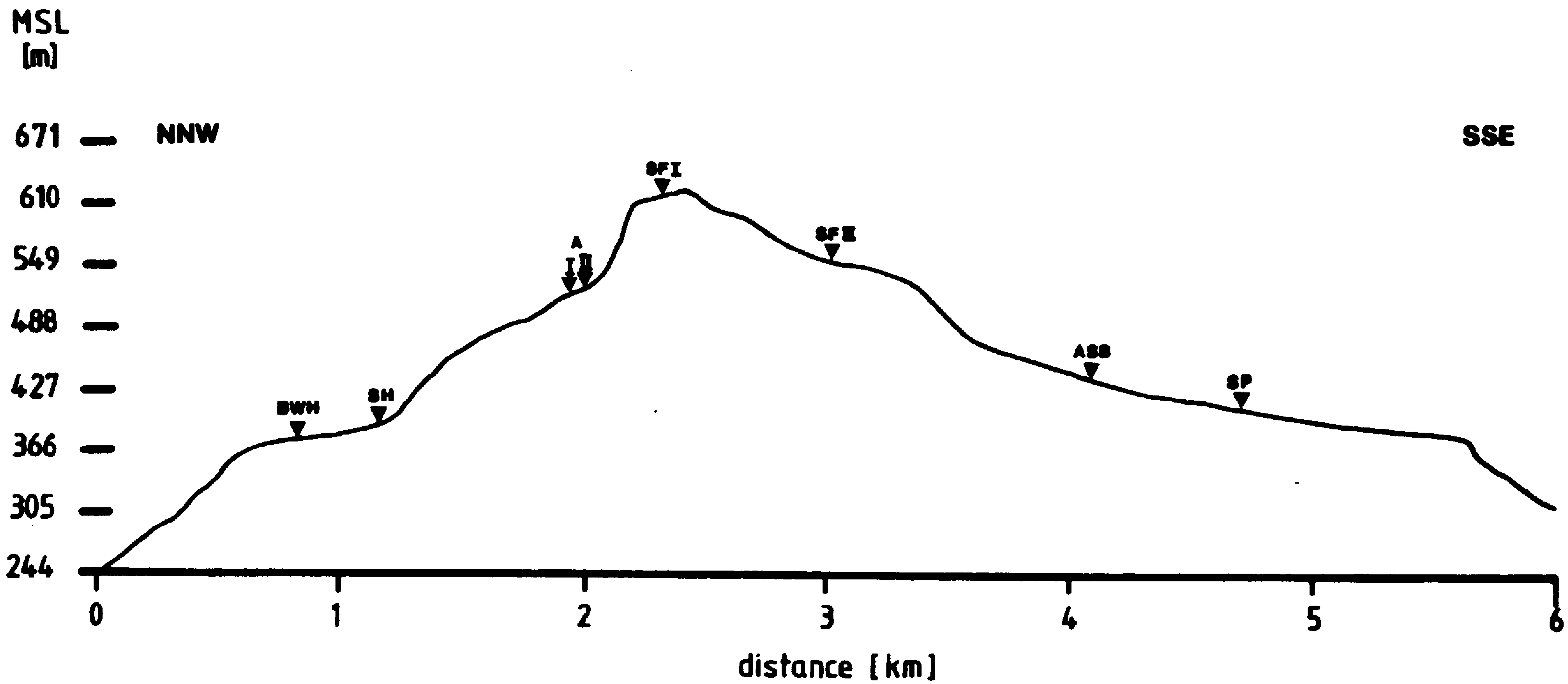


Figure 2.1. Section of Ingleborough along the transect line showing altitude of sampling sites.

identification were collected and their depth noted during the excavation of the monoliths. All peat and wood samples were stored at 2°C to inhibit the growth of degrading organisms. Field notes were made on the peat stratigraphy at each site.

2.2. Preparation of peat samples for percentage pollen counts

Peat samples were extracted from cores and monoliths at 2, 4 or 8cm intervals, after careful cleaning of the peat surface to avoid contamination.

The samples were prepared using standard methods. A small volume of peat (less than $1cm^3$) was first heated in potassium hydroxide (10% w/v) solution, sieved and then subjected to Erdtman's acetolysis (Moore & Webb, 1978). If mineral particles formed a major contaminant, bromoform flotation was used to separate the organic material (Moore & Webb, 1978). Two slides for each level were made from the final pollen preparation (mounted in glycerine jelly).

2.3. Preparation of samples for pollen concentration counts

A suspension of exotic pollen (*Ailanthus glandulosa*) was prepared following the methods of Matthews (1969) and Bonny (1972). To evenly suspend the pollen grains, the mixture was agitated by magnetic stirrer for at least two hours before sampling. Stirring was continued while determinations were made, using a haemocytometer with modified Fuchs-Rosenthal ruling and a chamber depth of 0.2mm. Counts were made until consistent values were reached and then 50 counts were taken and recorded. From these figures the mean and confidence intervals were calculated; see Section 2.7.2. and Bonny (1972).

The samples prepared for pollen concentration counts were treated in the same way as those for percentage pollen counts, except for the following modifications: $1cm^3$ of peat was measured accurately by displacement in water in a $5cm^3$ measuring cylinder. Matthews (1969) noted a tendency for some exotic pollen to remain in the discarded supernatant after the peat had been heated in potassium hydroxide solution. For this investigation the exotic pollen suspension was added after this stage in the preparation, so as to reduce the inaccuracy of the results due to undetected loss of pollen. The tubes containing the samples were weighed accurately and then drops of exotic pollen suspension were added, so as to give a pollen count in the region of 20-40% of total land pollen (TLP); the tubes were then reweighed. The pollen preparations were mounted in glycerine jelly and two slides were made per level as before.

Care was taken at all stages to avoid contamination or loss of pollen during the preparation. If loss or contamination were known to have occurred, the samples were immediately discarded and the process repeated with fresh peat.

2.4. Counting procedure

When pollen concentration or influx diagrams were required, 1,000 pollen grains were counted per level, 500 from each of the duplicate slides. The count consisted of terrestrial plant pollen (total land pollen or TLP) including exotic grains. Pollen of aquatic plants and spores were excluded from the pollen sum but were separately recorded. Although additions of the exotic suspension were estimated to give a count of between 20 to 40% of TLP, in a few cases a lower or higher percentage was accepted because of the scarcity of original material. If the percentage of fossil pollen was less than 50%, the count was continued until a total of five hundred fossil grains was achieved.

If only percentage pollen diagrams were required, a total of 500 grains was counted per level (although only 100-200 grains were counted for the brief, exploratory diagrams of the Arks II monolith and the Arks VI core).

A pollen reference slide collection and various texts (Moore & Webb, 1978; Faegri & Iverson, 1975; Erdtman, 1963) were used as aids to pollen identification. Routine pollen counting was carried out at a magnification of x 400. To identify difficult grains, a magnification of x 900 (oil immersion) was used.

2.5. Radiocarbon dates

Horizons to be dated were selected with reference to the following criteria:

a) the initiation of peat formation
b) important vegetational changes indicated in the pollen diagrams
c) marked changes in pollen concentration.

Twenty-five radiocarbon dates were obtained for the Ingleborough diagrams, processed at the NERC Radiocarbon Laboratory, East Kilbride. (For a list of these dates, see Appendix 1.)

Where peat had been collected as monoliths, a 1cm thick slice of peat was extracted for each level to be dated.

At Sunset Hole, three identical cores were taken to produce a sufficient volume of peat. The detailed pollen analysis of the first core revealed horizons suitable for dating. To allow the exact location of these horizons in the two "back-up" cores, pollen analysis was carried out on small samples of peat, up to 8cm above and below the depth recorded in the first core. A 2cm thick section of peat, lying 1cm above and below the horizon, was extracted for dating from each of the three cores.

At Arks II only one core was taken. A monolith (AIIm) was collected at a later date, as close to the original site as possible. However, the lower few centimetres of the pollen record appear to be missing from this monolith. The bottom 5cm of the core (AII) was pooled to give a basal date. The upper two horizons to be dated from the core overlapped with the Arks II monolith and so after pollen analysis of samples from the relevant areas of the monolith, 1cm thick layers of peat were sent to be dated.

Calibration of radiocarbon dates has not been attempted. This is because of the lack of a definitive calibration curve.

2.6. Percentage calculations

When pollen counts included exotic pollen, the percentages of each pollen taxon were calculated using a pollen sum of 1000 less the number of exotic grains counted.

2.7. Calculation of pollen concentrations

The mean concentration and 95% confidence intervals of exotic pollen grains in the glycerol suspension were calculated as follows:

$$\bar{y} = \bar{x}\left(\frac{1}{c}\right) \qquad 95\%\ \text{limits} = \bar{y} \pm t\sqrt{\frac{\bar{x}}{n}\left(\frac{1}{c}\right)}.$$

$\bar{y}$ = mean concentration of exotic pollen in grain cm^{-3};

$\bar{x}$ = mean of exotic grains per haemocytometer chamber;

c = volume of chamber in cm^3;
n = number of haemocytometer counts made;
t = Student's t value for $n - 1$ degrees of freedom;
$p = 0.05$.

The total number of exotic grains added to the sediment sample (Tx) was calculated using the estimate of the mean number of grains per cm^3 of suspension, the known weight of suspension added (w) and the known SG of the glycerol used:

$$Tx = \bar{y} \left(\frac{w}{SG}\right).$$

The fossil pollen concentration or number of fossil grains per cm^3 of peat (PC) is given by the equation:

$$PC = Tx \frac{(\text{number of fossil grains counted } Cf)}{(\text{number of exotic grains counted } Ce)}.$$

2.8. Estimation of time scale (Appendix 2)

In pollen diagrams for which radiocarbon dates are available, an estimate of the age of the undated levels has been calculated, using the following formula:

$$Te = \left(\frac{T_2 - T_1}{d}\right) \times m + T_1$$

where Te = Estimated date (BP)
T_2 = Older radiocarbon date (BP)
T_1 = Younger radiocarbon date (BP)
d = Depth of peat between T_2 and T_1 (cm)
m = Distance between the undated level and the younger radiocarbon-dated level

2.9. Calculation of pollen influx

Pollen influx values were calculated for each taxon using the following formula:

$$PI = PC/(T_2 - T_1)/d$$

where PI = Pollen Influx (grains $cm^{-2}y^{-1}$)
PC = Pollen Concentration (grain cm^{-3})
T_1 = Younger radiocarbon date (BP)
T_2 = Older radiocarbon date (BP)
d = Depth of peat between T_2 & T_1 (cm).

2.10. Confidence Limits

Confidence limits were calculated for one diagram but they tended to obscure rather than clarify the data, and in view of the time required for the calculations, they were omitted.

2.11. Construction of the pollen diagrams

Both percentage and influx diagrams have been constructed for the Braithwaite Wife Hole, Sunset Hole, Arks I, Simon Fell I and Allotment Shooting Box pollen profiles. For the Arks II, Arks IIm, Arks VIc, Simon Fell II, Sulber Pot and Hut Circle sites, only percentage diagrams have been produced. A column showing the stratigraphy of the peat profile, based on field notes and the macrofossil analysis, has been included at the beginning of each diagram. Radiocarbon dates are shown beside the levels sampled.

To facilitate comparisons with published diagrams, the convention of presenting arboreal pollen curves first has been followed. The curves for shrub pollen are presented next. A summary diagram follows, showing the proportions of arboreal, shrub and non-arboreal pollen. Generally, the spore and aquatic pollen curves are drawn after the summary curves. Non-arboreal pollen curves are presented on a separate diagram and have been loosely grouped into Gramineae and Cyperaceae pollen, acidophilous types, "ruderal" species (here referring to those most often associated with the activities of man) and then the remaining pollen types in alphabetical order. This arrangement was chosen to make comparisons between diagrams easier when considering local vegetational changes and anthropogenic effects. When only one or two grains of non-arboreal taxa were counted, these have been included at the end of the non-arboreal pollen diagram with a letter code (see Appendix 4 for a key to these and any other symbols used on the pollen diagrams).

2.12. Zonation of pollen diagrams

For ease of description and interpretation the diagrams have been divided into local pollen zones. This was achieved by noting major changes on the individual pollen curves and drawing a zone boundary where marked changes were seen in the proportions of several species. Boundary lines were drawn through the first level in which the change was seen to have occurred. Variations in pollen concentration were also taken into account. It must be stressed that the subdivision was based on the inherent features of the diagram without reference to the ecological or climatic implications of the data.

Hence, as far as possible, each pollen zone represents "a body of sediment with a consistent and homogenous fossil pollen and spore content that is distinguished from adjacent sediment bodies by differences in the kind and frequencies of its contained fossil pollen" (Gordon & Birks, 1972).

On the diagrams and throughout the text, pollen zones are denoted by the initials of the sampling site followed by the number of the zone (zones being numbered from the based upwards). In certain cases subzones have been inserted where more minor changes have occurred in the pollen spectrum but where the bulk of the assemblage remains the same.

2.13. Macrofossils

The cores and monoliths were sampled at varying intervals to give representative samples of the different stratigraphic layers. Each sample of peat was macerated overnight in about 10% nitric acid before being sieved (aperture 200µ), the debris being retained. Examination of the washings revealed that only seeds of *Juncus* passed through the sieve, but in all cases these seeds were still well represented in the remaining debris. The material was examined under a low power binocular microscope (x10 and x30) whilst moss leaves and *Juncus* seeds were studied under a high power microscope (x100 or x 400). Remains were identified by comparison with a seed reference collection and identification manuals.

Wood samples were prepared and sectioned by Paul Field and identified by Dr. D. D. Bartley, Plant Sciences Department, University of Leeds.

2.14. Sources of archaeological information

Information on the archaeology of the massif and the Craven Area was obtained from the literature and the Ordinance Survey archaeological record cards. Help was also obtained from the North Yorkshire Archaeological Department, County Council, Northallerton, and particularly from Mr. Alan King, based at the Ingleton Community Centre: an expert on the archaeology of the Craven Area, who has carried out extensive fieldwork, including excavations on the Massif itself.

2.15. Assumptions and sources of error

The many assumptions and sources of error encountered in pollen analysis have been borne in mind when describing and discussing the data collected. These have been summarised by Birks & Birks (1980) and Moore & Webb (1978).

In particular, when calculating the sediment accumulation rate, the radiocarbon date is used with no indication of the error margins. Also, the radiocarbon dates have not been recalibrated and hence do not represent calendar years. In some cases, a radiocarbon date may be equivalent to one of two calendar dates according to some recalibration curves (Pearson, et al. 1977). Normally a core sample for radiocarbon dating consisted of 2cm of peat core, in which case for calculations, the depth was taken as being the mid point.

Radiocarbon dates have not been obtained for the uppermost peat layers because of the danger of contamination by modern roots. In order to obtain an estimate of age for these layers the sediment accumulation rate of the previous zone is used. In these cases, and in others where a hiatus may well be present in the surface peats, estimates of age and the means by which they were obtained are described separately in the appropriate chapter.

The greater the depth of peat between radiocarbon dated levels the greater the chance of a change in growth rate or a hiatus occurring between them, thus severely reducing accuracy. Due to limited resources the number of horizons dated was not as great as hoped. However, extreme care was taken in choosing these horizons to minimise the problem.

3. BRAITHWAITE WIFE HOLE (NGR, SD 744 764)

3.1. Description of site

The Braithwaite Wife Hole site lies at an altitude of 354m (MSL) on the Great Scar Limestone plateau, within about 20m of Braithwaite Wife Hole itself. A monolith was dug from an area of shallow peat between two arms of limestone pavement. The present vegetation is dominated by *Eriophorum vaginatum*, *E. angustifolium*, *Deschampsia flexuosa*, *Trichophorum caespitosum* and *Juncus squarrosus*.

3.2. Stratigraphy

The stratigraphy of the site, based on field notes and detailed macrofossil analysis is as follows:

Depth (cm)	Description
0 - 7	Modern roots and unhumified plant remains.
7 - 16	Lightly humified *Eriophorum vaginatum* peat with *Sphagnum papillosum* leaves.
16 - 32	Moderately humified *Eriophorum vaginatum* peat with occasional wood fragments and *Polytrichum* remains. Birch fruits found at 24 and 28cm. Also a few *Juncus effusus* seeds with *Potentilla* achenes and *Carex* fruit.
32 - 50	Heavily humified wood peat (two pieces identified as *Betula* wood) with abundant monocot remains, *Juncus effusus* seeds and *Polytrichum* remains. *Carex* fruit with two bud scales and a catkin

	scale of Betula at 33cm. Rubus achene at 48cm. Mineral grains begin to appear from 40cm onwards.
50 - 81	Heavily clayey peat with abundant monocot remains and moss leaves of several species. Occasional to frequent wood remains. Juncus effusus and some J. conglomeratus seeds. Glyceria tp. seeds at 56, 64 and 72cm. Alnus fruit at 72 and 81cm. Potentilla erecta achenes at 64cm. Rubus achenes at 56 and 81cm. Rumex acetosa perianth segment at 64cm. Ranunculus flammula achene at 64 and 72cm. Cerastium holosteoides seeds at 72 and 81cm.
81 +	Sandy, grey-brown clay.

3.3. Discussion (Diagrams 3.1. and 3.2.)

The accumulation of clayey peat above sandy clay at this site began c. 4560 $\pm$ 50 BP and continued until c. 3840 $\pm$ 50 BP. This period of about 720 $\pm$ 100 years is covered by pollen zone BWH1. The presence of wood fragments and alder fruit, together with high percentages of Alnus pollen and an assortment of herbs including Caryophyllaceae, Filipendula, Trollius and moderate number of Filicales spores, suggests the presence of base rich alder carr on the sampling site. The understory was dominated by ferns and on the more open areas with herbs and grasses.

This zone shows several unusual features. There are very high percentage and influx values of Rumex acetosa/acetosella type pollen, sustained throughout the 720 year period (up to 29% of TLP) and the pollen concentration values are abnormally high. This, together with the presence of clay particles in the peat, might suggest that inwashing of older fossil pollen, perhaps of late glacial origin, may have occurred from the slopes above. However, if this were the case one would expect to find other pollen types such as large numbers of Artemisia and Pinus grains, which is not the case. Also, if foreign sediments have been deposited on this site, one would expect the ^{14}C dates to be highly inaccurate, and much earlier than the pollen record would suggest. The radiocarbon dates for this diagram do not seem anomalous, as there are no reversals and the sediment accumulation rate is well within the range shown by the other diagrams (20.57 yr cm^{-1}).

From this it seems more likely that inwash of older fossil pollen has not occurred to a significant extent, and that the plant community containing the Rumex population was contemporary with the alder carr.

Rumex acetosa grows in grassland, usually basic, or open spaces in woods such as clearings, paths and borders. The pollen and macro-remains of zone BWH1 point to the vegetation being base-rich alder carr but with open spaces. It is possible therefore that the unusually high Rumex acetosa/acetosella percentages are due to plants growing on the bog surface.

However, associated with Rumex pollen in the pollen spectra of this zone are very high percentages of Gramineae pollen, grains of ruderal pollen types such as Plantago lanceolata and Artemisia as well as occasional cereal grains. This tends to suggest that substantial areas of open grassland existed in the neighbourhood of the sampling site, on drier ground, probably on the base-rich soils over the limestone pavement. The presence of ruderal and cereal pollen types suggests that during the Middle to Late Neolithic Period, humans could well have been responsible for maintaining these grasslands through grazing of livestock and limited arable farming.

Although the perianth segment recovered from 64cm was Rumex acetosa, it is possible that the high pollen percentages are due to a greater or lesser extent to other species of Rumex, particularly Rumex acetosella. The presence of Rumex pollen is often stated as evidence of pastoral farming (Turner, 1970; Tinsley & Smith, 1974), or at least of grazing pressure on the vegetation, whether by wild or domesticated animals. Rumex acetosella or sheep's sorrel can often be seen in almost pure stands on acid pasture where sheep are particularly prone to congregate. Some of the Rumex grains may have come from such an acid grassland, upslope from the sampling site. However, evidence for this type of vegetation is not seen in the diagram from Sunset Hole; the next site on the transect above Braithwaite Wife Hole.

Betula, Quercus and Corylus pollen are also recorded in this zone in moderate numbers (between 5 and 15% of TLP). At least the latter two species would have been growing on the drier areas of the massif. The percentage and influx values of these species are not high, suggesting they did not form a continuous cover. This supports the suggestion that rather than growing on the peat surface, the grassland bearing large numbers of Rumex plants may have occurred on the drier slopes immediately above the sampling site or else on the well-drained soils over the flat limestone pavements. Clearance by man of the slopes above Braithwaite Wife Hole would have increased surface water runoff and may well have been the cause of waterlogging of the drift-covered shelf beside the limestone pavement, initiating peat formation.

Around 3840 $\pm$ 50 BP at the zone BWH 1/2 boundary the composition of the plant communities appears to have changed rapidly; the duration of the change was c. 18-40 years according to the ^{14}C dates. The percentage of arboreal pollen increases overall from about 50% to

65-70%, while percentages of ruderal species and other herbs fall. There is a steep decline in Alnus pollen percentages and influx values whilst those of Betula sharply rise at the boundary. There is a corresponding change in the stratigraphy of the peat from the earlier clayey monocot/wood peat to a wood peat with no mineral content. Betula catkin and bud scales and samples of wood identified as Betula, from zone BWH 2 peat suggest that the rise in Betula pollen percentages is due to the invasion of birch trees into the carr vegetation, displacing most, if not all, of the alder community. The evidence indicates that this was a change to more acid and wetter conditions. The curve for Filicales spores decreases whilst that of Sphagnum spores increases, and grains of Calluna pollen are present.

The growth rate of the peat assigned to zone BWH 2 increases from 20.57 yr cm^{-1} to 9.23 yr cm^{-1}, suggesting that more water may have been available. The mixture of moss types in the zone BWH 1 peat are replaced largely by Polytrichum remains in zone 2. Herbs that may well have contributed to the ground flora of the preceding alder carr were either absent or occurred only in reduced numbers in zone BWH 2, for example Caryophyllaceae, Rubiaceae, Trollius and Teucrium.

Apart from the local changes the percentages of Quercus, Ulmus, Pinus, Tilia, Fraxinus and Corylus grains appear to rise in zone BWH 2. NAP values fall, particularly those of Gramineae and Rumex, and ruderals are absent. This indicates a partial return of broad-leaved woodland to cleared, reasonably well-drained areas of the lower slopes and/or plateau of the massif. An increase in tree cover at this time is supported by the pollen influx diagram; however, it differs in the extent of the increase and in the woodland composition indicated. The decline in the numbers of Alnus, Rumex and Gramineae grains at the zone 1/2 transition is larger than the increase in Betula and other arboreal pollen grains. As the percentage values are dependent upon each other, this has caused an artificial rise in the percentage of certain taxa. The influx diagram shows that the number of Quercus and Ulmus grains reaching the site did not change, although the numbers of Corylus, Fraxinus and Tilia grains do increase, but not to such a marked degree.

Ash and hazel trees generally prefer relatively base-rich soils and both are good colonisers of open ground. There is strong evidence (Godwin, 1975; Pigott, 1969; Pennington, 1974; Conway, 1954) suggesting that the expansion of ash in the later Flandrian period reflects human clearance of the climax forest. Conway's pollen diagrams, for example, show a large increase in Fraxinus pollen frequencies during the historical period of forest clearance. Ash is now one of the most common tree species, growing as secondary woodland, on the limestone pavements and cliffs of the massif, where grazing sheep have difficulty in reaching them. Ashwoods of thin limestone soils such as these are generally thought to have had an anthropogenic origin, through selective felling of other species and particularly the great regenerative capability of ash itself.

In view of the apparent acidification of the drift-covered areas near Braithwaite Wife Hole, it seems likely that around 3840 $\pm$ 50 BP or the beginning of zone BWH2, ash and hazel scrub began to recolonise the open grassland communities over limestone on the plateau. This period of woodland regeneration together with the fall in frequencies of Rumex pollen, other ruderals and cereal grains, indicates a cessation or substantial reduction in agricultural activity. The Neolithic inhabitants may have moved to another location on the massif or further afield, or perhaps a general reduction in population occurred. One possibility may be that if the open ground was maintained by grazing, its long-term use as pasture may have accelerated denudation processes causing the exposure of bare limestone pavement in some areas (a process which may be extremely rapid according to Drew (1982) under suitable conditions. This would no longer support live-stock and so fresh pasture would have had to be sought elsewhere.

According to the radiocarbon dates, the forest regeneration phase was short-lived, lasting only about 80-160 radiocarbon years. The transition between zone BWH2 and BWH3 is marked in the pollen diagrams by the beginning of a steep decline in arboreal pollen and a corresponding rise of non-arboreal pollen frequencies.

Betula and *Alnus* pollen percentages decline, matched by the disappearance of wood fragments and birch fruits from the stratigraphic record, halfway through zone BWH3. This indicates a disappearance of birch (and possibly alder) trees from the sampling site, which was progressively taken over by *Eriophorum vaginatum* and *Polytrichum* bog.

The percentages of *Quercus*, *Tilia* and *Corylus* pollen also begin their final decline at the zone BWH2/3 boundary, showing that woodland on the drier slopes and pleateau near the sampling site was receding.

In the latter half of zone BWH3, c. 3650 BP, the curve for *Calluna* pollen shows a rapid rise and reaches high values by the end of the zone. No macrofossils of *Calluna* were identified in the equivalent section of peat, suggesting that *Calluna* was not a major constituent of the local bog community. Instead heather heathland may well have been taking over soils, once occupied by the trees, on the drier slopes.

The zone BWH2/3 boundary also marks the rise in Gramineae and Cyperaceae pollen, and the appearance and rise in curves of clearance indicator species, particularly *Plantago lanceolata* with *Pteridium* and *Urtica*. Other ruderal types were represented by a few grains such as *Rumex*, *Artemisia*, Chenopodiaceae and *Cannabis*/*Humulus* type. This evidence points strongly to zone BWH3 representing a final phase of forest clearance by man, although it is impossible to know to what extent climatic factors were involved.

The estimated date of 3680 BP suggests that the clearance phase began in the early to middle Bronze Age. When compared with the first agricultural phase, the second shows a very different spectrum of indicator species. Instead of high percentages of *Rumex acetosa*/ *acetosella*, the most abundant indicator taxa counted were *Plantago*, *Pteridium* and *Urtica*. The preponderance of these three genera again suggest mainly a pastoral farming regime, with a little arable farming indicated by the occasional cereal grains. The clearance or tree decline must have been extensive, bringing the arboreal percentage down to about 12% and the non-arboreal pollen up to 75-80% of the TLP, suggesting a virtually treeless landscape near the sampling site and possibly over a much larger area. *Fraxinus* pollen is the only tree type which does not decline in zone BWH3, as one might expect, in view of the ash trees growing on the limestone pavements today. Several herbaceous species are represented in the pollen diagram, which are normally found growing on the pavements, eg *Urtica*, *Succisa*, *Teucrium* and *Helianthemum*. It may well be that a combination of man's activities and the changing climate had already produced extensive areas of exposed limestone pavement by the Middle Bronze Age.

In zone BWH4 the percentages of *Calluna* pollen decline rapidly to very low frequencies and there is a correspondingly steep rise in Gramineae and to a lesser extent Cyperaceae percentages. The *Plantago lanceolata* curve shows a slight decline while those of *Rumex acetosa*/

acetosella and *Urtica* pollen increase. *Betula*, *Pinus*, *Ulmus* and *Fraxinus* show small increases in pollen percentages indicating a selective tree recovery.

At first sight the pollen record across the BWH3/4 boundary appears to be continuous; however, the concentration diagram shows a sharp fall in concentration of all pollen types When this, together with the changes described above, are compared with a similar dated change at the Allotment Shooting Box site (on the limestone plateau on the south-east side of the massif), evidence for a hiatus in peat growth can be seen lying between 12 and 16cm in the profile.

If it is assumed that there has been no hiatus between 12 and 16cm, the peat record would have terminated at the date of c. 3430 BP. It could be argued that above 16cm the peat growth was very slow with heavy erosion. However, the peat covered by zone BWH4 is a highly unhumified *Eriophorum/Sphagnum* peat, not an amorphous, heavily humified peat as one would expect if this were the case. Further discussion of this will be deferred till section 7.3, Allotment Shooting Box.

3.4 Summary

BWH1 : Peat initiation occurred at 4560 ± 50 yr BP under a base-rich alder carr. Mixed oak woodland was growing on the drier areas of the plateau and hillsides but open areas of grassland with *Rumex* were also in evidence. This, together with the presence of cereal grains, suggests that Middle-Late Neolithic man with a largely pastoral economy was living on the massif.

BWH2 : *Betula* carr takes over from the alder carr with conditions becoming wetter and more acid. *Rumex* is virtually absent and Gramineae declines as ash and hazel percentages rise. These trees appear to have recolonised calcium-rich soils on the limestone, indicating abandoned pasture and perhaps the colonisation of newly-exposed pavement.

BWH3 : c. 3680 yr BP : A second and far more extensive Early Bronze Age clearance phase begins with all tree and shrub species except *Fraxinus* declining steadily. At the end of this zone AP plus SP forms less than 15% of TLP while those of NAP rise to about 85%. The farming economy was again pastoral with some arable activity. Instead of *Rumex* the most abundant clearance indicators of this zone are *Plantago lanceolata*, *Urtica* and *Pteridium*.

On the sampling site Betula carr gives way to *Eriophorum/Polytrichum* peat and *Calluna* heath spreads over drier areas once occupied by trees.

BWH4 : There is evidence for a hiatus in peat growth between 12 and 16cm in the profile, suggesting that BWH4 consists of recent peat.

4. SUNSET HOLE (NGR, SD 745 759)

4.1. Description of site

The Sunset Hole core was taken from a site about 0.3km east of Sunset Hole at an altitude of 393m (MSL). The peat has formed in a hollow on a drift-covered shelf on the lower slopes of Ingleborough Hill. The site overlooks the northern side of the plateau and Southerscales Scars. The present peat surface does not appear to be growing and erosion channels have formed with bare redeposited peat, while intact peat is left as low mounds. These mounds are relatively dry and are covered by Eriophorum vaginatum, Calluna vulgaris, Cladonia sp and Vaccinium myrtillus. In lower, wetter areas of the bog surface Eriophorum angustifolium and Sphagnum spp become more common. Drainage on to the site is from the slopes above.

Three cores were extracted, and one monolith (0.50 m). Pollen analysis was carried out on the first core, the remaining cores being retained for radiocarbon dating (section 2.5.)

4.2. Stratigraphy

Depth (cm)	Description
0 - 8	Unhumified Sphagnum papillosum peat.
8 - 20	Very heavily humified Calluna and monocot peat with modern roots.
20 - 200	Light to moderately humified, reddish-brown, Eriophorum vaginatum/Calluna peat with modern roots.

200 - 240	Lightly humified Eriophorum vaginatum/angustifolium, Sphagnum spp and Calluna peat with fruits, cone scales and bud scales of birch and alder fruits. Wood fragments present at 224cm.
240 - 248	Sphagnum peat with monocot remains, Carex rostrata fruit, birch fruit, scales and leaf fragments, alder fruit and a few wood fragments.
248 - 250	Polytrichum and moss (cf Hylocomnium splendens), with fruit of Carex rostrata, birch and alder, and traces of Eriophorum vaginatum and Sphagnum sp.
250 - 304	Moderately-highly humified wood, Polytrichum and monocot peat with birch fruits and an alder fruit at 256cm. Distinct fungal hyphae and sclerotia.
304 - 330	Heavily humified wood and monocot peat with occasional Polytrichum remains and Juncus and Eleocharis/Isolepis type seeds. One Ajuga reptans seed was found at 328cm.
33o - 369	Very heavily humified wood peat, fruits of Cirsium arvense/vulgaris type, and seeds of Lychnis flos-cuculi and Ranunculus sp. Hazelnut fragments at 352cm and Selaginella megaspores from 352cm downwards. A large wood fragment filled the core between 344 and 349cm.
369 - 370	Clay, pebbles and organic matter with wood fragments, Carex sp fruit, Eleocharis/Isolepis seed

	and *Selaginella* megaspores.
370 +	Grading into blue-grey clay.

4.3. Discussion (Diagrams 4.1, 4.2, 4.3, 4.4, 4.5)

Peat accumulation at the Sunset Hole site began early in the Flandrian Period under damp woodland or scrub. The presence of hazelnut fragments in the peat together with high percentages of hazel pollen in the pollen count suggest that hazel was growing on or very near the sampling sampling site, probably with willow and possibly birch. Seeds and fruit of *Lychnis flos-cuculi*, *Cirsium* sp and *Ranunculus* sp with micro- and megaspores of *Selaginella selaginoides* were identified from the peat belonging to zone SH1, suggesting that, at least in places, there were openings in the tree canopy allowing the growth of more light-demanding communities. This is supported by the pollen evidence as Gramineae, Cyperaceae, *Filipendula* and other herb pollens are well represented in the zone. The very high percentage of Filicales spores indicate that ferns may well have been a dominant part of the carr's undergrowth. The presence of *Selaginella* and *Lycopodium* spores reflect the early age of this peat, as do the single grains of *Linnaea borealis* and *Polemonium caeruleum* normally associated with the Late-glacial or Pre-boreal periods.

Pine trees with hazel as an undershrub may have been growing near the site, as both species thrive on well-drained calcareous soils. *Linnaea borealis* is found today in coniferous woods up to 732m in the Alps. The high percentage of *Corylus* pollen may have resulted from the growth of pure stands of hazel as well as from individuals growing at the sampling site.

Halfway through zone SH1 the plant communities appear to change, the pollen and spores of *Selaginella*, Compositae, Umbelliferae, *Polemonium* and *Linnaea* giving way to those of

Pteridium, Caryophyllaceae, Cruciferae, *Potentilla* and Rubiaceae. Spore percentages of ferns and *Sphagnum* and Cyperaceae pollen percentages decline, while those of Gramineae and *Filipendula* rise. This may represent areas of open vegetation established in a cold dry climate giving way to a tall herb community under warmer and wetter conditions. The relatively young soils and differing migration rates of plant species after the retreat of the ice sheets may well have produced plant communities that we are unlikely to see today (West, 1960).

Changes also occur in tree and shrub pollen proportions as peat accumulated through this zone. *Corylus* pollen percentages decline while those of *Betula*, *Pinus*, *Ulmus* and *Quercus* increase, indicating a steady encroachment of mixed oak forest at the expense of hazel, perhaps due to the thickening of the tree canopy, reducing both flowering capacity and numbers. The rise in *Betula* pollen percentages may show birch invading the carr community on the sampling site as well as the surrounding woodland.

The total pollen influx values of this zone are very low, with a mean of only 2315 grains cm^{-2} yr^{-1}. This could indicate a sparse floristic covering with areas of bare rock and scree, or, alternatively, reflect the severe degree of humification and hence destruction of pollen.

However, the basal radiocarbon date of the Sunset Hole core is older than expected in comparison with other pollen diagrams from the area. A radiocarbon date of 9400 $\pm$ 100 BP was obtained for the peat sample taken at 367-368cm. High percentages of *Corylus* pollen are present at this level and continue throughout zone SH1. This information conflicts with that obtained from analysis of the Arks II core and monolith. The basal peat from the Arks II site appears to be much older than that of Sunset Hole, as it shows a peak of *Juniperus* pollen, no records of *Ulmus*, *Quercus* or *Alnus* pollen and *Corylus* values of less than

0.5% TLP. In the Arks II monolith, the rational rise (Smith & Pilcher, 1973) in the Corylus curve is dated to 8730 ± 80 BP, nearly 700 years later than the basal Sunset Hole date. Similar values for the age of the rational rise in the Corylus curve have been obtained by Hibbert et al. (1971) at Red Moss, and Godwin et al. (1957) at Scaleby Moss, these being 8880 ± 170 BP and 8809 ± 192 BP respectively. The radiocarbon-dated levels of the Arks and Sunset Hole diagrams compare well from the rational alder rise onwards. This suggests that the true age of the basal peat at Sunset Hole should lie between 8730 and 7450 BP.

The pollen influx values for zone SH1 are extremely low and the peat accumulation rate is 55.7 yr cm^{-1}, which, when compared with the average growth rate for the Ingleborough diagrams of 26 yr cm^{-1}, appears to be very slow. Usually, a high pollen concentration is associated with a slow peat growth rate, but this is not the case with zone SH1. This supports the evidence for the basal date being too ancient. If the peat growth rate of zone SH2 (30 yr cm^{-1}) is extrapolated back for zone SH1, the date of peat initiation can be estimated at c. 8760 BP.

It is possible that the basal layer contained late glacial sediment from the mineral layers below, or that carbonate dissolved from the limestone bands of the Yordale series washed on to the site from the slopes above, producing an artificially ancient radiocarbon date.

The boundary between zones SH1 and 2 (7450 ± 80 BP) has been drawn at the rational limit of Alnus pollen or the point at which the percentage curve begins to rise to sustained levels (Smith & Pilcher, 1973). It is also at this level that Pinus pollen percentages begin to decline.

This boundary coincides with a slight reduction in the degree of humification of the peat and an increase in the proportions of monocot remains. There appears to have been a brief opening up of the tree canopy in the locality, just before and across the boundary at c. 7450 BP, leading to the spread of fen communities on the bog surface. This is shown by small peaks in the percentage curves of Gramineae, Cyperaceae, Caryophyllaceae, *Filipendula*, *Potentilla* and Umbelliferae, together with isolated records of herbs such as *Trollius* and the presence of *Lychnis flos-cuculi* seeds. The peak in *Pteridium* spores and records of *Thalictrum*, *Succisa* and *Epilobium* grains also point to an opening up of the surrounding, drier woodland.

These herbaceous species appear soon to have declined in numbers, again leaving the carr vegetation as before, probably dominated by *Salix* and *Corylus*, still with an undergrowth of ferns but less so than before, with reeds and other monocots becoming more important.

As zone SH2 progresses, the number of herbaceous species represented in the pollen record tends to decline, particularly *Filipendula*, whilst *Calluna* is more consistently present. This, together with *Polytrichum* remains and later a peak in Sphagnum spore numbers, indicates a progressive move towards wetter and more acid conditions within the carr, followed by the spread of birch and perhaps a little alder on to the surface.

The periods between 7450 ± 80 BP and 6410 ± 80 BP, or zone SH2, was one of rising deciduous tree numbers in the region, expanding on to most of the remaining open ground. The percentages of *Betula*, *Ulmus*, *Quercus* and *Alnus* pollen rise while those of *Pinus* decline. *Corylus* pollen retains its previously high levels. Mixed oak wood encroached on the former pine-hazel-birch woods of the drier slopes. *Alnus* spread into the area, for the first time in any numbers (2-5% TLP), after 7450 ± 80 BP, perhaps gaining a footing on the wetter soils.

The growth rate of the bog during this period was still relatively slow at 29.71 yr cm^{-1} of peat, when compared with the average figure of 26 yr cm^{-1} (= average when all zones of influx diagrams are taken into account). This is supported by the still heavy degree of humification. According to the pollen influx values the number of arboreal and shrub pollen grains being deposited increased in zone SH2 while those of NAP decreased. This again reflects the spread and establishment of mixed deciduous forest on the Massif in this area.

The boundary between pollen zones SH2 and 3 (6410 ± 80 BP) has been drawn where <u>Pinus</u> percentages finally decline and <u>Alnus</u> pollen reaches high values, thus making it equivalent to Mitchell's Boreal-Atlantic Transition (BAT) (Smith and Pilcher, 1973). The steep rise in the <u>Alnus</u> curve, taking less than 180 years (an estimate based on the growth rate of 29.71 yr cm^{-1} of zone SH2) is unusual, though a similar rise was identified at Red Moss (Hibbert et al., 1971), dated to 7107 ± 120 BP. The radiocarbon date from a similar point in the rise in the Sunset Hole diagram is 6410 ± 80 BP, suggesting that in upland Yorkshire, alder appeared in large numbers much later than in lowland Lancashire. However, the rise in alder pollen is so abrupt, it is possible that peat growth stopped for a period, and perhaps erosion of the surface occurred before growth recommenced. The Boreal Period is generally believed to have had a fairly warm, dry climate, especially towards its close. It is possible that such dry conditions halted peat growth until the change to a more oceanic climate at the beginning of the Atlantic period, indicated in the Sunset Hole core by the high <u>Alnus</u> values. However, there is no evidence in the peat stratigraphy of a hiatus at this level. The subject of the Boreal/Atlantic Transition is fully discussed in the General Discussion (section 11).

Pollen zone SH3 spans the period between 6410 ± 80 BP and 5520 ± 90 BP. In this zone, broad-leaved forest reached its greatest extent. The drier slopes and limestone plateau near Sunset Hole bore oak, elm, lime (continuously present from the beginning of this zone) and hazel woodland with some birch, alder and possibly beech and hornbeam (although these are very early and could be due to long-distance transport of occasional grains from the south). The relative proportions of these species is difficult to determine, but insect-pollinated species such as lime may be severely under-represented and may well have formed a major constituent of the forest community despite the low pollen percentages encountered in the pollen preparations (see General Discussion, section 11). On the wetter soils, birch and alder trees predominated. The climate was warmer and wetter than in the previous zone and corresponds to the period of "Climatic Optimum".

Pollen zone SH3 has been sub-divided into three sub-zones according to minor modifications in the composition of the vegetation, particularly in the vicinity of the sampling site.

Subzone SH3a covers the period between 6410 ± 80 BP and c. 6060 BP (296-256cm). The peat type of this zone is much the same as that of zone SH2, however it is slightly less humified, containing more Polytrichum remains, together with birch fruit and an alder fruit at 256cm. This indicates that wet woodland was still growing on the site after 6410 ± 80 BP, but now the major species involved were Betula and Alnus. This is confirmed by high Betula and very high Alnus pollen percentages. The percentages of Corylus and particularly Salix pollen are still very high, suggesting that despite the absence of identified macro-fossils, willow also formed part of the carr with hazel on drier areas close by. Moderate percentages of fern spores (5-15% TLP), the disappearance of Pteridium spores and only low counts of herb pollen, indicate a dense tree canopy across the site with an understory of ferns and mosses, particularly Polytrichum moss.

The percentages of Corylus, Ulmus and Quercus pollen decline across the zone SH2/3a boundary, but this is an artefact as the high Alnus percentages have depressed those of other species. The influx diagram shows marked increases in the pollen influx of these taxa in subzone SH3a. In fact, the highest total land pollen influx values occur in this zone, with a mean of 46856 grains cm^{-1} yr^{-1}, due largely to the presence of high pollen producers such as alder, birch and hazel. The influx of non-arboreal pollen rises slightly but its percentages are very low, ranging between 1 and 18% TLP.

The peat of pollen subzone 3b (c. 6060 BP to c. 5860 BP) consists largely of moss and monocot remains with birch and alder fruit and bud scales. Wood fragments become rare and finally absent, replaced by an increased abundance of monocot remains. The percentage diagrams show a slight reduction in arboreal pollen, including Alnus and Corylus. Non-arboreal pollen percentages rise, mainly due to the increase in the Cyperaceae, Melampyrum and to a lesser extent the Gramineae curves. It is unusual to have such high percentages of Melampyrum pollen. Godwin (1975, p. 320), cites cases where it has been found associated with levels at which clearance of tree cover by fire has taken place. There is no evidence of a charcoal layer or other signs of clearance in the Sunset Hole diagram at the Melampyrum peak, though Pteridium and some ruderal species appear immediately afterwards. Godwin also remarks that Pigott found high frequencies of Melampyrum between 6550-5250 BP and that he thought it may have been abundant in fen communities. At Sunset Hole the Melampyrum peak also occurs within this time period and appears to be associated with a poor fen community.

Subzone SH3b represents a period of marked changes within the bog communities, from eutrophic to oligotrophic conditions. Although alder and birch trees were present, they appear to have been more widely spaced than before, or else were in the process of retreating to the margins of the bog. Eriophorum vaginatum appears for the first time but in small amounts, together with Carex remains, perhaps accounting for the large rise in Cyperaceae pollen percentages. This, together with the fall in Filicales percentages and rise in Sphagnum spores and Polytrichum remains, points to the increased waterlogging and progressive acidification of the bog, as does the change to a less humified peat between 248 and 256cm.

The subzone 3b/c boundary is positioned at the decline of the Melampyrum, Cyperaceae and fern pollen and spore curves as Calluna vulgaris pollen percentages rise for the first time with those of Gramineae. Pteridium spores reappear with a few grains of ruderal species, acidophilous species (e.g. Drosera rotundifolia and Empetrum nigrum) and high numbers of Sphagnum spores. This implies that the process of acidification underway in subzone SH3b continued into subzone SH3c. This is supported by the stratigraphy of the core at this level, consisting of lightly humified Eriophorum vaginatum and E. angustifolium peat with Sphagnum and Calluna remains.

The tree and shrub pollen curves do not show marked changes from those of the previous zone and birch fruit and scales and alder fruit are found in the peat showing that carr vegetation was still growing around the margins of the bog. The reappearance of Pteridium spores, coupled with the records of ruderal grains and the slight increase in Corylus percentages may be regarded as possible evidence for small-scale, short-term clearance of mixed deciduous forest by hunter-gatherers of the Mesolithic.

At 5520 $\pm$ 90 BP, an abrupt change in the forest composition occurred, marked here by the beginning of pollen zone SH4. The Ulmus, Tilia and Betula percentage curves decline steeply while there is a temporary decline in Alnus pollen percentages. The Corylus pollen curve rises as does that of Quercus to a lesser extent. Arboreal pollen falls from c. 54% to 40% across the boundary and rarely exceeds 45% thereafter. The influx diagram, however, shows an overall reduction in pollen influx from c. 23000 grain cm^{-2} yr^{-1} to less than 2000 grain cm^{-2} yr^{-1} at 180cm. By 172cm the total influx recovers to 11000 grains cm^{-2} yr^{-1}, the whole phase lasting only 200-300 years; however, the pre-elm decline influx levels are not regained. At first, all tree and shrub species decline except Fraxinus, but Quercus, Corylus and to a lesser extent Alnus recover again later. Apart from the initial dip in the curve, non-arboreal pollen influx remains relatively unaffected.

In zone SH4, macrofossils derived from trees are missing from the stratigraphy. Humification is a little heavier than in the previous zone and the growth rate of the peat was slower, 16.9 yr cm^{-1} as opposed to 8.3 yr cm^{-1}, but this is still above the average growth rate. The disappearance of Betula and Alnus fruit and scales from the stratigraphy suggests that birch and alder trees were no longer growing in the immediate vicinity of the sampling site.

Before 5520 $\pm$ 90 BP, elm and lime trees were growing as part of "mixed oak forest" on the base-rich soils of this part of the massif. After this date they no longer formed a major constituent of the forest. In the past it was believed that only elm was affected, and that the decline occurred synchronously across Britain around 5100 BP. The explanation for this is a subject of much controversy, and will be discussed fully in the General Discussion (section 11). From the Sunset Hole diagram it appears that in this area of the massif nearly all trees and shrubs and some herbs were affected and that the fate of Tilia in particular seems to have been linked with that of Ulmus at this time.

There is some evidence to suggest that anthropogenic factors may have been operating in the area at the time of the elm decline. The rise in Corylus pollen percentages, immediately after the zone SH3c/4 boundary, suggests an opening up of the forest canopy. Corylus colonises clearings quickly and pollen production is greatly increased with more sunlight. The peak of Plantago lanceolata pollen and a few ruderal grains also indicate clearance of forest cover, perhaps by late Mesolithic hunter-gatherers to attract wild game or by early Neolithic farmers.

Throughout pollen zone SH4, the peat consists mainly of Eriophorum vaginatum and Calluna remains. This is complemented in the pollen record by relatively high values of Gramineae, Cyperaceae and Calluna pollen, showing that Eriophorum/Calluna heath was growing on and around the sampling site between 5520 $\pm$ 90 BP and 3850 $\pm$ 80 BP. During this time the vegetation alternated between Calluna dominance with reduced Gramineae and Cyperaceae and then the latter groups becoming dominant with reduced quantities of Calluna. Similar oscillations in the vegetation have been recorded by many authors (e.g. Chambers, 1982 & 1983; Conway, 1954). This could represent either a "hummock and hollow" type of cyclic vegetational sequence (Tansley, 1949) or else more widespread changes across the bog surface.

From c. 4730 BP or about halfway through zone SH4, Plantago lanceolata pollen is continuously present together with frequent records of Pteridium, Rumex acetosa/acetosella type and Urtica pollen. This is the first time in the diagram that taxa, normally considered to be agricultural weeds or at least indicators of forest disturbance, appear in numbers. This suggests that areas were cleared in the forest for man's use, either on a small scale or on a larger scale but at a greater distance from the sampling site. This is supported by relatively high values of *Fraxinus* pollen (considering this is a poor pollen producer) and high *Corylus* percentages as both trees colonise cleared ground readily. The estimated age of 4730 BP, based on the radiocarbon dates obtained above and below this horizon, would place the beginning of this larger-scale clearance in the late Neolithic period.

The pollen zone SH4/5 boundary has been drawn at what appears to be the beginning of the final clearance of trees from the area, starting at 3850 ± 80 BP, and continuing gradually over the last two pollen zones. For the first time, non-arboreal pollen influx values and percentages exceed those of arboreal and shrub pollen.

This boundary also marks a secondary decline in the *Ulmus* and *Tilia* curves. The decline in *Ulmus* pollen percentages is less clearly defined but *Tilia* pollen is almost totally absent from this point onwards. This again suggests common factors at work on these two species in particular.

The local bog communities were much the same as for the previous zone. *Eriophorum vaginatum*-*Calluna* heath with *Sphagnum* continued to grow on the sampling site. The growth rate of the peat slowed down from 16.9 yr cm^{-1} to 22.0 yr cm^{-1}. Pollen influx values for total land pollen were also similar to those of pollen zone SH4.

The percentage values for *Plantago lanceolata* and *Pteridium* increase from the zone SH4/5 boundary as do the percentages of *Rumex*, *Urtica*, *Artemisia* and Chenopodiaceae pollen. This, together with the declining tree pollen percentages indicates more intensive forest clearance by man, with the preponderance of *Plantago*, *Pteridium* and *Urtica* and lack of cereal grains suggesting a bias towards pastoralism. This phase of activity persisted for about 600 years, between 3850 $\pm$ 80 BP and 3230 BP, and belonged to the early to middle Bronze Age.

In the second half of the zone SH5 the curves for Plantago lanceolata and Pteridium decrease and do not recover until the SH5/6 zone boundary at c. 2970 $\pm$ 60 BP. There is also a slight increase in pollen percentages of Betula, Corylus and Calluna, indicating a slight recovery of colonising trees and shrubs, before the resumption of full scale clearance. Although man's activities in the area did not stop, there appears to have been a period of c. 260 years when the population was reduced in numbers or had moved away from the vicinity, reducing grazing pressure and allowing light-demanding trees to recolonise previously cleared ground.

The beginning of the final pollen zone, SH6, marks the resumption of large-scale forest clearance. Arboreal pollen percentages rarely exceed 15% of total land pollen. The vegetation on the upper slopes and wetter areas in this region of the massif consisted largely of Calluna heath, as shown by its high pollen percentages. Grassland and perhaps some trees may have been growing on the limestone plateau below the site.

As before, the dominance of Plantago lanceolata pollen with lesser amounts of Pteridium, Rumex and Urtica would suggest predominantly pastoral farming being practised, but on a larger scale than before. The radiocarbon date of 2970 $\pm$ 60 BP places the beginning of this phase in the late Bronze Age period.

When using the estimated time scale based on the peat growth rate (22.0 yr cm^{-1} for zone SH5), the age of the bog surface would be c. 1820 BP, belonging to the early to middle Romano/British Period. The surface of the Sunset Hole site appears to have stopped growing and erosion is under way. The top few centimetres of peat may well contain a mixture of both old and modern pollen grains. If this is the case, the slight recovery of tree pollen, including that of elm, at the surface, may be due to the cultivation of small plantations on the limestone plateau, or the planting of trees around the farms in the surrounding valleys.

4.4. Summary

SH1	:	Peat initiation is dated to 9400 ± 100 BP but pollen evidence suggests the date should lie just after 8730 BP, particularly as *Corylus* pollen is already present in high percentages. Peat accumulation began under willow and hazel woodland with some open areas of fen communities. Climate appears to have been cool and dry but the temperature increasing. Pine-hazel and probably pure hazel stands were growing on the dry slopes and plateau in the area. *Quercus*, *Ulmus*, *Pinus* and *Betula* invade the woodland towards the end of the zone.
SH2	:	7450 ± 80 BP - 6410 ± 80 BP. *Alnus* pollen present, between 2-5% of total land pollen. Pine began to decline. Carr, similar to that of zone SH1, was growing on the site, but monocots became more abundant. Towards the end of the zone, wetter and slightly more acid conditions prevailed. Mixed oak wood was taking over the former woodland.

SH3	:	6410 ± 80 BP - 5520 ± 90 BP. Sudden expansion of alder in the vegetation taking an estimated 180 years only. A hiatus may have occurred in peat growth at the end SH2/3 boundary. Broadleaved forest covered much of the countryside.
3a	:	6410 ± 80 yr BP - 6060 BP. Birch and alder took over the carr vegetation with an understory of ferns and mosses.
3b	:	6060 BP - 5860 BP. Birch and alder trees thinned out as poor fen communities expanded.
3c	:	5860 BP - 5520 BP. Acidification of the sampling site continued with Eriophorum-Sphagnum-Calluna bog taking over from the remaining birch and alder trees.
SH4	:	5520 ± 90 BP - 3850 ± 80 BP. The percentage curves for elm and lime pollen decline together with that of birch. There is a sharp but short-lived fall in pollen influx at the beginning of the zone coinciding with small peaks in clearance indicator species, suggesting interference by late Mesolithic or early Neolithic peoples with the vegetation. Trees still covered much of the area but without as much elm or lime as before. Eriophorum-Calluna-Sphagnum peat was accumulating on the sampling site. At 4730 BP, halfway through the zone, clearance indicators show

increased farming activity belonging to the late Neolithic period.

SH5 : 3850 ± 80 BP - 2970 ± 60 BP. The final and steady clearance of trees from the area commenced. Non-arboreal pollen exceeds that of arboreal and shrubs for the first time. The curves for elm and lime pollen decline a second time. The percentages of clearance indicator species peak for c. 600 years (3850 ± 80 - 3230 BP) suggesting pastoral farming being practised during the early to middle Bronze Age. In the second half of the zone these indicators are reduced for c. 260 years between 3230 - 2970 ± 60 BP. Eriophorum-Calluna bog continued to grow on the sampling site, reflecting a much wider spread of acid heath on the upper slopes of the massif.

SH6 : 2970 ± 60 BP - surface. Pollen percentages of clearance indicator species increase.
Calluna heath covered much of the slopes. Tree species were probably restricted to inaccessible areas of the slopes and plateau. Pastoral farming predominated with a little arable from the late Bronze Age to the beginning of the Romano-British Period. Using the growth rate of zone SH5 peat, the surface date was estimated at 1820 BP. A hiatus in peat growth seems to have occurred so that the record is missing from Romano-British times onwards.

5. THE ARKS (NGR, SD 75 75)

5.1. Description of site

The Arks is the name of a corrie on the north-north-west side of the Ingleborough Massif, just below the col connecting Simon Fell with Ingleborough Hill. The basin floor lies at an altitude of about 533m (MSL), and slopes very gently downhill. A large expanse of deep peat has accumulated, the centre of which now consists of an oval arrangement of peat haggs, forming the edge of a crater-like hollow. Two natural drainage channels leave the bog and flow straight downhill to the north-west. Another, wider channel leaves laterally and turns downhill at the north-eastern arm of the Arks (plate 3 and fig. 5.1.). Several shallow pools have formed in the crater and actively-growing peat, dominated by *Sphagnum* spp, fills the rest.

To investigate the growth and structure of the bog, two transects (A and B) have been taken at right angles across it, the longest (transect A, 127m) lying roughly north-east/south-west (fig. 5.1.). The surface was levelled to determine the topography and borings were taken at intervals on the longest transect. The cores were retained for pollen analysis and identification of macrofossils. Notes were made in the field on the stratigraphy (fig. 5.2.).

It appears that most of the centre of the bog has been lost, perhaps via a bog-burst or else by steady but rapid erosion. A monolith (AI, the starting point of transect A) was cut from a peat hagg at the south-western end of the oval and, at a later date, a core (AII) was taken from within the crater. A second monolith (AIIm) was taken from the vicinity of the core, when the transects were laid out, to provide enough peat for radiocarbon dating. Pollen analysis was carried out on the Arks I,

Plate 3

The Arks basin showing the arrangement of peat haggs.

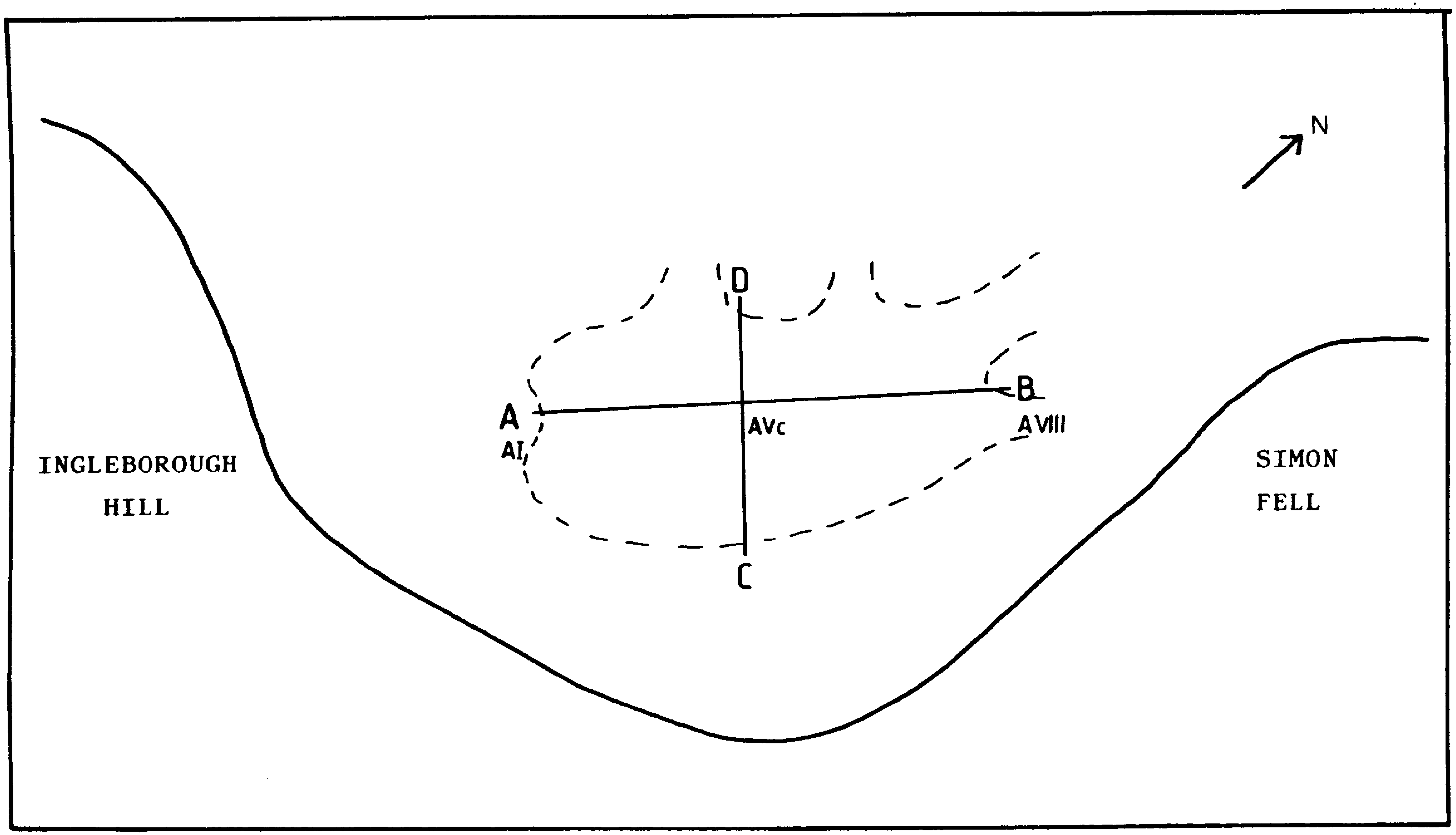


Figure 5.1. Sketch diagram showing the Arks basin and position of transects.

AII , AIIm and AVIc peat. Macrofossils were examined from all the cores and monoliths collected.

A considerable volume of water must drain into the bog from the Arks' scree slopes. Several streams arise in this area and coalesce further down the hillside. The present surface vegetation of the peat haggs tends to be dominated by Eriophorum vaginatum with Deschampsia flexuosa, Calluna vulgaris, Vaccinium myrtillus and Cladonia sp. Within the crater Eriophorum angustifolium, Sphagnum spp and Juncus spp thrive while the pools are dominated by Sphagnum spp.

5.2. Stratigraphy

The stratigraphy of the Arks monoliths and cores, based on field notes and detailed macrofossil analysis, is described below and in appendix 3, and shown in fig. 5.2.

5.2.1. Arks I (AI)

Depth (cm)	Description
0 - 8	Dark brown, very heavily humified Eriophorum vaginatum peat.
8 - 60	Heavily humified E. vaginatum-Calluna peat, resembling above with Sphagnum sp at some levels.
60 - 84	Dark reddish brown, very heavily humified, E. vaginatum-Calluna peat with Potentilla erecta and seeds of Juncus sp.
84 - 100	Paler, reddish brown, fibrous, moderately humified E. vaginatum-Calluna peat with Potentilla erecta and Juncus sp seeds and large Calluna twigs.

100 - 120	Moderate-heavily humified, extremely coarse, fibrous *E. vaginatum* peat still with *Potentilla erecta* fruit and *Juncus* and *Calluna* seeds.
120 - 138	Very heavily humified, cheesy-textured peat, otherwise as above.
138 - 150	Very heavily humified, coarse, fibrous *E. vaginatum* peat, otherwise as above.
150 - 160	Very heavily humified, darker, cheesy peat with *E. vaginatum* and fruit of *Potentilla erecta*.
160 - 161	Fragment of *Salix* sp wood.
160 - 168	As above with increasing mineral content, *Potentilla erecta* fruit and *Juncus* sp seeds and large wood fragments.
168 - 176	Very heavily humified wood-monocot, clayey peat ending at the peat/mineral interface.

5.2.2. Arks II core (AII)

Depth (cm)	Description
0 - 6	Unhumified *Sphagnum papillosum* remains.
6 - 8	Very heavily humified *Eriophorum vaginatum*-*Carex*, mixed monocot peat with *Calluna* shoots and a *Menyanthes trifoliata* seed
8 - 20	Relatively unhumified, dark, black-brown *E. vaginatum* peat.

20 - 21	As above but with coarse sand grains.
21 - 25	Lighter, reddish-brown, *E. vaginatum*-*Sphagnum*-*Polytrichum* peat, with *Calluna* twigs and a *Carex* sp fruit.
25 - 70	Light, reddish-brown, mixed monocot and moss peat with *E. vaginatum*, seeds of *Juncus* sp, *Carex rostrata* fruit and *Carex* sp fruit, together with achenes of *Ranunculus* sp and *Potentilla palustris*, and seeds of *Viola palustris*, *Menyanthes trifoliata*, *Montia fontana* and *Lychnis flos-cuculi*. Also with occasional woody fragments.

5.2.3. Arks II monolith (AIIm)

Depth (cm)	Description
0 - 16	Unhumified *Sphagnum* sp peat and *Eriophorum vaginatum* remains.
16 - 51	Dark, black-brown, humified *E. vaginatum*-*Calluna* peat with *Empetrum nigrum* seeds and *Potentilla erecta* achenes.
51 - 53	Large grains of sand, otherwise as for 53 - 72 cm.
53 - 72	Dark, mixed monocot peat with *E. vaginatum* leaf remains, *Juncus* sp seeds, *Carex* sp fruit. Also seeds of *Viola palustris* and *Potentilla palustris* achenes. Bands of *Sphagnum*-*Polytrichum* peat

	with woody fragments at 64cm and E. vaginatum-Polytrichum peat at 68cm.
72 - 78	As above with fine clay particles.
78 +	Grey, sandy clay.

5.3. Discussion (diagrams 5.1, 5.2, 5.3, 5.4, 5.5, 5.6 and 5.7)

Peat accumulation began in the Arks shortly before 9240 ± 90 BP, in a shallow basin on a gently sloping shelf, in the centre of the Arks semi-circle (plate 3, fig. 5.2.). The sub-stratum appears to have consisted of shattered rocks from the surrounding scree slopes and coarse grey sandy clay (as seen at the bases of the AI and AIIm profiles). Manley (1959) in his discussions of the post-Allerød climatic recession suggests that the Arks corrie would have contained a persistent snowbed and was the southern-most outlier of this period of glaciation, beginning between 11000 - 10000 BP. After sufficient amelioration of the climate the basin was colonised by plant life. Unfortunately we have no pollen record of this initial vegetation, as the Russian borer would not penetrate the substratum, preventing the sampling of the basal 16cm of peat.

The oldest peat collected belongs to the Arks II core, the combined basal 5cm giving a radiocarbon date of 9240 ± 90 BP. The vegetation growing on the site appears from the macro-fossils to have been composed of a mixture of monocots (Eriophorum, Juncus and Carex sp) with a variety of herbs preferring wet, fairly base-rich, habitats (e.g. Viola palustris, Potentilla palustris, Montia fontana, Lychnis flos-cuculi). The evidence for the presence of an open fen or reed-swamp type of community is supported by the pollen data. Non-arboreal pollen reaches over 80% of the total land pollen with Cyperaceae and Gramineae being the major components, but also with abundant Filipendula, Potentilla and Rumex pollen and a wide variety of other herb types. Some wood fragments were found in the peat which, together with the Betula and Salix pollen percentages, suggests that some birch and willow trees were also growing on the site.

The very low AP levels indicate an open landscape with patches of birch, juniper and perhaps willow scrub on the surrounding slopes. Other indicators of open ground present include Thalictrum, Artemisia and Chenopodiaceae. Pine trees appear to have formed a minor constituent of the vegetation during zone AII 1. However, Pinus is a prolofic pollen producer and its pollen is exceptionally well dispersed. Huntley and Birks (1983) point out that high pollen values ($>$50% of tree and shrub pollen) can be found today in treeless localities. They suggest that values $>$20% of tree and shrub pollen probably reflect local presence of small areas of pine in a forested landscape. In zone AII 1, Pinus pollen reaches only about 10% of tree and shrub pollen, which may indicate that pine trees were not growing on the massif at this time (9240 $\pm$ 90 - 8730 $\pm$ 80 BP), the Pinus pollen being a product of long-distance transport.

Juniper bushes, though abundant at first, declined steadily and Juniperus pollen is absent in the second half of zone AII 1. The decline in Juniperus pollen is well-documented from other sites (e.g. Red Moss, Hibbert et al., 1971) and this has often been put down to the spread of birch and pine forest out-shading the juniper. However, in the AII diagram the Betula and Pinus curves rise, but only after the Juniperus pollen has completely disappeared. It is interesting to note that juniper bushes can still be found on the limestone crags, particularly on the south side of the massif on Moughton Fell. There is also documentary evidence of juniper being far more widespread in the 19th century and of it disappearing rapidly from large areas for no clear reason (Cheetham, 1947), although heavy grazing pressure may have been operating.

Juniper pollen was not recorded from the AIIm or AVIc profiles which appear to have begun later than the AII profile. The basal peat from zones AIIm 1 and AVIc 1 is equivalent to that of the last few centimetres of zone AII 1, being a reddish-brown peat with similar seed types and monocot remains. By this time birch, and to a much lesser extent pine trees, had become more abundant, producing peaks in the pollen curves of these taxa. Empetrum and Sphagnum were taking over locally, perhaps indicating a relatively rapid change to wetter and more acid conditions, supported by the presence of Menyanthes seeds and the peak of Menyanthes pollen in the AII diagram.

The AII 1/2, AIIm 1/2 and AVI 2/3 boundaries mark the empirical limits (Smith and Pilcher, 1973) of the Ulmus, Quercus and at AII the Alnus pollen curves, as well as the steep rise in Corylus pollen percentages. Hazel woods or scrub encroached on birch and possibly pine on the drier slopes and limestone, while the first oaks and elms were migrating into the area. This rise in Corylus pollen has been radiocarbon-dated to just after 8730 ± 80 BP in the AIIm profile. A similar horizon in the diagram from Red Moss (Hibbert et al., 1971) was dated to 8880 ± 170 BP at at Scaleby Moss (Godwin et al., 1957) to 8809 ± 150 BP. This would suggest that at the Arks site there is a continuous pollen record at least until this time. Assuming the rises in Corylus pollen in the AII and AIIm profiles represent the same event, a growth rate of 11 yr cm^{-1} has been estimated for the basal peat.

Soon after the rise in the Corylus pollen curve, all three diagrams - AII , AIIm and AVIc - show an abrupt rise in the curves for Ulmus, Quercus and Alnus, with the appearance of Fraxinus pollen. The AIIc and AVIc diagrams show a fall in Betula percentages. At AIIm this horizon occurs at 52cm and has a radiocarbon date of 5830 ± 50 BP.

This indicates that the 16cm pf peat between the rise in the Corylus pollen curve and the rise in the curves for broadleaved trees represents 2900 years or a growth rate of 181 yr cm^{-1}. As the average growth rate for Ingleborough diagrams (minus the highest and lowest figures) is c. 26 yr cm^{-1}, there is strong evidence for a hiatus in the peat growth between the dated levels. This is supported by the presence of a layer of sandy peat in the stratigraphy, separating the reddish-brown reedswamp /fen peat from a black-brown, highly humified Eriophorum vaginatum-Calluna peat. This sand layer stretches between AIIm and AVIc on transect A (fig. 5.2.) lying at a depth of between -4.40m and -3.90m in the "crater" of the bog. At AIVc no sand grains were recorded but there was a clear transition between the two peat types.

The pollen record provides additional support for this interpretation, as the sand layers in AIIc, AIIm and AVIc coincide with the sudden increase in percentages of elm, oak and alder pollen. Also, there are slight differences between the three diagrams in terms of how soon after the Corylus rise these pollen types increase, suggesting that the profiles have been truncated with subsequent flooding and inwash of mineral at slightly different depths.

The pollen assemblage of the final zone in all three pollen diagrams consists mainly of Betula, Pinus, Ulmus, Quercus, Alnus, Corylus, Fraxinus and Calluna pollen. If there were no hiatus one would not expect to have Alnus and Fraxinus pollen present in any numbers at the rational limit of the Quercus and Ulmus curves. The amount of black-brown Eriophorum-Calluna peat lying above the sand layer varies between 12 and 52cm, but all three profiles end at the surface with a few centimetres of unhumified Sphagnum moss; an indication of the wet bog surface currently in evidence in the Arks "crater".

The oval arrangement of the peat haggs in the Arks (plate 3, and the general topography, fig. 5.2.) point to the bog's once possessing a coherent dome, the centre of which has since been lost. Two suggestions can be put forward as to the history of this site.

(a) Peat growth commenced in the Late Glacial to early Flandrian Period, after permanent ice had finally gone from the corrie. Accumulation continued as hazel migrated into the area and established itself as a dominant component of the vegetation. Between 8730 ± 80 BP and 5830 ± 50 BP peat growth stopped and erosion set in, the inwash depositing a layer of sand. Peat growth commenced again at c. 5830 ± 50 BP and continued, producing a slightly domed bog. A second hiatus in peat growth occurred much later, allowing extensive and prolonged erosion of the bog centre. Alternatively at this second stage a bog burst may have occurred.

Or (b) Peat growth commenced as described above, but continued late into the Flandrian Period, producing the domed bog. At this late stage, either peat growth stopped and erosion set in or the bog became unstable and the centre was lost, leaving a layer of sand lying unconformably on the ancient peat with a mixture of redeposited peat from the eroding haggs lying on top. The radiocarbon date obtained for the 52cm level of the AII monolith would then be an indication of the age of the flooding and erosion episode, or more likely, an average date of the mixed, redeposited peat.

Model (a) seems less probable than (b) for several reasons. When the final zones of the AII, AIIm and AVIc pollen diagrams are compared with zone AI 2, the equivalent zone of Arks I containing peat from 5830 ± 50 BP onwards, some clear differences can be seen. AP percentages from the crater peat lie around 20% compared with 30-40% in the AI diagram. This is due largely to the crater peat containing much fewer Alnus and Quercus pollen grains and less shrub pollen. The crater peat also shows peaks of Plantago lanceolata and Urtica pollen grains. In zone AI 2, Plantago lanceolata pollen is only recorded from the end of the zone and in percentages less than 0.5%, whilst Urtica pollen is absent. This latter point suggests at least some of the upper crater peat is of relatively modern origin.

The period of time missing from the record of the crater peat includes the period in which peat accumulation commenced at Arks I. It seems unlikely that peat initiation and subsequent growth would occur while immediately down-slope in the basin, peat growth had stopped and erosion set in. Model (b) is also supported by the fact that the date of 5830 ± 50 BP falls in the middle of zone AI 2, a period of very slow peat growth, calculated to have been 76 yr cm^{-1}. There are no signs of a change in conditions liable to promote the renewed growth of peat in the bog crater.

As peat accumulated in the Arks basin, the margins of the bog spread outwards and probably reached the Arks I site around 7200 BP. This date is an estimation, calculated by using the growth rate of the following zone. The stratigraphy of the AI profile shows similarities with that of the AVIIIc profile in that Eriophorum-monocot-Calluna-Sphagnum peat gives way near the base to a monocot and wood peat, although Empetrum is more common at AVIII. It is possible that these two profiles are much closer in age than the intervening basin peat, despite the 3.5m difference in base height.

Peat accumulation began at the Arks I site under a wood or scrub vegetation, of willow and possibly hazel and birch. The understory was dominated by ferns and monocots.

The presence of _Filipendula_, _Succisa_ and Umbelliferae pollen in zone AI 1 and the lack of significant _Calluna_ counts, indicates that a fairly base-rich, fen-like community also existed in the vicinity, probably in less dense areas of tree cover.

The drier slopes around the Arks site were mainly covered by hazel scrub, with occasional pine trees. The rising percentages of pollen from deciduous trees suggests that at a greater distance, perhaps in the sheltered valleys and on the plateau, mixed broad-leaved woodland was on the increase, as the temperature rise and their migration rates allowed. This consisted of oak and elm with perhaps pine and birch and an increasing amount of alder trees, the latter probably spreading along the stream sides and wetter areas.

The zone AI 1/2 boundary has been placed where alder pollen reaches high percentages, whilst those of hazel decline and _Calluna_ and Cyperaceae pollen become important amongst the non-arboreal pollen. This boundary has been radiocarbon-dated to 6400 $\pm$ 70 BP.

The peat of zone AI 2 shows a transition from a monocot-wood peat to one of _Eriophorum_-_Potentilla_. This is mirrored by the pollen evidence, since the curves for _Filipendula_, _Succisa_ and Umbelliferae decline as those of _Calluna_, Cyperaceae, _Potentilla erecta_ and _Sphagnum_ rise. This indicates a change to more acid conditions at the sampling site and possibly wetter, although the slow growth rate would argue against this. Trees disappeared from the bog surface at the beginning of the zone.

Zone AI 2 shows the highest arboreal pollen percentages of the profile, reaching 40% TLP. This represents the most wooded period of the massif's history, lying towards the end of the Mesolithic Period. There appears to have been a general increase in broadleaved woodland at the expense of the hazel and pine/hazel woods on the drier areas. The amount of birch trees increased and Fraxinus appeared for the first time. Alder trees were now common, particularly on the wetter areas, although they were not growing in the immediate vicinity of Arks I.

At c. 5030 $\pm$ 50 BP major changes occurred in the composition of the broadleaved woodland. The pollen curves for Ulmus and Tilia decline permanently while those of Betula and Quercus show temporary declines, and Corylus pollen percentages begin to recover from a decline. The pollen influx diagram shows a temporary decline in Ulmus pollen while Tilia pollen is permanently reduced. The overall pollen influx peaks after the AI 2/3 boundary due to the peaks in Quercus, Alnus, Fraxinus and Corylus pollen influx curves. From these results it appears that a rapid change occurred with a permanent reduction in the numbers of elm and lime, and temporary reduction in birch and oak trees in the woodland.

The pollen influx and concentration values fall steeply and then rise again at the Elm decline, possibly showing a brief increase in peat accumulation rate. This was also noted at the Sunset Hole site. Another similarity is that at the AI 2/3 boundary there are a few grains of Plantago lanceolata and a small peak in Pteridium spores. This may indicate a short clearance phase that occurred in the late Mesolithic or early Neolithic Periods. The Elm decline and associated phenomena are discussed in depth in the General Discussion (section 11).

The non-arboreal pollen in zone AI 3 consists largely of Gramineae, Cyperaceae, Calluna and Potentilla which, together with the macrofossils, show that an Eriophorum-Calluna heath/bog was growing at Arks I. Trees appear to have been absent from the Arks peat surface from before 5030 $\pm$ 50 BP onwards.

Between 5030 ± 50 and 3960 ± 50 BP the composition of the non-local vegetation remained fairly constant. However, c. 3960 ± 50 BP, the remaining elm and lime trees declined in numbers once again. Records of _Tilia_ are not consecutive and _Ulmus_ values rarely exceed 1%. Apart from these changes, the pollen spectra remain much as before. Records of _Plantago lanceolata_ and _Pteridium_ grains are a little more frequent as are those of other herbs not forming part of the bog communities, such as _Cirsium_, _Filipendula_, _Melampyrum_ and _Succisa_. This may indicate temporary and small-scale clearance of forest or else natural reduction in cover due to climate or pedological factors. The scree slopes now to be seen surrounding the Arks basin could well have been too steep and unstable to have borne mature broadleaved woodland, particularly under wetter conditions.

The pollen zone boundary of AI 4/5 has been drawn at the rational limits of the _Plantago lanceolata_, _Pteridium_ and cereal curves. _Calluna_ percentages rise steeply in pollen zone AI 5 and this, coupled with increasing Gramineae and Cyperaceae pollen percentages, reflects not only the _Eriophorum_-_Calluna_ bog communities still growing on the sampling site, but also a rapid expansion of _Calluna_ heath or bog on the surrounding slopes.

The pollen and spore curves of _Plantago lanceolata_ and _Pteridium_ peak in zone AI 5 while _Rumex_, _Artemisia_, Chenopodiaceae and _Urtica_ grains are common and cereal grains are continuously present. Tree species generally decline throughout this zone except birch and ash. These vegetational changes strongly suggest that after 3400 ± 50 BP or the middle Bronze Age, man was involved in a large-scale clearance of the oak-alder-hazel woodland. The variety of clearance-indicator species and presence of cereal grains points to both pastoral and arable farming being practised.

The date of the surface peat, if estimated using the growth rate of the previous zone (AI 4), is 1800 BP or 150 AD. It seems unlikely that the deterioration of the bog surface began much before the final layers of the AI monolith had accumulated. Removal of the centre of the bog is liable to have lowered the water table and possibly slowed or stopped peat growth.

There are several ways the current formation of peat haggs could have arisen:

a) the bog surface stopped growing (c. 1800 BP), perhaps because of a change in climate, or because the water table became too high, making the surface unstable. Rapid erosion ensued, removing the bog centre and cutting back the ring of peat haggs;

b) water collected to such an extent in the peat that a bog burst occurred, peat being lost suddenly downhill via the drainage channels already described. This would quickly lower the water table in the remaining haggs, stopping peat growth and allowing erosion to set in;

c) a "gill-brack" may have occurred, or snow avalanche, in the Arks basin. Such avalanches have been known to occur in the dales (Dakyns et al., 1890). A notable example of a gill-brack (c. 28th Jan., 1753) occurred on Whernside and was described by Thomas Thistlethwait, an eye-witness. After heavy snow and strong winds for over a week, a thaw began and with it, heavy rain. The snow, no longer able to hold the rain, slipped down the hillside "with incredible Swiftness Driving great rocks Stones and Earth all before it Roaring Like Claps of Thunder". Such was the violence of the avalanche that farm buildings were swept aside and a family of seven killed in the process.

The slopes surrounding the Arks bog are very steep, and similar snowfalls may well have taken place here. It is possible that a "gill-brack" may have occurred, scouring the centre of the bog.

It is difficult to suggest what is the most likely history of the Arks peat; however the presence of a clear sand layer would suggest a single event initiated the erosion phase rather than a long-term continuous process, hence favouring b) or c).

5.4. Summary

It is evident, from the orientation of the peat haggs within the Arks, that all the sites described in this chapter once belonged to the same peat formation.

AII 1 Peat accumulation began in the Arks basin shortly before 9240 $\pm$ 90 BP, under open fen and reed swamp communities with occasional birch and willow trees. The surrounding countryside was also open, rich in herbaceous species, with patches of birch, juniper and willow scrub. Occasional pine trees were beginning to appear in the area after the juniper bushes had declined.

AII 1(end), AIIm 1 & AVIc 1 - Empetrum, Sphagnum and Menyanthes became major constituents of the local plant communities, while more birch and perhaps more pine trees were growing in the surrounding area that in the previous zone.

AII 2, AIIm 2 & AVIc 3 (8730 ± 80 BP) - The boundary coincides with the abrupt rise in _Corylus_ pollen curve indicating the rapid and widespread expansion of hazel on to the slopes and perhaps on to the bog surface in places. A few oak, elm and alder trees were growing amongst the hazel and hazel/pine woods growing on the drier soils.

AII 3, AIIm 3 & AVIc 4 - Soon after the _Corylus_ pollen rise a layer of sand appears in the stratigraphy of all three sites at the interface of two different peat types. This appears to represent a hiatus in peat growth growth. A date of 5830 ± 50 BP was obtained for the beginning of the above zones. However, it seems most likely, when considering the evidence, that this date represents an average date for a mixture of old and more modern peat.

AI 1 The expanding bog surface probably reached the AI site at c. 7200 BP, when wet woodland or scrub of willow, birch and perhaps hazel, with an understory of ferns and monocots was growing on the sampling site. The surrounding slopes were covered with hazel scrub with occasional pine trees. Other broad-leaved trees were on the increase, such as oak and elm.

AI 2 (6400 ± 70 BP) - The boundary marks a change to more acid conditions as an _Eriophorum-Potentilla_ peat takes over from the wood peat, and trees finally disappear from the bog surface. Alder trees now are common, particularly in wetter areas, but not on the bog surface in the vicinity of Arks I.

The evidence suggests mixed oak-elm-lime and hazel woods were growing on the drier slopes. This zone represents the most wooded era on the massif.

AI 3 (5030 ± 50 - 3960 ± 50 BP) - This period begins with the permanent decline in elm and lime pollen curves, coinciding with small peaks in disturbance-indicator species and a short-term fall in pollen influx. This may well represent interference with the vegetation by Late Mesolithic or early Neolithic man for a short period. Eriophorum-Calluna peat had taken over the bog surface.

AI 4 (3960 ± 50 - 3400 ± 50 BP) - Beginning of the zone is marked by the secondary decline in elm and lime pollen, leaving the woodland consisting largely of oak, alder and hazel. First signs of continuous farming activity by man.

A5 (3400 ± 50 BP - present) - Calluna heath and bog spreads rapidly on the higher slopes. A large-scale, mid Bronze Age clearance phase begins with signs of both pastoral and arable farming techniques being practised. Calluna heath spreads rapidly on the hill slopes, while AP percentages fall to low levels. The growth rate of the previous zone has been used to estimate the age of the surface peat, this being c. 1850 BP. This suggests that a second and much later hiatus has occurred. Evidence is discussed indicating that loss of peat from the centre of the bog occurred after this date and was either due to rapid but long-term erosion or was initiated by a single event such as a "bog-burst" or a "gill-brack".

6. SIMON FELL (NGR, SD 751 749 & 751 746)

6.1. Description of site

Simon Fell is the lower summit to the east of Ingleborough Hill, with which it merges (plates 1 and 2). The bedrock consists mainly of grits and sandstone of the Yoredale Series; however the Main Limestone also outcrops on the fell (Green Hill). A large proportion of the summit area is covered by deep blanket peat now severely eroded.

The first Simon Fell monolith (SFI) was cut from a peat hagg situated on the col (617m, MSL) connecting Simon Fell with Ingleborough Hill (plate 4a). The second monolith (SFII) was taken from another peat hagg on the far side of the summit, facing south, at the same altitude (plate 4b).

The present vegetation of the sites is dominated by *Eriophorum vaginatum* and *Deschampsia flexuosa* with *Festuca ovina*, *Cladonia* spp, *Vaccinium myrtillus* also relatively common. The majority of the water reaching the sites does so as rainfall, although there may be some lateral drainage.

6.2. Stratigraphy

The stratigraphy of the two sites, based on field notes and detailed macro-fossil analysis, is as follows:

6.2.1. Simon Fell I

Depth (cm)	Description
0 - 68	Highly to moderately humified, black, oxidized, *Eriophorum vaginatum*-*Calluna* peat. Occasional bands of less humified peat with

Plate 4a

The Simon Fell I site and the summit of the Arks scree slopes.

Plate 4b

The Simon Fell II site and Green Hill on the summit of Simon Fell.

	Sphagnum remains and some levels containing Empetrum nigrum fragments.
68 - 144	Lighter brown, moderately to heavily humified, cheesy peat with Eriophorum vaginatum-monocot remains and Potentilla erecta seeds. Some Sphagnum leaves present.
144 - 160	Heavily to very heavily humified, mixed monocot peat with Juncus sp seeds and Carex spp, Ranunculus, Rubus idaeus and Potentilla erecta fruits.
160 - 176	Clay with a heavily humified organic component. Juncus seeds and Rubus achenes with monocot remains.

6.2.2. Simon Fell II

Depth (cm)	Description
0 - 4	Relatively unhumified Eriophorum vaginatum remains with Racomitrium canescens.
4 - 16	Dry, red-brown, very heavily humified peat.
16 - 48	Dark, black-brown, heavily humified, E. vaginatum-Sphagnum peat with Calluna remains (mainly preserved as charcoal)
48 - 83	Generally less humified, E. vaginatum-Calluna peat, otherwise as above.

83 - 120	Yellowish-brown, fibrous, light to moderately humified, E. vaginatum-monocot-Calluna-moss peat with Sphagnum spp and Aulacomnium palustre.
120 - 200	Yellowish-brown, fibrous, relatively unhumified monocot-moss peat peat with E. vaginatum, Sphagnum spp spp, Polytrichum commune and Aulacomnium palustre.
200 - 208	Clayey, sandy, monocot-Polytrichum peat with Carex spp, Juncus sp and E. vaginatum remains. Seeds of Erica sp, grass sp and Ajuga reptans and Potentilla erecta fruit.
208 +	Grey, sandy clay.

6.3. Discussion (diagrams 6.1, 6.2, 6.3, 6.4, 6.5, 6.6)

6.3.1. Simon Fell I

The estimated date for the beginning of peat growth at Simon Fell I (based on the sediment accumulation rate of the following zone, SH2) is 4900 BP, or just after the elm decline.

The initial deposits of the profile consist of clayey mud with an increasingly organic content. By 4720 $\pm$ 50 BP the mud was almost entirely organic in nature. Plant macrofossils are scarce and poorly preserved in these first few centimetres. Nowhere in the peat monolith were woody remains found other than the stems of Calluna plants. Unlike the Arks site, wood fragments were not found in the erosion channels (cut down to bedrock) between the peat haggs, having been washed out of the peat. This suggests that at least from 4900 BP onwards, no trees were growing on or in the immediate vicinity of the site. This is supported by low arboreal pollen percentages of $< 30\%$ throughout most of the profile.

The high percentages counted for Filicales spores, and *Filipendula* and Cyperaceae grains with those of *Pteridium*, *Sphagnum* and Umbelliferae, suggest a monocot-dominated vegetation with abundant ferns and a diverse herbaceous flora. It is possible that Simon Fell has always lain above the tree line. However, in view of the high *Corylus* and *Pinus* levels in zone SFI, it may well be that hazel and pine were growing on the site before 4900 BP but before peat accumulation commenced, they retreated, perhaps remaining only on the better drained limestone on Simon Fell as climate and soil conditions worsened. It is also possible that trees had completely disappeared from the Fell top and tree and shrub pollen were transported to the sampling site from the lower slopes. However, the fact that percentage and pollen influx values for *Pinus* pollen are higher at Simon Fell I than those from Arks I would argue against this. A third possibility is that *Pinus* pollen and spores of Filicales and *Polypodium* have accumulated in the mineral soil due to differential pollen preservation and that pine trees and ferns were not nearly as abundant as the record suggests.

Other tree pollen values are lower, suggesting that the oak-alder-hazel communities were situated on the lower slopes on plateau, not on the summit.

The SFI 1/2-zone boundary (4720 $\pm$ 50 BP) marks a sudden decline in tree and shrub pollen with the corresponding rise in herbaceous pollen values.

In the peat profile, the clayey peat merges into a mixed monocot peat, just above the boundary. Both the macrofossil and pollen evidence suggest that the local vegetation did not change unduly with the transition.

Seeds of Juncus, Carex, Ranunculus, Rubus idaeus and Potentilla were found, which, together with pollen counts of Cyperaceae, Filipendula, Rosaceae, Rubiaceae, Umbelliferae, Caltha and Caryophyllaceae indicate a species-rich marshland, still growing on the site.

Other herbaceous species show a very different behaviour across the boundary. Percentages of Gramineae and Rumex acetosa/acetosella type rise to high values and many other ruderal grains were counted. These indicate that woodland or scrub clearance had occurred and the preponderance of Rumex and Pteridium grains points to pastoral farming practices in the Neolithic Period as the cause. The non-arboreal pollen types present resemble those of zone BWH1 and probably indicate the presence of a similar plant community. (See section 3.3. and 11.)

As the vegetation in the immediate vicinity of the SFI monolith appears not to have been greatly affected by the clearance, the question arises as to where the clearance took place. There is little sign of this event in the pollen record of the Arks or Sunset Hole, indicating either an area on the Simon Fell summit or else the pollen belonged to the long distance component, perhaps from the vicinity of Braithwaite Wife Hole or even further afield.

The percentage curves of Corylus and Pinus pollen decline sharply at the SFI 1/2 boundary. The curves for Ulmus and Alnus pollen show slight reductions, whilst Quercus levels rise slightly. Pollen influx values for tree and shrub taxa are low at the beginning of zone SFI 2, particularly those of Pinus and Corylus, but are higher than those of the previous zone. This is mostly due to the improved degree of pollen preservation rather than increased tree numbers.

From the above evidence it can be proposed that from c. 4720 $\pm$ 50 BP (the beginning of zone SFI 2) the hazel woodland or scrub, perhaps with pine trees, was temporarily cleared on the Simon Fell summit and/or upper slopes. The clearance probably occurred on the drier limestone soils (e.g. Green Hill), under the control of the Neolithic inhabitants. If the pollen indicative of clearance had travelled from a long distance, it would most probably also have been deposited on the Arks I and Sunset Hole sites.

This clearance phase was shortlived, lasting around 400 years, according to an estimate based on the depth and growth rate calculated for the zone. Tree and shrub pollen types return to former percentage levels excepting *Pinus*, which appears to have been permanently eradicated from the area (if its presence in the pollen record was not an anomaly due to pollen degradation). The pollen percentage curve for *Fraxinus* rises at this level and this tree may have been an opportunistic coloniser of the previously cleared ground. The curves for Gramineae, *Rumex* and *Pteridium* decline sharply and other ruderal species are reduced in numbers; however, some ruderal grains are still present, suggesting that the cleared sites had not been fully reclaimed by woodland or scrub, or else farming activity had not ceased altogether on the massif.

The end of the clearance phase, occurring halfway through SFI 2, also marks a change in the stratigraphy of the peat, from the species-rich marshland to a more acid and species-poor bog community dominated by *Eriophorum vaginatum*, *Potentilla erecta* and *Sphagnum* spp. It is not clear whether this was a result of the clearance activity or a climate change to wetter conditions, perhaps increasing the degree of leaching, or simply the next in a series of autogenic changes produced by the growth of the plant communities themselves.

The pollen evidence again supports the macrofossil evidence in that Filipendula, Umbelliferae and Rubiaceae percentages decline rapidly at the change-over and many other herbs are reduced in percentages. The curve for Potentilla pollen percentages increases while Gramineae and Cyperaceae pollen are well represented.

Zone SFI 3 represents a second and more pronounced clearance phase. After an initial peak, due almost entirely to alder pollen, the arboreal pollen percentages show a steady decline from over 35% to less than 20%. The Corylus pollen curve shows a similar pattern. Betula is the only tree to show an increase, and does so from the end of zone SFI 2 onwards. The pollen curves of all the other tree types decline, including that of Fraxinus. Elm pollen percentages fall to permanently low levels and lime pollen all but disappears halfway through the zone.

The peat at the sampling site was much the same as that belonging to the previous zone, as is the 'local' element of the pollen spectra. However, Sphagnum spores increase in numbers in zone SFI 3 and so do the percentages of Calluna pollen, suggesting that conditions became wetter and perhaps more acidic.

The range of vegetational disturbance indicators is different in this second phase. Peaks occur in the pollen curves of Plantago lanceolata, Pteridium and Urtica, while Rumex and Chenopodiaceae pollen, the major indicators in the first phase, are virtually absent. The large numbers of indicator grains and the lack of stratigraphic change suggest that fairly large-scale clearance was taking place on the massif butnot on or very near the sampling site. The decline in trees such as lime, elm and oak points to the mixed oak woods on the lower slopes and in the valleys being most involved. Alder trees do not appear to have been affected and this may be due to its preference for wet hollows on the Ingleborough hillsides; these being unsuitable for agricultural purposes. The low arboreal pollen values suggest that at least by the end of the zone, large areas if not the whole of Simon Fell were completely open. This was probably achieved by a combination of forest clearance under man's influence and the spread of heath due to the affect of climatic deterioration on the upland soils.

This second clearance phase drew to a close at c. 2920 ± 50 BP. Hence the phase lasted about 900 years in all and spanned the Early-Late Bronze Age, ending a little before the Iron Age.

The boundary SFI 3/4 has been drawn where marked changes in both the local and regional vegetation occurred. The macrofossil analysis shows a change from the lighter brown, _Eriophorum vaginatum_-_Potentilla erecta_ peat to a darker _E. vaginatum_, _Calluna_, _Empetrum_ and _Sphagnum_ peat. This is reflected by the abrupt and high increase in _Calluna_ pollen and _Sphagnum_ spores with a rise in the _Empetrum_ pollen percentages, and indicates the spread of these species on to the bog surface, causing the sharp decline in grass and _Potentilla_ pollen. This may have been an autogenic change, but its abruptness would argue more for a sudden climatic change or possibly the removal of a heavy grazing pressure. Over-grazing has been known to reduce the heather population on moorlands.

The numbers of ruderal grains encountered in zone SFI 4 are much reduced, while arboreal pollen percentages rise sharply, revealing a period of woodland recovery. Birch, oak, alder, ash and hazel are the main taxa involved. Elm and lime trees did not appear to recover in numbers; this may be due to their eradication from the massif in the preceeding clearance phase. The small numbers of elm grains recorded could well be from the long-distance component of the pollen rain.

Birch and ash trees thrived during this phase. Agriculture must still have been practised on the massif as ruderals continue to be represented in the pollen rain and cereals appear throughout this zone. The pollen influx values of arboreal, shrub and non-arboreal pollen types are reduced, indicating that despite the apparent recovery of trees, they may still have been reduced in actual numbers. However, since NAP influx values are affected as well, it is equally possible that a change in peat growth rate is involved.

The tree recovery phase ended with another burst of agricultural activity, marked by the zone SFI 4/5 boundary and dated to 2310 ± 50 BP. This indicated that the duration of the previous phase was approximately 600 years.

The third and final clearance phase, recorded in the peat profile, again appears to have had little effect on the stratigraphy and macrofossils, suggesting that the changes in pollen spectra were not due to local vegetational changes. All the remaining tree and shrub species decline in numbers. Arboreal pollen falls to as low as 8% while non-arboreal pollen, consisting largely of _Calluna_ pollen, exceeds 80%. Large areas of the massif's slopes would have now been cleared of forest and covered by _Calluna_ heath.

Plantago lanceolata and _Pteridium_ spores are again the most important indicators of pasturing and clearance. Cereal grains are now consistently present with small numbers of _Rumex_ and _Urtica_ grains. Weed and other herb grains are generally more abundant than in zone SFI 4, indicating a general increase in cleared or open areas.

According to the peat growth rate calculations, there was either an extremely slow peat growth rate in this zone or, more likely, some peat is missing. It is possible that a hiatus has occurred in peat growth as for the Braithwaite

Wife Hole and Allotment Shooting Box sites. However, the curves appear reasonably consistent and so it seems that peat growth stopped and has not recommenced. Using the growth rate calculated for zone SFI 4 to extrapolate forwards, the surface peat would then have been deposited c. 1400 BP or c. 550 AD, i.e. in Anglo-Saxon times. Erosion would have set in after this date and has been continuing ever since. The peat on Simon Fell is very heavily eroded and the run-off channels have scoured down to bedrock.

6.3.2. Simon Fell II

Percentage pollen counts only were recorded for this profile and no radiocarbon dates are available, at present. Tentative dates will be suggested based on comparisons drawn from the dated Simon Fell I diagram.

Peat growth commenced under a mixed monocot peat. As with the opening zone of SFI, no wood fragments were found here, or at any other level in the profile, indicating that trees did not grow on the sampling site during this period.

Without radiocarbon dates it is difficult to compare the two diagrams as there are certain major differences between them, which whll be discussed later. However, on comparison of the pollen spectra, it would appear that peat accumulation began at SFII whilst the first clearance phase was occurring at SFI. In zone SFII 1 high percentages of Gramineae pollen coincide with a peak in the *Rumex acetosa*/*acetosella* curve with continuous records of Caryophyllaceae and Ranunculaceae. The rising *Corylus*, *Alnus*, *Quercus* and *Ulmus* values suggest that the clearance phase was well advanced and trees were beginning to recover again. *Pinus* pollen percentages quickly decline in this zone and neverreach the same level again. The peat type of zone SFII 1 is very similar to that of zone SFI 2, being a mixed monocot peat slowly being transformed to an Eriophorum vaginatum-Sphagnum-Potentilla erecta peat.

In zone SFII 2 the pollen percentages of tree taxa have risen to over 30% and there are high values for Corylus pollen, suggesting that woodland was growing close to the sampling site but not on it. The high percentages of Ulmus pollen compared with those of SFI could indicate that this peat was in fact of pre-elm decline age. However the behaviour of the curve later in the profile would suggest it is of post-elm decline age and may be due to the presence of woodland quite high on the hillsides, particularly on the south-east side. Alternatively, the difference between the Ulmus pollen percentages of the two sites may be due to variable pollen fallout across the plateau (Price & Moore, 1984 and section 11.5).

At the zone SFII 1/2 boundary the variety of herb pollen types is reduced while the curves for Ranunculaceae, Rumex and Potentilla decline and the Sphagnum curve rapidly peaks in this zone, indicating a change to wetter and more acid conditions. The appearance of Calluna and Empetrum pollen at the end of the zone supports this.

Zone SFII 3 begins with a minor disturbance of the vegetation as indicated by the peak in the Rumex curve. Other ruderal species do not increase in numbers, nor do the percentages of Graminese pollen increase. This event is not recorded in the SFI diagram and so would seem to have been very localised. The Rumex peak coincides with a trough in the curve for Corylus pollen and this may indi-indicate that hazel scrub or woodland was cleared either on the limestone of the Fell or on the south-east slopes. The woods lower down the mountain side were composed of oak, elm, birch, lime and hazel with alder, the latter particularly on wetter soils.

Calluna-*Empetrum* heath or bog spread on to the sampling site during zone SFII 3 as shown by the rising pollen curves of *Calluna* and *Empetrum* and declining percentages of Gramineae and Cyperaceae, while *Calluna* macrofossils appear in the peat. *Calluna* and *Empetrum* appear to have been more abundant, earlier at the Simon Fell II site compared with Simon Fell I.

The zone SFII 3/4 boundary is marked by the decline in elm, lime and birch pollen and the first appearance of a continuous *Plantago lanceolata* pollen curve. As in the previous diagrams, elm and lime pollen percentages never regain their former values whereas those of *Betula* rise again before the end of the zone. This boundary seems to correspond to the SFI 2/3 boundary (dated to 3810 $\pm$ 50 BP).

The continuous presence of *Plantago lanceolata* pollen together with some *Pteridium* and *Rumex acetosa*/*acetosella* type indicates that the woodland cover was being disrupted throughout zone SFII 4. However, the high *Corylus*, *Alnus* and Quercus percentages together with *Fraxinus* and *Betula* indicates that any clearance was small scale and did not lead to permanent deforestation.

The zone SFII 4/5 boundary line has been drawn to mark the second decline in the *Ulmus* and *Tilia* curves, the former reaching very low levels while the latter is absent. The curves of *Pteridium* and *Plantago lanceolata* rise from the boundary to c. 2-3% each, while the arboreal and shrub pollen percentages begin to decline. Gramineae and *Calluna* percentages rise. This indicates an intensification of clearance activity, sustained for a long period, making complete forest regeneration impossible. The situation was aggravated by the spread of *Eriophorum*-*Calluna* communities, although it is impossible to distinguish how much climatic factors rather than human interference have influenced this spread. The peat of this zone remains as before, dominated by *Eriophorum*, *Calluna* and *Sphagnum*, a community still present on the site today.

The zone SFII 5/6 boundary marks the beginning of the final decline of tree and shrub pollen. Arboreal pollen percentages fall to as low as 12% while non-arboreal pollen percentages almost reach 80% TLP, values similar to those found at SFI (zone SFI 5).

Zone SFII 6 is one of very high Gramineae, *Calluna*, *Plantago lanceolata* and *Pteridium* percentages, showing much of the massif or at least the upper slopes to have been covered by *Eriophorum*-*Calluna* heath or grassland. The continued decline of tree pollen values to the end of the profile must represent widespread clearance on the lower slopes.

At the end of the profile there is a slight tree recovery similar to that of Simon Fell I. It is almost certain that the SFII peat stopped growing before the present, as has been noted for the previous diagrams. The last level may well represent a mixed layer of ancient and modern fossil remains.

6.4. Summary

SFI 1 Peat growth commenced at SFI c. 4900 BP, just after the elm-decline. Hazel shrubs with occasional pine trees appear to have been the most common species on the Fell or upper slopes.

SFI 2 (4720 $\pm$ 50 - 3810 $\pm$ 50 BP) - The boundary marks the beginning of a "Landnam" phase at c. 4720 $\pm$ 50 BP, in the early Neolithic Period. The major indicators of this phase are high *Rumex* and Gramineae percentages. The Simon Fell II profile begins as the clearance phase tails off, again with

Rumex and Graminese the most common herbs, but species diversity is less than at Simon Fell I. From the differences in percentages of ruderals and arboreal pollen it seems that the site of clearance was nearer to Simon Fell I than Simon Fell II. Tree species recover after this phase but a second *Rumex* peak can be seen later in the Simon Fell II diagram.

At the end of the clearance phase the pollen spectra indicate a change to wetter and more acid conditions at both sites. The curves for *Calluna* and *Empetrum* pollen rise sooner and to higher levels at Simon Fell II than at Simon Fell I, indicating that these two species played a more dominant role in the vegetation at the former site.

SFI 3 (3810 $\pm$ 50 - 2920 $\pm$ 50 BP) (SFII 4) - A second clearance phase begins, this time indicated by the appearance of continuous curves of *Plantago lanceolata* pollen and *Pteridium* spores. These boundaries also mark a decline in the elm and lime pollen curves. At Simon Fell I the date for the beginning of the second clearance phase was 3810 $\pm$ 50 BP, and it continued through to 2920 $\pm$ 50 BP, hence belonging to the Early to Late Bronze Age. Halfway through zone Simon Fell I 3 and at the Simon Fell II 4/5 boundary, the curves for elm and lime pollen decline again, this time the *Tilia* pollen curve becoming discontinuous.

SFI 4 (c. 2920 ± 50 - 2310 ± 50 BP) - A tree recovery phase is indicated by the Simon Fell I diagram while only slight evidence for this occurs in the Simon Fell II diagram, thus supporting the suggestion that the clearance occurred closer to Simon Fell I than Simon Fell II.

SFI 5 (2310 ± 50 BP - present surface) - A third clearance phase began, once again dominated by pollen of Plantago lanceolata, Pteridium and Urtica. This corresponds to zone SFII 6 with a similar pollen assemblage. At both sites the local vegetation consisted largely of Calluna, Empetrum and Eriophorum.

Using growth rate calculations it can be estimated that the profile at Simon Fell I ends c. 1400 BP, or in Anglo-Saxon times. At some time after this date, growth must have stopped and erosion set in. A similar pattern can be seen at Simon Fell II. Both sites are heavily eroded today.

7. ALLOTMENT SHOOTING BOX (NGR, SD 764 737)

7.1. Description of site

A monolith was extracted at the Allotment Shooting Box site, which lies at an altitude of 434m (MSL) on the lower slopes of Simon Fell. These slopes are largely covered by shallow blanket peat, up to 1m in depth. There are no obvious signs of erosion and the peat appears to be actively growing. The present vegetation consists mainly of *Eriophorum vaginatum*, *E. angustifolium*, *Juncus* spp, *Deschampsia flexuosa* and *Carex* spp. Drainage on to the site is from the slopes above. Recently, channels have been dug across the area through to the boulder clay, to improve drainage.

7.2. Stratigraphy

Depth (cm)	Description
0 - 7	Pale brown *Sphagnum* moss; moderately humified.
7 - 34	Lightly humified, *Sphagnum*-*Polytrichum*-*Eriophorum vaginatum* peat with *Erica*, *Calluna* and *Juncus* remains.
34 - 51	Darker, heavily humified, monocot peat with twigs, *E. vaginatum*, *Juncus* spp, *Erica*, *Calluna* and *Sphagnum* remains.
51 - 53	Paler band, otherwise as above.
53 - 78	Dark, varyingly humified *Phragmites*-*Eriophorum* peat with *Juncus* and *Viola palustris* seeds, birch and alder fruit, scales, birch bark and wood remains, together with leaf fragments of a dicotyledonous plant similar to *Betula*.

78 - 94	Moderately humified, dark brown, monocot-*Phragmites*-wood peat with *E. vaginatum*, *Juncus* seeds and bud scales. Fragment of *Betula* wood at 80cm and *Salix* sp from this horizon in the excavation trench.
94 - 104	Transition, *Polytrichum*-*Phragmites* peat with monocot and wood remains.
104 +	Blue-grey clay.

7.3. Discussion (diagrams 7.1, 7.2, 7.3, 7.4)

Peat began to accumulate at the Allotment Shooting Box site around 5740 ± 60 BP under a mixture of carr or waterlogged woodland and reedswamp (*Phragmites*). Tree trunks and branches were found during the excavation of the monolith and three pieces of wood were extracted from zone ASB1 peat, later identified as one piece of *Betula* and two pieces of *Salix* sp wood. The arboreal percentages of this zone are mostly over 50% TLP, consisting largely of *Betula*, *Corylus* and *Alnus* pollen. *Salix* pollen is continuously present, but by no means in high percentages. Since wood of *Salix* sp has been identified it appears that willow is highly under-represented by the pollen count and may have formed a major constituent of the local vegetation despite little evidence for this in the pollen diagram. From their high pollen counts *Betula*, *Alnus* and *Corylus* were probably also growing on or very near to the sampling site.

As well as *Phragmites* and *Polytrichum* moss, the undergrowth would appear from the pollen evidence to have contained ferns and *Filipendula* with Umbelliferae and *Lonicera*. About halfway through the zone, the Filicales curve declines while that of *Sphagnum* spores rapidly rises. The *Filipendula*, Umbelliferae and *Lonicera* counts are replaced by those of Gramineae and *Melampyrum* pollen.

78 - 94	Moderately humified, dark brown, monocot-Phragmites-wood peat with E. vaginatum, Juncus seeds and bud scales. Fragment of Betula wood at 80cm and Salix sp from this horizon in the excavation trench.
94 - 104	Transition, Polytrichum-Phragmites peat with monocot and wood remains.
104 +	Blue-grey clay.

7.3. Discussion (diagrams 7.1, 7.2, 7.3, 7.4)

Peat began to accumulate at the Allotment Shooting Box site around 5740 $\pm$ 60 BP under a mixture of carr or waterlogged woodland and reedswamp (Phragmites). Tree trunks and branches were found during the excavation of the monolith and three pieces of wood were extracted from zone ASB1 peat, later identified as one piece of Betula and two pieces of Salix sp wood. The arboreal percentages of this zone are mostly over 50% TLP, consisting largely of Betula, Corylus and Alnus pollen. Salix pollen is continuously present, but by no means in high percentages. Since wood of Salix sp has been identified it appears that willow is highly under-represented by the pollen count and may have formed a major constituent of the local vegetation despite little evidence for this in the pollen diagram. From their high pollen counts Betula, Alnus and Corylus were probably also growing on or very near to the sampling site.

As well as Phragmites and Polytrichum moss, the undergrowth would appear from the pollen evidence to have contained ferns and Filipendula with Umbelliferae and Lonicera. About halfway through the zone, the Filicales curve declines while that of Sphagnum spores rapidly rises. The Filipendula, Umbelliferae and Lonicera counts are replaced by those of Gramineae and Melampyrum pollen.

This tends to indicate a change to poor fen or more acid conditions than before on the bog surface. The appearance of birch bud scales and birch wood as macrofossils near the end of zone ASH indicate the growth of this tree on the sampling site.

Trees were also growing on the drier ground at this time. These were mainly Quercus, Ulmus, Tilia and Alnus with Corylus as an undershrub, suggesting that mixed oak forest was growing on dry areas of the plateau, and the surrounding slopes.

There are almost continuous curves of Rumex acetosa/acetosella, Pteridium and a few grains of Plantago lanceolata pollen present from 5740 ± 60 BP onwards. This suggests that some clearance of forest cover may have been taking place in the Late Mesolithic Period.

The zone ASB 1/2 boundary (c. 5160 ± 60 BP) has been drawn where marked changes in forest composition occur, as indicated on the pollen diagram. At this level the Betula and Ulmus percentage pollen curves decline abruptly as those of Quercus, Alnus and Corylus increase.

Trees continued to grow on the sampling site during zone ASB2. Wood fragments were found in the peat, together with fruit of alder and birch. The high percentages of Alnus pollen suggest that alder was the more dominant tree, although the herbaceous layer on the sampling site also changed slightly in composition. Phragmites, Eriophorum and Juncus sp were major constituents with Sphagnum, but otherwise a much-reduced species diversity. Melampyrum and Filipendula pollen are almost absent in this zone, again indicating a progressive change to more acid and wet conditions.

Both the radiocarbon date of 5160 ± 60 BP and the decline in the Ulmus pollen curve point to this being the "elm decline". In the pollen influx diagrams the curves for Betula and Ulmus pollen do decline. However, the influx values of Corylus, Quercus and Alnus show no or little increase, in contrast to their pollen percentages. From this we can assume the increased percentages of these three taxa are due, at least in part, to the fall in Betula and Ulmus counts (the effects of percentage interdependence). This is supported by the overall decrease in arboreal pollen percentages.

Zone ASB2 also opens with the beginnings of peaks in the Rumex acetosa/acetosella type and Plantago lanceolata curves and to a lesser extent in the Urtica and Gramineae pollen curves. This represents a long-term clearance phase from 5160 $\pm$ 60 BP to 4440 $\pm$ 60 BP, lasting about 720 years. The lack of cereal grains and high Rumex percentages again indicate fairly local grazing of livestock and a general emphasis on pastoral farming. This is a similar pollen spectrum to those of zones BWH1 and SFII 1.

It is clear from the macrofossil evidence that trees were still growing on the sampling site and that conditions were very wet. This points to the clearances having taken place away from the sampling site, in mixed deciduous woodland on the drier soils, probably over the limestone, although the general absence of Calluna and Empetrum pollen would suggest that heath had not spread on to the surrounding slopes as yet and these were probably also supporting woodland. It is difficult to judge the extent of woodland from the ASB diagram because of the vast quantities of pollen produced by the tree species of the local carr vegetation.

The end of the clearance phase, c. 4440 $\pm$ 60 BP, the ASB 2/3 boundary, is marked by the sharp rise in arboreal and shrub pollen, in both the percentage, and to a lesser extent the influx diagrams. The arboreal pollen percentages rise to 70% TLP which, together with macrofossils of alder and birch fruit, bud scales and wood indicate a general thickening of the tree canopy on the sampling site and a dominance of alder and birch in the community. Phragmites and Eriophorum were still growing on the site, but Filicales spores become more abundant in the peat as Sphagnum spore counts are reduced, indicating a more shade-tolerant undergrowth. Filipendula, Melampyrum and Umbelliferae pollen reappear and the diversity of species recorded has increased, suggesting a return to a poor fen type peat or perhaps drier conditions.

The total pollen influx for this zone is much the same as for the previous zone; however the arboreal component has increased, while the non-arboreal component has decreased. This zone represents a decline in land use as shown by the reduced number of clearance indicators and subsequent woodland recovery, mainly by species most able to colonise quickly. However, even elm appears to have recovered slightly in numbers. The duration of the tree recovery phase was c. 790 years.

Around 3650 $\pm$ 60 BP or at the ASB 3/4 boundary, arboreal pollen percentages start their final decline. Plantago lanceolata, Pteridium, Urtica and other ruderals reappear in the pollen record. Only small quantities of Rumex pollen were counted in zone ASB4. Rumex plants seem to have been more abundant in the previous clearance phase, although both phases appear to have been largely pastoral. There are no records of cereal pollen in this zone.

The stratigraphy of the peat changes at the end of zone ASB3 from a Phragmites-Eriophorum peat with birch and alder remains to a monocot peat with twigs, Eriophorum, Erica, Calluna and Sphagnum remains. The percentages of Calluna pollen and Sphagnum spores rise rapidly at the beginning of zone ASB4 to high values, showing a rapid spread of waterlogged Calluna community across the bog surface and the surrounding slopes.

Arboreal pollen percentages fall to 20-25% TLP supporting the presence of large areas of open ground. As well as cleared areas and acid heath there were probably open areas of drier soil, relatively base-rich and so most likely over limestone, where a wide variety of other herbs were growing such as Helianthemum, Melampyrum, Aster tp, Filipendula and Umbelliferae. The level of pollen influx in this zone is similar to that of the previous zone; however the openness of the countryside is reflected by the increased non-arboreal component and decreased arboreal and shrub pollen components.

The ASB 4/5 zone boundary has been drawn at an abrupt decline in arboreal and shrub pollen percentages, and all concentrations and influx values, herbaceous types being the least affected. The stratigraphy at this level changes from a dark, very heavily humified monocot peat with a few twigs (possibly of Calluna) to a very lightly humified Sphagnum-Polytrichum-Eriophorum peat. The date for this change is only 890 $\pm$ 60 BP, whilst that of the previous boundary was 3650 $\pm$ 60 BP. This indicates that the 12cm of peat of zone ASB4 should represent 2760 years and have a peat growth rate of 230 yr cm^{-1}. The average growth rate for the rest of the profile is 26 yr cm^{-1}. This evidence strongly suggests that a hiatus in peat accumulation has occurred, beginning at a depth of 34cm. Using the growth rate, calculated for zone ASB3, of 49 yr cm^{-1}, the estimated age of the old peat surface at the end of ASB4 is 3156 BP or in the late Bronze Age. Peat began to grow again on the site c. 890 $\pm$ 60 BP or around the time of the Norman Conquest. The present bog surface at the Allotment Shooting Box site appears to be actively growing. If we assume this to be true and the modern surface to have a date of 0 BP, then the growth rate for the zone ASB5 peat is 26.2 yr cm^{-1}, or very close to the average growth rate for all the diagrams.

If the above is correct, then this is the only recent peat encountered during this investigation with the possible exception of the upper zone of the Braithwaite Wife Hole profile and the Hut Circle samples. Arboreal pollen falls as low as 4% TLP and the non-arboreal percentages increase accordingly. Otherwise the pollen spectra of zone ASB5 are very similar to those of ASB4 including the same types of ruderal or pastoral pollen. However, Rumex and Urtica pollen are more abundant in the modern peat and cereal grains appear for the first time, suggesting some arable farming but pastoral farming being the most extensive, the Rumex and Urtica peaks suggesting heavy grazing pressure. At the surface, as in other diagrams, there is a slight increase in AP percentages, probably reflecting the establishment of tree plantations on the massif and in the valleys around farmsteads. Also, Calluna pollen declines near the surface, being replaced by high percentages of Gramineae and Cyperaceae pollen (see section 11.3.7).

7.4. Summary

ASB1 (5740 $\pm$ 60 - 5160 $\pm$ 60 BP) - Peat initiation occurred around 5740 $\pm$ 60 BP under a mixture of Salix and Betula carr and Phragmites reedswamp. Conditions on the sampling site became wetter and more acid towards the end of the zone. On drier ground a "mixed oak" forest with elm was growing. The presence of indicators of disturbed ground may point to forest interference by Mesolithic man.

ASB2 (5160 $\pm$ 60 - 4440 $\pm$ 60 BP) - The elm curve declines together with that of Betula at the beginning of the zone and is dated to 5160 $\pm$ 60 BP. Elm trees appear to have been reduced in numbers in the mixed oak forest.

Alder and birch carr with species-poor reedswamp occupied the site. This zone represents a Neolithic clearance phase with the main indicator species being Rumex acetosa/acetosella tp, Plantago lanceolata and Urtica, lasting c. 720 years. This would seem to indicate local grazing by livestock.

ASB3 (4440 ± 60 - 3650 ± 60 BP) - A tree recovery phase lasting c. 790 years, marked by a sharp rise in arboreal pollen percentages up to 70% TLP. Alder and birch still abundant on the sampling site but with a more species-rich and shade-tolerant understory.

ASB4 A second clearance phase beginning around 3650 ± 60 BP during the Early Bronze Age, where arboreal pollen values begin their final decline. Plantago lanceolata, Pteridium and Urtica pollen were the main clearance indicators in this phase, Rumex pollen being present only in small quantities. Calluna heath or bog spread over large areas in this zone and trees retreat from the bog surface. AP percentages fall to 20-25% TLP, showing that large areas of open ground were appearing.

ASB5 The beginning of this zone is dated to 890 ± 60 BP. A hiatus appears to have occurred in the peat close to 34cm depth; the old peat surface having a date of approximately 3156 BP belonging to the Late Bronze Age. Peat of this zone is a light humified moss-Eriophorum peat with no tree remains and appears to have grown continuously to the present.

8. SULBER POT (NGR, SD 773 736)

8.1. Description of site

The Sulber Pot site is located on the south-east side of the massif at an altitude of 389m (MSL) on the limestone plateau. The deposits consist of shallow blanket peat, accumulating only a few metres east of bare limestone pavement and Sulber Pot itself. Water enters the bog only as rainwater. The vegetation occupying the site at present is a community comprised of *Eriophorum vaginatum*, *Trichophorum caespitosum*, *Sphagnum* spp, *Calluna vulgaris* and *Narthecium ossifragum* plants.

8.2. Stratigraphy

Depth (cm)	Description
0 - 30	Dark black-brown, very heavily humified, fibrous monocot peat with *Eriophorum vaginatum*, *Juncus* spp, *Potentilla erecta*, *Calluna vulgaris*, *Erica* and *Racomitrium lanuginosum* remains.
30 - 36	Dark, black-brown, more cheese-textured peat, otherwise as above.
36 - 70	Relatively unhumified, orange-brown, mixed monocot peat with *Eriophorum vaginatum* remains, *Carex* spp and *Potentilla erecta* fruit, *Juncus* spp seeds and *Polytrichum* remains. Towards the base, *Viola palustris* and *Sagina* seeds were found.
70 - 72	Transition peat to a grey, sandy clay with decayed monocot remains.

8.3. Discussion (diagram 8.1.)

Peat initiation began under a species-rich fen or wet grassland vegetation. The species present included *Eriophorum vaginatum*, *Juncus* spp, *Carex* spp, *Potentilla*, *Viola palustris* and *Sagina* sp. The lack of wood fragments in the stratigraphy is supported by the low arboreal pollen percentages, in suggesting that the area around the Sulber Pot site was treeless at this time. *Alnus* is the most abundant tree pollen type and was probably derived from communities growing on wetter soils at some distance from the sampling site.

The predominance of Gramineae and *Rumex acetosa/acetosella* type pollen, together with that of *Plantago lanceolata* and other ruderal species, strongly indicates the presence of large areas of open ground in the vicinity, both on and off the limestone. The grassland was probably maintained by grazing as the above species are indicative of pastoral farming. The similarity between the pollen spectra of zone SP1 and zone ASB2 suggests that they may be of a similar age.

Herbs such as *Stellaria*, *Succisa*, Ranunculaceae and Umbelliferae are relatively abundant in terms of their pollen percentages, together with spores of Filicales and *Polypodium*. These species could well have belonged to the community on the sampling site, particularly Filicales and *Polypodium*, as fern spores are commonly found at the bases of most of the profiles studied here. However, these herbs were probably also growing in base-rich grassland over the limestone shelf. The record of *Helianthemum* pollen again points to open conditions on the drier soils of the lime-stone. Ferns including *Polypodium* form a major constituent of the communities occupying the grykes of the limestone pavement today.

The zone SP1/2 boundary has been drawn at the beginning of a phase of tree recovery with the percentages of Betula, Ulmus, Tilia, Quercus, Alnus and Fraxinus pollen rising. The overall arboreal pollen percentages increase from less than 20% to 30-40% TLP. However, wood fragments were not found in the peat of this zone, suggesting that trees were still not growing on the sampling site. The decline in the diversity of herb pollen types, together with the rise in the curves of Cyperaceae, Calluna, Potentilla and Sphagnum pollen, indicate a change to more acid conditions locally.

Although Rumex pollen percentages decline at the boundary, those of Plantago lanceolata remain at similar levels, while Pteridium spores and other ruderal types increase in numbers. The fall in Rumex pollen percentages suggests a reduction in grazing pressure, as also indicated by the increased arboreal percentages. However, the other clearance indicators show that pastoral farming activities did not cease altogether and that the nearby vegetation remained open, but with a shift in the component species.

The increased arboreal percentages may be due, in part, to the effect of the abrupt, almost halving of the Gramineae and Rumex percentages. The mixed deciduous woodland was probably growing on the drier soils on some parts of the limestone plateau and in the valleys at this time. Although the percentages of Ulmus pollen increase at the zone SP1/2 boundary, they do not reach very high values, suggesting that peat initiation on the Sulber Pot site occurred after the elm-decline or after c. 5100 BP.

The tree recovery was short-lived and the zone SP2/3 boundary has been placed at the start of a steady decline in arboreal pollen percentages (from c. 30%, ultimately to 3.4% TLP in zone SP4). Herb species are generally more abundant in pollen zone SP3. The curves of Plantago lanceolata pollen and Pteridium spore percentages rise, indicating an intensification of clearance and general disturbance of the vegetation. Rumex pollen does not regain its former high levels however, perhaps indicating a different kind of agricultural regime. There may also have been a slowing of the peat growth in this zone as the peat becomes heavily humified.

The boundary between zones SP3 and 4 marks the abrupt rise in the Calluna pollen curve. Calluna remains appear in the peat together with those of the previously present Eriophorum vaginatum, Juncus sp and Potentilla erecta. In this zone Calluna spread over the bog surface and may well have been the major constituent of the bog community from this point onwards. Gramineae and Potentilla percentages show a corresponding decrease. Calluna heath was probably also spreading on to the drier soils of the limestone plateau and hillslopes above.

Cereal grains are present in small numbers throughout zones SP2, 3 and 4 showing that arable farming practices were carried out almost continuously from the zone SP1/2 boundary onwards. The low percentages may be due to the lack of cultivation sites near the sampling area or else these were very restricted in number.

In the last 4cm of peat the arboreal pollen percentages rise again, as has been noted at the majority of sites sampled. Judging by the dates calculated for the surface samples of the other peat profiles, it seems unlikely that there is a continuous pollen record, to the present day, at Sulber Pot. A hiatus may have occurred near the present surface and peat growth recommenced at a later date or peat growth may simply have stopped and erosion set in.

There are no radiocarbon dates available for the Sulber Pot diagram; however some of the major vegetational changes may be tentatively dated by comparison with the

Allotment Shooting Box diagram, these sites being adjacent to each other on the NW/SE transect.

The distinctive peak of Rumex acetosa/acetosella pollen associated with high Gramineae values suggests that pollen zone SP1 is equivalent to ASB2. At the Allotment Shooting Box this clearance phase begins with the elm decline, with a radiocarbon date of 5160 $\pm$ 60 BP. At Sulber Pot, peat growth was initiated, apparently just after the elm decline. The end of the Rumex clearance phase at the ASB site was dated to 4440 $\pm$ 60 BP. The zone SP1/2 boundary appears to coincide with this horizon, putting the first clearance phase in the Neolithic to Early Bronze Age.

The major difference between the two sites in this period is that trees were growing on the ASB site but not at Sulber Pot. The arboreal pollen percentages of the former averages c. 45% while the latter lies between 15 and 20% TLP. Wood fragments were also found in the peat of the ASB monolith but not in the SP monolith. The macrofossils in the ASB peat were of alder and birch with Alnus and Corylus being the most abundant tree and shrub pollen types. Despite the low AP values at Sulber Pot, the majority of arboreal and shrub pollen also belonged to Alnus and Corylus. This indicates that wet woodland, particularly with alder, was occupying the lower slopes of S. E. Ingleborough such as those at the Allotment Shooting Box. At the same time Sulber Pot was nearer to the cleared areas, putting these firmly on the limestone shelf or at least the shallow base-rich soils of the plateau.

At Sulber Pot the tree recovery phase (zone SP2) ends with the secondary decline in elm pollen, dated at ASB to 3650 $\pm$ 60 BP, or in the Early Bronze Age. This second clearance phase shows similar pollen spectra at both sites, as Rumex pollen is no longer a major component being overshadowed by Plantago lanceolata, Pteridium and Urtica pollen.

At ASB it is estimated that there is a gap in the pollen record between C. 3160 BP and 890 ± 60 BP. The hiatus is marked by a sudden and pronounced decrease in the percentages of arboreal and shrub pollen. There are no such indications at Sulber Pot; however, as mentioned above, it seems unlikely that there is a continuous pollen record to the present. This site may resemble the deposits at Braithwaite Wife Hole more as the hiatus occurs much closer to the surface.

8.4. Summary

SP1 Peat began to accumulate under a species-rich fen or wet grassland vegetation, during a clearance phase, indicated by the presence of high percentages of Gramineae and *Rumex acetosa*/*acetosella*-type pollen. There appears to have been large areas of open ground in the vicinity, including the sampling site. The pollen spectra of this clearance phase are similar in nature to those of zone ASB2, suggesting a Neolithic to Early Bronze Age date.

SP2 This zone represents a phase of woodland recovery, with most tree species showing increased percentages. On the sampling site the vegetation was open, however, and conditions were becoming more acid. *Rumex* percentages decline but other ruderal types increase, suggesting that areas of the plateau around the site were still mainly open.

SP3 The zone begins with what appears to be the secondary decline in *Ulmus* pollen, dated in the ASB diagram to 3650 ± 60 BP or the Early Bronze Age. Most tree pollen curves decline while *Plantago lanceolata*, *Pteridium* and *Urtica* are the major disturbance indicators.

SP4 Calluna communities spread rapidly across the bog surface and quite possibly parts of the surrounding drier areas. The arboreal pollen decline carries on from the previous zone, falling as low as 3.4% TLP, but a slight recovery is noted at the end of the zone.

Judging by the other diagrams studied here, it seems unlikely that a continuous pollen record is present at the Sulber Pot site. A hiatus may have occurred in the peat growth, and then recommenced at a later date.

9. HUT CIRCLE (NGR, SD 740 718)

9.1. Description of site

A small monolith of peat was cut from above the floor of a hut circle, situated at the head of a small valley below Newby Moss, on the south side of the Ingleborough Massif. The hut circle is one of several within a settlement site, lying in the shelter of the valley, just below the limestone plateau at an altitude of 366m (MSL). The settlement was recently found by the owners of Fell Gate Farm and was surveyed by Mr. Alan King, who carried out preliminary excavations on one of the hut circles. The settlement also appears to consist of enclosures, walls and droveways, the latter still with banks clearly visible.

Mr. King collected a monolith which was approximately 25cm deep, and he supplied five samples from it for pollen analysis, taken at 5cm intervals.

9.2. The pollen diagram

All five samples are of a similar nature. Arboreal pollen percentages are below 10%, shrub pollen below 6% and non-arboreal pollen above 86% TLP. Calluna pollen is by far the most abundant type with high values for Gramineae and unusually low ones for Cyperaceae pollen. Plantago, Pteridium and Rumex grains are present, but not in large quantities. One or two cereal grains were counted, together with a fairly wide variety of other herbs.

9.3. Discussion (diagram 9.1.)

The high Calluna percentages of these samples, when compared with the pollen spectra of the Allotment Shooting Box diagram, suggest they accumulated after 3650 $\pm$ 60 BP. The extremely low arboreal and shrub pollen percentage values resemble those of the most recent peat at Allotment

Shooting Box, peat deposited after the hiatus c. 890-0 BP.

The evidence suggests that either the hut circle was exposed until after 890 BP when a change to wetter conditions allowed the growth of peat-forming communities, or that peat accumulated on the site, burying the hut circle, but then growth stopped and erosion set in. The erosion would have removed more or less all the peat, before peat growth recommenced after 890 BP.

On several areas of the limestone plateau including that above the hut circles, a mosaic of limestone grassland and acidophilous plant communities can be seen (Bartley & Clark, 1979). Small patches of _Calluna_ and _Empetrum_, on a few centimetres of peat, can be seen forming raised islands amongst the otherwise calcicole communities growing on thin soil over limestone. These peat "islands" appear to be decaying rather than spreading, and tend to support the argument for there being a period of erosion in the past.

The pollen evidence cannot be used to throw light on the date of abandonment of the hut circle because of the likelihood of a hiatus in peat growth.

The peat accumulated under Calluna heath or bog with, at most, occasional, isolated trees in the neighbouring area. _Plantago lanceolata_ and _Pteridium_ are present, but in relatively small numbers, suggesting that there was some disturbance of the vegetation.

10. THE ARCHAEOLOGY OF THE INGLEBOROUGH MASSIF

10.1. Palaeolithic Period

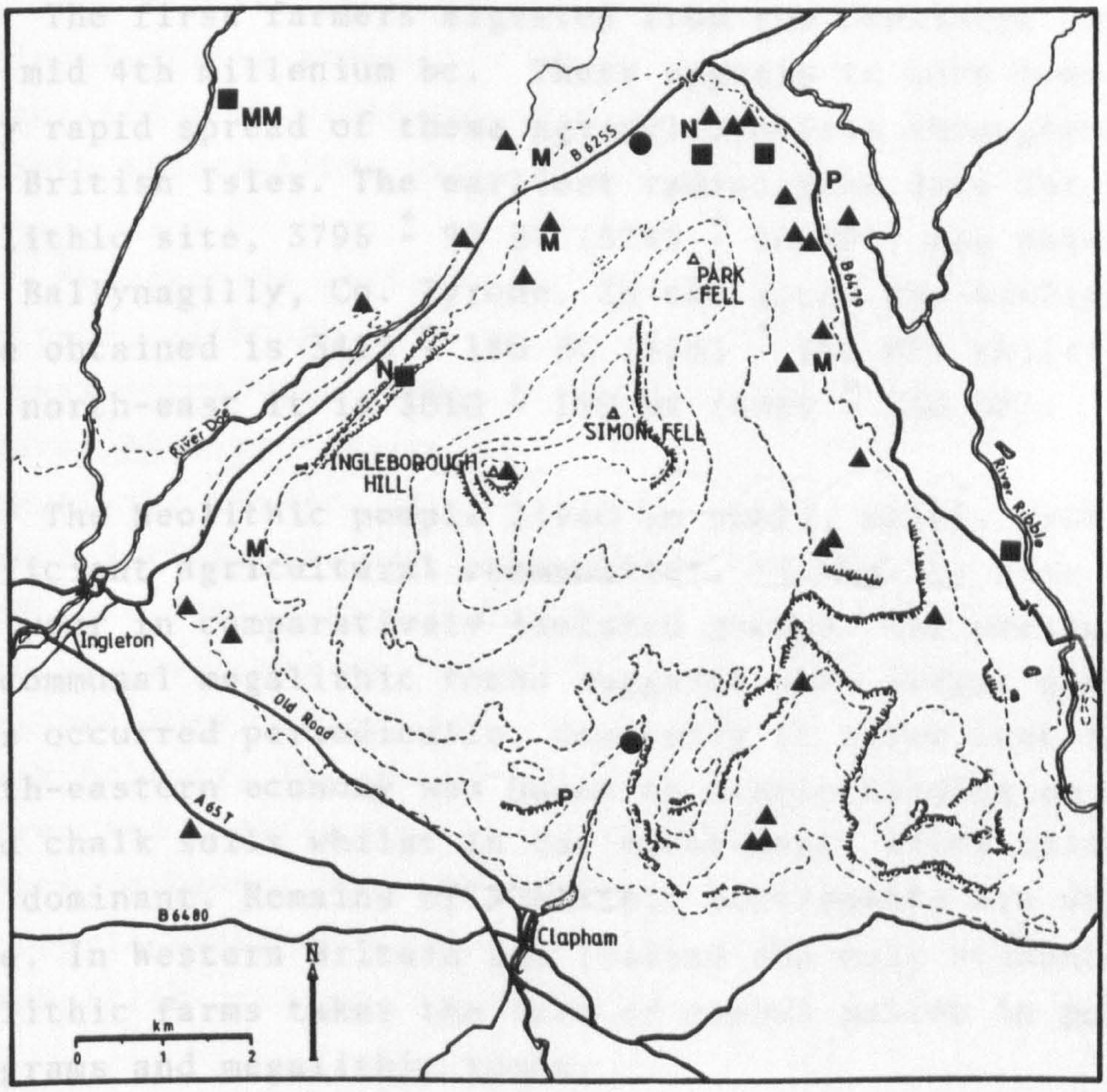
Very few Palaeolithic finds have been made in the Craven Area and none have been recorded from the Ingleborough Massif itself. In Victoria Cave near Settle (12km to the south-west) two worked pieces of antler were found and assigned to the Magdalenian culture of around 10000 BC (Longworth, 1965).

10.2. Mesolithic Period

The first people to occupy the Craven area in any numbers appear to have been Mesolithic hunter-gatherers (Tardenoiseans). Their visits were probably seasonal (living in the highlands only in summer) but occurred over a long period of time (c. 10250 - 5650 BP). The characteristic microliths produced by Mesolithic man have been seen on the scars of Ingleborough, particularly near Dowlas Moss (King, personal communication). On Malham Moor particularly to the east of the massif, many microliths have been found. They occur both scattered and concentrated in a few small areas where the numbers have reached several thousand. Finds have included implements such as knives, scrapers, points and harpoon barbs (Raistrick and Holmes, 1962).

Where microliths have been found associated with organic deposits, they are almost always in mineral soil beneath upland peat. However, at Stump Cross, near Grassington, on an eastward extension of the Great Scar Limestone, microliths were found embedded in organic deposits (Walker, 1956). Within a cleft of a millstone grit erratic, mud and peat had accumulated, preserving a record from zone V to VIIb (Godwin's zonation). Pollen analysis of the mud adhering to the flints suggests they belong to the boundary between zones VI and VIIa or early

Figure 10.1. Map showing the position and age of archaeological finds on the Ingleborough Massif.



● Neolithic
■ Bronze Age
▲ Iron Age or Romano-British
N Norse
M Medieval
P Post-Medieval

VIIa, i.e. just after the Pinus maximum and the rational limit of Alnus pollen. Abundant fragments of charcoal and pieces of charred wood were recovered from the same level as the flint.

10.3. Neolithic Period

The first farmers migrated from the Continent during the mid 4th millenium bc. There appears to have been a very rapid spread of these agriculturalists throughout the the British Isles. The earliest radiocarbon date for a Neolithic site, 3795 ± 90 BC (5745 ± 90 BP), was obtained for Ballynagilly, Co. Tyrone. In the south the earliest date obtained is 3415 ± 180 BC (5365 ± 180 BP) whilst in the north-east it is 3010 ± 150 BC (4960 ± 150 BP).

The Neolithic people lived in small, mainly self-sufficient agricultural communities, living for most of the year in comparatively isolated groups. The presence of communal megalithic tombs suggests that larger groupings occurred periodically. Generally it seems that the south-eastern economy was based on arable farming on the good chalk soils whilst in the north-west, stock raising was dominant. Remains of Neolithic settlements are very rare. In Western Britain and Ireland the only evidence of Neolithic farms takes the form of cereal pollen in pollen diagrams and megalithic tombs.

In the Later Neolithic, c. 4450 - 3600 BP, megalithic passage graves appear, the normal burial rite being cremation. The lack of domestic sites may be due to their being constructed of light perishable materials or alternatively the farmers may have been partly transhumant. Henges and stone circles were constructed during this period. In the north and west there appear to be significant relationships between stone circles and routes or trackways for the transportation of stone axes from their sources. In this area the circles tend to be 8-10 miles apart and may have acted as rallying points for the tribes (Megaw & Simpson, 1981). Later these circles took on a funerary role.

In the Late Neolithic, two pottery traditions can be distinguished, Peterborough ware and Rinyo-Clacton (grooved ware). The Peterborough tradition stretched from southern England to Yorkshire. In the north and west, regional styles appear. In Derbyshire this pottery is associated with cists and polished flint axes, while less certain associations occur with polished stone axes.

No camps or settlements have been identified in the district, although some caves have yielded pottery and perhaps occupation layers. On Ingleborough only three records have been made for this period. On the southern edge of the massif, in Clapdale, a rock shelter called Foxholes (NGR, SD 7566 7147) was investigated in 1913-14 (Ordnance Survey Antiquity Number (OSAN) SD 77 SE 5). Here, a rough walled enclosure ran to the cliff face. In one corner were disturbed human remains and sherds of rough pottery. The enclosure contained traces of fire-places and charred bones, together with flint and chert flakes, a hammer stone and bones of red deer and horses. In debris within the cave were the remains of wild ox, giant Irish deer, wolf and boar.

An unusual burial, belonging to the Late Neolithic Period, was found on Over Pasture, approximately 0.7km west of South House Farm (NGR, SD 787 741). The body was laid in a gryke, 2.3m long by 0.46m wide and 0.41m deep, and was partly covered with limestone blocks. The posture of the inhumation is not known, but the orientation was south-north. The almost complete skeleton was that of a woman, about 35 to 40 years old and not more than 1.47m tall. Later investigation of the gryke revealed a large polished stone axe (OSAN, SD 77 NE 11; Gilks & Lord, 1985). The shape of this axe, together with the stone's surface and core colouring, identifies it as the product of one of the axe-chipping sites on Great Langdale or Scafell Pikes in the Cumbrian mountains, and belongs to the Group VI Cumbrian axe type. Group VI axes have been found on Later Neolithic open occupation sites on the Yorkshire Wolds, on the carboniferous limestone of the Peak District and on the well-drained sandstone terraces, forming the eastern edge of the Pennines in West Yorkshire. They have also been found mixed with occupation debris and burials in a number of caves in Craven and Derbyshire (Gilks and Lord, 1985). Evidence for the dating of Group VI axes comes from forest clearance in pollen diagrams from lake sediments of the fourth millenium bc (sixth millenium BP) in the vicinity of Great Langdale and Langdale Pikes (Pennington, 1970), and secondly from two radiocarbon dates from axe chipping floors, of 2730 $\pm$ 135 BC (4680 $\pm$ 135 BP) and 2524 $\pm$ 52 BC (4474 $\pm$ 52 BP) (Gilks & Lord, 1985). In the north of England the Group VI axes appear to be associated with three co-existing types of pottery, namely Grooved Ware, All-Over-Cord and early style Comb Decorated Beakers. Together these span the end of the Later Neolithic and the beginning of the Early Bronze Age c. 4050 - 3650 BP. Looking at all the finds from caves and rock shelters around Settle, Gilks and Lord (1985)see evidence of wide-spread occupation of the Craven Uplands during the Later Neolithic and in view of this and the above evidence they conclude that the Selside burial belongs to the late 5th millenium BP.

The remaining recorded Neolithic site is a cairn, resembling a degenerate form of chambered long cairn in plan (NGR, SD 7567 7836). It is approximately 29m in diameter and was formerly 1.6m high. The cairn is thought to have been opened around 1800 AD and is said to have contained a "stone coffin and an entire human skeleton" (OSAN, SD 77 NE 1). Although there is some doubt as to its age, the cairn is thought to be Late Neolithic.

Generally neolithic burials took place in longbarrows or cairns. These are rare in the Pennines and when found appear to be degenerate types such as that on Ingleborough; Giants' Graves on Pen-y-ghent (NGR, SD 857 746) is another example. The site consists of a nearly circular bank about 2.5m wide and 0.6m high surrounding a much disturbed area, which contained two cists and a number of hollows, clearly representing similar structures. Scattered bones belonging to more than one adult and child were found. The whole site is suggestive of a multiple cist burial mound or even a "passage grave" type (Bennet, 1936).

Gilks (1973 & 1981) has been studying the finds (mostly ceramic and lithic) and burials from 15 caves and rock shelters around Settle. The most notable are Elbolton, Foxholes, Jubilee, Lesser Kelcoe, Raven Scar (Gilks, 1981) and Sewell's where both crouched and contracted burials occurred, some in small unroofed cists of slab and boulder construction similar to those found in some northern megalithic tombs. Giants Graves, Pen-y-ghent and the Bordley Circle (also known as the Druid's Altar) on Malham Moor are two examples of such tombs. Thick coarse fragments of pottery have been found from bowls decorated with stabbed lines or lines of dots, some potters using a broken bird bone to incise the clay while others used finger tips or nails. This pottery has been assigned to the Later Neolithic Peterborough Culture (Longworth, 1965). However, Gilks (1973) comments that judging by the fabric of some fragments of pottery, comparisons should not be made with the "Peterborough" pottery of the north but with the decorated wares of the Midlands and southern England. At Elbolton cave (Gilks, 1973) the duration of burial and occupation covered the period between 3600 - 3400 BP. Occupation appeared to have been prolonged, and the evidence recovered is comparable with that obtained from other, Later Neolithic and Early Bronze Age cave burial/ occupation sites in West Yorkshire, Derbyshire and north

Staffordshire. Looking at the evidence overall, it seems that during the Later Neolithic the caves and rock shelters of Craven were preferred not only for the disposal of the dead, but for occupation, and the great majority of excavated sites have produced evidence for both forms of usage. However, it is possible that settlements did exist but that no traces of them have survived. Stones from ruined sites may well have been utilised by farmers from the succeeding periods. Alternatively, some structures, together with the topsoil, may have been lost down solution cracks or grykes in the limestone.

10.4. Bronze Age

The early Bronze Age began c. 3950 BP with a major incursion of peoples from the Continent. This was the Beaker Culture, so named because of the drinking cups found buried with the dead. Major changes occurred in the burial rites, from the collective inhumation or cremation during the Later Neolithic Period, to crouched, single inhumations in either flat graves or pits beneath round barrows. At the time of the migration of Beaker peoples, the country appears to have had a considerable indigenous population already. There is no evidence for the Beaker people forming an autocracy in the early centuries, rather they appear to have lived side by side or in mixed societies, producing an amalgam of native traditions and innovations which formed the basis of the Early Bronze Age (Megaw & Simpson, 1981).

During the Late Neolithic/Early Bronze Age, evidence of animal bones recovered from archaeological sites suggests that pigs were the most abundant domesticated animals followed in order of importance by cattle, sheep/goats and then horse. At this time there still appeared to be a heavy dependence upon wild animals for food as well as skins, etc. At Mount Pleasant the mixed, but largely Beaker levels contain almost the same relative numbers of domesticated ungulate bones as the preceeding Late Neolithic levels. Later in the Bronze Age, cattle became the most common ungulates with sheep more numerous than pigs. It appears that at first horses were kept mainly to be eaten, as it is not until the Late Bronze Age that metal harnesses and fittings for horse-drawn vehicles are found. Following the Beaker culture, a change in economic structure appears to have increased reliance upon domesticated stock-animals, relegating wild animals to a secondary role.

Crop-growing appears to have formed a larger part of the economy in south-eastern England, but in the north-west stock-raising took precedence. The principal crop was barley (Hordeum spp.); however small quantities of emmer (Triticum dicoccum) and small spelt (T. monococcum) were also cultivated.

Once again there are very few records of Bronze Age finds on the Ingleborough Massif. During a survey begun in 1965, continuing 3.2km east and west of the river Ribble from Ribblehead (NGR, SD 766 789) to Wigglesworth (NGR, SD 810 569), more than 50 cairns were identified ranging from 0.60 - 1.20m high and 3.65 - 10.67m in diameter. It has been suggested that these are Bronze Age, field clearance cairns, although this is by no means certain (OSAN, SD 77 NE 11).

A few metallic Bronze Age finds have come to light. Around 1962 a looped spearhead was found near Scale Mire Farm (NGR, SD 721 705) on the south-western side of the massif (OSAN, SD 77 SW 10). At Ingleton, a flanged axe (OSAN, SD 77 NW 2) and a large disc-headed pin with a perforation in the pin shaft, hidden beneath a diamond-shaped plate (King, 1970) were found. The latter find appears to belong to about 700 BC (2650 BP).

Just outside the north-western boundary of the massif (NGR, SD 709 787) between the spurs of Whernside and Gargareth lies a cairn called Apron Full of Stones. This monument measures 23-24m in diameter, partly eroded on the north-eastern side. On partial excavation (King, 1978) two elongated pits were found as well as a sub-rectangular grave containing a cremation burial and also several flint fragments. King suggests that Apron Full of Stones belongs to the Late Neolithic/Early Bronze Age burial tradition.

As has been mentioned above, many of the limestone caves in the Craven area where archaeological finds have been made, contain occupation and burial debris spanning the Late Neolithic Period through to Early Bronze Age (Gilks, 1973 & 1981). An example of this is Raven Scar Cave (NGR, SD 730 757) on the north-west side of the Ingleborough Massif. Several hearths were found together with an arc of limestone slabs and blocks set on edge, against the cave wall and containing human bones and teeth, fragments of a deer antler and a boar tusk blade. A similar feature was found at the rear of the chamber containing many comminuted human bones, an amber bead, a sherd of Later Neolithic pottery, fragments of an All-Over-Cord Beaker, two flint flakes and a plano-convex knife. Excavation of the floor between these two features produced a large assemblage of animal remains, scraps of Later Neolithic pottery, Beaker sherds, part of an Early Bronze Age Collared Vessel, a variety of flint scrapers, a tanged-and-barbed arrowhead and a bone whistle (Gilks, 1981). This again demonstrates the continuity of usage of such sites by the Late Neolithic and Early Bronze Age peoples.

No above-ground settlement sites have been recorded for the Ingleborough Massif, but Raistrick (1962) describes a Bronze Age House (NGR, SD 894 648) near Comb Scar and a farm complex, Dew Bottoms (NGR, SD 912 692) on Malham

Moor. The house lay on a small limestone terrace and was sub-rectangular in shape. The only finds were fragments of flint, two of them worked in typical Bronze Age fashion, and a few fragments of dark brown pottery of local Bronze Age type. The farm site is much more difficult to date, and could belong any time between the Late Neolithic and Roman times.

Other Bronze Age finds in the Craven Area include a stone circle (now destroyed) near Cleatop Park and bronze implements on the fell edges above Scaleber and near Rathmell. Also, a group of Bronze Age barrows is found on the fell between Stackhouse and Feizor, and above Giggleswick Scar. The dispersion of the Bronze Age remains in the Dales of West Yorkshire points to an immigration via York (Raistrick, 1962).

10.5. Iron Age/Romano-British Period

By far the most abundant archaeological remains on the Ingleborough Massif and the limestone uplands in general belong to these periods. For the first time, the primary sources of evidence for the period are settlement sites. In the north and west far fewer artefacts have been found and these tend to be dated to Roman times. With the arrival of radiocarbon dating, it has been realised that this was simply the last stage of a long period of occupation. The chronology for this period is very difficult to determine and is still a matter of controversy, particularly in terms of whether the changes occurring were brought on by invasion of iron-age peoples from the Continent or by trade along already well-established trade routes (Megaw & Simpson, 1981).

It is generally believed (Megaw & Simpson, 1981; Cunliffe, 1978) that in the Lowland zone, extensive arable farming was practised, while in the Highland zone pastoralism was more important. The characteristic

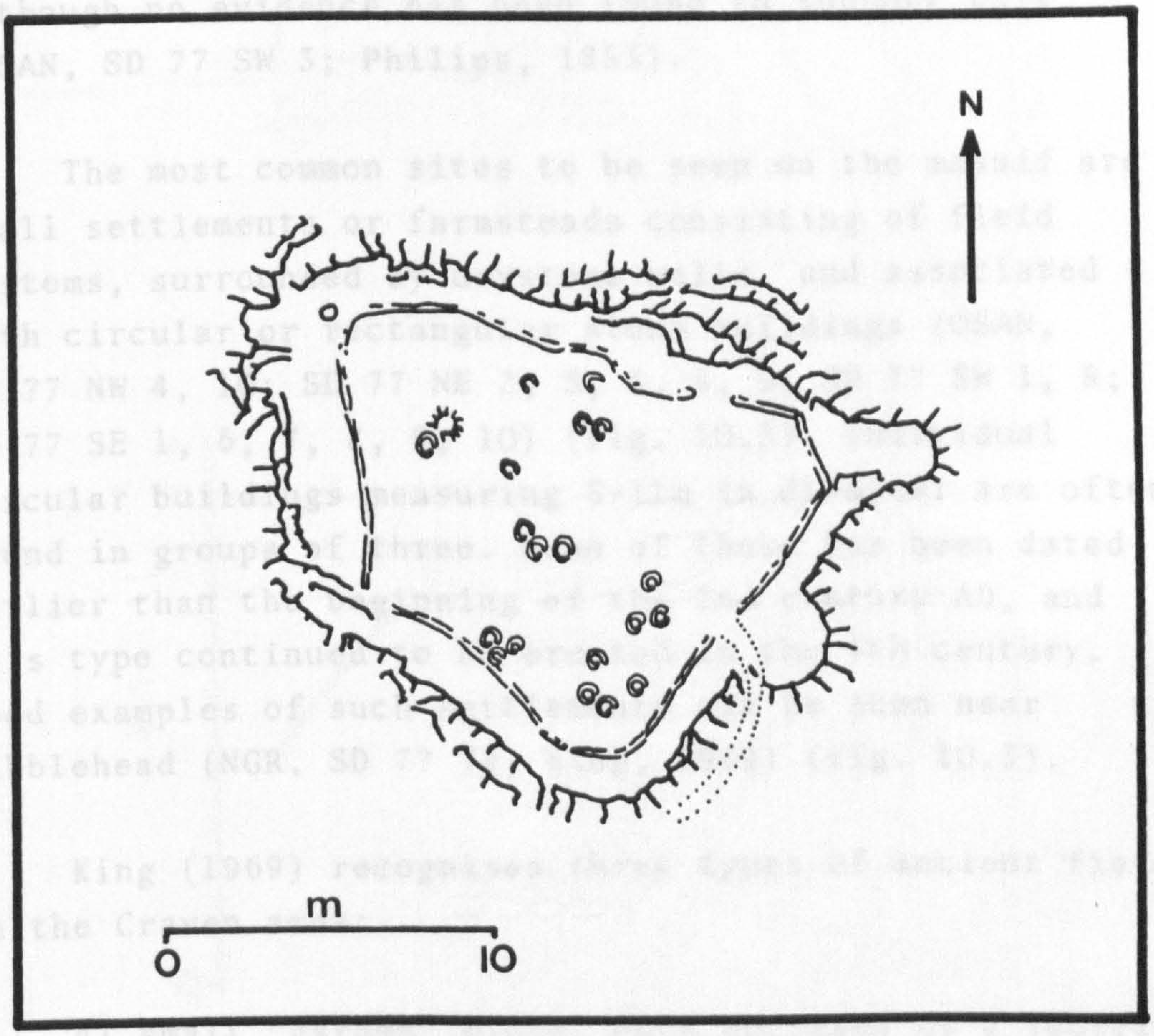
"Celtic fields" were small and square, and were ploughed by means of simple bow-ard ploughs. Hulled barley replaced the naked varieties which predominated in the Bronze Age while emmer wheat gave way to spelt. These new cereals could be sown in winter, thus spreading labour out across the year. Cattle, sheep, pigs, horse and dog were kept in varying proportions while hunting and gathering appears to have been relatively unimportant. Highland Zone sites regularly show a greater proportion of cattle than those of the Lowland Zone.

There appears to have been more continuity between the Bronze Age and Iron Age periods than previously thought, particularly with respect to the hillforts (Megaw & Simpson, 1981).

The Iron Age infiltration and later occupation of the Craven area was continuous, probably from the 2nd century BC until the end of the Roman occupation in the early 5th century AD. These people formed part of the Brigantes, a hill tribe of the central and northern Pennines at the time of the Roman conquest of the North. They suffered a major defeat by the Romans at Stanwick Park in 74 AD. The Craven Highlands were never occupied by Romans and the greatest expansion of Iron Age settlements probably occurred there after this defeat.

One of the main Iron Age sites on the massif is the hillfort (NGR, SD 742 746) on the summit of Ingleborough Hill, dated 300 BC - 100 AD according to Longworth (1965) (King, 1970; OSAN, SD 77 SW 1; Philips, 1853; Raistrick, 1938). This consists of a fortified rampart, following the summit's edge and enclosing an area of about six hectares. The enclosure measures 330m from north-west to south-east, by 230m, and 19 hut circles can be seen within it. A great deal of damage has been done to the structure at various times. The beacon and cairn were built from its stones in Victorian times. For this reason the best

Figure 10.2. Plan of Ingleborough hillfort showing position of hut circles.



(taken from Philips, 1853)

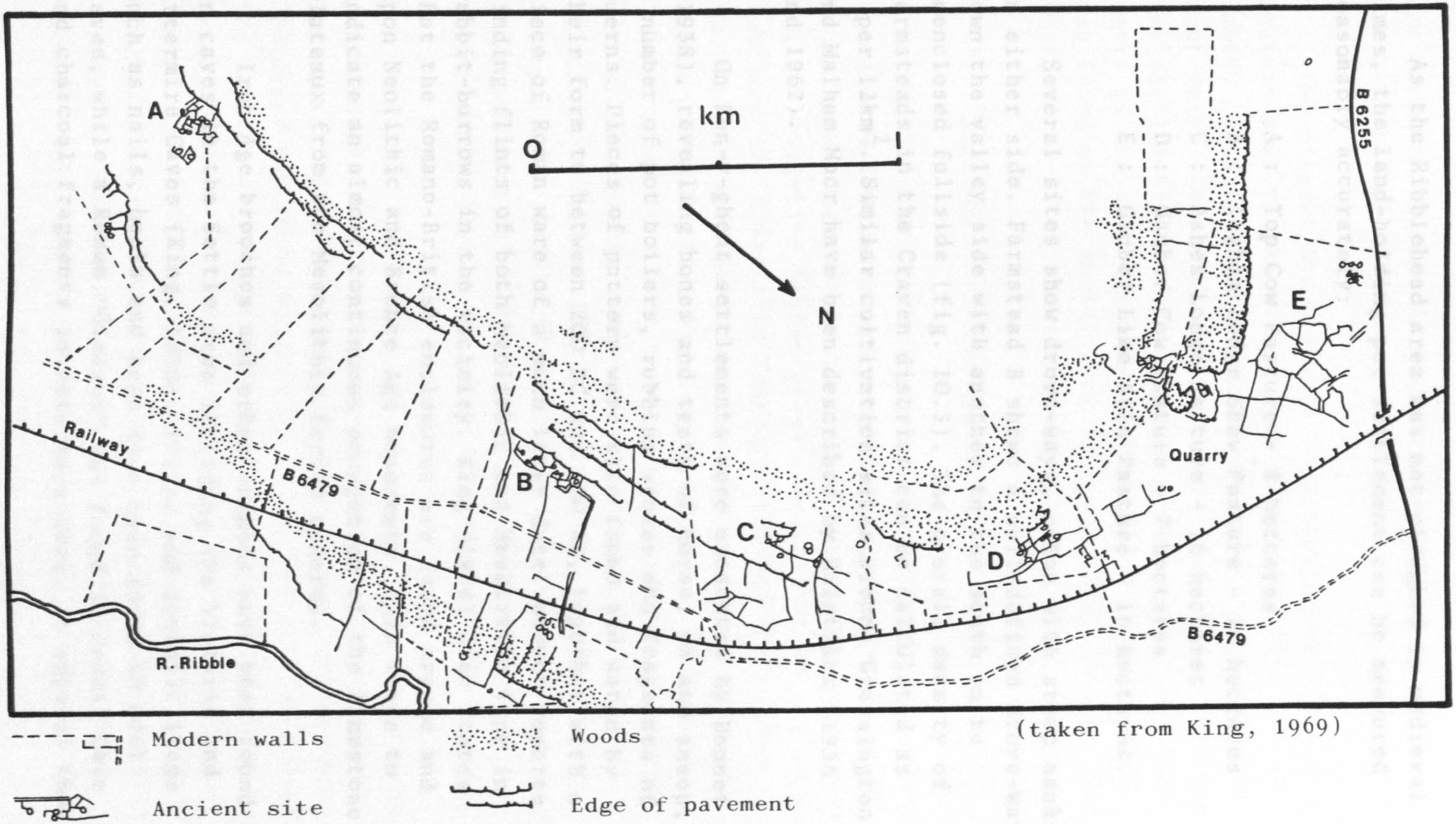
description of the site was published by Philips (1853), before much of the destruction had taken place (fig. 10.2).

Within sight of the hillfort, below on a shoulder of the main plateau, is the ditched and banked earthwork of Yarlsber Camp, which is assumed to be of similar age, although no evidence has been found to support this (OSAN, SD 77 SW 3; Philips, 1853).

The most common sites to be seen on the massif are small settlements or farmsteads consisting of field systems, surrounded by drystone walls, and associated with circular or rectangular stone buildings (OSAN, SD 77 NW 4, 10; SD 77 NE 2, 3, 4, 5, 9; SD 77 SW 1, 8; SD 77 SE 1, 6, 7, 8, 9, 10) (fig. 10.3). Individual circular buildings measuring 5-11m in diameter are often found in groups of three. None of these has been dated earlier than the beginning of the 2nd century AD, and this type continued to be erected in the 4th century. Good examples of such settlements can be seen near Ribblehead (NGR, SD 77 78; King, 1969) (fig. 10.3).

King (1969) recognises three types of ancient fields in the Craven area:

a) small "garden" plots, each enclosed by a loosely built stone bank, probably topped by a fence or hedge. King suggests that these collectively cover too extensive an area to be only stock pounds and that some at least were arable plots for "seed" corn rather than "flour" corn;
b) larger, arable fields up to 0.2 hectares, square to oblong but can have a length to breadth ratio of up to 5:1. These are also enclosed and may be lynchetted;
c) pastoral fields of about 0.5 hectares, with extended, double-banked entrances.



(taken from King, 1969)

Figure 10.3. Plan of Iron Age field systems and other features at Ribblehead.

As the Ribblehead area was not ploughed in medieval times, the land-holding per settlement can be measured reasonably accurately:

A : Top Cow Pasture - 8 hectares
B : Ingham Lodge Shaw Pasture - 26 hectares
C : Ashes Lodge Pasture - 16 hectares
D : Gauber Cow Pasture - 7 hectares
E : Gauber Lime Kiln Pasture - 16 hectares.

Several sites show drove-ways, often with steep banks on either side. Farmstead B shows a well-defined drove-way down the valley side with another to the south on to unenclosed fellside (fig. 10.3). The overall density of farmsteads in the Craven district can be calculated as 1 per 12km^2. Similar cultivation sites around Grassington and Malham Moor have been described by Raistrick (1936 and 1962).

On Pen-y-ghent settlements were excavated by Bennet (1938), revealing bones and teeth of horse, ox and sheep, a number of pot boilers, rubbing stones and fragments of querns. Pieces of pottery were also found and dated by their form to between 200 BC and 200 AD, together with a piece of Roman ware of a much later date. Bennet reports finding flints of both Neolithic and Mesolithic type in rabbit-burrows in the vicinity. King (1978) also states that the Romano-British enclosures are found around and upon Neolithic and Bronze Age monuments. This tends to indicate an almost continuous occupation of the limestone plateaux from the Mesolithic Period onwards.

Iron Age brooches and other remains have been found in caves in the Settle area including the Victoria and Attermire Caves (King, 1970). Knives and domestic items such as nails, hooks and keys have been found in most caves, while a Roman "Gladius" was found in Sewell Cave and charcoal fragments in Attermire Cave. It appears that the caves of the Craven district were occupied during all archaeological periods.

The present Low Sleights road (B6255) on the north-western edge of the massif lies along the route of the Roman, Lancaster to Bainbridge road. This road probably post-dates the occupation period of the hillfort but not the settlements of the limestone plateau. Within a kilometre of the road a bronze sestertius of Antonius Pius was found on the massif near Ingleton (NGR, SD 714 746, OSAN, SD 77 SW 6), dated to 138-161 AD.

10.6. Dark Ages and Medieval Period

In the Dark Ages, Anglian and later Danish settlers penetrated the Dales and generally settled in places which have since become the modern villages. They tended not to occupy the higher ground; however it is not known how long the Brigantian remnants remained there. On Malham Moor this period is represented by the Priests House (NGR, SD 897 674), a rectangular building with inside dimensions of 4.6m by 2.7m. The house structure and various bronze articles suggest that this was the house of an Anglian priest or hermit, probably of 7th century date (Raistrick, 1962). Two coins have also been recorded from Prior Rakes and were identified as Northumbrian stycas, coins of King Eanred (807-841 AD).

In 1974-76, a site was excavated by King (1977) at Ribblehead (NGR, SD 766 784) on the limestone pavement. It consisted of three buildings and associated enclosures. Evidence was found suggesting timber uprights were used to support a roof, perhaps of thatch, which may have come right down over the stub walls. One of the smaller buildings showed signs of being used as a smithy. Finds included a long iron spearhead, knives and three bronze coins, all minted in York around the mid-9th century. Further excavation produced a further four 9th century coins and a Scandinavian knife. This suggests that Ribblehead was occupied in the second half of the 9th century by Scandinavian settlers (OSAN, SD 77 NE 12).

Raistrick (1962) maintains that much of the settlement of the Pennines dates from the Anglo-Saxon Period as borne out by the many Anglo-Saxon derived place-names, particularly on the good limestone soils of Craven.

The upland was again occupied in the 10th and 11th centuries by Norsemen. These were essentially sheep farmers who established settlements of scattered farms, many of which have persisted to the present day, together with their Norse names. There are foundations of several Norse farmsteads on Malham Moor (Raistrick, 1962).

According to the Domesday accounts the entire Craven area was "waste". However, evidence of settlement sites suggest otherwise, particularly on the limestone.

In the 12th century the land was given over to the monasteries, particularly of Fountains and Bolton, under whom the Norse inhabitants continued to farm. The monasteries soon developed an efficient and extremely profitable system of sheep-ranching on the upland (Raistrick, 1962) and this continued until the time of the Dissolution in 1535. Several medieval farmsteads have been recorded from the massif (OSAN, SD 77 NE 6; SD 77 NW 6; SD 77 SW 5, 9) as shown in fig. 10.1.

In 1863, an interesting find of a log boat (dugout canoe) came to light whilst the land, formerly part of Giggleswick Tarn, was being drained (NGR, SD 8073 6459). The boat was made from a single ash tree and was later radiocarbon dated to 615 $\pm$ 40 BP (c. 1335 ad) (McGrail and O'Connor, 1979).

10.7. Present

Many settlements in the Craven Area are now located in the river valleys where good permanent grazing and arable land is reasonably abundant. These settlements tend to be small and act as market centres for their own regions.

The Ingleborough Massif and the Craven Area as a whole is still grazed, mainly by sheep, though drainage programmes have allowed grazing of a larger number of cattle on the uplands recently.

11. GENERAL DISCUSSION

11.1. Peat initiation and growth

Clear phases of peat initiation on the massif cannot be identified from the Ingleborough diagrams, as the date of peat initiation at each site appears to be different. However, the Braithwaite Wife Hole, Simon Fell I and II, and Sulber Pot diagrams begin soon after the elm decline, or c. 5100 BP, while Allotment Shooting Box begins just beforehand, suggesting a late Atlantic, early Sub-Boreal spread of waterlogged soils and carr.

The growth rates of the peat for all the diagrams have been summarised in fig. 11.1. At both the Arks I and Sunset Hole sites, peat growth appears to have begun very slowly. However, at Sunset Hole the growth rate of 56 yr cm^{-1} is artificially low due to the anomalous basal radiocarbon date (9400 $\pm$ 100 BP). If a date of c. 8700 BP is assumed to be correct (section 4.3.) then the modified growth rate would be 35 yr cm^{-1}.

In contrast to this, the low peat growth rate of zone AI 1, 76 yr cm^{-1}, appears to be realistic because the pollen evidence supports the radiocarbon dates, both in terms of the changes in the individual pollen curves and the total pollen concentration, which is very high.

11.2. Pollen concentration and influx values

The pollen concentration diagrams have not been included in this work as it was thought that they did not convey a great deal of additional information to that of the influx diagrams. Where significant differences were identified, these have been mentioned in the text.
Fig. 11.2. shows the mean pollen concentration for each zone in each peat profile.

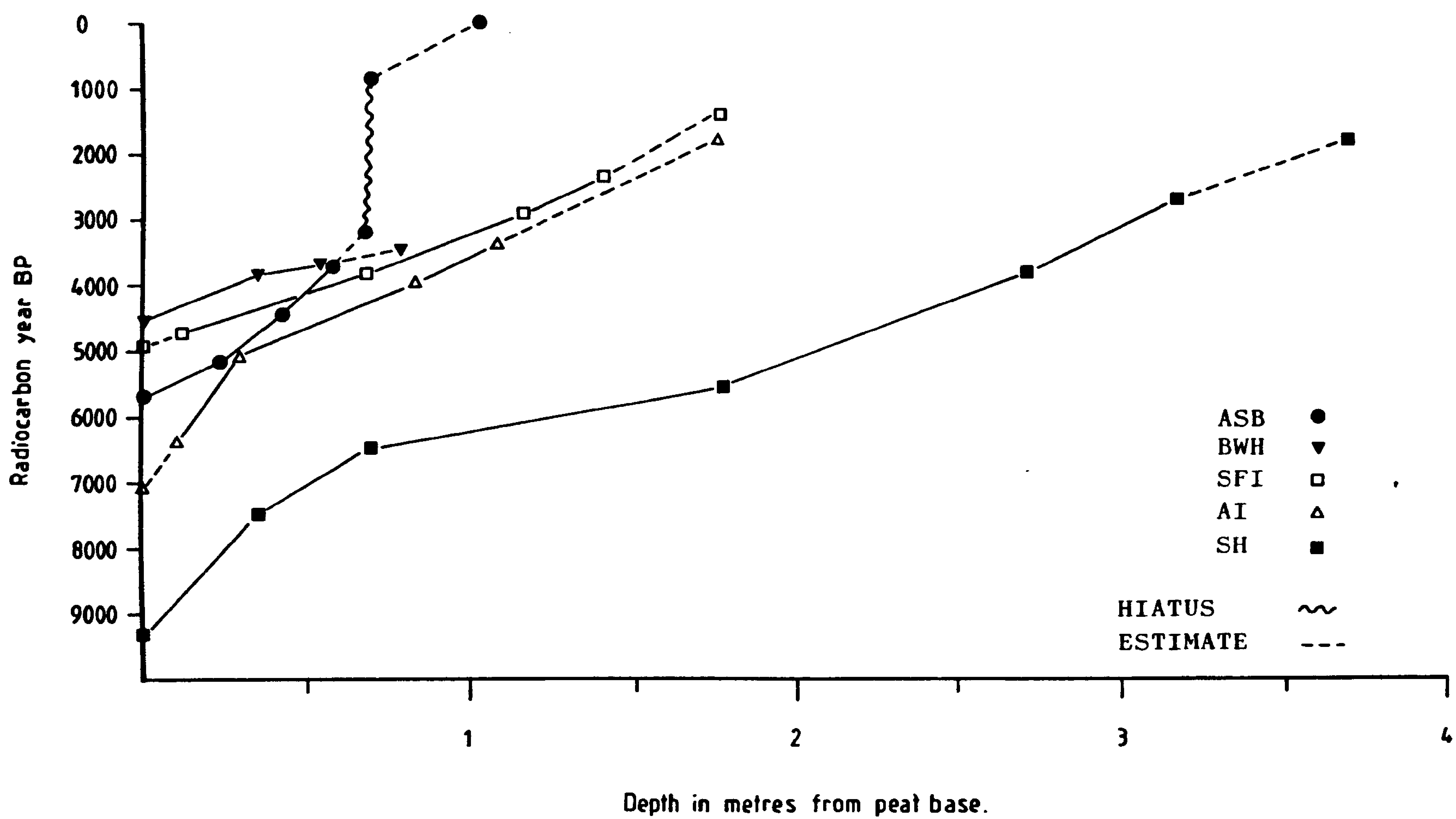
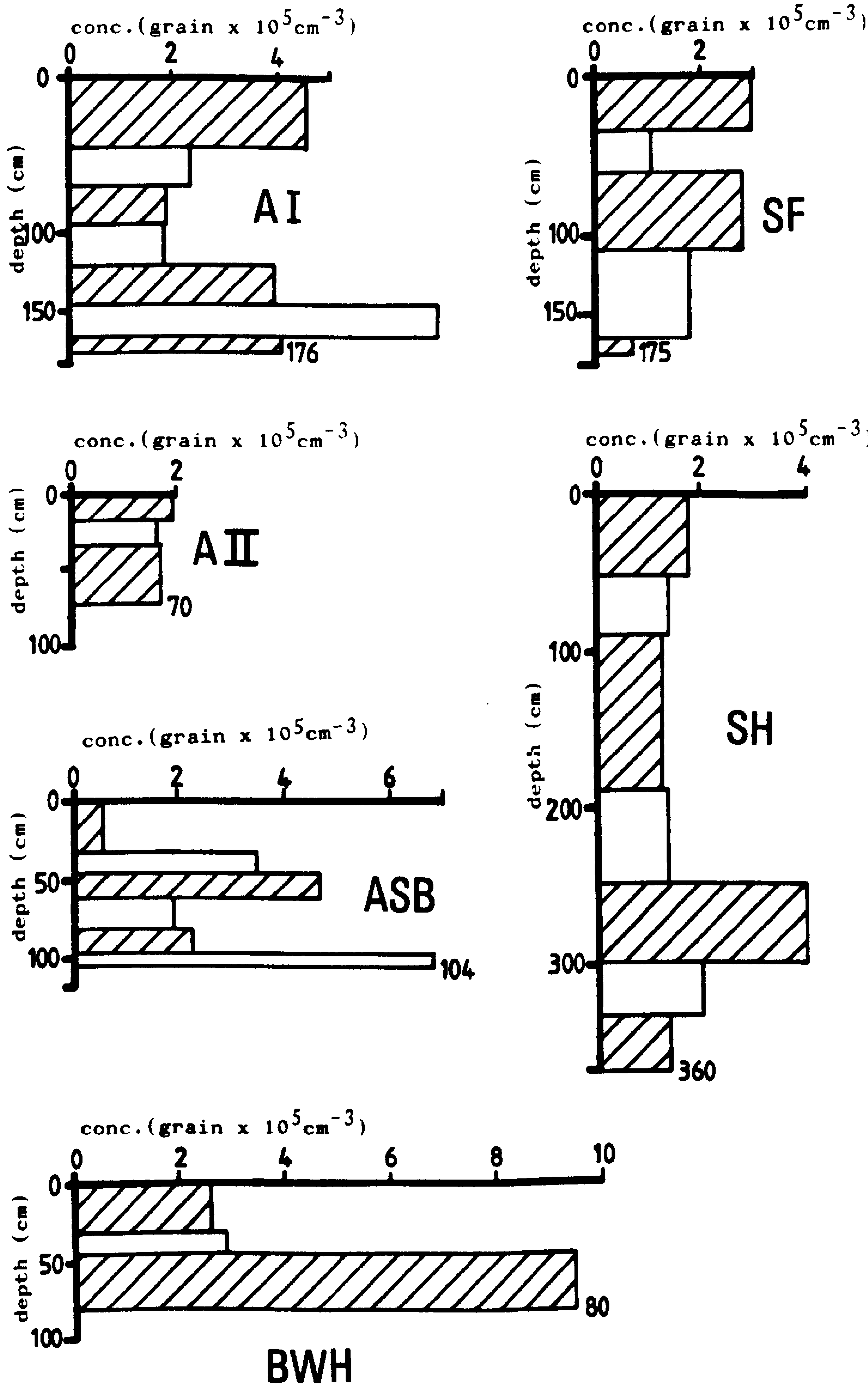


Figure 11.1. Graph of peat growth rates for the radiocarbon dated diagrams.

Figure 11.2. Mean pollen concentration per zone for all radiocarbon dated profiles.



The highest pollen concentrations tend to occur in wood/mineral peat near the base of the profiles in zone BWH1, ASB1 and AI 2. This may be due to a slow rate of growth at the beginning of peat formation, coupled with the presence of heavy pollen producers (e.g. *Alnus*, *Betula*, *Corylus*) growing on the bog surface or close by. The highest pollen concentration of all occurs at the base of the Braithwaite Wife Hole profile, where an average figure of 940,000 grain cm^{-3} (discussed below) was obtained.

Once acid conditions had set in, generally lower pollen concentrations are found, due both to increased growth rate and also to the absence of heavy pollen producers on the bog surface and in the general vicinity. Higher values in this phase tend to be due to *Calluna* producing large amounts of pollen on the bog surface.

The main reason for using pollen influx values is to overcome the problem of the interdependence of pollen percentages. Such problems occur, for example, when a highly productive pollen producer such as *Betula* retreats or is removed from the bog surface. The percentage of other pollen types increases even though the abundance of the parent plants in the vegetation has not altered (cf. zone ASB 1/2, section 7). However, there are a number of inherent problems in the method, reducing the accuracy of pollen influx data, due largely to the following variables:

a) Variation in the rate of peat growth or a hiatus in between radiocarbon dates may severely affect the influx values. Also, as the radiocarbon dates have not been recalibrated, the pollen influx values may be larger than one would expect, since recalibrated dates tend to be older than ^{14}C - dates;

b) If the radiocarbon dates are inaccurate, false influx values will be calculated for each level in the zones above and below the dated horizon. Such inaccuracies could easily be missed. Also, when calculating the peat growth rate, the radiocarbon date is used without reference to its confidence limits.

c) Fossil pollen will be lost by degradation to a greater or lesser extent throughout the profile but particularly at the base. As some pollen types are differentially removed due to the fragility of their exines, the pollen of the remaining species will become concentrated.

d) Ancient pollen (i.e. pollen not derived from the contemporary pollen rain) may be carried into the sampling area by erosion and inwash from another site.

The above points beg the question as to whether influx diagrams are a valuable tool in palaeoecological studies or whether the above variables make their interpretation too involved.

Most investigations including the use of pollen influx methods have been carried out on lake sediments (e.g. Pennington, 1973; Craig, 1978; Bennett, 1981). Data obtained from such sites cannot be easily compared with influx data from peat profiles. Firstly, pollen tends to be concentrated in lake sediments and the degree of concentration varies depending on the morphometry of the basin (Pennington, 1973). This effect is so marked that some authors prefer to refer to pollen influx as pollen deposition rate (Davies, 1969, in Pennington, 1973). Lake sites tend to produce a more homogenous sediment than peat sites. On peat the pollen deposition is independent of peat growth and so normally there is a clear inverse relationship between pollen concentration and the rate of peat growth. This can be seen, on the whole, in the Ingleborough diagrams; however at Braithwaite Wife Hole in zone BWH1, very high pollen concentrations coincide with a quicker-than-average peat growth, for which it is difficult to find an explanation.

In peat bogs, the rate of peat growth often varies considerably over short periods of time. This creates the need for more radiocarbon-dated levels than would perhaps be needed for a lake sediment. At several points in the Ingleborough diagrams, more frequent radiocarbon-dated levels would have greatly clarified the situation, particularly where it was suspected that a hiatus had occurred.

Craig (1978) and Bennett (1981) suggest that under certain circumstances, particularly if there is a variable peat growth rate, concentration data may be more significant than influx data. In general, this has not been true for the Ingleborough diagrams. When information was required about particular vegetational changes, both influx and concentration diagrams were consulted in an attempt to determine which variations were truly indicative of vegetational changes and which were artefacts due to the method. Without the absolute pollen data, the hiatus at Braithwaite Wife Hole might not have been detected and that at Allotment Shooting Box so clearly defined. At times the concentration diagrams showed changes in the pollen curves, otherwise obscured in the influx diagrams due to low values. Similarly, when sharp changes in the concentration curves occurred, the influx diagrams were consulted to see if this reflected an increase in pollen production or simply a change in peat growth rate.

It is interesting to note that at the bases of the Sunset Hole, Arks I and Simon Fell I diagrams the total pollen influx values are very low. Since the date of peat initiation at these sites ranges from c. 8700 to 4900 BP and the stratigraphy is also different, it would seem that pollen degradation may be the cause.

The interpretation of pollen influx diagrams would become a little easier if more data were available on modern pollen influx rates in a range of plant communities. This should at least give some idea of how variable pollen influx can be from site to site within the same community, between communities and the influx due to regional as opposed to local pollen sources.

11.3. Chronozones for the vegetational history of Ingleborough

The pollen records revealed at the eight sites studied on the massif can be compared and described with the help of eight chronozones, ING I-VIII as described below:

ING I	c. 9240 - 9000 BP
ING II	c. 9000 - 8730 BP
ING III	c. 8730 - 7450 BP
ING IV	c. 7450 - 5500 BP
ING V	c. 5500 - 3600 BP
ING VI	c. 3600 - 2500 BP
ING VII	c. 2500 - 1550 BP
ING VIII	c. 890 - 0 BP.

The chronozones and the peat profiles in which they can be found are summarised in fig. 11.3. Each chronozone will be discussed below in turn, in terms of the vegetation growing on the Ingleborough Massif and the Craven area as a whole, finally putting the results in a regional context. To determine the sequence of vegetational changes within the Craven area, frequent references have been made to the pollen data obtained from the following sites:

(over page)

Figure 11.3. Summary diagram and tentative correlations of local pollen zones and chronozones.

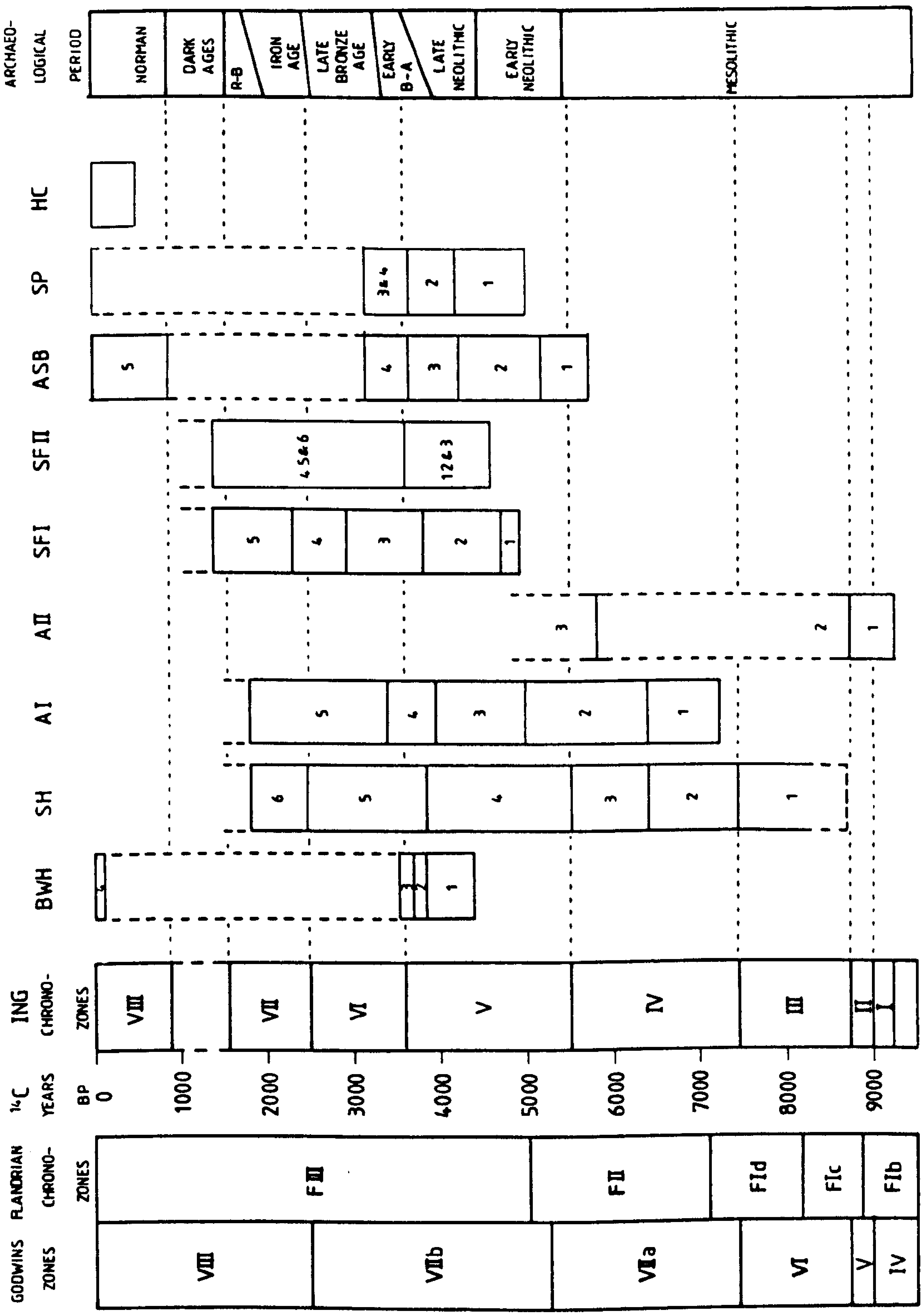


Table 11.1. Sites most frequently referred to in the General Discussion

Site	Area	Altitude (MSL)	Author	Date
Helwith Moss	Ing.	244m	Gosden	(1965a)
Thieves Moss	Ing.	348m	"	(1965a)
Scar Close	Ing.	305m	"	(1965 & 1968)
Howrake Rocks	Ing.	381m	"	(1965 & 1968)
Moughton Fell	Ing.	381m	"	(1965 & 1968)
Eshton Tarn	Craven	144m	Jones	(1977)
White Moss	Craven	190m	"	(1977)
Linton Mires	Craven	191m	"	(1977)
Threshfield Moor	Craven	282m	"	(1977)
Martons Both	Craven		"	(1977)
Tarn Moss	Craven	381m	Pigott & Pigott	(1963)

Radiocarbon dates have been compared with those obtained from:

Red Moss	Lancs.	152m	Hibbert et al.	(1971)
Scaleby Moss	Cumb.	33m	Godwin et al.	(1957).

11.3.1. Chronozone ING I (c. 9240 - 9000 BP)

Peat belonging to this chronozone, ING I, was only found at the Arks II site (zone AII 1). The combined basal 5cm of the peat core gave a radiocarbon date of 9240 $\pm$ 90 BP. Peat accumulation began in the shallow corrie basin under fen and reedswamp communities with occasional willow and birch trees. The surrounding countryside was open, rich in herbaceous species, with a small amount of birch, willow and juniper scrub. The presence of large, tree-less areas is shown by the non-arboreal percentages of c. 80% TLP.

It is difficult to be more specific as to what plant communities were occupying the massif at this time. The wide variety of species recorded from sites with deposits of this age clearly indicates that past communities do not necessarily have modern analogues (West, 1960). The non-arboreal pollen types of zone AII 1 include Saxifraga oppositifolia, (still growing on the limestone cliffs, just below the summits of Ingleborough Hill and Pen-y-ghent), Lotus, Hypericum, Trollius, Compositae, Caltha, Artemisia, Chenopodiaceae and Urtica. Scattered bushes of juniper can be found today on Moughton (on the south-east corner of the massif) associated with a ground cover of bryophytes, often with Vaccinium myrtillus, Calluna vulgaris and occasionally Listera cordata (Bartley and Clark, 1979). This community may well have survived throughout the Flandrian Period on the exposed limestone crags of the area.

Chronozone ING I belongs to the period of ameliorating climate after the retreat of the glaciers, when trees were gaining a foothold in the vegetation. A temporary maximum of Juniperus pollen has long been associated with this period. Its subsequent decline is normally attributed to the shrubs being shaded out by incoming tree species, particularly birch. However, during the steady decline of Juniperus pollen percentages in zone AII 1, tree and other shrub pollen percentages maintain constant levels. The only curve that increases as *Juniperus* percentages fall is that of Cyperaceae pollen. Similarly, at Thieves Moss, troughs in the *Juniperus* curve match peaks in that of Cyperaceae, and other herbs such as *Artemisia* and *Thallictrum*. This suggests that juniper scrub could have given way to an open sedge-grass-herb community rather than woodland.

Zone AII 1 corresponds with zone IV (Godwin's zonation) at Thieves Moss and has similar pollen spectra. However, at Thieves Moss, *Betula* pollen reaches up to 65% TLP compared with c. 15% at AII. In the Arks II diagram, Cyperaceae, Gramineae, Filipendula and other herbs reach much higher percentages. Birch woodland was apparently growing densely near to Thieves Moss but only scattered trees near the Arks.

When the pollen diagrams of White Moss, Eshton Tarn, Threshfield Moor, Linton Mines and Tarn Moss are compared, a broader view of conditions in the Craven area can be gained. The range of species growing around each site is very similar to those indicated by the Thieves Moss and Arks II diagrams. At White Moss, Threshfield Moor and Linton Mires, arboreal pollen percentages lie in the range of 10-20% TLP during the *Juniperus* pollen decline, but these percentages rise rapidly around the end of the decline. The Arks II diagram follows the same pattern except for the slight delay in arboreal pollen increase. Thieves Moss however appears to have been very close to a pocket of birch woodland, perhaps sheltered by the limestone crags bordering the northern edge of the Moss.

At Red Moss the end of the juniper decline was dated to 9586 $\pm$ 200 BP and at Scaleby Moss to 9557 $\pm$ 209 BP. At Threshfield Moor the *Juniperus* decline occurred before 9430 $\pm$ 100 BP. However, at the Arks on Ingleborough the decline occurred after 9240 $\pm$ 90 BP, while at Tarn Moss, although there are no radiocarbon dates available, the juniper curve does not decline until after the _Corylus_ pollen curve rises. Clearly there is a great deal of variation, but this may well be due to altitude, as Tarn Moss lies at 381m (MSL) and the Arks at 533m (MSL) or about 100-150m higher than the highest of the other sites mentioned.

As previously discussed the date of 9400 $\pm$ 100 BP for the base of the Sunset Hole diagram is not acceptable and so the peat of zone SH1 belongs to a later chronozone than ING I.

11.3.2. Chronozone ING II (c. 9000 - 8730 BP)
(pollen diagrams AII, AIIm & AVIc)

At first, this chronozone is similar to the previous chronozone except that at Arks II (second half of zone AII 1) the _Juniperus_ pollen is no longer recorded and the numbers of _Betula_ and _Pinus_ grains begin to increase. Most sites in the Craven area show the same pattern, with birch woodland in particular spreading over much of the area, although at Linton Mires pine woodland was more in evidence. In some places _Corylus_ was becoming more common, but still only in small numbers whilst in the Arks, hazel appears to have been almost absent.

Later in the chronozone (zones AII2, AIIm 1 and AVIc 1 & 2) arboreal pollen continues to increase with _Betula_ showing the highest percentages of TLP. _Corylus_ pollen now appears regularly, though generally under 5%. Occasional grains of _Ulmus_, _Quercus_, _Tilia_ and _Alnus_ appear for the first time in the pollen record. These were probably derived via long-distance transport from sites further south or of lower altitude as they are present in such small numbers. _Corylus_ appears to have been the first invader of the birch-dominated uplands. The chronozone ends with the rapid and extensive spread of hazel into the vegetation of the massif.

11.3.3. Chronozone ING III (c. 8730 - 7450 BP)

(pollen diagrams AII, AIIm, AVIc & SH)

Chronozone ING III commences with a rapid increase in the Corylus pollen percentages and continues until the rational limit of the *Alnus* pollen curve. A continuous pollen record is not available from the deposits studied for this investigation. The Arks II, Arks IIm and Arks VIc diagrams show the *Corylus* rise but soon after a hiatus in peat growth has occurred with the deposition of a few centimetres of mixed peat on top, before the present bog surface (see section 5.3). Peat accumulation appears to have begun after the *Corylus* rise at the Sunset Hole site (section 4.3).

At the AIIm site the *Corylus* rise was radiocarbon-dated to 8730 ± 80 BP. This compares well with 8880 ± 170 BP at Red Moss and 8809 ± 192 BP at Scaleby Moss. Hazel appears to have colonised mainly open ground as Gramineae, Cyperaceae, *Filipendula* and other light-demanding herbs such as *Rumex* show much decreased pollen percentages. Birch and willow trees were also affected, though to a lesser extent, and pine percentages rise slightly before the hiatus cuts the record short. Hazel may have competed with the smaller trees for light, but formed an understory beneath the taller pines.

The pollen record at Helwith Moss begins just before the *Corylus* rise and is similar to that described for the Arks diagram except for lower *Betula* pollen percentages and slightly higher *Pinus* percentages (TLP). Arboreal pollen percentages before the ING II/III boundary are under 25% TLP.

At Thieves Moss the birch and willow woods described for chronozone ING II were largely replaced by hazel, leaving the non-arboreal pollen curves relatively unchanged.

There are clearly minor differences between sites in the Craven area, over the changes in the plant communities at this time. At Eshton Tarn and White Moss, birch woodland was replaced by hazel, whilst at Threshfield Moor and Linton Mires, both _Pinus_ and _Betula_ were replaced to a large extent. This implies that the local conditions played at important role in the vegetational changes occuring at this horizon.

The Sunset Hole pollen diagram appears from the pollen evidence to follow on from the Arks diagrams. According to the estimated date of c. 8760 BP, peat initiation occurred at Sunset Hole just after the steep rise in _Corylus_ pollen percentages. _Pinus_ pollen percentages have risen to high values, greater than those of _Betula_ pollen, while _Corylus_ percentages range between 30-60% TLP.

In the area surrounding Sunset Hole, the vegetation consisted largely of pure stands of hazel scrub/woodland with areas of pine wood, perhaps with hazel as an understory. Pine pollen percentages reach over 30% TLP while those of _Corylus_ reach almost 60% TLP. Birch may have been growing on the sampling site or as a constituent of the community on the drier soils. Halfway through pollen zone SH1 the rational limits of the _Ulmus_ and _Quercus_ pollen curves occur, as oak and elm trees migrated into the existing plant communities. The Sunset Hole site itself was under woodland or carr during this period. It is likely that willow was a major constituent of this wetland vegetation. The _Salix_ pollen percentages in zone SH1 barely reach 5% but this is high compared with its percentages at other times. At the Arks I and ASH sites the _Salix_ percentage pollen values do not exceed 6% and 2% respectively, even though willow branches occur in the peat.

The Sunset Hole site on the north-west side of Ingleborough can be compared with the two sites, Helwith Moss and Thieves Moss, studied by Gosden on the south-east side, in order to give a general picture of the vegetation on the massif at this time. At first the vegetation at Helwith Moss was much the same as that at Sunset Hole, with pine and hazel dominating. Later, however, Ulmus pollen is far more abundant at Helwith Moss than Quercus pollen, the latter increasing only after the rational limit of Alnus pollen.

At Thieves Moss, Pinus pollen percentages remain below 10% TLP, while Corylus percentages reach over 70%. Clearly almost pure hazel scrub was growing around Thieves Moss at this time. As with Helwith Moss, elm pollen is present in much higher percentages than oak pollen. Clearly hazel and pine were abundant over the whole of the massif from the valleys around its periphery to the limestone plateau and up to at least 393m (MSL) (and 533m according to the pollen spectra of AI 1, in the following chronozone ING IV).

Taking the Craven area as a whole, one feature is common to all the pollen diagrams consulted - Tarn Moss (381m), Threshfield Moor (282m), Linton Mires (191m), White Moss (190m), Eshton Tarn (144m) - as well as the Ingleborough diagrams, in that Corylus pollen is present in very high percentages indicating its abundance throughout, from hillsides at 393m in altitude to valley bottoms at 144m (MSL).

There are however differences in the proportions of tree species accompanying the hazel. At Tarn Moss, Threshfield Moor and Linton Mires, pine appears to have been the most abundant tree species, with elm and oak gradually gaining importance but not dominance. However, at the lower altitude site of White Moss, birch is the dominant tree while pine, elm and oak are present in reduced and fairly equal percentages. At Eshton Tarn the Corylus pollen percentages are particularly high while those of Betula, Ulmus, Quercus and Pinus are much lower and roughly equal.

From this there appears to be a general trend for pine and hazel to have been more abundant on the higher limestone plateaux and drier hillslopes while broadleaved woodland was spreading in the valleys and on lower ground in general.

At the two lowland sites, Red Moss and Scaleby Moss, birch was the most abundant tree type although later in the zone at Red Moss, the Pinus pollen curve rises to a maximum as Betula pollen declines.

A general trend has been noted (Pennington, 1974; Godwin, 1975, p. 459) for pine to have been more numerous in the south and east at this time while birch was more numerous in the north and west. The pollen diagrams drawn from data for the Craven area, discussed above, show how variable the vegetation can be in a relatively small area, some showing hazel-pine communities being most prevalent, while others, hazel-birch communities.

Most of the higher altitude sites fall into the pine-hazel category. Pigott & Pigott (1963) noted the development of a well-defined pine-hazel phase and remarked that this was exceptional for the north of England.

At the end of zone SH1 the percentage curves for Corylus, Pinus, Salix, Filicales and Sphagnum grains decline while those of Betula, Ulmus and Quercus rise. The presence of Pteridium spores and a Rumex grain suggest an opening up or thinning of the woodland canopy. Arboreal and non-arboreal pollen percentages increase at the expense of shrub pollen. This is supported by the decrease in the pollen concentration of Corylus, and to a lesser extent, Pinus pollen. However, there is only a slight increase in the concentrations of Betula, Ulmus and Quercus pollen. The evidence indicates that hazel scrub (perhaps with occasional pine trees) was being thinned or cleared in the vicinity of the sampling site. This may well have been due to the activities of Mesolithic man. Previously it was thought by many authors that, as a hunter-gatherer, man was governed by his environment, supposedly without the socio-economic means to change it. However, there is a growing body of evidence to the contrary. This has been discussed at length by Smith (1970, 1984), Jacobi et al. (1976), Simmons (1975) and Mellars (1976) and will be referred to again in section 11.3.4.

It is clear that man utilised hazel and pine during the Mesolithic period as pieces of these woods showing possible signs of working were found by Mitchell (1955) at Terome Bay, Northern Ireland, in the late Boreal layer containing early Larnian flint implements. Mesolithic horizons containing flints are often also associated with charcoal deposits, for example, Stump Cross, near Grassington (Walker, 1956).

Smith (1984) cites evidence for the apparent clearance by fire of the woodland in the Boreal Period from Dartmoor (Simmons, 1964), Baremosse II (Nilsson, 1967) and Newferry, Co. Down (Smith, 1984). Here, high amounts of charcoal were found associated with a decline in *Pinus* and *Corylus* pollen. Smith suggests that the clearance of hazel and pine forest led to the opening of the canopy, allowing the incursion of alder trees which out-competed the other species.

It is interesting to note that at the zone SH 1/2 boundary, *Corylus* pollen percentages rise together with those of *Alnus*, contrasting with the above findings. No significant quantities of charcoal were found associated with these events at Sunset Hole, nor any Mesolithic artefacts, although abundant evidence for Mesolithic man has been found in the Ingleborough area (section 10.2). It seems likely that the pollen data reflects slight and short-term interference with the vegetation in the vicinity of Sunset Hole, prior to the rational *Alnus* pollen rise at 7450 $\pm$ 80 BP. Such interference may well have accelerated the soil deterioration already in progress and so have speeded up the development and spread of acid bog.

11.3.4. Chronozone ING IV (c. 7450 - 5500 BP)
(pollen diagrams SH, AI and ASB)

The period during which Alnus migrated into the country and increased greatly in numbers marks an era of pronounced vegetational and climatic change. This was the last occasion most plants could disperse into Britain by natural processes as the landbridge between Britain and the rest of Europe finally submerged c. 8700 BP (Simmons, 1981). The importance of these changes around what is generally known as the Boreal Atlantic Transition (BAT) has led to a great deal of controversy.

When choosing samples for ^{14}C analysis, there may be a conflict between those levels which give maximum information about local vegetational change and those that enable correlation of pollen zones to be made between one diagram and another.

Originally, Blytt & Sernander zoned the post-glacial (Holocene) period on lithological changes apparently correlated with climatic change. The period we are concerned with here belongs to the transition between their Boreal (dry and continental climate) to the Atlantic Periods (wet and oceanic). Later, Godwin established a different scheme of zonation for Britain based on changes in the pollen spectra (of trees and shrubs) of pollen diagrams. These generally correlate with Blytt & Sernander's divisions. Godwin associated his zone VIc/VIIa boundary with the Boreal/Atlantic Transition. Mitchell (1951, from Godwin, 1975) defined the transition as where the pine curve declines as the alder curve rises (here known as Mitchell's BAT).

The assumption that pollen zones are synchronous across most of Britain and even Western Europe has now been shown to be incorrect through the widespread use of radiocarbon dating (Hibbert et al., 1971; Smith & Pilcher, 1973). Indeed the situation can now be seen to be far more complex. Because of this, pollen diagrams are now divided into local pollen zones, which can be correlated by radiocarbon dates. Unfortunately, the varied zonation schemes described above have led to slightly different horizons being chosen for dating, thus making comparison of dates particularly fraught for the period.

The major vegetational changes occurring around the BAT are at follows:

a) the rational _Alnus_ pollen curve rise (beginning of ING IV);
b) the expansion of _Alnus_ (here defined as the point at which the rising _Alnus_ curve levels off
c) the beginning of the decline in the _Pinus_ pollen curve;
d) the end of the decline in the _Pinus_ pollen curve;
and e) changes in the _Betula_, _Quercus_ and _Ulmus_ curves.

The rational _Alnus_ pollen percentage rise can be seen in both the SH and AI diagrams. Comparison is rendered difficult as the AI peat appears to have started growing immediately before this horizon. Hence, part of the pollen record is taken from peat with a high mineral content, with associated problems such as poor or differential pollen preservation. Secondly, the growth rate at AI seems from the ^{14}C- data to have been extremely slow. This has condensed a long period of time into a few centimetres of peat and so relatively few samples have been taken within chronozone ING IV.

At Sunset Hole the rational rise in Alnus pollen is radiocarbon-dated to 7450 ± 80 BP and so peat initiation at Arks I probably began around this date.

The percentages of Alnus pollen in pollen zones SH2 and AI 1 range between 3-10% TLP. The stratigraphy is also similar, excepting the high mineral content of AI peat. They both consist of heavily humified wood (Salix sp) and monocot remains indicating a carr type of vegetation on site. The variety of herbaceous species present also suggests fairly base-rich fen communities, e.g. Filipendula, Succisa, Potentilla, Umbelliferae and Ranunculus spp. Continuous but small percentages of Pteridium spores occur together with individual ruderal pollen grains, perhaps indicating natural soil disturbance, or possibly man-made. Before the end of zones SH2 and AI 1 the Filipendula curve declines while the percentages of Succisa and Potentilla pollen rise, possibly showing increasing acidity.

From the pollen spectra it seems that at the beginning of chronozone ING IV there was a general covering (on the north-west face of Ingleborough at least) of hazel woodland with less pine than in the previous zone. Oak and elm trees were on the increase and willow was abundant in the wetter basins. This was the vegetation the alder trees were beginning to encroach on, probably spreading into the area via the waterways.

Despite the overal similarity, differences can be seen between the two sites. The percentages of arboreal, shrub and non-arboreal pollen at Sunset Hole were 50-60%, 35-40% and 4-15% respectively, and at AI were 10-22%, 65-70% and 15% TLP. The values of NAP are similar but at Arks I shrub pollen dominates while at Sunset Hole tree pollen dominates. This indicates that at the lower site, Sunset Hole, pine, birch and oak were more abundant in the woodland, while further up the slopes hazel stands with occasional pines dominated. Perhaps the colder, more exposed upper slopes of

Ingleborough were less easily colonised by the broadleaved forest trees. Another possibility is that Arks I was close to the tree-line where a more open canopy may have existed.

At the end of zones SH2 and AI 1, Alnus pollen percentages rise to high values as Pinus percentages fall to low ones. The radiocarbon dates for this horizon are in very close agreement. The first appearance of high Alnus percentages (the "expansion" of Alnus) was dated to 6400 $\pm$ 70 BP at Arks I and 6410 $\pm$ 80 BP at Sunset Hole. However, again there are differences between the two diagrams.

The Alnus curve for AI rises steeply but steadily to about 15% TLP, while at SH there is an abrupt rise to about 40% TLP. Using the estimated growth rate for zone SH2 of 30 yr cm^{-1}, this vegetational change would have taken less than 180 years - a very rapid spread of Alnus if this is the case. Unfortunately, it is not possible to carry out a similar calculation for AI because of the anomalous growth rate of the following zone and the high mineral content of the initial zone. A similar figure of about 200 years was calculated by Craig (1978).

The percentages of Alnus and Betula pollen are much higher at Sunset Hole than at Arks I. At Sunset Hole, a wood-Polytrichum-monocot peat accumulated, with fruit, catkin and wood fragments of birch and alder. At Arks I a cheesy Eriophorum peat was laid down with Potentilla erecta seeds. The only wood fragments present were Calluna twigs. From the evidence it seems that dense birch and alder carr encroached on the SH site at this time, while 800m further up the hillside the bog surface at the Arks site did not carry trees. The site was covered instead with an Eriophorum-dominated community. This is supported by the pollen analytical evidence. The AI diagram shows Calluna with percentages of 7-15% TLP and significant percentages of Gramineae and Cyperaceae pollen. These three taxa are either absent or present only in low percentages in the Sunset Hole diagram.

The peat growth rate at both sites changes with the alder expansion. At Sunset Hole the estimated growth rate was 30 yr cm^{-1} in zone SH2, but 8 yr cm^{-1} in SH3a. This shows a substantial speeding up of the peat accumulation and would normally be accompanied by a reduction in pollen concentration. However, concentration values peak (as do influx values) in zone SH3a, due largely to high numbers of _Alnus_, _Betula_ and _Corylus_ grains, while non-arboreal pollen does not increase. This supports the previous evidence that _Alnus_ and _Betula_ were growing on site, being heavy pollen producers. _Corylus_ seems to have been just as important in the vegetation, compared with the previous zone, if not more so. The change from a slow growth rate to a fast rate, together with the alder rise, suggests a dry climate being superseded by wetter conditions. However, the change at Sunset Hole is sudden and a brief hiatus in peat accumulation could have occurred. The drying peat may have stopped growing and erosion could have set in before increased precipitation allowed growth to resume. Similar evidence has been found at other sites, referred to by Godwin (1975, p. 462) as an obscure and tiresome hiatus in the sequence of deposits.

The AI site, however, provides conflicting evidence at this horizon, around 6400 BP. As at Sunset Hole, the pollen concentration increases but at AI it is more pronounced and affects all taxa including low pollen producers. The growth rate appears to become much slower, 76 yr cm^{-1} (cf. average growth rate for all diagrams = 26 yr cm^{-1}), and influx values show only slight increases. There is always the possibility of a hiatus having occurred in zone AI 2, but no stratigraphic evidence for this has been identified. Hence, on their own, the data from Arks I suggests that the maximum _Alnus_ values coincided with the onset of much drier conditions, causing a slowing of bog growth.

As the two sites concerned are only 800m apart, the discrepancies in the vegetational history must be due to very local influence. The answer may lie in differences between the topography of the two sites. The Sunset Hole core was taken from deep peat, formed in a basin, with steep slopes rising above on one side. Wetter conditions may have encouraged the growth of alder and increased the peat growth rate. However, the magnitude of the rise in pollen influx at Sunset Hole may be partly due to a slower growth rate during zone SH3a. If the growth rate in zones SH3b and c speeded up, the influx values would be artificially high in zone SH3a and low in the following two zones.

At Arks I peat initiation occurred sometime after the rational _Alnus_ rise and before the expansion of _Alnus_. Increasingly wet conditions may have caused the corrie bog margins to advance, reaching the AI boring site at this time. Most of the bog lies on a slope, as can be seen in Fig. 5.2. It is possible that the direction of drainage was away from the AI side, to the N and NE, causing very slow peat growth. Faster bog growth may only have been possible once the bog dome had reached a certain size, spreading drainage more evenly.

A broader view of the vegetation growing on Ingleborough in this period can be achieved by comparing the pollen diagrams of Helwith Moss and Thieves Moss with those of Sunset Hole and Arks I. At Thieves Moss the rational _Alnus_ rise occurs at the top of the peat record as the later peat is missing. At Helwith Moss both the rational rise and expansion of _Alnus_ are represented. On the south-east side of the massif acid peat was accumulating on the two raised bogs at Thieves Moss and Helwith Moss. This is borne out by both stratigraphic and pollen evidence as much higher values of Ericaceae and _Sphagnum_ occur at these two sites compared with Arks I and Sunset Hole. At all sites, Corylus and Pinus pollen dominate the land plant genera but in varying ratios. At Helwith Moss and Sunset Hole, Pinus together with Quercus and Ulmus trees appear to have been at least co-dominant, while at Arks I and Thieves Moss, Corylus is far more important. Pinus values are very low indeed at Thieves Moss (cf. Scaleby Moss, Godwin et al., 1957). At Helwith Moss, Pinus was already a much reduced component of the local woodland by the time of the rational Alnus rise, while at Sunset Hole and Arks I pine was still abundant. Perhaps this is a function of the higher altitude. The expansion of the Alnus curve is steep but steady at Helwith Moss, not nearly as abrupt as that at Sunset Hole.

To compare Ingleborough with the Craven District as a whole we can use the pollen diagrams of Jones (1977). At White Moss, Eshton Tarn and Threshfield Moor, the Alnus curve rises steadily with a correspondingly long overlap of the Pinus curve, showing Pinus co-existing with Alnus for a relatively long period. However, a sudden Alnus rise and Pinus decline was recorded at Linton Mires. This is not really comparable with Sunset Hole because there is a change to an extremely slow growth rate at this horizon. The behaviour of Quercus and Ulmus curves varies greatly from site to site, again suggesting the influence of local factors on the spread of these genera.

Pigott & Pigott's (1963) diagram from Tarn Moss, Malham Tarn, is similar to that of Sunset Hole. Pinus and Corylus pollen percentages dominate during the rational Alnus pollen rise. The pine decline complements a relatively steep rise in the Alnus curve, though not as steep as that of Sunset Hole. The change is marked in the stratigraphy by Sphagnum rubellum and S. imbricatum becoming the dominant species. Similar changes can be seen at Helwith Moss, perhaps lending further evidence to suggest an increased precipitation/evaporation ratio in the area.

Unfortunately, radiocarbon dates are not available for Helwith Moss and Thieves Moss. Reference, in this respect, can be made to Martons Both (Jones, 1977), Red Moss (Hibbert et al., 1971), and Scaleby Moss (Godwin et al., 1957).

The date of the rational *Alnus* rise at Red Moss was 7460 ± 150 BP which is in good agreement with the Sunset Hole date of 7450 ± 90 BP. At Scaleby Moss a reversal in the dates has occurred, and this horizon was not dated directly. However, it would appear to have occurred just before 7354 BP. At Martons Both the date was 7680 ± 100 BP. The expansion of the *Alnus* curve at Red Moss was as abrupt as that at Sunset Hole. The dates were 7107 ± 120 BP at Red Moss, 6400 ± 70 BP at Sunset Hole, and 6410 ± 80 BP at Arks I. At Scaleby Moss and Martons Both the *Alnus* expansion was slower, flattening off at c. 6948 BP and 6930 BP respectively. From this date it appears that alder became a dominant or co-dominant feature of the vegetation on Ingleborough, later than at Scaleby Moss, Red Moss and Martons Both. It is interesting to note that at all the sites mentioned above, *Sphagnum* or cottongrass/*Sphagnum* bog was growing on the surface after the alder expansion, except at Sunset Hole. This may be due to the type of sites sampled, the others all being raised bog.

To put Ingleborough in its regional context, the general picture for Britain as a whole and NW England in particular will be briefly discussed for this period of the Quaternary.

Originally the appearance and expansion of *Alnus* was considered to be due to increased wetness of climate.

It was assumed that the expansion of Alnus and corresponding decline in Pinus pollen was synchronous across most of England. However, Smith & Pilcher (1973) found that the rational rise in Alnus pollen varied in age from before 7500 BP to just before 5000 BP, or a range of some 2500 years. The range was shown to be even greater for Mitchell's BAT.

More recently, Huntley & Birks (1983) have used radiocarbon data in an alternative way, drawing "isopoll" maps of Britain. The authors suggest that 2% Alnus pollen represents a local but sparse presence. By 8000 BP the 2% value was exceeded at one site in south-east England. where one would have expected immigration to have begun. Smith (1984) interprets the 2-10% isopolls as representing the migration front in which Alnus assumed some importance in the vegetation. From these, a wave of expansion can be traced, fanning out northwards and westwards from south-east England. The front reached the Welsh borders by 7500 BP, Scottish borders by 7000 BP, southern Scotland and eastern Ireland by 6500 BP and central Ireland and north-west Scotland by 6000 BP. The date of 7450 $\pm$ 80 BP for the rational Alnus rise at Sunset Hole on Ingleborough conforms well with this general pattern.

Huntley & Birks (1983) suggest a lack of suitable nutrient-rich soils and competition as limiting factors in the spread of alder. They do not hold climatic change to be responsible for controlling either the rate or direction of migration. They see a local role only for climatic change, e.g. western Scotland.

The above may well explain the metachroneity of the radiocarbon dates for the rational Alnus rise, but does not really explain the sudden expansion some time later, as seen at Sunset Hole. At many sites in Great Britain this appears to have been very rapid. In Ireland on the other hand, expansion is generally slow, although the two patterns are not mutually exclusive.

McVean (1956) approached this problem in his auto-ecological studies of Alnus. He gives three possibilities for the sudden expansion: (1) a rise of sea-level producing higher watertables and initiating hydroseres, (2) increase of precipitation/evaporation ratios leading to moister surface soil in spring, and (3) destruction of or interference with existing vegetation by climatic or biotic factors, e.g. Mesolithic forest clearance. These effects would have operated by reduction of competition. Evidence for these points will be discussed in turn.

(1) It seems unlikely that the rise in sea-level could cause an abrupt expansion of Alnus in the vegetation of a site as far inland and at such an altitude as Ingleborough. The general increase in oceanicity of the climate with Britain's insularisation would presumably have been too gradual, unless a critical threshhold was passed.

(2) There is much evidence for a period of dryness occurring in Flandrian Ic, before the main alder rise, or at least in the latter half (Oldfield, 1960; Godwin and Tallentine, 1951; Clark & Godwin, 1967; Pennington, 1964, 1970, 1981; Brown, 1962; Singh & Smith, 1973). The pollen evidence generally shows Flandrian Ic as a period with dry mire surfaces. Pinus and Calluna pollen increases, perhaps representing the spread of these types on to the mires. In Flandrian Zone II wetter conditions prevailed, flooding mire surfaces and allowing the spread of alder carr. There is also much evidence for reworked lake margins at this time.

The disappearance of mineral in the peat at Arks I and the sudden increase in peat growth rate at Sunset Hole around the BAT may be seen as further evidence for increased wetness at these sites, associated with the rise in *Alnus* pollen. However, Smith (1984) makes the point that although the climatic conditions in western Ireland and north-west Scotland after 6500 - 7000 BP were theoretically favourable for alder, pollen diagrams show generally a slow and late spread of alder. The situation is clearly more complicated.

(3) Smith (1970, 1984) cites several examples of places where the activities of Mesolithic man are associated with the *Alnus* expansion. He concludes (1970) with the statement that vegetational changes that were under way as a result of differential migration rates, soil development and climatic change may have been accelerated by human activity. He describes sites where occupation layers and associated charcoal coincide with the BAT. He draws attention to the secondary maximum of hazel seen at several sites and suggests it is due to destruction of woodland by Mesolithic man. The removal of local competition may have assisted the establishment of *Alnus*.

There is little evidence at Sunset Hole or Arks I to indicate man's involvement in the BAT changes except for the presence of low levels of *Pteridium* percentages and one or two grains of ruderals. *Corylus* pollen falls at the BAT at Arks I and there is a temporary decline at Sunset Hole around the rational *Alnus* rise, but no true secondary *Corylus* maximum. It is impossible to determine if the pollen record is reflecting natural clearings (by fire or other means) or small-scale human interference (see below).

It is interesting to note that despite the general appearance of a *Pinus* maximum before the *Alnus* rise, at Scaleby Moss pine percentages remain low and steady while *Betula* dominates and declines with the *Alnus* rise. At

Thieves Moss it is hazel that fills this role. This, together with the highly variable behaviour of the Alnus curve from site to site in this period sheds severe doubt on the usefulness of the "Mitchell's BAT" as a horizon to correlate one diagram with another. This clearly relies on the crossing point of two independent curves and will vary greatly. From this information we can see that the vegetational changes occurring in this particular period of the Flandrian, in the relatively small Craven District and also in the north-west Pennines, show marked local variations, presumably depending on different local limiting factors such as altitude, soil conditions, microclimate and man's interference.

The beginning of the expansion of alder c. 6400 BP is only covered by the pollen records at Sunset Hole and Arks I, but the latter part of the chronozone, after 5740 ± 60 BP, is present at Allotment Shooting Box.

At Arks I the vegetation on site consisted largely of Calluna, Gramineae, Cyperaceae and Potentilla, showing that acid bog communities were well established here at an early date.

At both Sunset Hole and Allotment Shooting Box, carr communities were growing. However, at Sunset Hole, wood fragments become rare in the stratigraphy towards the end of the zone, although birch and alder fruit were found throughout. Arboreal pollen percentages in zone SH3a reach 60-70% TLP, falling in zone SH3 b & c to 50-60%. At Allotment Shooting Box, peat initiation occurred at a time corresponding to late zone SH3b or 3c, and arboreal pollen shows c. 50-55% TLP, while a wood peat continued to accumulate to the end of the zone. In contrast, at Arks I arboreal pollen percentages range between 35-40% TLP.

At Sunset Hole the dense alder-birch-willow carr thinned out in zone SH3b with an increase in Cyperaceae and *Melampyrum* pollen as well as *Sphagnum* spores. Here *Melampyrum* pollen reaches 4% TLP. Some authors associate *Melampyrum* pollen with disturbance of the vegetation by fire (Turner, 1981). As no charcoal was found in these levels it seems more likely, as Pigott suggests (Godwin, 1975) that it was a natural constituent of a poor fen community in this instance. At the beginning of zone SH3c, the rising acidity is marked by the change to a *Calluna*, Cyperaceae and Gramineae dominated herb layer, although birch and alder trees were still present in the vicinity in large numbers.

At the Allotment Shooting Box site in the initial carr vegetation, birch was more abundant than alder, while willow was also present. The herb layer resembles that of zone SH3b in that relatively high values (almost 10% TLP) of *Melampyrum* pollen were counted, although at Allotment Shooting Box Gramineae, not Cyperaceae, were the co-dominants. This probably reflects the abundance of *Phragmites* remains found in the peat. *Calluna* remains do not appear in zone ASB1, but the rise in *Sphagnum* spores and decline in those of Filicales, together with the reduction or disappearance in *Filipendula*, *Lonicera*, *Succisa* and Umbelliferae again indicates a change to more acid conditions on site.

From this we can deduce that immediately after the alder rise, ombrogenous mires were spreading on the upper slopes or at least growing in hollows on Ingleborough. Lower down the slopes relatively base-rich alder/birch carrs were growing in waterlogged basins, but, in time, these too were subject to acidification, the communities changing from carr/fen to poor fen and then to cottongrass/ *Calluna* heath. As the bog acidity rose, the trees retreated to the periphery of the bogs, and did not return, except at Allotment Shooting Box where the predominance of *Phragmites* indicates very poor acid conditions were not reached.

There is a wide variation in the growth rates of peat at the three sites, i.e. SH, 8 yr cm^{-1}; ASB, 24 yr cm^{-1}; AI, 76 yr cm^{-1}. This was due to both the situation of the deposits and the type of peat-forming communities growing there. The Calluna/Eriophorum bog community of Arks I appears to have been drier and much slower growing than the alder/birch carr and birch/alder/Phragmites carr of Sunset Hole and Allotment Shooting Box respectively.

Despite the differences in the local pollen spectra, the three sites show a strong degree of similarity in the regional view of the vegetation. Around 6400 BP, Tilia and Fraxinus pollen appears in the pollen diagrams. The migration of these thermophilous trees into the area was governed by competition with other species and edaphic conditions as well as the warmer climate. This mixture of broadleaved trees and shrubs, generally known as "mixed oak forest", has been detected, with minor variations, over much of the country in this period. At all three sites Quercus pollen is more abundant than Ulmus pollen, and Tilia percentages are very small but generally present. Tilia flowers are entomophilous and pollen is released when the woodland is in full canopy, thus ensuring the under representation of this tree in pollen diagrams (Grieg, 1982; Pigott & Huntley, 1980). Correction factors have been calculated by several authors. Anderson (1976) proposed that assuming Quercus to have a correction factor of x 1, then Tilia percentages would have a correction factor of x 8. Despite its under-representation in pollen diagrams, the numbers of Tilia pollen grains counted for the Ingleborough diagrams suggest that it was not a dominant constituent of the mixed oak forest but was consistently present.

At all sites, particularly towards the end of chronozone ING IV, pollen of Plantago lanceolata, Rumex _acetosa/acetosella_ and other ruderal types, together with _Pteridium_ spores enter the record. This indicates that areas of open and disturbed ground were present, and is supported by the increase in frequency of _Fraxinus_ pollen.

On such a site as the Ingleborough Massif, it seems likely that disturbed ground persisted throughout the Flandrian vegetational changes because of the steep, unstable slopes and cliffs found particularly around the summit and valley sides. However, the increase in disturbance indicators suggests that either a critical threshhold was reached due to soil deterioration, causing a thinning or retreat of tree cover, or else man was increasingly interfering with the vegetation.

It is widely believed now that Mesolithic hunting groups occupied large areas of the uplands before c. 5000 BP. In the Southern Pennines (Jacobi et al., 1976) the evidence suggests regular and recurrent burning of the vegetation by Mesolithic man over a 4000 year period which led to a suppression of closed tree cover over large areas of land above c. 350m. The hunter-gatherers appeared to have occupied an altitudinal belt of c. 350-500m in this area. On the North York Moors, studies suggest that a closed canopy of forest grew up to c. 245m while above 335m this may have been absent. For the Pennines and Dartmoor, an average tree line of c. 366m has been suggested (Simmons, 1975) but suggestions of 650-675m are common. On Ingleborough, hazel scrub with a limited number of trees appears to have been occupying the higher slopes of the massif. It is possible that the summits of Ingleborough Hill, Simon Fell and Park Fell were above the tree line; however there is some evidence for the growth of hazel on the drier soils of Simon Fell in the Neolithic Period (section 11.3.5). Remains of birch trees have been found at over 610m in West Yorkshire and hazel nuts have been found preserved beneath peat at 533m on Fountains Fell (Raistrick, 1962).

In Scotland today the highest densities of red deer are found near dense stands of small trees in close proximity to heather, water and wallow. Game would have concentrated around the tree line, thus helping to explain the distribution of the Mesolithic activity. Furthermore, deliberate burning of small areas of forest, in addition to greatly increasing the mobility of the human groups, has led to a substantial improvement in the economic potential of the environment (Simmons, 1975; Mellars, 1976; Jacobi et al., 1976). It has been suggested that burning would have improved the quality and quantity of forage resources for herbivorous animals. This would lead to improved growth-rate in young animals, maximum size attained by mature individuals and the reproductive rates of the females.

It seems likely that the effect of burning on vegetable resources would likewise be to increase abundance, particularly of hazel nuts which it is believed formed a major component of the Mesolithic economy. Hazel flourishes in fire-affected landscapes and flowers more freely when unshaded (Mellars, 1976). The controlled use of fire would have provided human communities with a powerful means of influencing the distribution of food resources. Animals would concentrate at the burnt sites allowing easy location and clearings could be made within reasonable distance of water supplies, other food sources and settlement areas (Mellars, 1976).

The clearance of forest and consequently enhanced rates of soil leaching may well have accelerated the spread of blanket bog, particularly at the relatively fragile tree-line. Throughout chronozone ING IV in the Ingleborough diagrams, arboreal pollen percentages remain fairly steady, however those of *Corylus* pollen decline at Arks I and Allotment Shooting Box. At the Arks site, *Calluna* pollen appears in this zone and the loss of hazel trees/bushes may reflect the progressive encroachment of acid blanket bog, perhaps speeded up by Mesolithic activity. However, little charcoal has been recorded from the peat at these sites.

At Helwith Moss (Gosden 1965), lying at 244m (MSL) on the south-east corner of the massif, Ulmus pollen percentages are higher than those of Quercus, suggesting that in the valleys elm may have been more abundant than in the hillside woodland. For the whole of this chronozone, a cotton-grass/Sphagnum peat was accumulating on the Moss. Acid conditions prevailed here much earlier than at the sites sampled on the plateau and hillsides above. There is little evidence in the Helwith Moss diagram of disturbance indicators.

A similar picture to that described above can be seen in the pollen diagrams published for the Craven District (Jones, 1977; Pigott & Pigott, 1963). Raised bogs were growing in the valleys, similar to Helwith Moss. Ruderal species tend to be less apparent except at Malham Tarn (Pigott & Pigott, 1963), when compared with the Ingleborough diagrams. This may reflect the size and impassability of the lowland bogs. It is likely, however, that Mesolithic man avoided the waterlogged areas and concentrated on the better-drained soils of the limestone plateaux.

11.3.5. Chronozone ING V (c. 5500 - 3600 BP)

(pollen diagrams SH, AI, ASB, BWH, SFI, SFII & SP)

Chronozone ING V begins with the sudden fall in Ulmus pollen percentages or the "elm decline", dated at Sunset Hole, Arks I and Allotment Shooting Box to 5520 ± 90 BP, 5030 ± 50 BP and 5160 ± 60 BP respectively, and ends with the less marked secondary decline in Ulmus and Tilia pollen. These dates differ by up to 490 years, unusually large especially as Sunset Hole is less than 1km from the Arks and 3km from Allotment Shooting Box.

Smith & Pilcher (1973) studied the radiocarbon dates obtained for important horizons and came to the conclusion that most of the vegetational developments of the early part of the postglacial period across Britain and Ireland are non-synchronous. The elm decline, however, appeared synchronous within the limits of the methods. The dates taken at the end of the elm decline in general fall at c. 5000 BP while dates obtained for the beginning have their means between c. 5300 and 5100 BP. Hibbert et al. (1971) found similar results when comparing British and North European elm decline dates. The Allotment Shooting Box and Arks I dates fall well within the range described by Smith & Pilcher; however that of Sunset Hole is very early. The earliest date quoted by Smith & Pilcher was 5465 $\pm$ 20 BP at Shippea Hill, Cambridgeshire (Clark and Godwin, 1962). One of the examples used by Hibbert et al. (1971), Ranviken Bay, stands out from the rest with a date of c. 5450 BP. Similarly, a date of 5490 $\pm$ 140 BP was recorded by Bartley (1975) for Rishworth Moor. These dates are definitely exceptions to the general rule.

If the three radiocarbon dates for the elm decline on Ingleborough are correct, it is very difficult to suggest reasons for their diversity. Possibly, elm trees growing locally on drier slopes around the Sunset Hole site disappeared earlier than on the massif as a whole. However, this seems extremely unlikely, as the soil on the 1km of hillside between Arks I and Sunset Hole would have been relatively shallow and increasingly acid, judging by the expansion of <u>Calluna</u> and <u>Eriophorum</u> heath or bog seen at the two sampling sites. Such conditions would be unfavourable for elm, suggesting that elm pollen accumulating in the two peat bogs was derived from regional sources or from the pavement area. This would tend to suggest the radiocarbon date for Sunset Hole is too early and this is supported by the dates of 5010 $\pm$ 110 BP at Eshton Tarn, Craven Lowlands (Jones, 1977), 5010 $\pm$ 80 BP at Red Moss, Lancashire (Hibbert et al., 1971), and

4895 ± 65 BP at Scaleby Moss, Cumberland (Godwin et al., 1957) for the end of the elm decline.

The Sunset Hole, Arks I and Allotment Shooting Box percentage pollen diagrams show a permanent decline in the Ulmus pollen curve and permanent or long-lasting reductions in Betula pollen percentages. The Tilia pollen curve declines in both the Sunset Hole and Arks I diagrams. At Sunset Hole, Quercus pollen percentages remain as before, but there is a sharp, temporary decline in Alnus pollen, while Corylus pollen shows sustained higher percentages. At Arks I, there is a temporary decline in the Quercus and Corylus pollen curves, while there is a short-lived rise in Alnus pollen values.

At Allotment Shooting Box the reduction in Betula pollen percentages is most pronounced and is matched by an equally rapid rise in Alnus pollen percentages. This, together with the stratigraphic evidence, appears to represent the replacement of birch by alder on the sampling site. It may be that the fall in Betula percentages in all three diagrams at this horizon reflects changes in the local vegetation on or near the bog surface. At Allotment Shooting Box, Quercus and Corylus pollen percentages also rise.

The Sunset Hole and Arks I diagrams show a fall in arboreal pollen percentages and permanent rises in shrub and non-arboreal pollen, indicating an overall reduction in tree cover on the massif. At Allotment Shooting Box the arboreal, shrub and non-arboreal pollen percentages remain much as before, due to the continued growth of carr at the sampling site.

Despite the lack of clear stratigraphic changes, the average sediment accumulation rates for the three sites changes at the ING IV/V boundary. At Sunset Hole the change is from 8 to 17 yr cm^{-1} of peat, at Arks I, 76 to 20 yr cm^{-1}, and at Allotment Shooting Box, 24 to 40 yr cm^{-1}. The wide spacing between radiocarbon-dated horizons means that it is impossible from the influx diagrams alone to determine if the rate changed at the elm decline or gradually throughout the two zones. To gain as much information as possible, percentage, concentration and influx diagrams need to be consulted.

At all three sites the influx and concentration values confirm that Ulmus pollen does decline in numbers at the same level as the decline in percentages of Ulmus pollen. On the whole the influx concentration diagrams reflect the events described above for the percentage diagrams. However, the Ulmus pollen influx curves appear to decline a little sooner than in the percentage curves at Arks I and Allotment Shooting Box.

The main additional feature shown by the influx diagrams is a marked, temporary reduction in pollen influx just after the elm decline at Sunset Hole, and just before it at the Arks I and Allotment Shooting Box sites. This event is most pronounced at Sunset Hole and Arks I, TLP influx falling from 2340 to 1869 grain cm^{-2} yr^{-1} and 9407 to 3279 grain cm^{-2} yr^{-1} respectively. At Allotment Shooting Box the TLP influx values fell from 8578 to 3743 grain cm^{-2} yr^{-1}. This is reflected in the concentration diagrams of Sunset Hole and Arks I only. This could either be due to a true reduction in the pollen influx to the sites or else a temporary period of rapid peat growth. If the pollen influx was much lower in this phase one would expect this to be due to the absence of specific pollen types. However, at Sunset Hole and Arks I the pollen influx of AP, SP and NAP were greatly reduced, while at Allotment Shooting Box the same pattern occurred but to a much lesser extent. This would tend to suggest a temporary period of rapid peat accumulation took place. The point of lowest influx can be estimated at 5334, 5182 and 5257 BP at Sunset Hole, Arks I and Allotment Shooting Box respectively, using the radiocarbon date of the elm decline and the relevant sediment accumulation rate.

Gramineae and Cyperaceae pollen tend to dominate the non-arboreal pollen, immediately after the elm decline, while Calluna percentages temporarily fall. This pattern is found in all three diagrams suggesting wet, acid areas on the massif may have changed towards a grass-sedge dominance at this time, perhaps indicating slightly wetter conditions. Alternatively, grassland may have increased where the woodland on drier slopes had been opened up at the elm decline. Filicales spore percentages fall at the elm decline while those of Sphagnum tend to rise. This may again reflect the increase in soil acidity and possibly a rising water table.

At both Sunset Hole and Arks I, small peaks of ruderal pollen types occur; at Sunset Hole just after the elm decline and at Arks I just before, i.e. at levels corresponding to the low pollen influx values. At Arks I Plantago lanceolata, Pteridium, Rumex acetosa/acetosella type, Artemisia and Chenopodiaceae grains are recorded. At Sunset Hole, the same species occur, together with Urtica grains. Pteridium spores at both sites appear before the rest and all these taxa become very rare later in the zone. This evidence suggests that small-scale, temporary clearance of woodland occurred near these sites c. 5300-5200 BP, probably by Early Neolithic farmers to graze livestock or else to attract wild game, which formed such an important part of their subsistence. It is possible also that Late Mesolithic hunter-gatherers were responsible, as the Mesolithic culture may well have overlapped with the Neolithic, perhaps at different altitudes (Simmons, 1975) (sections 10.2 and 10.3). Clearance of forest would increase runoff from the hillslopes and may well account for the temporary increased growth rate of the peat, discussed above.

At the Allotment Shooting Box site a different picture is presented. Small numbers of ruderal grains are continuously present from the initial layers of the peat profile (ING IV, section 11.3.4) indicating a long-term though low-key occupation of the area around Allotment Shooting Box from 5740 BP onwards. Shortly after the elm decline the pollen curves for ruderal types peak and this will be discussed later on in this section.

Of the work carried out by Sheila Gosden, only one site, Helwith Moss, included peat of elm decline age. In the Helwith Moss diagram there is no evidence for disturbance of the vegetation at this horizon and, excepting a slight and temporary fall in _Alnus_ percentages, none of the other tree species are affected. The bog surface at this time consisted of _Eriophorum_-_Sphagnum_ peat with _Calluna_ remains.

In the Craven Area as a whole there is evidence of small-scale forest disturbance at the elm decline. At Tarn Moss, Linton Mires, White Moss I and Eshton Tarn, a few ruderal pollen grains are recorded. It is interesting to note that the _Pinus_ pollen curves in the Tarn Moss and Linton Mires diagrams finally fall to background low values at this level. At Eshton Tarn there is a temporary fall in _Betula_, _Quercus_ and _Corylus_ pollen curves and a rise in that of _Alnus_. There have been no other concentration or influx diagrams produced for the Craven district, so it is impossible to say if the pollen influx/concentration fluctuations noted for the Ingleborough diagrams occurred elsewhere in the area at this time. However, such studies have been undertaken to the north-west of the massif, particularly in the Lake District, and these will be discussed below.

The elm decline has been the subject of much controversy over the years. Many theories have been put forward to explain the phenomenon; however no firm conclusions have yet been reached.

Four main variables are particularly discussed in relation to the elm decline, these being climate, soil deterioration, disease and man's interference. Originally, a change in climate was thought responsible for the elm decline because of its apparent synchroneity across a wide area of north-west Europe. As only elm appeared to be affected, a selective factor had to be involved. The elm decline occurs at Blytt & Semander's Atlantic/Sub-Boreal transition and it was thought that a change to a more continental climate with colder winter temperatures prevented the regeneration of elm. However, relatively thermophilous trees such as *Tilia* and *Fraxinus* (still regenerating on the limestone pavement of Ingleborough today) together with *Ilex* and *Hedera* continue well past the elm decline.

There is scanty evidence for a climatic change at the beginning of the Sub-Boreal Period. Godwin (1975) points out that there is no evidence of peat humification at this time to indicate dry conditions, nor convincing evidence of lower lake levels. Indeed, the idea that wetter rather than drier conditions prevailed at the elm decline is gathering momentum (Moore & Chater, 1969; Pennington et al., 1972). Mackereth (1965, 1966), in studies of lake sediments, associated increased halogen concentrations with increased rainfall. At Angle Tarn there was an increasing iodine/carbon ratio during the Sub-Boreal Period (Flandrian zone III, Chronozone ING V). Tutin (1969) accepted this as an indication of increased precipitation/evaporation ratio just before 5000 BP. Pennington & Lishman (1971) however related this to inwash from surrounding soils. Conway (1954) suggests in her discussion of Pennine blanket peats that there is often a stratigraphic change near the elm decline. This is from a highly humified amorphous peat to a *Sphagnum*-rich peat, suggesting increased wetness of the sites.

A process closely related to climatic change is that of soil deterioration. Mackereth (1965) suggests that the Mesolithic period was a time of rapid soil leaching, from his analyses in the Lake District. He regarded non-limestone soils as reaching the limits of elm regeneration at the end of the Atlantic Period. Walker (1966) saw the elm decline in inland northern Cumbria as due to progressive soil depauperation allowing its replacement by oak.

The recent, rapid spread of dutch elm disease throughout Britain has led to many suggestions that the disease may have caused the Sub-Boreal decline of the elm. This would of course have been highly selective and would not explain some of the associated phenomena (see below). No direct evidence for disease has been found. Moore (1984) records the discovery by M. Girling of wing cases from the beetle _Scolytus scolytus_, 10cm below the elm decline, at a site on Hampstead Heath, London. This beetle acts as the carrier of the fungus _Ceratocystis ulmi_, the cause of dutch elm disease. It must be stressed however that 10cm of peat can represent a long time-span and that the presence of the beetle does not automatically indicate the presence of the fungus.

Moore (1987) has also analysed humus profiles from Scords Wood, near Westerham, once rich in elm but later (1978) attacked by dutch elm disease. This killed all the adult elm trees within four years. The pollen diagram showed a reduction in _Ulmus_ pollen percentages of similar proportions to the ancient elm decline and an increase in pollen percentages of weed species due to the opening of the woodland canopy.

Most people now tend to believe that the vegetational changes occurring around the elm decline are due to a large extent, if not entirely, to man's activities. This was suggested by Troels-Smith (1960a) who thought Neolithic man was selectively using elm, ivy and mistletoe as fodder plants for livestock. Elm leaves are still utilised in this way in some countries. Cattle eat elm bark if given a chance, easily ring-barking the trees. Also, in times of famine, a type of bread can be made from the layers immediately beneath the bark (Grieves, 1976).

Relatively recently it has been observed by several authors, particularly through the use of absolute diagrams, that elm is not affected in isolation (Birks, 1965; Pennington, 1975; Sims, 1973). This has been found to be the case with the Ingleborough diagrams. Birks (1965) notes that *Tilia* values fall, to a certain extent, with the *Ulmus* percentages at Holcroft Moss (cf. AI and SH). He also estimated absolute tree pollen frequencies by counting the number of traverses required to complete equivalent counts of uniformly prepared slides. Immediately above the decline at both Holcroft Moss and Lindow Moss the number of such traverses almost trebled, indicating a much lower pollen concentration. At these sites the stratigraphy at this level consisted of birch/alder carr. At the equivalent levels in the Sunset Hole and Arks I profiles, *Eriophorum*-*Sphagnum*-*Calluna* peat was found. This suggests that the fall in pollen concentration was not due to factors operating in situ.

Pennington (1975) in her paper on the effect of Neolithic man on the environment in north-west England finds that at all the sites investigated, there were traces in lithostratigraphy, sediment composition and pollen analysis of the effects of increased run-off from the catchments, coinciding almost exactly with the steep fall in elm pollen. She interprets this as the result of an increased precipitation/evaporation ratio. She notes that in upland sites, the curves for *Betula* and *Pinus* pollen decline along with the elm while on lowland sites *Quercus* pollen declines with that of elm. It appears that in the uplands, Early Neolithic man was clearing the birch-pine forest while elm was preferentially removed (by one means or another) lower down the slopes in the mixed-oak woods. In the lowlands nearer the coast mixed-oak forest was being cleared.

At Sunset Hole, birch and alder decline along with elm and lime. At this level in the stratigraphy, birch and alder seeds disappear, suggesting that this may represent a local bog change (perhaps brought on by increased run-off or autogenic change) rather than direct clearance by man. The elm and lime would have been removed from mixed-oak forest, probably centred on the limestone plateau. At Arks I, birch and hazel decline along with elm and lime. This may indicate the clearance of light hazel and birch woodland in the vicinity of the higher altitude Arks I site at the time of the elm decline.

The clearance phase at Sunset Hole lasted about 200-350 years, between c. 5560 and 5200 BP. At Arks I, the duration was about 500-700 years, between c. 5487 and 4792 BP. Since these dates are estimates, it is difficult to tell whether the clearance phase at Arks I was indeed longer than that at Sunset Hole or whether they represent the same event. At Blea Tarn (Pennington, 1975) the period of maximum deposition of pollen of grasses and <u>Plantago lanceolata</u> lasted about 300 years; comparable with the above.

At Allotment Shooting Box clearance indicators are continuously present from the date of peat initiation (5740 $\pm$ 60 BP). This is the same as the oldest radiocarbon date yet obtained from a Neolithic archaeological site, Ballynagilly, Co. Tyrone (section 10.3). At c. 5000 BP the pollen curves of disturbance indicators rise, marking the beginning of a long-term clearance phase.

From the above evidence and that of Helwith Moss, a general picture of the Ingleborough Massif can be proposed for this period around the elm decline. Disturbance of the vegetation on Ingleborough began on the limestone plateau, at least as early as 5740 ± 60 BP, either representing small-scale clearance by Mesolithic man using fire or else very early activity by Early Neolithic peoples. About 200 years or so later, temporary clearance occurred at a higher altitude (Sunset Hole and Arks I) and perhaps in the valleys (Helwith Moss). After 5000 BP a major clearance phase began on the plateau while activity up-slope and into the valley bottom was reduced or curtailed entirely for a period.

Five of the seven sites studied on the massif show evidence of this major clearance phase, the timing and duration of which can be summarised as follows:

SITE	RADIOCARBON DATE	DURATION (years)
BWH	(peat base) 4560±50 - 3840 ± 50 BP	c. 720
SFI	4720±50 - c. 4135 BP	c. 585
SFII	no dates available	
ASB	c. 5000 - c. 4340 BP	c. 600
SP	no dates available.	

At all five sites, peaks occur in the pollen curves of _Rumex acetosa/acetosella_ type and Gramineae. Starting with Braithwaite Wife Hole on the north-western end of the transect across the massif, each site will be discussed in turn and then the general events across the massif will be summarised.

At Braithwaite Wife Hole the _Rumex_ percentages are particularly high, around 10% TLP rising to a maximum of 29.7% TLP, and a perianth bract of _Rumex acetosa_ was found in the peat. The arboreal percentages are around 50%, but this is mainly due to the high values of Alnus pollen, as alder wood was growing on the site at this time. The percentages of _Quercus_ and _Corylus_ pollen are low, those of *Ulmus* very low and *Pinus* and *Tilia* pollen is virtually absent. This suggests that open ground was created at the expense of mixed, broadleaved woodland, growing on the drier areas of the limestone plateau.

At 3840 ± 50 BP the clearance phase ended with an abrupt decline in the *Rumex* percentages as a short woodland regeneration phase set in. Birch trees replaced alder in the wet hollow of the sampling site which, together with the peak in *Sphagnum* spores indicates wetter and more acid conditions. The mixed woodland partly regenerated with *Fraxinus* and *Corylus* increasing. The end of the forest regeneration came around 3646 BP with the beginning of a second clearance phase.

The *Rumex*/Gramineae clearance phase reappears in the Simon Fell I diagram. Here, *Corylus* and *Pinus* woodland or scrub was cleared at some distance from the site, probably on the drier, base-rich soils of the Main Limestone (Green Hill) on Simon Fell summit. *Rumex* pollen is consistently present at 2-3% TLP, not nearly as pronounced as at the Braithwaite Wife Hole site but clearly similar in nature.

After the clearance phase, trees and *Corylus* recover again and *Fraxinus* becomes an important constituent of the woodland. At 3810 ± 50 BP, the curves for *Plantago lanceolata* and *Pteridium* grains rise, showing a second clearance well underway before the secondary *Ulmus* and *Tilia* decline c. 3736 BP. At Simon Fell II, peat initiation began during the first clearance phase and *Rumex* pollen is present in similar percentages to those of Simon Fell I.

At Allotment Shooting Box, c. 5000 BP, the pollen percentage curves of *Rumex acetosa*/*acetosella* type and to a lesser extent *Plantago lanceolata*, *Urtica* and *Pteridium* rise and later peak, *Rumex* pollen reaching

17.2% TLP. Gramineae pollen maintains high percentages as in the previous zone. This clearance phase drew to a close c. 4340 BP as alder trees took over locally and other tree percentages increase slightly. Throughout these two phases the peat at the sampling site consisted of Phragmites-Eriophorum peat with varying amounts of wood fragments and birch and alder fruit. The tree regeneration phase ended around 3650 BP with the beginning of another clearance phase. However, ruderal pollen types are still recorded in small numbers between the clearance phases.

At Sulber Pot, a site similar to Braithwaite Wife Hole in that it lies between blocks of limestone pavement, the clearance phase is well marked. Rumex pollen reaches over 5% TLP and Plantago lanceolata pollen grains are continuously present. The arboreal pollen percentages are about 15% TLP, suggesting that large areas of open ground were in the vicinity of the sampling site. Corylus values are high but in the absence of an influx diagram for Sulber Pot it is impossible to tell if this represents extensive hazel scrub or simply increased percentage values due to the low numbers of arboreal pollen grains. No trees were growing on the site itself as the peat is a monocot-Eriophorum type.

At the end of the Rumex-Gramineae clearance phase, clearance indicator species are reduced in numbers but are still present continuously. Arboreal pollen of deciduous trees, including Fraxinus, increases in numbers showing recolonisation of previously cleared land. The secondary decline in elm and Tilia pollen occurred around the 40cm level but unfortunately no radiocarbon dates are available.

At Sunset Hole there is no evidence for this major clearance phase; however, pollen grains of Pteridium and Rumex are present consistently, though in very small numbers, from the elm decline onwards and the curve for Plantago lanceolata returns again (after the initial short-term clearance), by c. 4828 BP. Eriophorum-Calluna-Sphagnum peat accumulated here throughout chronozone ING V. The second decline in Ulmus and Tilia pollen lies at 3850 ± 50 BP which is also the date of the beginning of a major clearance phase.

Similarly, at Arks I there is no indication of a clearance in the Early Neolithic period. Apart from one or two grains of Plantago lanceolata, consistent curves for ruderal species do not appear until c. 3680 BP. The peat during the whole of this period consists of Eriophorum with Calluna remains. Corylus pollen is present in very high percentages.

From the above evidence it seems clear that extensive and long-term clearance of forest cover occurred during the Early Neolithic Period and the beginning of the Late Neolithic on the limestone plateau on both sides of the massif. The lack of evidence from the Sunset Hole and Arks I sites may be due to the fact that both these sites consisted of Eriophorum-dominated bog, which may have covered a large area, uninviting to man and animals. On the summit of Simon Fell the presence of this clearance phase after its absence at Arks I and Sunset Hole may be due to the presence of suitable soils over the Main Limestone outcrop (section 1.1). Between the summit and the limestone plateau the hillside is steep and many parts are covered by blanket peat at present.

The vegetation on the massif at this time was a mosaic of different communities, a product of differences both in altitude and geology. The clearance phase began around the close of the climatic optimum, hence with average temperatures higher than today. On the summit of Simon Fell hazel and perhaps pine were occupying the drier soils on the Main Limestone, while extensive areas of

Eriophorum bog were developing elsewhere. On the higher slopes hazel appears to have dominated the woodland with lesser numbers of mixed-oakwood species. Over some of the slopes, however, *Eriophorum-Calluna* bog was developing, as in the Arks basin. Lower down the slopes mixed-oak wood became more abundant but still *Eriophorum-Sphagnum-Calluna* peat was growing over basins and badly-drained sites such as Sunset Hole. On the limestone plateau itself, mixed-oak wood was growing, except where drift-lined pockets were occupied by alder, birch and willow carr (Braithwaite Wife Hole and Allotment Shooting Box).

During the clearance phase, mixed-oak wood was cleared on the limestone soils of the plateau, leaving the carr woodland standing. On Simon Fell's summit, hazel and possibly pine were cleared.

The high percentages of *Rumex* pollen are very unusual for clearances at this time. The question arises whether the pollen belonged to *Rumex acetosa* or *Rumex acetosella*. The bract found at Braithwaite Wife Hole in the peat of this age was identified as being *Rumex acetosa*. It is possible that *R. acetosa* was growing under the sparse damp woodland on the sampling site; however, on further investigation no other macrofossils of *Rumex* were found, nor were they found at other sites in peat of this phase. This, together with the strict correlation between the *Rumex* pollen peaks and those of other clearance indicators, argues against its presence on the sampling site.

The unusual nature of the pollen spectra of this clearance phase and the link between the relevant sites and the limestone suggests that *Rumex acetosa* was growing in damp basic grassland and woodland edges, particularly on the limestone pavement, and was maintained by Neolithic farming activities.

It is also possible that a mixture of R. acetosa and R. acetosella contributed to the Rumex pollen curve. Tinsley & Smith (1974) during their studies on contemporary pollen spectra decided high Rumex pollen percentages indicated intense, local grazing pressure. The author has seen almost pure carpets of Rumex acetosella growing in acid, upland grassland, in areas where sheep tend to congregate. Turner (1964) found that at Tregaron Bog, in a predominantly pastoral farming area, percentages of Plantago sp pollen and Pteridium acquilinum spores were significantly higher than at East Anglian moss sites. where mostly arable farming was practised. Frequencies of pollen of Compositae cereal, Cruciferae, Artemisia and Chenopodiaceae grains were on the whole higher in the East Anglian series. Rumex pollen was found at both sites and was not considered to show a significant difference between them, although the figures are slightly higher near the pastoral farming area.

Clearly the pollen spectra from the early neolithic clearance phase on Ingleborough do not fit exactly into either set. Small numbers of cereal grains were found at Sulber Pot and Braithwaite Wife Hole, suggesting that crops were being grown on the limestone soils. However, significant numbers of Cruciferae, Artemisia, Compositae and Chenopodiaceae were not recorded. On the other hand, at Sulber Pot, Allotment Shooting Box, Simon Fell and, to a lesser extent, Braithwaite Wife Hole, Plantago sp pollen is also well represented, suggesting a heavy pastoral bias. From this it could be tentatively suggested that parts, if not most, of the limestone plateau around the edges of the massif were being intensively farmed, both for crop growing and stock rearing. On the summit of Simon Fell and near Allotment Shooting Box, only grazing of livestock may have occurred.

Supporting evidence for extensive forest clearance on the Carboniferous Limestone soils comes from the work of Kelly & Walsh (1978). They carried out pollen analysis on soil from beneath the burial cairn, Apron Full of Stones (section 10.3.) just to the west of the massif. Low ratios of of tree to non-tree pollen were found, indicative of the impact of Neolithic man on the forest cover.

Most archaeological finds belonging to the Neolithic period in the Craven district have been found in caves of the Carboniferous Limestone (section 10.3). These caves may well have been occupied during the clearance phase. Raven Scar Cave (Gilks, 1981) where occupation and other debris were found lies within 2km of Braithwaite Wife Hole, and Foxholes Cave is just under 2.5km from the Allotment Shooting Box and Sulber Pot sites.

The date of the clearance phase coincides with those from the axe-chipping floors in the Great Langdale area (Pennington, 1975). The presence of one of these axes on Ingleborough, in the Selside Gryke burial, indicates that trade-routes existed between the two communities.

During and towards the end of the Neolithic clearance phase there are signs of increased run-off and acidity on the sampling sites. At Braithwaite Wife Hole, immediately after the clearance, _Sphagnum_ spores peak and the _Calluna_ pollen curve begins. At Simon Fell, the _Rumex_ pollen curve declines as the _Potentilla_ curve rises, and _Eriophorum_ becomes abundant in the peat. _Potentilla_ again rises as _Rumex_ pollen declines at the Sulber Pot site, suggesting that an acid grassland took over, with the first appearance of _Calluna_ in the vicinity. At the Allotment Shooting Box site conditions were still sufficiently base-rich to support alder carr, but a rise in the water-table may have occurred.

At all five sites showing evidence of long-term Neolithic disturbance a short, forest-regeneration phase took place afterwards. The duration of this phase at each site is as follows:

SITE	RADIOCARBON DATES	DURATION (years)
Braithwaite Wife Hole	c. 3840-3646 BP	c. 200
Simon Fell I	c. 4135-3588 BP	c. 550
Allotment Shooting Box	c. 4340-3650 BP	c. 700.

During the period of forest regeneration, clearance indicators such as Plantago lanceolata and Rumex pollen did not disappear entirely from the pollen record. At the three sites close to the limestone there is clear evidence indicating that although farming activity may have been reduced, it continued without a break in this area until the end of the forest regeneration phase. It is possible that different parts of the massif were occupied at this time, or else a reduction in the population occurred. At Braithwaite Wife Hole the drop in the Rumex pollen curve was very abrupt, possibly indicating a relatively sudden abandonment of the land.

Although the broad-leaved trees of mixed-oak woods show increases after the clearance ended they do not recover their pre-clearance levels and a greater proportion of efficient recolonisers, Fraxinus and Corylus, are shown in the pollen diagrams.

The only other pollen diagram for a site on Ingleborough which covers this period is that of Helwith Moss. There is no evidence in this diagram of a marked Neolithic clearance phase. This indicates that Neolithic man preferred the rich, light soils of the limestone plateau to the wetter and heavier - and when not waterlogged - more densely-wooded soils of the valleys.

This is supported by the findings of Jones (1977) at Eshton Tarn and White Moss. At both sites, small numbers of ruderal pollen types were found throughout the Neolithic Period, but they did not form continuous pollen curves. A small and very short-lived peak in Rumex obtusifolius pollen was recorded at White Moss I, around the elm decline (dated to 5080 ± 100 BP). However, there is no evidence for a long-term Rumex acetosa/acetosella-Gramineae-dominated clearance phase during the Neolithic Period in these diagrams. This strongly supports the theory that Neolithic farmers concentrated their efforts on the plateaux of the Carboniferous Limestone.

11.3.6. Chronozone ING VI (c. 3600 - 2500 BP)

(pollen diagrams BWH, SH, AI, SFI, SFII, ASB, SP)

This chronozone begins with the secondary decline in Ulmus and Tilia pollen. This horizon is more difficult to identify than the first Ulmus decline, as both pollen types are present only in small percentages before the decline. Despite this, the horizon can be found in all seven diagrams. The Ulmus pollen curve declines to very low values, although the pollen is generally continuously present afterwards, while grains of Tilia are almost absent.

The secondary decline in the curves for Ulmus and Tilia pollen also marks the beginning of the Early Bronze Age and a major clearance phase. At all sites the indicator species of clearance are now dominated by Plantago lanceolata and Pteridium with smaller numbers of Urtica, Rumex, Artemisia and Chenopodiaceae. This suggests that either different farming techniques to those of the Late Neolithic were being used in the Early Bronze Age, although still based on pastoralism, or else pedological changes had occurred on the limestone producing a different range of clearance indicators under the same system of land management. Similar indicator pollen spectra to this second major clearance phase can be seen in many Highland Zone pollen diagrams (e.g. Simmons & Cundill, 1974; Tallis and Switsur, 1973; Chambers, 1978).

During this Early Bronze Age clearance phase, acid *Eriophorum*, or *Calluna-Eriophorum* bog, already well established on the wetter slopes above, took over the lower slope and plateau peats, finally ousting the wet woodland or carr. The *Sphagnum* curves peak in this zone at the Braithwaite Wife Hole, Sulber Pot, Simon Fell I, Simon Fell II and Allotment Shooting Box sites, indicating either increased rainfall or else increased run-off caused by forest clearance.

Away from the areas where peat was accumulating the woodland was depleted during this time. The sites closest to the limestone (Braithwaite Wife Hole, Sunset Hole, Allotment Shooting Box, Sulber Pot, Simon Fell I) again show heaviest clearance, a mixture of deciduous trees being removed from the drier, lighter limestone soils. At Sunset Hole, Simon Fell I and Sulber Pot, the *Fraxinus* pollen curve also declines, suggesting that secondary woodland was being cleared again. Although the reduction in tree numbers near Simon Fell I does not appear to have been as great as that on the plateau (arboreal pollen falls from c. 40% to less than 25% compared with the Sulber Pot site where it falls from c. 30% to less than 5% TLP), there is some evidence to suggest that this reflects a decline in tree numbers on the summit rather than a long-distance record of events on the plateau. At the Arks I and Simon Fell II sites, either side of Simon Fell I on the transect, clearance indicators are not nearly as abundant as at Simon Fell I. At Arks I, tree species do not appear to decline, although *Corylus* pollen does so (either due to clearance of local hazel scrub or the spread of acid bog communities). At Simon Fell II, *Quercus* and *Alnus* pollen curves rise while other tree species decline. *Corylus* percentages rise to high values.

From this it would appear that some trees, with a high proportion of hazel, survived on the upper slopes at this time, particularly on the south-east side of the massif, while the more base-demanding communities were being cleared on the plateau. Alternatively, it is possible that the long-distance arboreal pollen component of the pollen rain may have been concentrated at the Arks I and Simon Fell II sites (cf. Price & Moore, 1984). Towards the end of the Early Bronze Age the arboreal pollen percentages on the hillsides were reduced to c. 30% TLP (Sunset Hole, Arks I, Simon Fell II, Allotment Shooting Box) while near the limestone on Simon Fell I it had fallen to less than 25% TLP and next to the limestone pavement (Braithwaite Wife Hole and Sulber Pot) to 5-12% TLP. According to surface pollen studies (Cundill, 1979; Tinsley & Smith, 1974; O'Sullivan, 1973) such arboreal pollen percentages indicate that some light woodland was probably growing close to, but not on, the bog surfaces at Sunset Hole, Arks I, Simon Fell II and Allotment Shooting Box, while at Simon Fell I, Braithwaite Wife Hole and Sulber Pot, large areas of open ground were present around the sites.

At Helwith Moss, the decline in *Tilia* pollen coincides with the beginning of a rise in the *Ulmus* curve, which, in turn, declines later when *Tilia* pollen is virtually absent. Without radiocarbon dates it is impossible to say where the Early Bronze Age begins in this profile. However, throughout the profile above the elm decline, arboreal pollen remains c. 30-40% TLP, which suggests that woodland clearance was not as extensive here as on the limestone plateau. As the bog surface was under *Eriophorum*-*Sphagnum* peat and the dimensions of the bog were relatively large, an arboreal pollen percentage of 30-40% TLP probably represents quite dense woodland beyond the periphery of the bog.

The pollen record at the Braithwaite Wife Hole, Allotment Shooting Box and Sulber Pot sites ends during the Early Bronze Age or towards the beginning of the Late Bronze Age. The estimated date of the hiatus at

Braithwaite Wife Hole (the BWH 3/4 boundary) is c. 3535 BP, and at Allotment Shooting Box (the ASB 4/5 boundary) is 3156 BP. Although radiocarbon dates are not available for the Sulber Pot diagram, it bears a strong resemblance to that of Braithwaite Wife Hole, and from this it is assumed that the hiatus is also present here. Unless the peat grew extremely slowly (of which there is no evidence in the stratigraphy) there is not enough peat depth above the Neolithic clearance phase to represent a continuous pollen record to the present.

At Braithwaite Wife Hole, just before the hiatus, arboreal pollen had fallen to c. 10-20% TLP while non-arboreal pollen reached c. 80% TLP. At Sulber Pot, at a similar level (8cm), arboreal pollen had fallen to c. 5% TLP while non-arboreal pollen had risen to c. 88% TLP. Some trees were still growing on the Allotment Shooting Box site at this time, as shown by the presence of wood fragments in the peat. Despite this, arboreal pollen percentages are as low as c. 25% and non-arboreal as high as 55% TLP. This suggests that large areas of the limestone plateau were almost totally cleared of trees during the Early Bronze Age on both the north and south sides of the massif. Slightly further up the slopes at Allotment Shooting Box some trees (mainly birch and alder) were growing in the wetter areas but the landscape was still very open. At all three sites, Calluna pollen reaches high percentages at the beginning of the Early Bronze Age and these remain high until the hiatus is reached. It is difficult to ascertain to what extent man's activities, climate or autogenic changes, or a combination of these factors, influenced this vegetational change.

The pollen record continues into the Late Bronze Age at only four sites: Sunset Hole, Arks I, Simon Fell I and Simon Fell II. These sites tend to fall into two groups, with Arks I and Simon Fell II in one and Sunset Hole with Simon Fell I in the other.

At Arks I there are only slight signs of disturbance of the vegetation (continuous but very low levels of _Plantago lanceolata_ and _Pteridium_ grains) until c. 3400 BP around the beginning of the Late Bronze Age, when the percentages of disturbance indicators increase. During the Late Bronze Age there are minor oscillations in the pollen curves, with those of _Calluna_, _Pteridium_ and _Plantago_ rising as arboreal and shrub pollen decline. However, woodland clearance appears to have continued throughout the Late Bronze Age.

Calluna pollen percentages rise to high values c. 3213 BP or just after the beginning of the Late Bronze Age. At Simon Fell II, _Calluna_ had been abundant on the bog surface since before the Early Bronze Age; however the _Plantago lanceolata_ and _Pteridium_ percentage curves do resemble those of Arks I in that they form a single peak late in the sequence.

At Simon Fell I the marked clearance of the Early Bronze Age declines slightly at c. 3140 BP, before increasing again, together with the _Calluna_ and cereal curves c. 2994 BP. However, at this point tree pollen percentages also increase. This could well be due to a large extent to the sharp fall in Gramineae and _Potentilla_ percentages for which the rise in _Calluna_ pollen percentages does not completely compensate. The influx diagrams show an overall decline in arboreal and shrub pollen. The slight peak of arboreal and shrub pollen influx in zone SFI 5 still has lower values than in the previous zone (SFI 4).

The Sunset Hole pollen diagram also shows a decline in the _Plantago lanceolata_ and _Pteridium_ pollen and spore curves at the beginning of the Late Bronze Age c. 3234. This corresponds with a brief rise in the _Betula_ and _Corylus_ percentage curves. Around 2970 BP - 2882 BP, _Plantago lanceolata_ and _Pteridium_ grains become more abundant as arboreal pollen declines again, indicating intensified clearance activity, although no cereal grains were found. Calluna was well established at Sunset Hole from the elm decline onwards, but there is a sharp increase in Calluna pollen percentages at the end of the Late Bronze Age.

According to the archaeological evidence, particularly from cave debris, the Late Neolithic occupation of the massif was continuous with that of the Early Bronze Age (section 10.4.) or the Beaker Culture. However, in the pollen diagrams there is evidence at some sites for a temporary reduction in interference by man with the vegetation before renewed and widespread clearance in the Early Bronze Age. As in the case of the Neolithic clearance phase, activity appears to have been concentrated on the limestone plateau and the summit of Simon Fell. The Simon Fell I diagram is the only one which suggests a clearance phase extending across the Late Neolithic/Early Bronze Age boundary. Both cultures made use of the limestone caves for occupation, while hut remains assigned to the Bronze Age have been found on the plateaux in the Craven Area. According to the pollen evidence, woodland clearance during this period was widespread, at least on the limestone soils. This suggests that the scarcity of Bronze Age finds on the massif may be due to their poor preservation or simply indicate that these communities did not produce many durable artefacts.

2450 Around the beginning of the Late Bronze Age (c. 3950 - 3650 BP) at the sites previously showing few signs of woodland clearance, Arks I and Simon Fell II, the percentages of Plantago lanceolata and Pteridium grains increase as the final disappearance of trees begins. At Sunset Hole and Simon Fell I, the sites nearer to the limestone, a trough in the curves of the above taxa indicate a brief reduction in clearance activities before their final intensification later in the Late Bronze Age (between c. 3350 BP and 2450 BP). These differences may reflect a shift in the centres of population on the massif or else perhaps a decline in the population, perhaps followed by an influx of new colonisers from the Vale of York (section 10.4).

During the Bronze Age as a whole, Calluna spread over large areas of the massif's surface, often associated with increased numbers of Sphagnum spores. This may well indicate relatively dry but increasingly acid bog surfaces. The process of soil degradation that had continued throughout the millennia was no doubt accelerated by man's interference with the vegetation. The shift from a Rumex acetosella/acetosa and Gramineae-dominated Neolithic clearance phase to later phases dominated by Plantago lanceolata and Pteridium could well reflect the lowered pH of the soils rather than a major change in type of land-use practised by man.

With the opening of chronozone ING VI or the beginning of the Early Bronze Age, the first major clearance phase begins at Eshton Tarn (3600 $\pm$ 100 BP). As with the Early Bronze Age clearance on Ingleborough, the main indicator taxa are Plantago lanceolata, Pteridium, and to a much lesser extent, Rumex acetosa/acetosella type. However, Plantago lanceolata pollen levels are far higher in comparison with those of the other indicator species in the Eshton Tarn diagram compared with those of the Ingleborough diagrams. Arboreal pollen percentages are around 30-40% TLP throughout the Early Bronze Age but c. 3120 $\pm$ 90 BP there is a sharp rise in cereal pollen coinciding with a fall in arboreal pollen percentages. This suggests an intensification of arable farming close to the Eshton Tarn site.

At White Moss, small numbers of clearance indicators are present but must represent either small-scale or long-distance clearance throughout the Bronze Age as arboreal pollen percentages are not affected.

11.3.7. Chronozone ING VII (c. 2500 - 1550)

(pollen diagrams SH, AI, SFI, SFII)

All four pollen diagrams indicate that the Iron Age Period began with the massif covered by extensive areas of blanket bog and heath. Arboreal and shrub pollen percentages generally decline throughout this period and indicators of soil disturbance are frequent, suggesting that clearance was still taking place. However, it is still not clear as to what extent climatic deterioration was influencing the tree decline. All sites show very high values of *Calluna* pollen, perhaps indicating a drier bog surface. Arboreal and non-arboreal pollen percentages lie between 5-25% and 70-90% respectively, again indicating an open countryside.

Some differences can be detected between the sites in this period. At Simon Fell I, the apparent forest regeneration phase, already underway in the Late Bronze Age, continued until c. 2310 BP, ending with a sharp rise in the *Plantago lanceolata* curve.

At Arks I, an unusually wide variety of herbaceous taxa is represented in the pollen diagram. The source of this pollen may have been the scree slopes of The Arks. Here, a mosaic of calcicole and calcifuge communities can be found today, where bands of sandstone and limestone of the Yordale series (section 1.1.) are exposed and where springs arise at several places.

Around 2100 - 2000 BP, in the Arks I diagram (8-12cm in depth) there is a peak in the *Plantago lanceolata* and *Pteridium* curves, coinciding with a small peak in *Cannabis* type pollen. A similar pattern can be seen in the Simon Fell II diagram. Although most records of *Cannabis* pollen in the literature belong to Anglo-Saxon times or later (Godwin, 1975), evidence from Skelsmergh Tarn (Walker, 1955), indicates possible Romano-British cultivation.

Cannabis was mentioned by several Roman writers, the earliest being Lucilius, about 100 BC (Godwin, 1967). Although the dating of levels within this zone depends on estimates based on the previous zone's peat growth rate, it seems possible that some Cannabis was cultivated in the Ingleborough area during the Iron Age/Romano-British Period.

The numerous ancient settlement sites to be found on the plateau together with the hillfort containing 19 hut circles attests to the massif's being well-populated in the Iron Age. Indeed, from the remnants of settlements and field systems on other parts of the limestone shelf, it appears that Iron Age man preferred the soils of the Carboniferous Limestone throughout the Craven district (section 10.5).

From the pollen evidence (particularly the presence of pollen and spore curves for Plantago lanceolata and Pteridium at all four sites), large areas of the massif were grazed by livestock at this time. This is supported by the archaeological evidence as steep-sided droveways can still be seen, leading up from the settlements on to the fell sides. Similarly the records of cereal grains from the peat of this period indicate that at least some of the fields described by King (1969) were sown with crops (section 10.5).

There is no evidence for a break or marked change in agricultural activity between the Bronze and Iron Ages, which suggests a continuity between the two.

At Arks I and Sunset Hole the peat record appears to have been truncated before the end of the Iron Age. Assuming there to be no modern peat lying unconformably upon the ancient peat, the surface would have a date of 1814 BP (130 ad) at Arks I and 1826 BP (125 ad) at Sunset Hole.

At Simon Fell I the estimated date for the surface is 1395 BP (555 ad), belonging to the beginning of the Dark Ages (c. 1550-884 BP). In the last two levels sampled of the peat profile, the percentages of tree pollen increase, suggesting that the amount of agricultural activity was reduced. The archaeological record of this period (section 10.6) suggests that Anglian settlers moving into the Craven Area settled mainly in the valleys. If this were the case, one would expect that a certain amount of tree recovery would have taken place on the limestone plateau.

During the Iron Age to Romano-British Period at White Moss and Eshton Tarn, there appears to have been little change in farming practices. At Eshton Tarn, clearance of woodland and intensive pastoral and arable farming were practised. At White Moss however, the landscape was still well-wooded with only slight signs of interference by man. This may indicate that in the west of the Craven Area, during the Iron Age, man preferred to occupy the limestone plateau. In the east the lowlands were better utilised.

At Tarn Moss (Pigott & Pigott, 1963), although there are no radiocarbon dates for this diagram, it seems that a sharp intensification of agricultural activity, both arable and pastoral, occurred at the beginning of the Iron Age. Plantago lanceolata is again the most common clearance indicator, although Rumex pollen and Pteridium spores are also present.

Clearly, within the Craven district, there is a great deal of variation in the times and extent of occupation by man of different areas.

11.3.8. Chronozone ING VIII (c. 890 - 0 BP)
(pollen diagrams ASB, BWH)

The peat belonging to this chronozone appears to represent a resumption of peat growth after a hiatus. At Allotment Shooting Box, regrowth began (ASB5) around 890 ± 60 BP (c. 1060 ad) at the beginning of the Norman Period , and seems to have continued growing to the present (section 7.3). During this period, arboreal and shrub pollen percentages are very low (about 5-10% TLP). The non-arboreal pollen component consists largely of *Calluna*, Gramineae, Cyperaceae and ruderal grains whilst influx and concentration values are very small for all pollen types.

In the Braithwaite Wife Hole diagram, the last zone (BWH4) is similar to that of the Allotment Shooting Box diagram, although arboreal and shrub pollen do not fall to such low numbers and Gramineae rather than *Calluna* is the most abundant pollen type. At both sites a change in the stratigraphy coincides with changes in the pollen curves. Generally an *Eriophorum*-wood peat (heavily humified in the case of Allotment Shooting Box) gives way to a lightly humified *Eriophorum*-*Sphagnum* peat.

After 890 ± 60 BP wet, acid *Eriophorum* bog grew on top of the old, previously-eroded peat surface, perhaps indicating a period of wetter climate. At Allotment Shooting Box, *Calluna* was common while at Braithwaite Wife Hole, species of Gramineae were more abundant. During the Norman Period and after, the landscape appears to have been virtually tree-less, much as it is today. Occasional trees may have survived on the limestone pavements or in other inaccessible places. The intensive system of sheep farming favoured by the monasteries no doubt served to keep the landscape open.

In all the Ingleborough pollen diagrams the arboreal and shrub pollen curves increase at the surface. This is probably due to the presence of recent plantations on the plateau and the planting of trees around the farmhouses of the area. Similar trends have been recorded by other authors (e.g. Jones, 1977; Pigott & Pigott, 1963).

At the same time as the tree pollen increases, most of the Ingleborough diagrams show increased Gramineae percentages while those of Calluna decline. Similar changes occur in the diagrams from Scar Close, Moughton Fell and Howrake Rocks, and appear to represent the replacement of heather by grasses on the bog surface. At Sunset Hole and Arks II the surface peat was also found to contain large amounts of "soot" or fine particles of charcoal. Similar observations have been made by Chambers (1983) from upland peats, north-west of Merthyr Tydfil. Radiocarbon analyses of peat from within a few centimetres of the bog surface have produced dates much older than samples immediately below them (Chambers et al., 1979). Further investigation showed that significant quantities of carbon from the combustion of fossil fuel have been raining down on to the surface vegetation, and so increased the ratio of ^{12}C to ^{14}C isotopes. The recent degeneration of heather moorland may be due to changes in land management since the Industrial Revolution started, or else directly to atmospheric pollution.

11.4. The influence of man on the vegetation of the Ingleborough Massif in its regional context

Comparisons between pollen diagrams from other areas and the Ingleborough diagrams are made difficult for two main reasons. Firstly, radiocarbon-dated diagrams or at least diagrams with sufficient post-elm decline dates are rare. Since the effect and extent of human interference varies so much from one side to another, without dates it is almost impossible to correlate horizons with any degree of certainty. There is always the risk that a hiatus in peat growth and subsequent erosion, perhaps with later regrowth, has occurred.

The second problem is the pollen sum used during the calculation of pollen percentages. All the Ingleborough diagrams have been constructed using total land pollen (TLP) as the pollen sum. Most other authors, particularly in early studies, have used total arboreal pollen, with or without Alnus pollen, or Corylus or other abundant pollen producers. When total arboreal pollen is used as the sum, herb pollen percentages tend to be higher than those obtained by using total land pollen. This effect is most obvious in the Late Glacial and post-elm decline periods, as tree pollen tends to be relatively scarce, therefore more gains must be counted to achieve the required number of arboreal grains.

Bearing the above in mind, the influence of man on the vegetation of the Ingleborough Massif will be compared in turn with different areas of Northern Britain.

11.4.1. Uplands south of Ingleborough

In the area of the South Pennines the first evidence of a major clearance phase appears to belong to the Iron Age or Romano-British Period (Hicks, 1971; Conway, 1954; Tallis & Switsur, 1973; Bartley, 1975; Birks, 1965).

In North Derbyshire, Hicks (1971) found evidence for only small-scale clearance during the Neolithic Period, similar to that found at Arks I and Sunset Hole on Ingleborough. The first appearance of cereal pollen occurs during a short period of activity c. 3740 $\pm$ 100 BP in the Early Bronze Age at Leash Fen. On Ingleborough, cereal grains were noted at Sulber Pot and Braithwaite Wife Hole for the Neolithic Period beginning before 4560 $\pm$ 50 BP.

Conway (1954) studied Southern Pennine blanket peats (e.g. Kinder, Bleaklow, Ringinglow) and found no evidence for Neolithic man occupying the uplands. Only minor records of indicator species were made for the Bronze Age.

At both Featherbed Moss (Tallis & Switsur, 1973) and Rishworth Moor (Bartley, 1975) small peaks of clearance indicators occur from the elm-decline onwards. This shows a continuous but low-key occupation of these areas until the Iron Age.

11.4.2. North York Moors

According to Jones et al. (1979) and Simmons and Cundill (1974) the major clearance phases on the moors belong to the Bronze Age and then the Iron Age/Romano-British Period, and again to the Medieval Period.

11.4.3. Uplands north of Ingleborough

To the north, at Moor House, Teesdale (Chambers, 1978) after an initial phase of Bronze Age deforestation, a prolonged and pronounced Iron Age clearance occurred. In south and east Durham (Bartley et al., 1976) short-term and small-scale Neolithic clearances occurred and carried on into the Bronze Age. However, at Bishops Middleham, a massive Bronze Age clearance took place. Widespread clearance did not occur till later. At Thorpe Bulmer there is evidence for extensive cultivation of hemp and some cereals from 2064 BP, rising to a maximum in the Roman Period. This lends further credence to the records of *Cannabis*-type pollen dated to c. 2094 - 2000 BP at Arks I, here suggesting a small-scale cultivation of hemp on or near Ingleborough.

11.4.4. Uplands of the west and north-west

To the west of the Craven District, sites have been studied by Oldfield (1960, 1967) and Smith (1959) in Lowland Lonsdale. Although interpretation is hindered by a lack of radiocarbon dates, it seems that after small-scale disturbance of the vegetation in Neolithic times and slightly larger ones during the Bronze Age, the first major clearance phase at these sites occurred in the Iron Age.

Further north and west, in the Lake District, Pennington (1975) describes diagrams from many sites. Small forest clearings appear to have taken place before the elm decline at Blea Tarn c. 5650 - 5050 BP. Such clearances were noted by Walker (1966) at Ehrenside Tarn and also in the Allotment Shooting Box and Sunset Hole sites on Ingleborough. After the elm-decline at Blea Tarn the Neolithic clearance phase lasted c. 500 years; a similar duration to those noted for the Ingleborough diagrams (section 11.3.5).

Pennington (1975) sees evidence for widespread destruction of forest in the uplands and coastal plain during the Neolithic Period in the Lake District. This clearance brought about permanent changes in the vegetation and soils. Similarly, on Ingleborough, the Neolithic clearances may well have hastened the depauperisation of the soils due to leaching and facilitated the rapid spread of _Eriophorum_-_Calluna_ bog or heath. The unusual quantities of _Rumex acetosa_/_acetosella_ type pollen recorded for the long-term Neolithic clearance phase may well be due to the close proximity of the limestone.

11.4.5. Summary

The Ingleborough diagrams tend to reflect the same sequence of events as those of the north-west. The evidence as a whole suggests that during the Neolithic and Bronze Age, human populations tended to be concentrated in areas where resources were particularly good (e.g. Great Langdale axe sites). This leads to finding occasional areas where extensive clearance has occurred, while the majority of sites show only small-scale interference. In the Iron Age, most pollen diagrams in the Northern Region show extensive clearance and crop-growing, suggesting a bigger, widespread human population. None of the studies consulted for this work showed similar pollen spectra in the Neolithic Period to those of Ingleborough, with high percentages of *Rumex* and Gramineae pollen. This may well be due to the unusually close proximity of the limestone to pollen-preserving deposits.

11.5. Peat deposits on the limestone pavements of Ingleborough

On many areas of limestone pavement today, peat can be seen, either on a thin layer of drift or even in direct contact with the limestone. Gosden (1965, 1968) investigated this phenomenon by means of pollen analysis in order to shed some light on its developmental history.

Scar Close is an area of limestone pavement on the shelf of the Carboniferous limestone, to the north-north-east of Braithwaite Wife Hole. The pavement has well-developed clints and grykes, while here and there, peat "islands" with a vegetation dominated by *Calluna* and *Vaccinium* rest on its surface, often across grykes. Towards the rising hillside, the drift-covered limestone bears a wetter acid bog dominated by *Eriophorum* spp. A few trees of *Acer pseudoplatanus* and *Fraxinus excelsior* with bushes of *Corylus avellana* are growing in the grykes.

On studying the stratigraphy at Scar Close, the peat was found to consist of Calluna, Eriophorum, Sphagnum, Carex and Molinia remains. The layering was indistinct; however, Eriophorum and Sphagnum appear to have increased in more recent times. The relatively high values for Alnus pollen, particularly in the basal clay, and low values for Ulmus, the presence of an occasional grain of Fagus and up to 120% TAP of Plantago lanceolata pollen, all suggest that the Scar Close peat is very recent in origin (Gosden, 1968).

One would expect that the Braithwaite Wife Hole and Sulber Pot diagrams would compare well with those of Scar Close. Both these sites lie close to the limestone. Braithwaite Wife Hole lies only 1.5km south-south-west of Scar Close and lies in a similar position to the drift peats (profiles A1 and B1) studied by Gosden. However, both Braithwaite Wife Hole and Sulber Pot appear to be a lot older. The deepest of Gosden's profiles appears to start just before a sharp rise in Calluna pollen. This rise is close to the top of the profile at the Braithwaite Wife Hole and Sulber Pot sites and peat appears to be missing at the top. At Scar Close, Moughton Fell and Howrake Rocks only acid moorland peat is present, although Alnus pollen is concentrated in the basal clay. At Braithwaite Wife Hole alder wood fragments are present in the peat until the old erosion surface is reached (12cm depth), although acidification was underway, indicated by increasing amounts of Eriophorum remains. From this it seems that the Braithwaite Wife Hole and Sulber Pot peats began to accumulate almost 1000 years before those studied by Gosden on the limestone.

Calluna remains were not found in the uppermost layers of the old peat at Braithwaite Wife Hole and yet pollen percentages of this plant rise, suggesting the spread of communities elsewhere, perhaps reflecting the vegetation on the hillslopes and plateau around Scar Close. If so, the Scar Close diagrams take over where the Braithwaite

Wife Hole and Sulber Pot diagrams stop. If this is the case, a date of c. 3683 BP can be suggested for the peat initiation at the deepest Scar Close profiles.

The difference in age is probably due to the fact that at Braithwaite Wife Hole and Sulber Pot peat accumulated in shallow basins beside the limestone pavement and the current peat surface lies below the level of the clint surfaces. At Scar Close the deeper peat profiles developed on glacial drift, level with or raised slightly above the present bare limestone surface.

During the period of maximum climatic deterioration (Sub-Atlantic Period or chronozone ING VI) podsolisation occurred over the glacial drift at Scar Close, impeding drainage and allowing the growth of peat. Gosden suggests that an open alder woodland with hazel bushes and many ferns changed to mixed moorland with heather grasses and some sedge.

By the period of peat formation the development of the gryke system would have been well advanced. Gosden describes two possible mechanisms to explain the present arrangement of peat islands on the limestone:

1. A shallow layer of drift covered the limestone surface, allowing the build-up of peat. The drift was steadily washed down the widening grykes, leaving peat in contact with the limestone. The raised pH and improved drainage would have promoted decay of the peat from the bottom upwards, as seen from the pollen diagrams. Acids from the peat would have in turn speeded up the dissolution of the limestone.

2. The drift cover was lost early and peat was produced directly on the limestone during a

> period of very high humidity, from local centres or by creeping out from the hillside edge of the drift where the peat is now situated.

Gosden concluded that without further evidence it was not possible to decide which of the two mechanisms had operated.

11.6. The erosion of peat on the massif

Erosion of the peat on Ingleborough takes a wide variety of forms. On the summit of Ingleborough Hill, no peat is visible and much of its surface consists of bare rock. It is not known to what extent, if at all, the rock was covered in the past. On the upper slopes of Simon and Park Fell, the peat blanket (about 2m deep) is deeply dissected by erosion channels, cutting down to bedrock, as seen at many other high plateau sites. Below this, in the Arks basin, peat accumulated forming what looks like a raised bog structure. Here the centre of the bog has been lost, possibly through a bog-burst or gill-brack (section 5.3.) after c. 1800 BP (the approximate date of the surface peat at Arks I). Deep channels are cut into the peat downhill from here. On the lower slopes at Sunset Hole, erosion is taking place in a network of less-developed channels. On the lower slopes near the limestone, the peat growth at Braithwaite Wife Hole, Sulber Pot and Allotment Shooting Box either stopped earlier (since there is a 2000 year difference in surface dates) or else more peat is missing. This could be due to peat-cutting for domestic use by man. Later, c. 890 BP, peat growth recommenced on these lowest peats, indicating increased precipitation at this time. Areas of the limestone grass-land on Ingleborough bear small decaying islands of peat in amongst swards of calcicole species, matching the peat islands described above, now found lying on bare limestone of exposed pavement.

From this evidence it appears that great quantities of peat have already been lost from the massif, probably within the last millennium.

APPENDIX 1

Radiocarbon dated levels

SITE	DEPTH (cm)	DATE (BP)	LAB. NUMBER
BWH	80	4560 ± 50	SRR - 2543
"	46	3840 ± 50	SRR - 2542
"	32	3720 ± 50	SRR - 2541
SH	367 - 368	9400 ± 100	SRR - 2594
"	332 - 333	7450 ± 80	SRR - 2593
"	297 - 298	6410 ± 80	SRR - 2592
"	190 - 191	5520 ± 90	SRR - 2591
"	91 - 92	3850 ± 80	SRR - 2590
"	52	2970 ± 60	SRR - 2589
AI	164	6400 ± 70	SRR - 2547
"	146	5030 ± 50	SRR - 2546
"	92	3960 ± 50	SRR - 2545
"	68	3400 ± 50	SRR - 2544
AII	67 - 70	9240 ± 90	SRR - 2597
AIIm	68	8730 ± 80	SRR - 2596
AIIm	52	5830 ± 50	SRR - 2595
SFI	164	4720 ± 50	SRR - 2551
"	108	3810 ± 50	SRR - 2550
"	60	2920 ± 50	SRR - 2549
"	36	2310 ± 50	SRR - 2548
ASB	104	5740 ± 60	SRR - 2612
"	80	5160 ± 60	SRR - 2611
"	62	4440 ± 60	SRR - 2610
"	46	3650 ± 60	SRR - 2609
"	34	890 ± 60	SRR - 2608

Radiocarbon dates obtained by Dr. D. D. Bartley and Dr. I. Jones for sites in the Craven District (personal communication):

SITE	DATE (BP)	LAB. NUMBER
Eshton Tarn	5010 ± 110	Birm 663
	3600 ± 100	Birm 662
Eshton Tarn 'M'	3120 ± 90	SRR - 2481
White Moss	5080 ± 100	Birm 665
	1470 ± 100	Birm 666
Threshfield Moor	9430 ± 100	SRR - 2480
Martons Both	7680 ± 100	
	6930 ± 90	

APPENDIX 2

Estimated time scales

Braithwaite Wife Hole

DEPTH (cm)	DATE (BP)
0	3425
4	3462
8	3499
12	3535
16	3572
20	3609
24	3646
28	3683
32	3720
36	3748
40	3785
44	3822
46	3840
48	3902
56	4066
64	4231
72	4395

Sunset Hole

0	1826
8	2002
16	2178
24	2354
32	2530
40	2706
48	2882
52	2970
56	3058
64	3234
72	3410
80	3674
88	3762
92	3850
96	3917
104	4052
112	4187
120	4322
128	4457
136	4592
144	4727
150	4828
156	4930
164	5065
172	5200
180	5334
188	5469
191	5520
192	5528

Sunset Hole cont.

DEPTH (cm)	DATE (BP)
196	5561
204	5628
208	5661
216	5728
224	5794
232	5861
240	5927
248	5994
256	6061
264	6127
272	6194
280	6260
288	6327
296	6393
298	6410
300	6499
304	6618
312	6856
320	7094
328	7331
332	7450
336	7617
344	8063
352	8509
360	8954
368	9400

Arks I

0	1814
4	1907
8	2000
12	2094
16	2187
20	2280
24	2374
28	2467
32	2560
37	2677
40	2747
44	2840
48	2933
52	3027
56	3120
60	3213
64	3307
68	3400
72	3493
80	3680

Arks I cont.

DEPTH (cm)	DATE (BP)
88	3867
92	3960
96	4039
104	4198
112	4356
120	4515
128	4673
136	4792
144	4990
146	5030
148	5182
152	5487
156	5791
160	6096
164	6400
168	6704
172	7009
175	7237

Simon Fell

0	1395
8	1598
16	1802
24	2005
32	2208
36	2310
40	2412
44	2513
48	2615
52	2717
56	2818
60	2920
64	2994
68	3068
72	3143
80	3291
88	3439
96	3588
104	3736
108	3810
112	3875
120	4005
128	4135
136	4265
144	4395
148	4460
152	4525
156	4590
160	4655
164	4720
168	4784
176	4915

Allotment Shooting Box

DEPTH (cm)	DATE (BP)
0	0
8	209
16	419
24	628
32	838
34	890
36	3156
40	3354
44	3551
46	3650
48	3749
52	3946
56	4144
60	4341
62	4440
64	4520
68	4680
72	4840
76	5000
80	5160
84	5257
88	5353
96	5547
100	5643
104	5740.

APPENDIX 3

Arks III core (AIIIc)

Depth (cm)	Description
0 - 8	Living and decaying *Sphagnum* remains
8 - 32	Very dark, brown-black, heavily humified peat with traces of *Sphagnum*, *Calluna vulgaris*, *Eriophorum vaginatum* and woody fragments
32 - 58	Very heavily humified peat as above but with more wood fragments. Larger fragments at 43 - 45cm together with birch bark
58 - 75	Lighter, reddish-brown, lightly humified, mixed monocot peat, composed of *E. vaginatum*, *Juncus* sp, *Carex rostrata* remains with *Empetrum nigrum* and *Potentilla palustris* seeds. *Sphagnum* sp and *Polytrichum* sp leaf remains are present at some levels. Many *Empetrum nigrum* shoots and seeds found at 68cm
91 -	Solid base - basal 16cm of peat lost due to the point of the "Russian" borer.

Arks IV core (AIVc)

Depth (cm)	Description
0 - 10	Living *Sphagnum* sp plants
10 - 14	Decaying *Sphagnum* sp and *Eriophorum vaginatum* remains

14 - 21	Very heavily humified, dark, black-brown peat, containing <u>Calluna</u> and monocot remains including <u>E. vaginatum</u>. Contaminated by modern roots
21 - 44	Lighter, reddish-brown, mixed monocot peat, light to moderately humified, with <u>E. vaginatum</u> and <u>E. angustifolium</u> leaf remains, woody fragments and <u>Empetrum nigrum</u> seeds. Grades into a similar peat but with <u>Carex</u> sp fruit, and <u>Juncus</u> sp, <u>Potentilla palustris</u>, <u>Viola palustris</u>, <u>Montia fontana</u> and <u>Lychnis flos-cuculi</u> seeds
61	Solid base.

<u>Arks V core</u> (AVc)

<u>Depth</u> (cm)	<u>Description</u>
0 - 10	A mixed peat of <u>Sphagnum</u> sp., <u>Eriophorum vaginatum</u> and modern roots with older, decayed, woody flakes
10 - 14	Very dark, heavily humified, brown-black fibrous peat containing decayed <u>E. vaginatum</u> and <u>Calluna</u> remains with a few wood fragments
14 - 16	As above with sand grains, <u>Carex rostrata</u> fruit and very decayed wood remains
16 - 16.5	Band of coarse sand
16.5 - 19	As for 14 - 16cm
19 - 40	Lighter, reddish-brown, mixed monocot peat, light to moderately humified with <u>E. vaginatum</u>, <u>Carex rostrata</u> and <u>Carex</u> sp remains. <u>Potentilla</u>

	palustris and Menyanthes trifoliata seeds with occasional decayed wood fragments
40 - 42	Polytrichum sp band
42 - 50	Similar to 19 - 40cm with dicotyledenous leaf remains (cf. birch) and occasional twigs and birch bark
66 -	Solid base.

Arks VI core (AVIc)

Depth (cm)	Description
0 - 8	Modern roots and Sphagnum sp grading into a heavily humified, sandy peat with Eriophorum vaginatum remains, Empetrum nigrum seeds and Potentilla erecta achenes
8 - 10	As above without contamination with modern remains
10 - 16	Very heavily humified peat, as above, with a much higher sand content. Calluna flower and Phragmites flakes at 16cm together with bud scales and woody fragments
16 - 22	Very dark, black-brown, moderately humified E. vaginatum/E. angustifolium peat with frequent Sphagnum sp. and Polytrichum sp leaves
22 - 50	Lighter, reddish-brown, light to moderately humified monocot peat, mainly of E. vaginatum remains with Sphagnum sp leaves and woody twigs. Becoming moderately humified towards 50cm

66 -	Solid base.

Arks VII core (AVIIc)

Depth (cm)	Description
0 - 8	Modern roots
8 - 16	Lighter brown, Eriophorum vaginatum peat with modern roots
16 - 41	Dark, black-brown, very highly humified E. vaginatum-Calluna peat with occasional moss leaves
41 - 55	Relatively unhumified, E. vaginatum-moss-Calluna peat with Empetrum nigrum seeds
55 - 73	Very heavily humified, dark cheesy peat containing Calluna remains with E. vaginatum leaf fragments and Empetrum nigrum seeds
89 -	Base, probably clay.

Arks VIII core (AVIIIc)

Depth (cm)	Description
0 - 8	Dark, fibrous, modern roots
8 - 20	Medium to heavily humified Eriophorum vaginatum/E. angustifolium-monocot peat with moss leaves
20 - 28	Reddish, unhumified Sphagnum peat with Calluna and monocot remains and one stalk of Empetrum nigrum
28 -160	Very heavily humified, reddish-brown, monocot peat with E. vaginatum remains, traces of Calluna and

	increasing quantities of charcoal. Several small, dark, more humified bands throughout
160 - 175	Grades from the previous peat type to a more humified wood-monocot peat with flakes of birch bark
191 -	Solid base.

APPENDIX 4

Symbols used in the pollen diagrams and fig. 5.2.

Arboreal and shrub pollen:

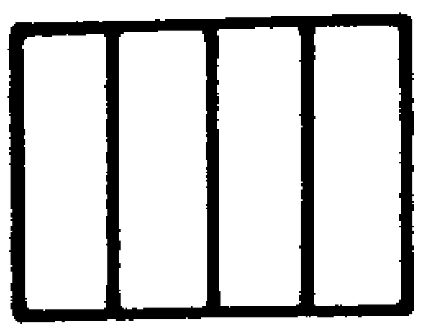
Fagus	F
Carpinus	C
Hedera	H
Ilex	I

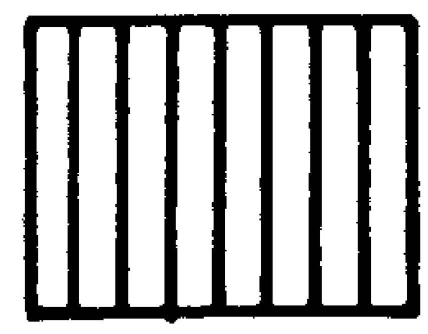
Non-arboreal pollen:

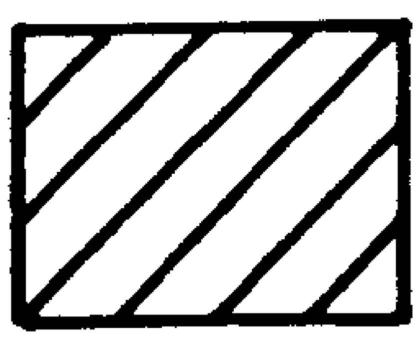
Artemisia	A
Anchusa	An
Aster	As
Chenopodiaceae	C
Caltha tp	Ca
Callitriche	Cc
Centaurea tp	Ce
Cirsium tp	Ci
Cannabis tp	Cn
Cruciferae	Cr
Caryophyllaceae	Cy
Drosera rotundifolia	Dr
Empetrum	Em
Epilobium	Ep
Ericales	Er
Gentianella	G
Helianthemum	H
Hypericum	Hp
Jasione	J
Compositae liguliflorae	l
Leguminosae	L
Lathyrus tp	La
Labiatae	Lb
Linum catharticum	Lc
Ligustrum	Lg
Liliaceae	Li
Linnaea	Ln
Lonicera	Lo
Lythrum salicaria	Ls
Lotus tp	Lt
Lysimachia tp	Ly
Mercurialis tp	M
Melampyrum	Mp
Mentha tp	Mt
Menyanthes	My
Narthecium	N
Ononis tp	O
Papaver tp	P
Poterium tp	Pe
Polygonum tp	Pg
Plantago major/media tp	Pm
Polemonium caeruleum	Po
Primula tp	Pr
Potamogeton tp	Pt
Prunella tp	Pu
Rumex sp	R
Rubus chamaemorus	Rc
Rhinanthus tp	Rh
Sambucus tp	Sa
Succisa	Sc
Sedum tp	Sd
Serratula tp	Se
Scrophularia tp	Sh
Sinapis tp	Si
Stellaria tp	St
Saxifragaceae	Sx
Trollius tp	T
Typha angustifolia	Ta
Teucrium scorodonia	Te
Thallictrum	Th
Sparganium/Typha tp	Ty
Valeriana	V
Viburnum tp	Vb
Vicia tp	Vc.

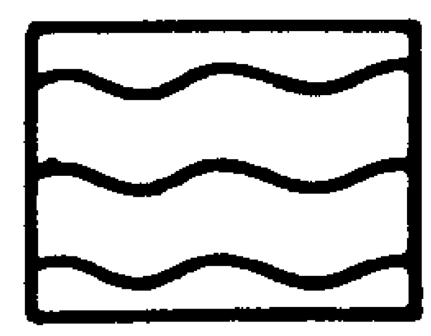
Compositae tubuliflorae	t

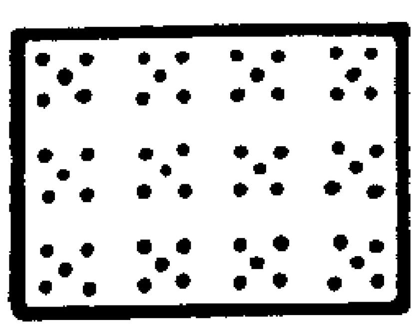
Key to stratigraphic symbols used in the diagrams.

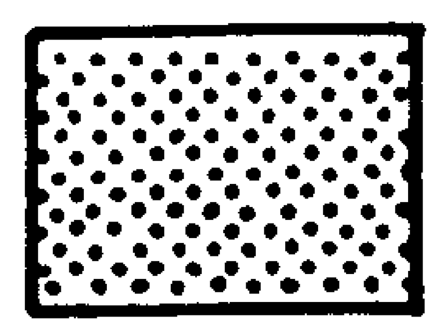
 monocot peat

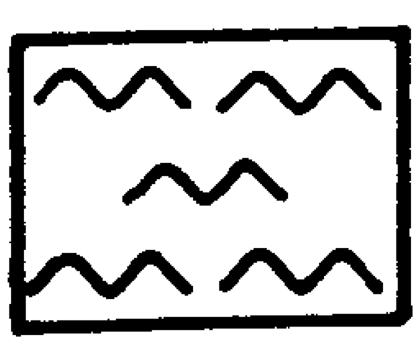
 Phragmites

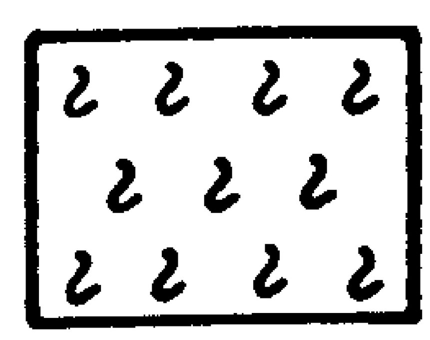
 disturbed peat

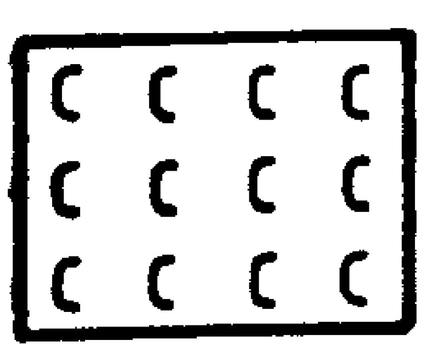
 Shagnum

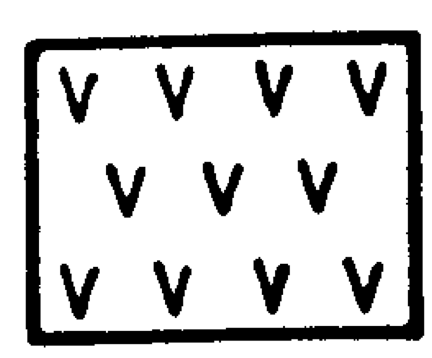
 clay/mineral

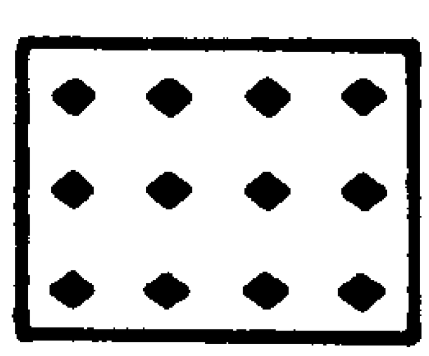
 sand

 Eriophorum

 moss

 Calluna

 wood

 Betula/Alnus fruit

REFERENCES

Anderson G J (1976), "The pollination biology of Tilia" J Botany, 63 1203-1212

Bartley D D (1975), "Pollen analytical evidence for prehistoric forest clearance in the upland area west of Rishworth, W.Yorkshire", New Phytol, 74 375-381

Bartley D D, Chambers C, Hart-Jones B (1976), "The vegetational history of parts of South and East Durham", New Phytol, 77 437-468

Bartley D D, Clark S C (1979), "A vegetation survey of the Ingleborough S.S.S.I.", University of Leeds Industrial Services Ltd, Leeds

Bennet W (1936), "Giants' Graves, Penygent", Yorks Archaeol J, 33 318-319

Bennet W (1938), "Iron Age settlements in Penigent Gill", Yorks Archaeol J, 34 413-419

Bennett K D (1985), "Devensian late-glacial and Flandrian vegetational history at Hockham Mere, Norfolk, England", New Phytol, 95 457-504

Birks H J B (1965), "Pollen analytical investigations at Holcroft Moss, Lancashire and Lindow Moss, Cheshire", J Ecol, 53 299-314

Birks H J B, Birks H H (1980), "Quaternary Palaeoecology", Edward Arnold, London

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

Brown A P (1977), "Late-Devensian and Flandrian history of Bodmin Moor, Cornwall", Phil Trans Roy Soc Lond B, 276 251-320

Bullock P (1971), "The soils of the Malham Tarn area", Field Studies, 3 381-408

Chambers C (1978), "A radiocarbon-dated pollen diagram from Valley bog, on the Moor House National Nature Reserve", New Phytol, 80 273-280

Chambers F M (1982), "Two radiocarbon-dated pollen diagrams from high-altitude blanket peats in South Wales", J Ecol, 70 445-459

Chambers F M (1983), "Three radiocarbon-dated pollen diagrams from upland peats North-west of Merthyr Tydfil, South Wales", J Ecol, 71 475-487

Chambers F M, Dresser P Q, Smith A G (1979), "Radiocarbon dating evidence on the impact of atmospheric pollution on upland peats", Nature (Lond), 282 829-831

Cheetham C A (1947), "Moughton Scar", The Naturalist, 1947 59-61

Clapham A R, Tutin T G, Warburg E F (1962), "Flora of the British Isles", 2nd Edition, Cambridge University Press

Clark J G D, Godwin H (1962), "The Neolithic in the Cambridgeshire Fens" Antiquity, 36 10-23

Clayton K M (1966), "The origin of the landforms of the Malham Area" Field Studies, 2 359-384

Conway V M (1954), "Stratigraphy and pollen analysis of Southern Pennine blanket peats" J Ecol, 42 117-147

Craig A J (1978), "Pollen percentage and influx analyses in south-east Ireland: a contribution to the ecological history of the late-glacial period" J Ecol, 66 297-324

Cundill P R (1979), "Contemporary pollen spectra on the North York Moors" J Biogeog, 6 127-131

Cunliffe B (1978), "Iron Age communities in Britain", revised Edition, Routledge & Kegan Paul, London

Dakyns J R, Tiddeman R H, Gunn W, Strahan A (1890), "The geology of the country around Ingleborough, with parts of Wensleydale and Wharfedale" Memoirs of the Geological Survey of London, 1890 87-96

Drew D P (1982), "Environmental archaeology and karstic terrains. The example of the Burren, Co. Clare, Ireland", British Archaeological Reports, Int Ser 146 115-127

Dunham K C, Hemingway J E, Versey H C (1953), "A guide to the geology of the district around Ingleborough", Proc Yorks Geol Soc 29 77-115

Erdtman G, Praglowski J, Nilsson S (1963), "An introduction to a Scandinavian pollen flora" vols I and II, Almqvist & Wiksell, Stockholm

Faegri K, Iversen J (1975), "Text book of pollen analysis" 3rd Edition, Munksgaard, Copenhagen

Gilks J A (1973), "The Neolithic and early Bronze Age pottery from Elbolton Cave, Wharfedale", Yorks Archaeol J, 45 41-54

Gilks J A (1981), "Ingleton, Ravenscar Cave, SD 730 757" in "Yorkshire Archaeological Register: 1981", Yorks Archaeol J, 54 171-172

Gilks J A, Lord T C (1985), "A late Neolithic crevice burial from Selside, Ribblesdale, North Yorkshire", Yorks Archaeol J, 57 1-5

Godwin H (1967), "The ancient cultivation of hemp", Antiquity, 41 42-49

Godwin H (1975), "The history of the British Flora", 2nd Edition, Cambridge University Press

Godwin H, Tallentire P A (1951), "Studies of the Post-glacial history of British vegetation XII Hockham Mere, Norfolk", J Ecol, 39 285-307

Godwin H, Walker D, Willis E H (1957), "Radiocarbon dating and post-glacial vegetational history: Scaleby Moss", Proc Roy Soc Lond B, 147 352-366

Gordon A D, Birks H J B (1972), "Numerical methods in Quaternary palaeoecology: I. Zonation of pollen data", New Phytol, 71 961-979

Gosden M S (1965), "An investigation into the origin and nature of some organic deposits of the Ingleborough region", PhD thesis, University of Leeds

Gosden M S (1968), "Peat deposits of Scar Close, Ingleborough Yorkshire", J Ecol, 56 345-354

Grieg J (1982), "Past and present lime woods of Europe", British Archaeological Reports, Int Ser 146 23-55

Grieve M (1976), "A modern herbal", Penguin Books, Harmondsworth

Hibbert F A, Switsur V R, West R G (1971), "Radiocarbon dating of Flandrian pollen zones at Red Moss, Lancashire", Proc Roy Soc Lond B, 177 161-176

Hicks S P (1971), "Pollen - analytical evidence for the effect of prehistoric agriculture on the vegetation of North Derbyshire", New Phytol, 70 647-667

Huntley B, Birks H J B (1983), "An atlas of past and present pollen maps for Europe: 0 - 13000 years ago", Cambridge University Press

Jacobi R M, Tallis J H, Mellars P A (1976), "The southern Pennine Mesolithic and the ecological record", J Archaeol Sci, 3 307-320

Jones I P (1977), "Studies in the Flandrian vegetational history of the Craven district of Yorkshire", PhD thesis, University of Leeds

Kelly M, Walsh J (1978), "Pollen analysis of soil beneath Apron full of Stones burial cairn, Kingsdale", Yorks Archaeol J, 50 30

King A (1970), "Early Pennine settlement", Dalesman, Clapham

King A (1978a), "Early agriculture in Craven, N.Yorkshire" in "Early land allotment in the British Isles", British Archaeological Reports, Int Ser, 48 pp 109-114

King A (1978b), "Gauber high pasture, Ribblehead - an interim report", in "Viking age York and the North", Council for British Archaeology Research Report No.27, Ed. Hall R A, CBA, London

King A (1978), "Apron full of Stones, a prehistoric cairn, Thornton in Lonsdale, North Yorkshire", Yorks Archaeol J, 50 25-30

Longworth I (1965), "Yorkshire", Cory, Adams & Mackay

Mackereth F J H (1966), "Some chemical observations on post-glacial lake sediments", Phil Trans Roy Soc Lond B, 250 165-213

Manley G (1957), "The climate at Malham Tarn", Annual Report of the Council for the Promotion of Flandrian Studies, 1957 43-56

Manley G (1959), "The late-glacial climate of N.W.England" Liverpool & Manchester Geol J, 2 188-215

Matthews J (1969), "The assessment of a method for the determination of absolute pollen frequencies", New Phytol, 68 161-166

McGrail S, O'Conner S (1979), "The Giggleswick Tarn logboat", Yorks Archaeol J, 51 41-49

McVean D N (1956), "Ecology of Alnus glutinosa (L.)Gaertn. VI. Post-glacial history", J Ecol, 44 331-333

Megaw J V S, Simpson D D A (Eds), (1981), "Introduction to British prehistory", Leicester University Press

Mellars P A (1976), "Fire, ecology, animal populations and man; a study of some ecological relationships in prehistory", Proc Prehist Soc, 42 15-46

Mitchell G F (1955), "A Mesolithic site at Toome Bay, Co. Londonderry", Ulster J Archaeol, 18 1-16

Moore P D (1984), "Hampstead Heath clue to historical decline of elms", Nature (Lond), 312 103

Moore P D, Chater E H (1969), "The changing vegetation of west-central Wales in the light of human activity", J Ecol, 57 361-379

Moore P D, Webb J A (1978), "An illustrated guide to pollen analysis", Hodder & Stoughton, London

Oldfield F (1960), "Studies in the post-glacial history of British vegetation: Lowland Lonsdale", New Phytol, 59 192-217

Oldfield F (1967), "The palaeoecology of an early Neolithic waterlogged site in northwestern England", Review of Palaeobotany & Palynology, 4 67-70

Ordnance Survey Antiquity Records, (series), Ordnance Survey, Southampton

O'Sullivan P E (1973), "Contemporary pollen studies in a native scots pine ecosystem", Oikos, 24 143-150

Pearson G W, Pilcher J R, Baillie M G L, Hillam J (1977), "Absolute radiocarbon dating using a low altitude European tree-ring calibration", Nature (London), 270 25-28

Pennington W (1964), "Pollen analysis from the deposits of six upland tarns in the Lake District", Phil Trans Roy Soc B, 248 205-244

Pennington W (1970), "Vegetation history of the N.W. of England: a regional synthesis", in "Studies in the vegetational history of the British Isles" Eds Walker D & West R G, Cambridge University Press

Pennington W (1973), "Absolute pollen frequencies in the sediments of lakes of different morphometry", in "Quaternary plant ecology" 14th Symposium of the British Ecological Society, pp 79-104, Eds Birks H J B, West R G , Blackwell, Oxford

Pennington W (1974), "The history of British vegetation", English Universities Press, London

Pennington W (1975), "The effect of Neolithic man on the environment in N.W.England: the use of pollen diagrams", in "The effect of man on the landscape: the highland zone" Council Brit Archaeol Res Rep 11, 74-85, Eds Evans J G, Limbrey S, Cleere H, CBA, London

Pennington W (1981), "Sediment composition in relation to the interpretation of pollen data", in "Proceedings of the IVth International Palynological Conference, Lucknow, 1976-77" 3 188-213

Pennington W, Lishman J P (1971), "Iodine in lake sediments in northern England and Scotland", Biol Rev, 46 279-313

Perry I, Moore P D (1987), "Dutch elm disease as an analogue of Neolithic elm decline", Nature (Lond), 326 72-73

Philips J (1853), "The rivers, mountains and sea coast of Yorkshire", John Murray, London

Pigott C D, Huntley J P (1980), "Factors controlling the distribution of Tilia cordata at the northern limits of its geographical range. II. History in North-west England", New Phytol, 84 145-164

Pigott C D, Pigott M E (1963), "Late-glacial deposits at Malham, Yorkshire", New Phytol, 62 317-334

Price M D, Moore P D (1984), "Pollen dispersion in the hills of Wales: a pollen shed hypothesis", Pollen et Spores, XXVI 127-136

Raistrick A (1931), "The glaciation of Wharfedale, Yorkshire", Proc Yorks Geol Soc, 22 9-30

Raistrick A (1936), "Prehistoric cultivation at Grassington, Yorkshire", Yorks Archaeol J, 33 166-174

Raistrick A (1938), "Iron-age settlements in W.Yorkshire", Yorks Archaeol J, 34 115-150

Raistrick A, Holmes P F (1962), "Archaeology of Malham Moor", Field Studies, 1 1-28

Sims R E (1973), "The anthropogenic factor in East Anglian vegetational history: an approach using A.P.F. techniques", in "Quaternary plant ecology" 14th Symposium of the British Ecological Society, pp 223-236, Eds Birks H J B, West R G, Blackwell, Oxford

Simmons I G (1964), "Pollen diagrams from Dartmoor", New Phytol, 63 165-180

Simmons I G (1975), "Towards an ecology of mesolithic man in the uplands of Great Britain", J Archaeol Sci, 2 1-15

Simmons I G (1981), "Sea-level in the Mesolithic", in "The environment in British prehistory", pp 83-89, Eds Simmons I G, Tooley M J, Duckworth, London

Simmons I G, Cundill P R (1974), "Late quaternary vegetational history of the North York Moors. I. Pollen analysis of blanket peats", J Biogeog, 1 159-169

Simmons I G, Innes J B (1981), "Tree remains in a North York Moors peat profile", Nature (Lond), 294 76-78

Singh G, Smith A G (1973), "Post-glacial vegetational history and relative land and sea level changes in Lecale, Co. Down", Proc Roy Irish Acad, 73B 1-51

Smith A G (1959), "The mires of South-western Westmorland: stratigraphy and pollen analysis", New Phytol, 58 105-127

Smith A G (1970), "The influence of Mesolithic and Neolithic man on British vegetation", in "Studies in the vegetational history of the British Isles" pp 81-96 , Eds Walker D, West R G, Cambridge University Press

Smith A G (1984), "Newferry and the Boreal-Atlantic Transition", New Phytol, 98 35-55

Smith A G, Pilcher J R (1973), "Radiocarbon dates and vegetational history of the British Isles", New Phytol, 72 903-914

Sweeting M M (1950), "Erosion cycles and limestone caverns in the Ingleborough district", Geog J, 115 63-78

Sweeting M M (1964), "Some factors in the absolute denudation of limestone terrains", Erdkunde, 18 92-95

Sweeting M M (1965), "Denudation in limestone regions: a symposium", Geog J, 131 34-37

Tallis J H, Switsur V R (1973), "Studies on southern Pennine peats VI. A radiocarbon dated pollen diagram from Featherbed Moss, Derbyshire", J Ecol, 61 743-751

Tansley A G (1949), "The British Isles and their vegetation", Cambridge University Press

Tinsley H M, Smith R T (1974), "Surface pollen studies across a woodland/heath transition and their application to the interpretation of pollen diagrams", New Phytol, 73 547-565

Troels-Smith J (1960), "Ivy, mistletoe and elm: climatic indicators - fodder plants: a contribution to the interpretation of the pollen zone border VII-VIII", Danm Geol Unders, IV series, 4 1-32

Turner J (1964), "The anthropogenic factor in vegetational history. I. Tregaron and Whixall Mosses", New Phytol, 63 73-90

Turner J (1970), "Post-Neolithic disturbance of British vegetation", in "Studies in the vegetational history of the British Isles" pp 97-116, Eds Walker D, West R G , Cambridge University Press

Tutin W (1969), "The usefulness of pollen analysis in interpretation of stratigraphic horizons both late-glacial and post glacial", Mitt Int Verein Theor Angew Limnol, 17 154-164

Walker D (1955), "Studies in the Post-glacial history of British vegetation XIV. Skelsmergh Tarn and Kentmere, Westmorland", New Phytol, 54 222-254

Walker D (1956), "A site at Stump Cross near Grassington, Yorkshire and the age of the Pennine microlithic industry" Proc Prehist Soc, 22 23-28

Walker D (1966), "The late quaternary history of the Cumberland lowland", Phil Trans Roy Soc B, 251 1-20

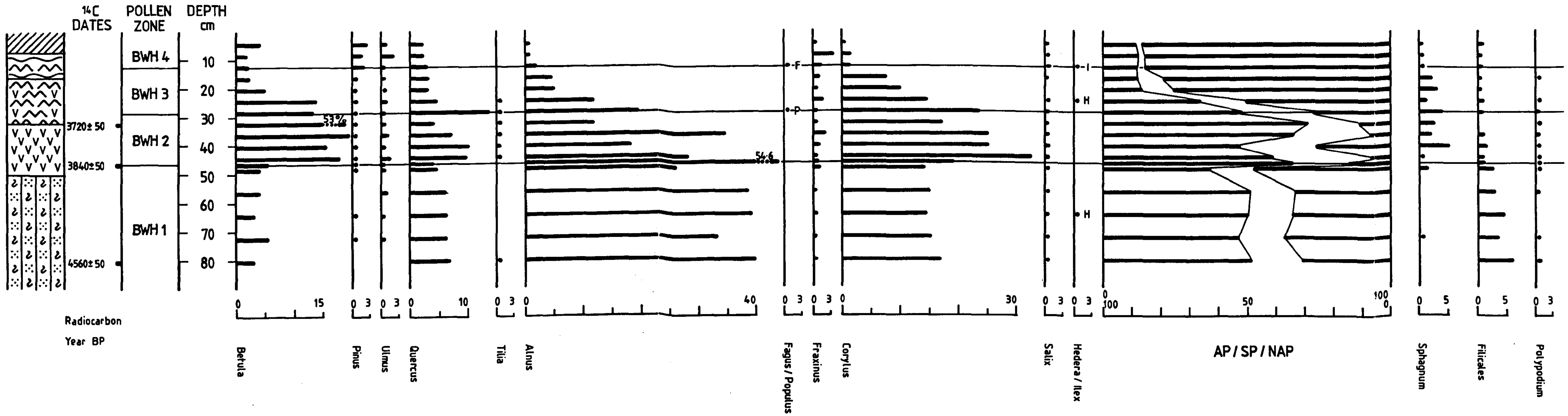
West R G (1960), "Inter-relations of ecology and quaternary palaeobotany", J Ecol, 52 (supplement), Brit Ecol Soc Jubilee Symposium

DIAGRAM 3.1

BRAITHWAITE WIFE HOLE

% Pollen diagram

S. SWALES



BRAITHWAITE WIFE HOLE

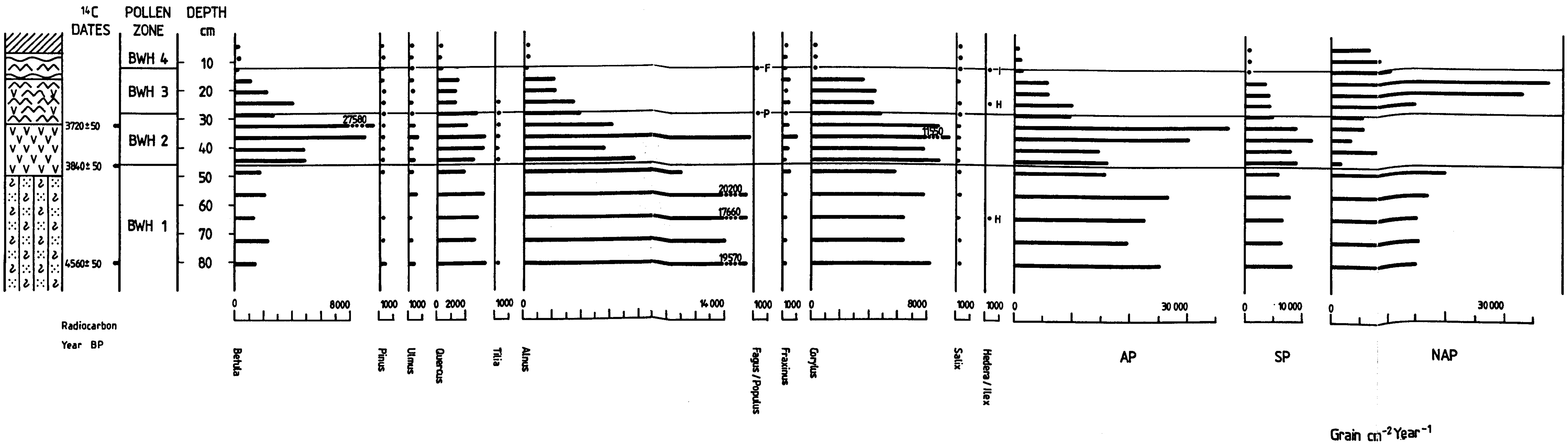
% Pollen diagram

DIAGRAM 3.2

BRAITHWAITE WIFE HOLE

Pollen influx diagram

S. SWALES



BRAITHWAITE WIFE HOLE

Pollen influx diagram

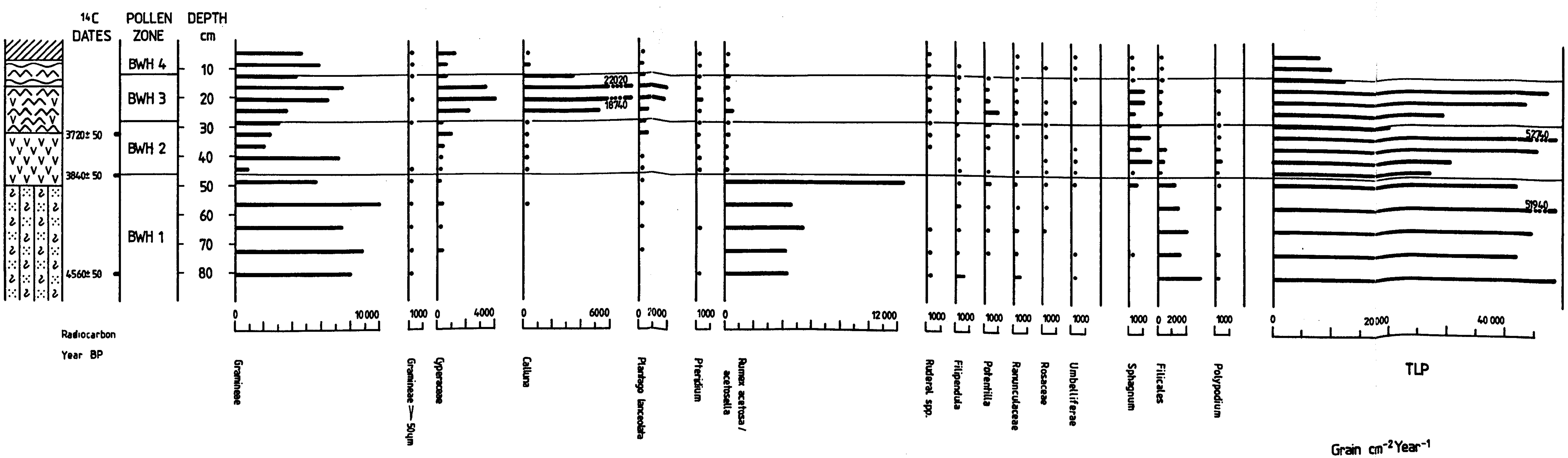


DIAGRAM 4.1

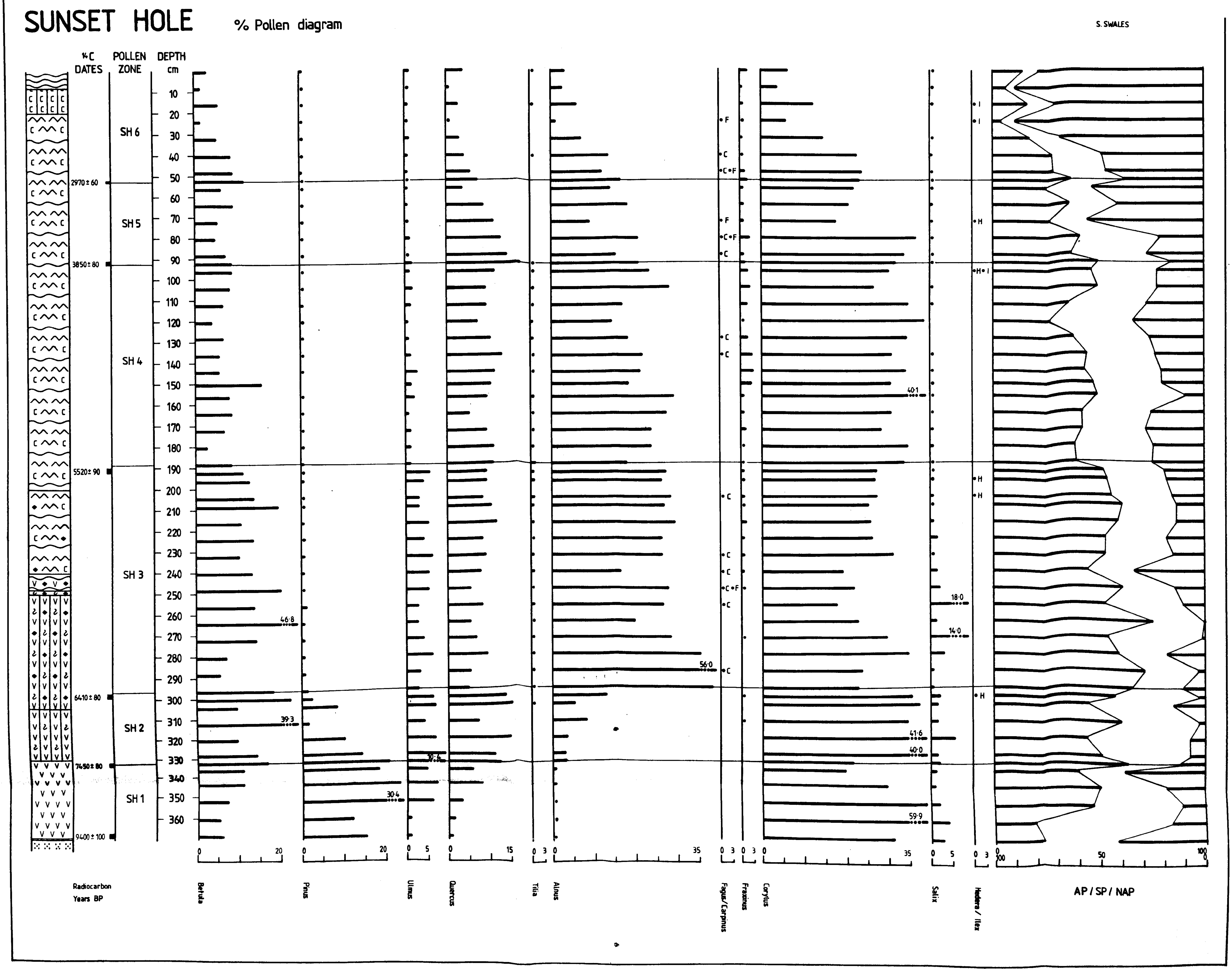

SUNSET HOLE
% Pollen diagram
S. SWALES
14C DATES
POLLEN ZONE
DEPTH cm
2970 ± 60
3850 ± 80
5520 ± 90
6410 ± 80
7450 ± 80
9400 ± 100
SH 6
SH 5
SH 4
SH 3
SH 2
SH 1
Radiocarbon Years BP
Betula
Pinus
Ulmus
Quercus
Tilia
Alnus
Fagus / Carpinus
Fraxinus
Corylus
Salix
Hedera / Ilex
AP / SP / NAP
46·8
39·3
30·4
56·0
40·1
41·6
40·0
59·9
18·0
14·0

DIAGRAM 4.2

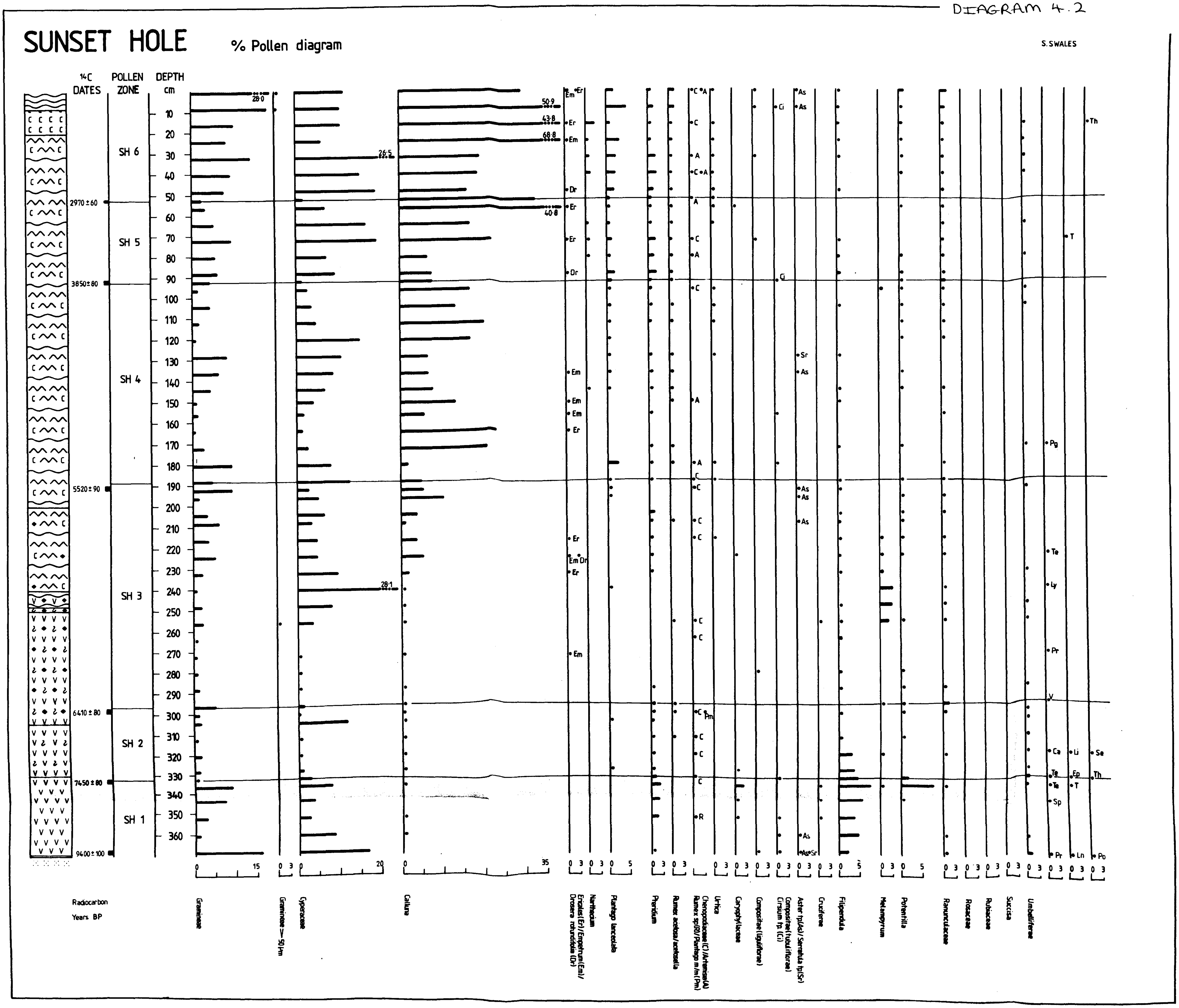

SUNSET HOLE
% Pollen diagram
S. SWALES
14C DATES
POLLEN ZONE
DEPTH cm
SH 6
SH 5
SH 4
SH 3
SH 2
SH 1
2970±60
3850±80
5520±90
6410±80
7450±80
9400±100
Radiocarbon Years BP
Gramineae
Gramineae >50 μm
Cyperaceae
Calluna
Ericales (Er)/Empetrum (Em)/Drosera rotundifolia (Dr)
Narthecium
Plantago lanceolata
Pteridium
Rumex acetosa/acetosella
Rumex sp. (R)/Plantago m/m (Pm)
Chenopodiaceae (C)/Artemisia (A)
Urtica
Caryophyllaceae
Compositae (liguliflorae)
Compositae (tubuliflorae)
Cirsium tp. (Ci)
Aster tp. (As)/Serratula tp. (Sr)
Cruciferae
Filipendula
Melampyrum
Potentilla
Ranunculaceae
Rosaceae
Rubiaceae
Succisa
Umbelliferae

DIAGRAM 4.3

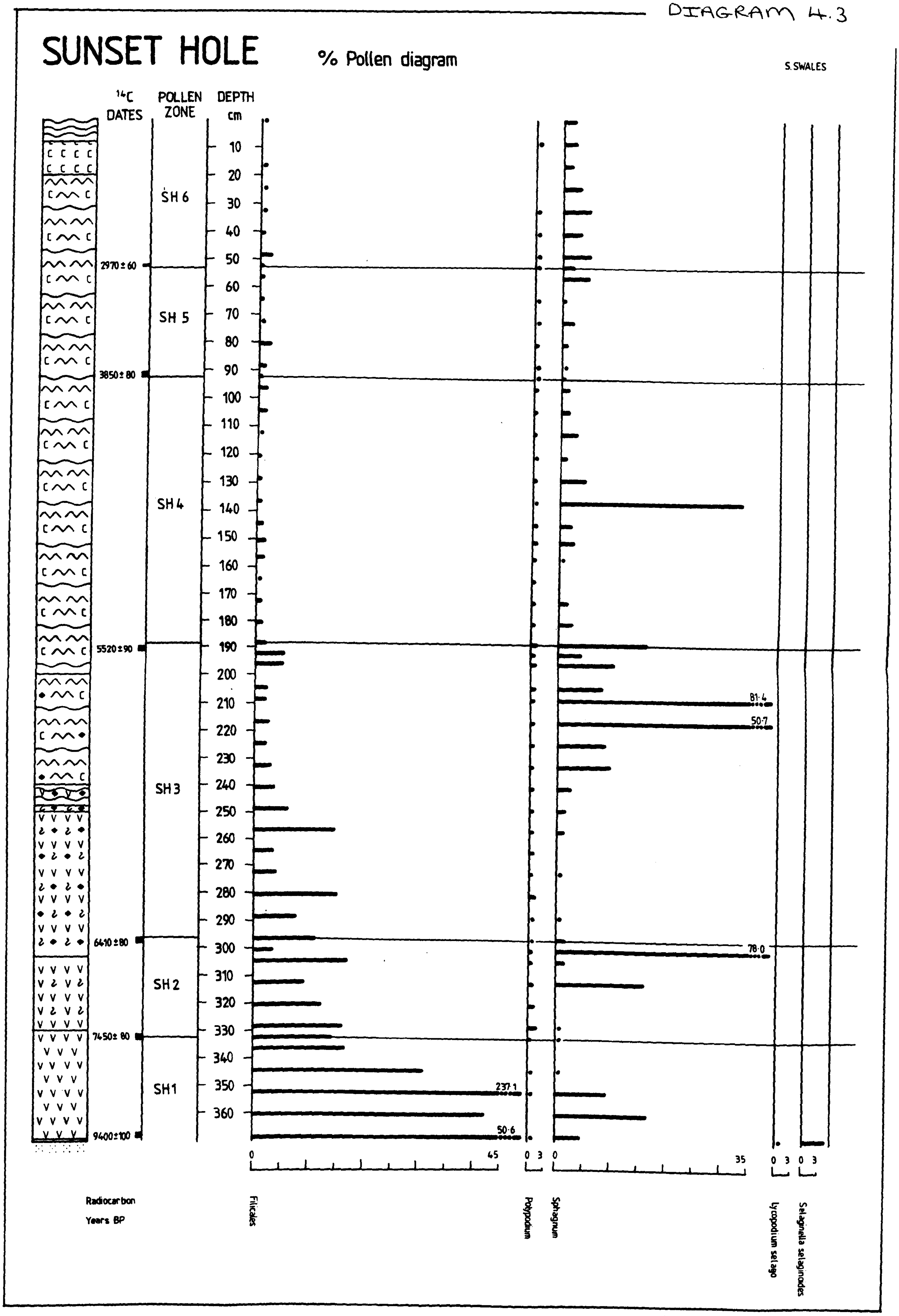

SUNSET HOLE
% Pollen diagram
S. SWALES
14C DATES
POLLEN ZONE
DEPTH cm
2970 ± 60
3850 ± 80
5520 ± 90
6410 ± 80
7450 ± 80
9400 ± 100
SH 6
SH 5
SH 4
SH 3
SH 2
SH 1
237·1
50·6
81·4
50·7
78·0
Radiocarbon Years BP
Filicales
Polypodium
Sphagnum
Lycopodium selago
Selaginella selaginoides

DIAGRAM 4.4

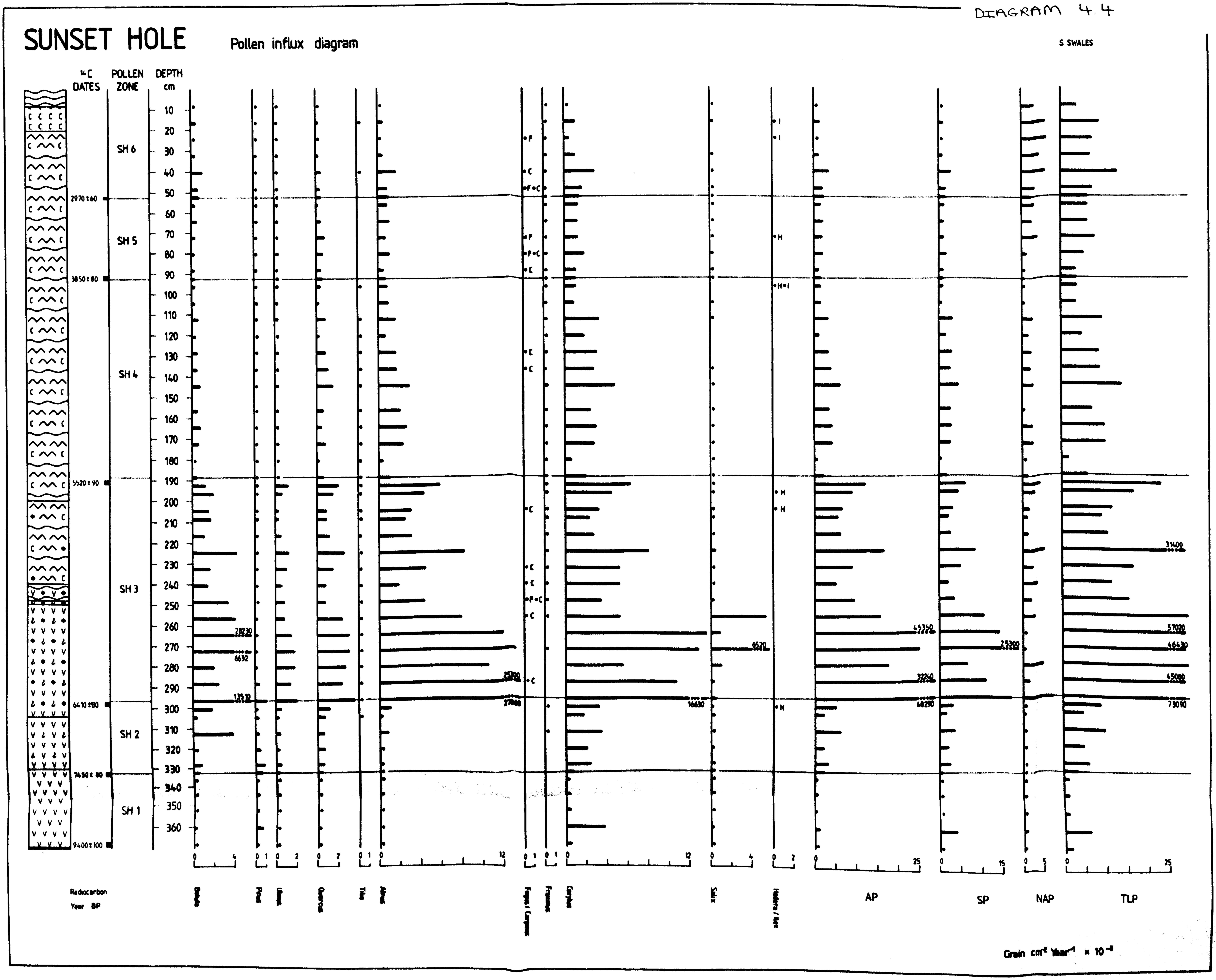
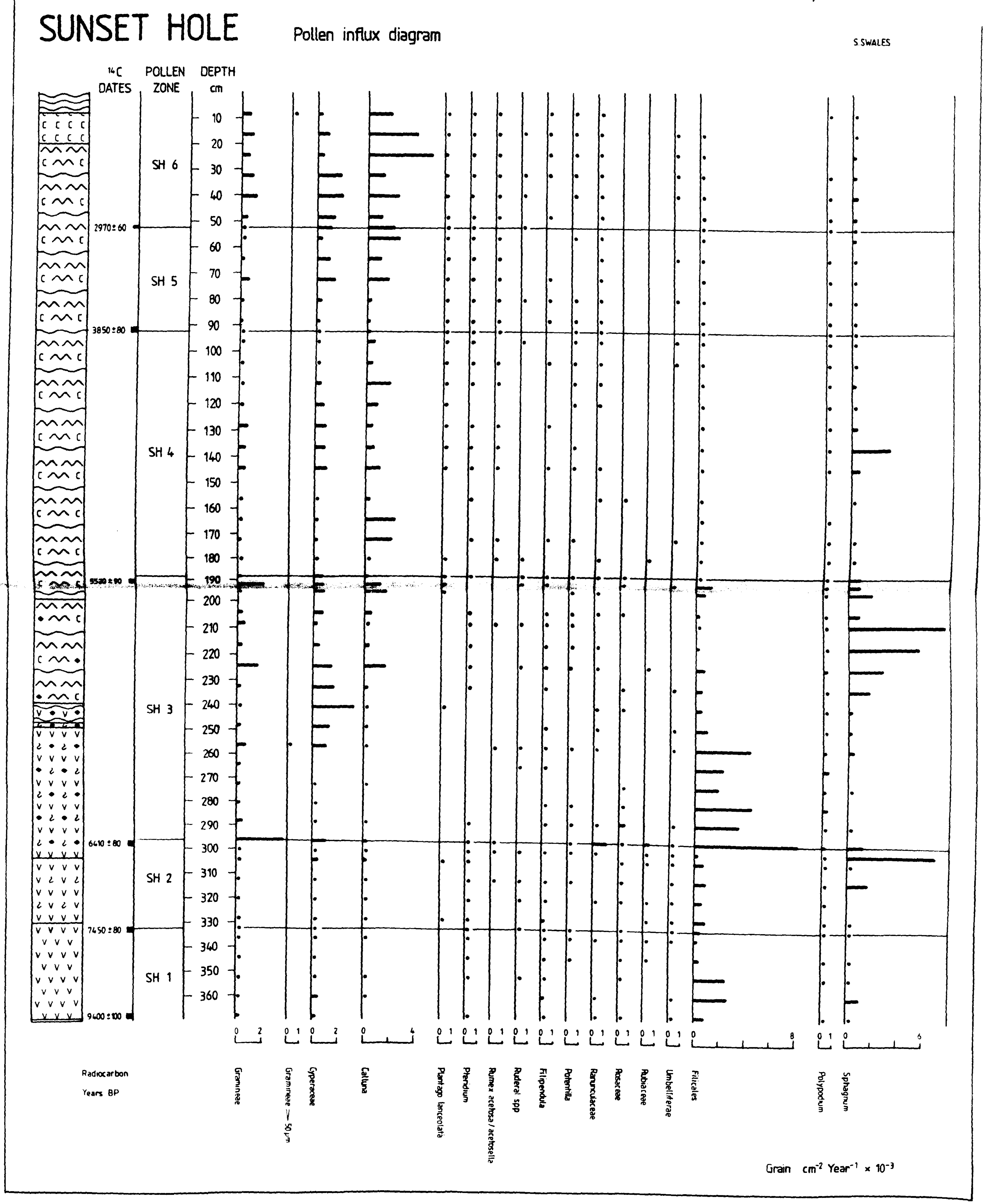

SUNSET HOLE
Pollen influx diagram
S SWALES
14C DATES
POLLEN ZONE
DEPTH cm
SH 6
SH 5
SH 4
SH 3
SH 2
SH 1
2970±60
3850±80
5520±90
6410±80
7450±80
9400±100
Radiocarbon Year BP
Betula
Pinus
Ulmus
Quercus
Tilia
Alnus
Fagus / Carpinus
Fraxinus
Corylus
Salix
Hedera / Ilex
AP
SP
NAP
TLP
Grain cm⁻² Year⁻¹ × 10⁻³

DIAGRAM 4.5



SUNSET HOLE
Pollen influx diagram
S. SWALES
14C DATES
POLLEN ZONE
DEPTH cm
2970 ± 60
3850 ± 80
5520 ± 90
6410 ± 80
7450 ± 80
9400 ± 100
SH 6
SH 5
SH 4
SH 3
SH 2
SH 1
Radiocarbon Years BP
Gramineae
Gramineae > 50 µm
Cyperaceae
Calluna
Plantago lanceolata
Pteridium
Rumex acetosa / acetosella
Ruderal spp
Filipendula
Potentilla
Ranunculaceae
Rosaceae
Rubiaceae
Umbelliferae
Filicales
Polypodium
Sphagnum
Grain cm^{-2} Year^{-1} × 10^{-3}

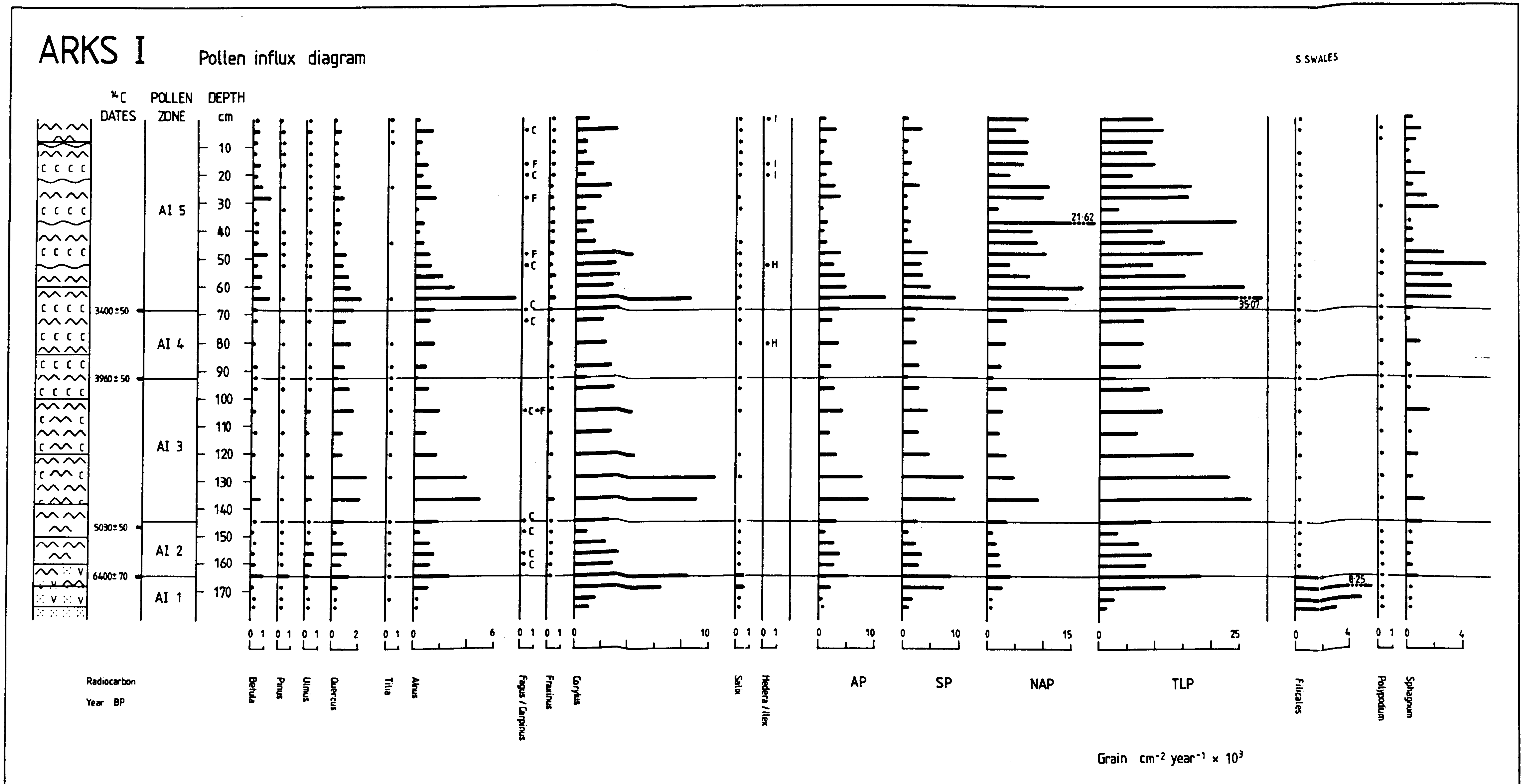
DIAGRAM 5.1

ARKS I
% Pollen diagram
S.SWALES
14C DATES
POLLEN ZONE
DEPTH cm
3400±50
3960±50
5030±50
6400±70
AI 5
AI 4
AI 3
AI 2
AI 1
Radiocarbon Years BP
Betula
Pinus
Ulmus
Quercus
Tilia
Alnus
Fagus / Carpinus
Fraxinus
Corylus
Salix
Hedera / Ilex
AP / SP / NAP
Filicales
Polypodium
Sphagnum

DIAGRAM 5.2


ARKS I
% Pollen diagram
S. SWALES
14C DATES
POLLEN ZONE
DEPTH cm
3400 ± 50
3960 ± 50
5030 ± 50
6400 ± 70
AI 5
AI 4
AI 3
AI 2
AI 1
Radiocarbon Years BP
Gramineae
Gramineae >50 µm
Cyperaceae
Calluna
Empetrum
Ericales / Drosera rotundifolia (Dr)
Narthecium
Plantago lanceolata
Pteridium
Rumex acetosa/acetosella
Rumex spp.
Artemisia (As) / Cannabis tp. (Cn)
Chenopodiaceae
Urtica
Compositae
Aster tp. (As) / Centaurea tp. (Ce)
Cirsium tp. (Ci) / Serratula tp. (Se)
Cruciferae (Cr) / Caryophyllaceae (Cy)
Filipendula
Melampyrum
Potentilla
Ranunculaceae
Rosaceae
Rubiaceae
Sambucus tp.
Succisa
Umbelliferae

DIAGRAM 5.3



ARKS I
Pollen influx diagram
S. SWALES
14C DATES
POLLEN ZONE
DEPTH cm
3400±50
3960±50
5030±50
6400±70
AI 5
AI 4
AI 3
AI 2
AI 1
21·62
35·07
8·25
Radiocarbon Year BP
Betula
Pinus
Ulmus
Quercus
Tilia
Alnus
Fagus / Carpinus
Fraxinus
Corylus
Salix
Hedera / Ilex
AP
SP
NAP
TLP
Filicales
Polypodium
Sphagnum
Grain cm-2 year-1 × 10^3

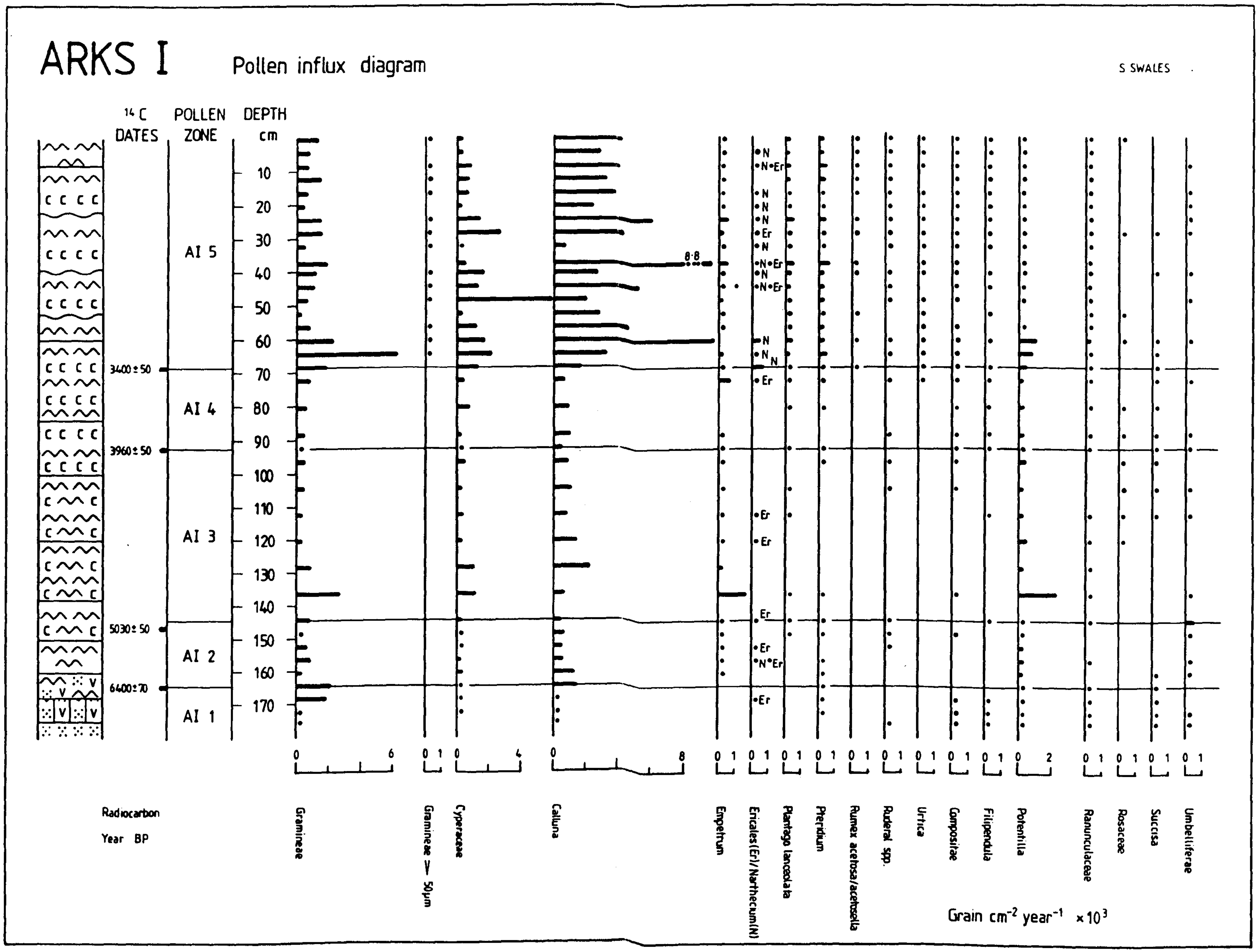
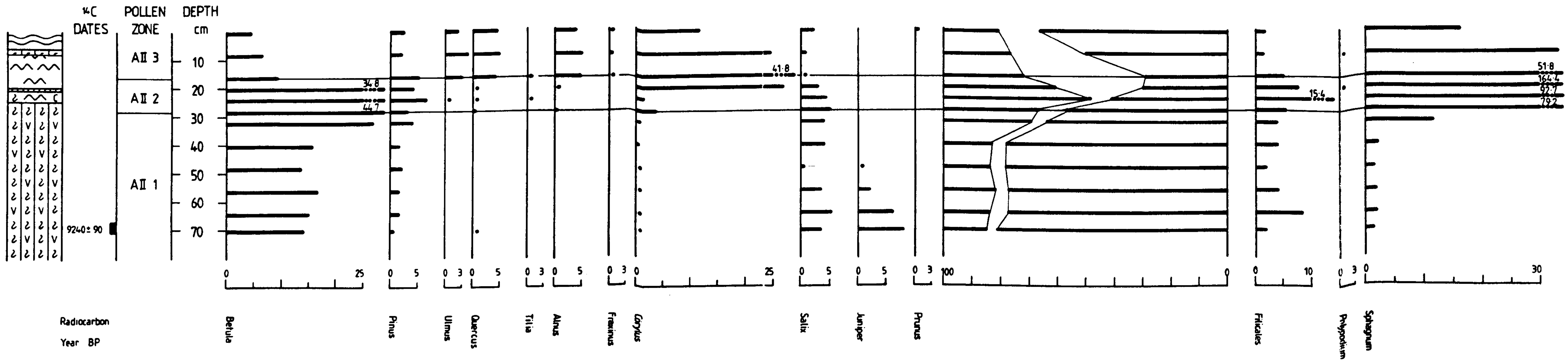

ARKS I
Pollen influx diagram
S SWALES
¹⁴C DATES
POLLEN ZONE
DEPTH cm
3400±50
3960±50
5030±50
6400±70
AI 5
AI 4
AI 3
AI 2
AI 1
Radiocarbon Year BP
Gramineae
Gramineae ≥ 50μm
Cyperaceae
Calluna
Empetrum
Ericales(Er)/Narthecum(N)
Plantago lanceolata
Pteridium
Rumex acetosa/acetosella
Ruderal spp.
Urtica
Compositae
Filipendula
Potentilla
Ranunculaceae
Rosaceae
Succisa
Umbelliferae
Grain cm⁻² year⁻¹ ×10³

DIAGRAM 5.5

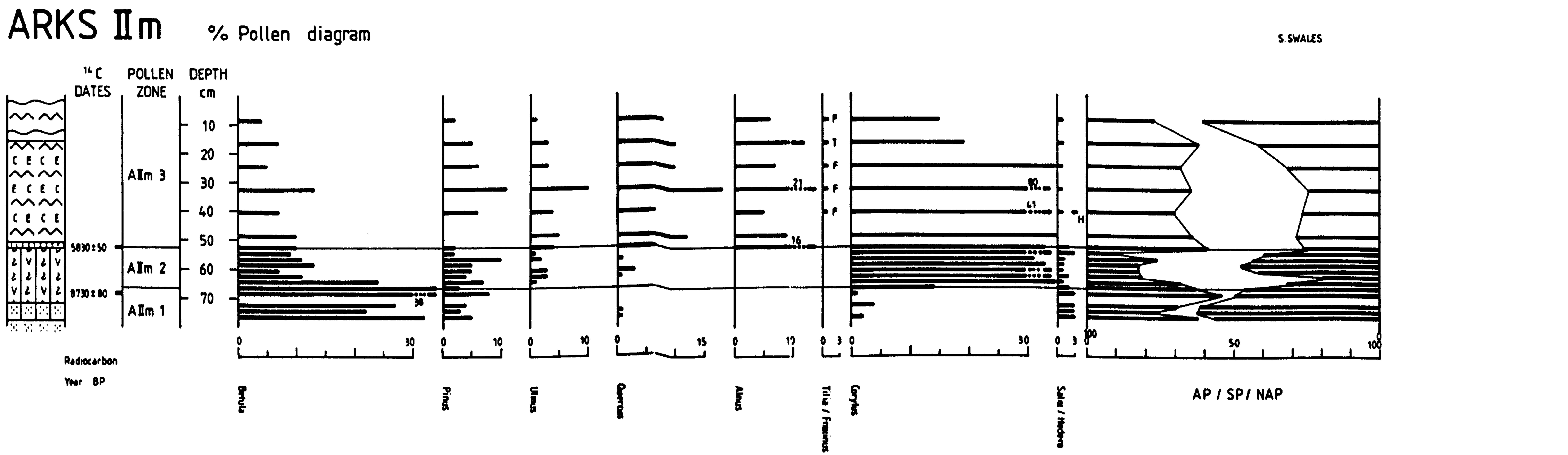
ARKS II % Pollen diagram

S. SWALES



ARKS II % Pollen diagram

DIAGRAM 5.6


ARKS IIm % Pollen diagram
S. SWALES
¹⁴C DATES
POLLEN ZONE
DEPTH cm
AIIm 3
AIIm 2
AIIm 1
5830 ± 50
8730 ± 80
Radiocarbon Year BP
Betula
Pinus
Ulmus
Quercus
Alnus
Tilia / Fraxinus
Corylus
Salix / Hedera
AP / SP / NAP

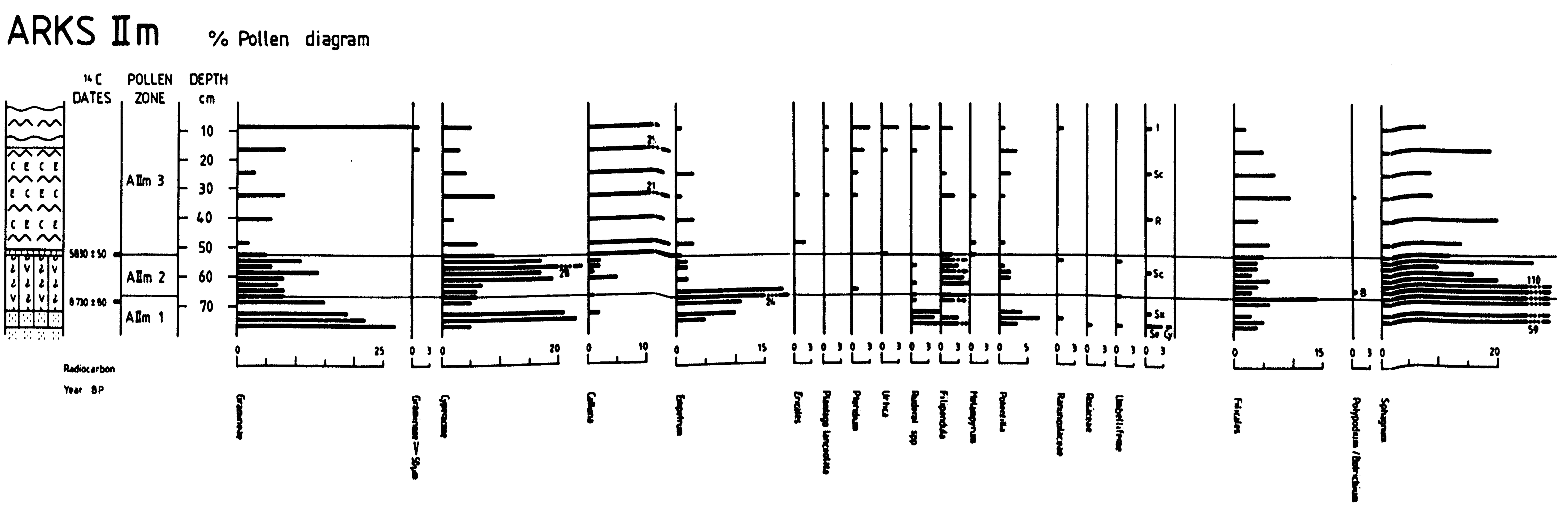
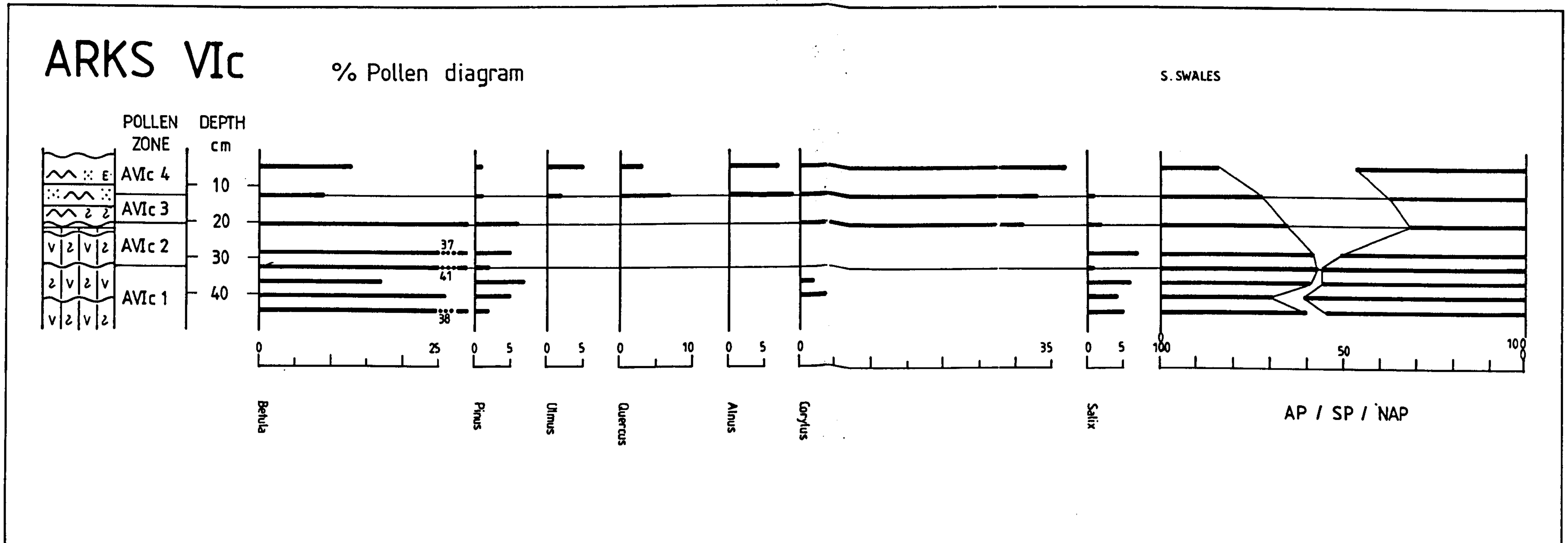

ARKS IIm % Pollen diagram
¹⁴C DATES
POLLEN ZONE
DEPTH cm
AIIm 3
AIIm 2
AIIm 1
5830 ± 50
8730 ± 80
Radiocarbon Year BP
Gramineae
Cyperaceae
Calluna
Empetrum
Ericales
Plantago lanceolata
Pteridium
Urtica
Rubiaceae spp
Filipendula
Melampyrum
Potentilla
Ranunculaceae
Rosaceae
Umbelliferae
Filicales
Polypodium / Botrychium
Sphagnum

DIAGRAM 5.7


ARKS VIc
% Pollen diagram
S. SWALES
POLLEN ZONE
DEPTH cm
AVIc 4
AVIc 3
AVIc 2
AVIc 1
10
20
30
40
37
41
38
Betula
Pinus
Ulmus
Quercus
Alnus
Corylus
Salix
AP / SP / NAP

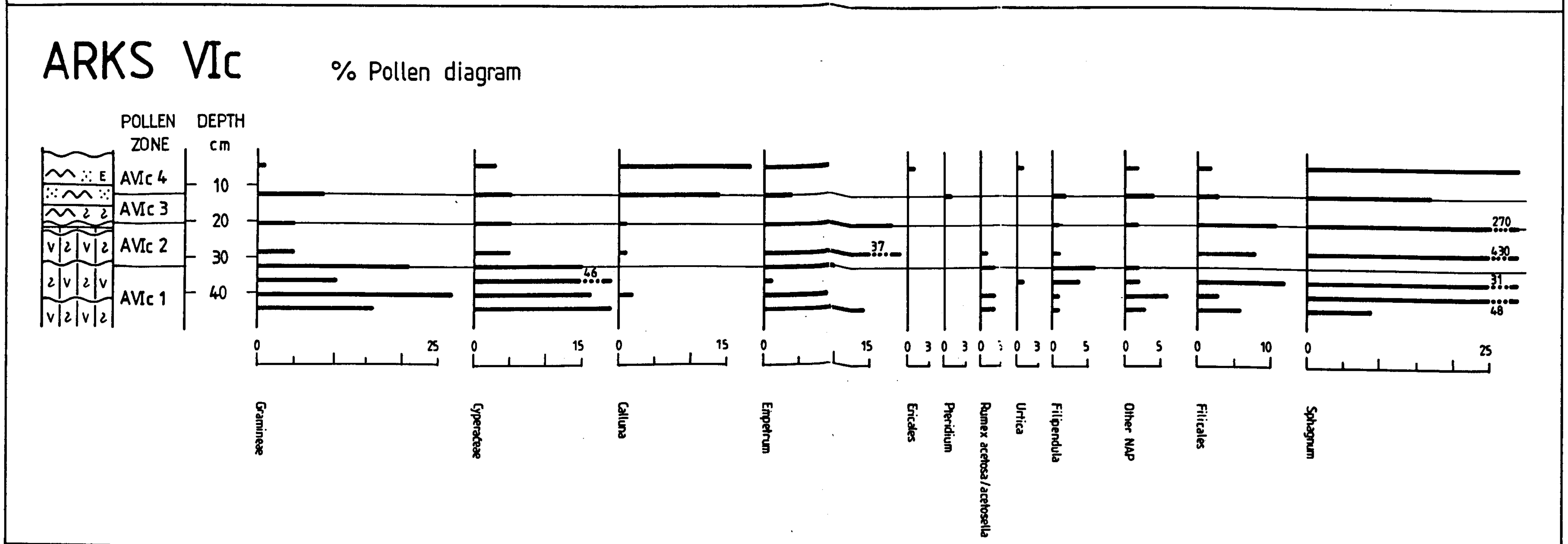

ARKS VIc
% Pollen diagram
POLLEN ZONE
DEPTH cm
AVIc 4
AVIc 3
AVIc 2
AVIc 1
10
20
30
40
46
37
270
430
31
48
Gramineae
Cyperaceae
Calluna
Empetrum
Ericales
Pteridium
Rumex acetosa/acetosella
Urtica
Filipendula
Other NAP
Filicales
Sphagnum

FIGURE 5.2

The stratigraphy of the Arks basin

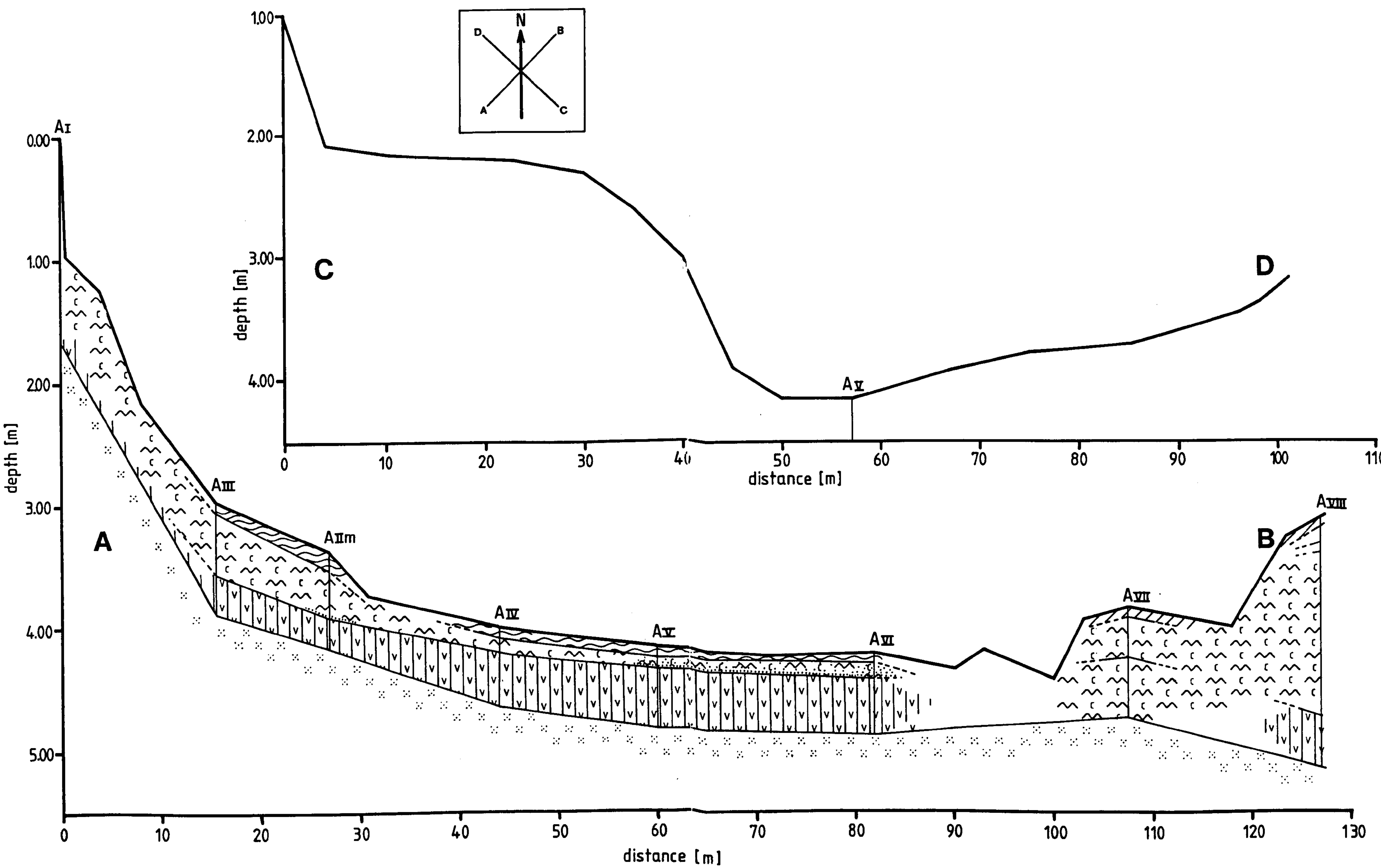
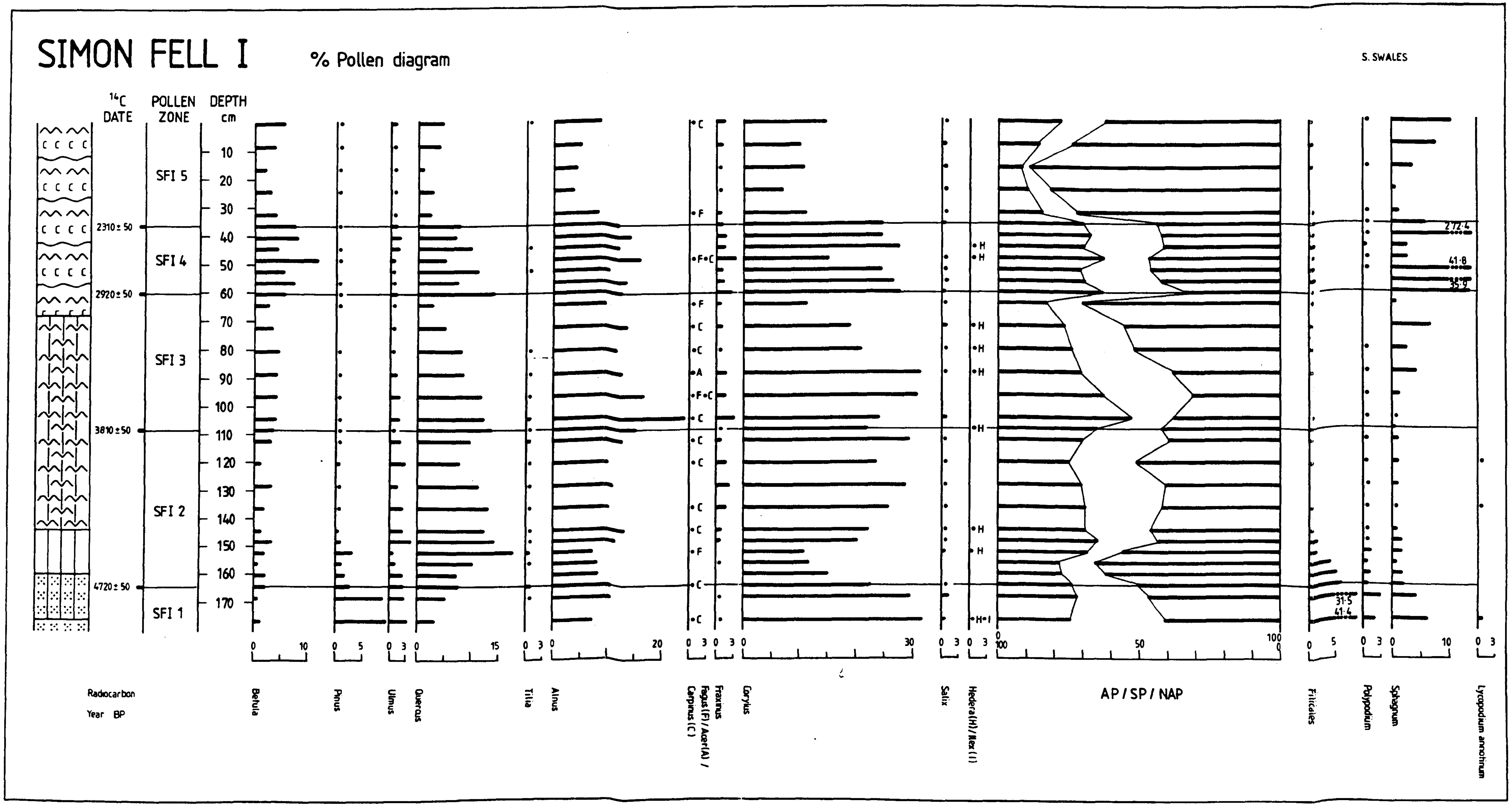


DIAGRAM 6.1

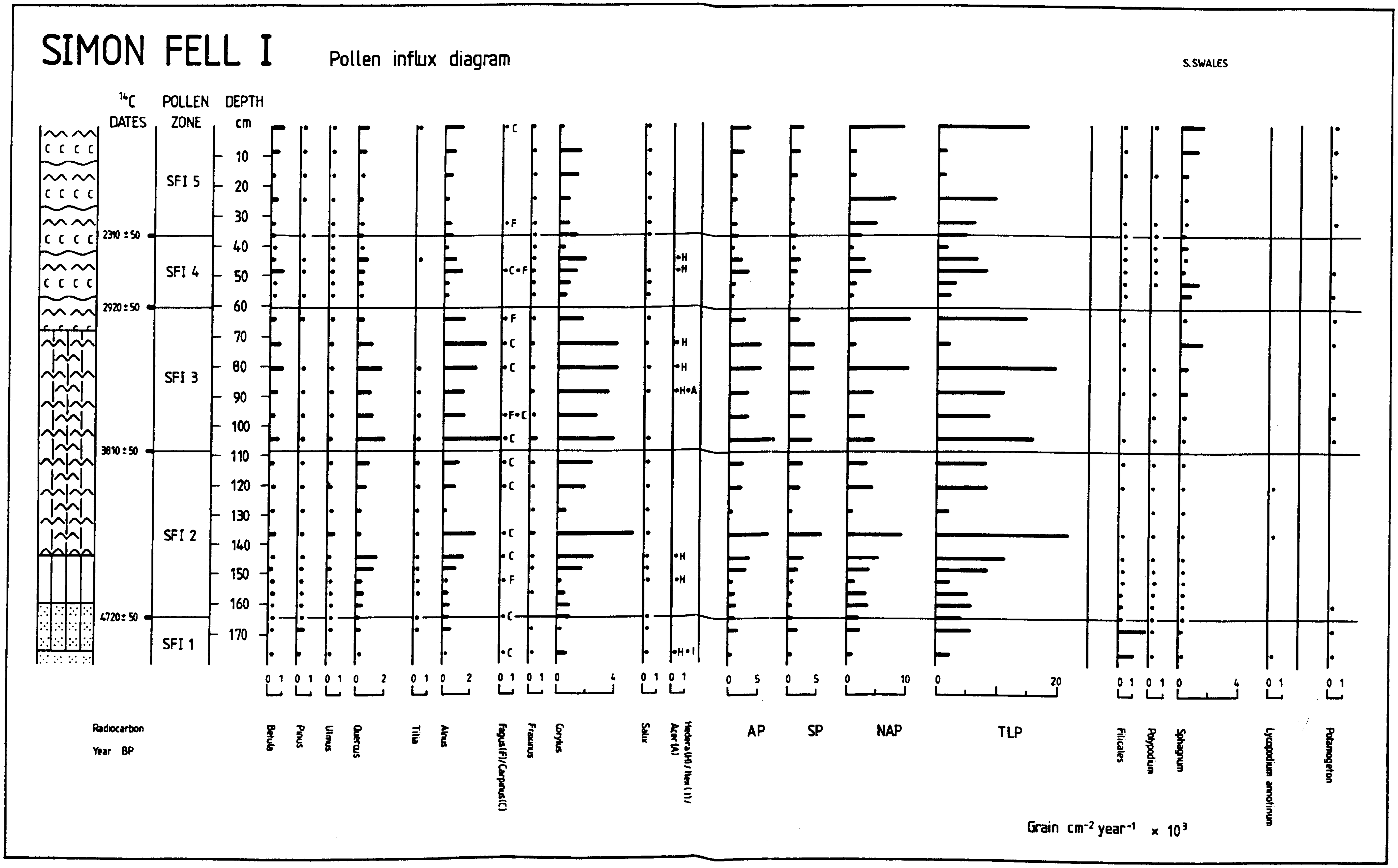


SIMON FELL I
% Pollen diagram
S. SWALES
^{14}C DATE
POLLEN ZONE
DEPTH cm
2310 ± 50
2920 ± 50
3810 ± 50
4720 ± 50
SFI 5
SFI 4
SFI 3
SFI 2
SFI 1
Radiocarbon Year BP
Betula
Pinus
Ulmus
Quercus
Tilia
Alnus
Fagus (F) / Acer (A) / Carpinus (C)
Fraxinus
Corylus
Salix
Hedera (H) / Ilex (I)
AP / SP / NAP
Filicales
Polypodium
Sphagnum
Lycopodium annotinum
272·4
41·8
35·9
31·5
41·4

DIAGRAM 6.2

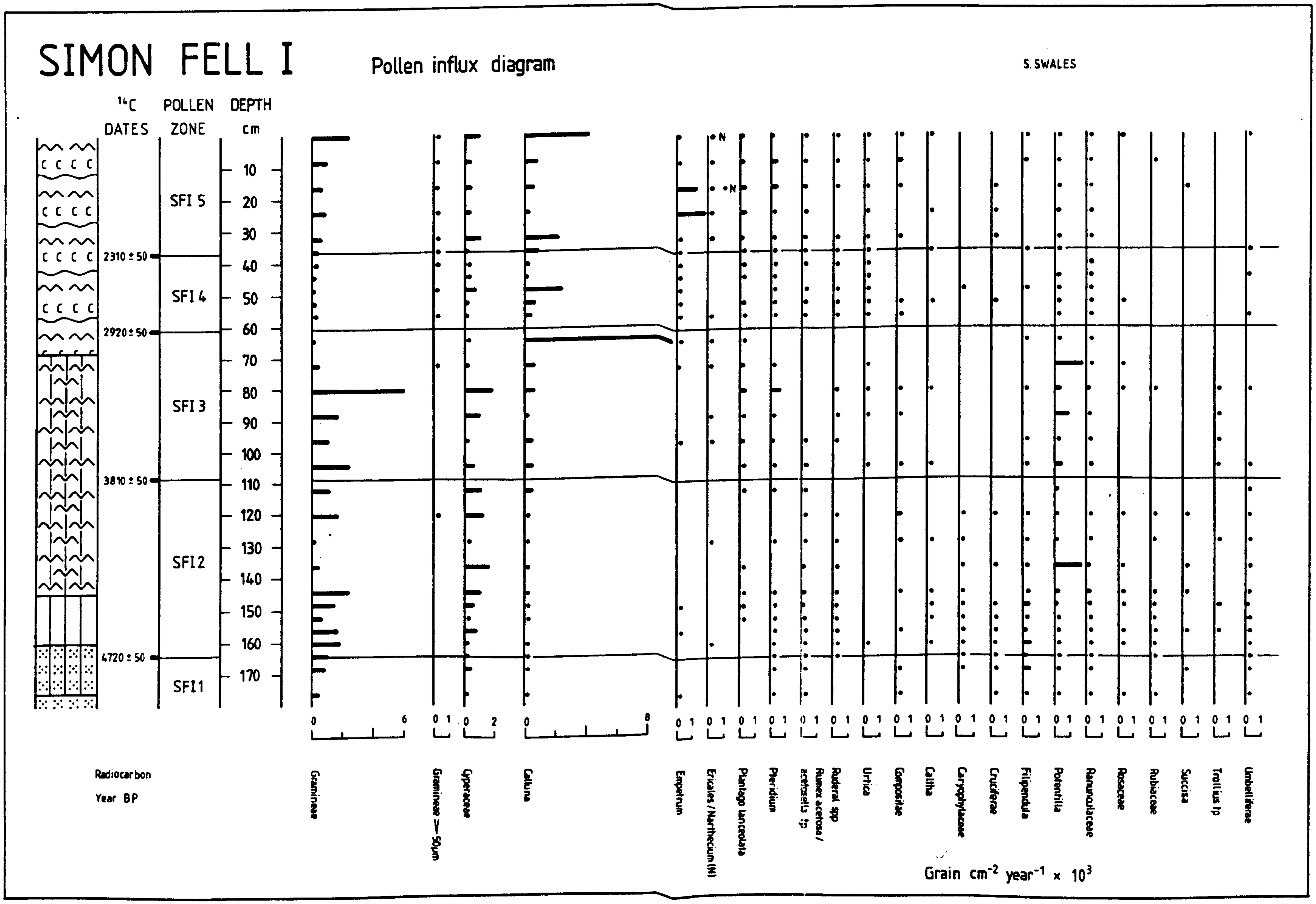

SIMON FELL I
% Pollen diagram
S.SWALES
14C DATES
POLLEN ZONE
DEPTH cm
SFI 5
SFI 4
SFI 3
SFI 2
SFI 1
2310 ± 50
2920 ± 50
3810 ± 50
4720 ± 50
Radiocarbon Year BP
Gramineae
Gramineae > 50 µm
Cyperaceae
Calluna
Empetrum
Narthecium (N) Ericales/
Plantago lanceolata
Pteridium
Rumex acetosa/ acetosella tp
Rumex sp(R)/Plantago sp(P)
Cannabis tp (C)/
Artemisia
Chenopodium
Urtica
Compositae liguliflorae (l)/ tubuliflorae (t)
Serratula tp(Se)/Aster tp(A)
Cirsium tp (Ci)/
Caltha
Caryophyllaceae
Cruciferae
Filipendula
Potentilla
Ranunculaceae
Rosaceae
Rubiaceae
Succisa (Sc)/Trollius tp (T)
Umbelliferae
Potamogeton

DIAGRAM 6.3



SIMON FELL I
Pollen influx diagram
S. SWALES
14C DATES
POLLEN ZONE
DEPTH cm
2310 ± 50
2920 ± 50
3810 ± 50
4720 ± 50
SFI 5
SFI 4
SFI 3
SFI 2
SFI 1
Radiocarbon Year BP
Betula
Pinus
Ulmus
Quercus
Tilia
Alnus
Fagus (F)/ Carpinus (C)
Fraxinus
Corylus
Salix
Hedera (H) / Ilex (I) / Acer (A)
AP
SP
NAP
TLP
Filicales
Polypodium
Sphagnum
Lycopodium annotinum
Potamogeton
Grain cm-2 year-1 × 10^3

DIAGRAM 6.4



SIMON FELL I
Pollen influx diagram
S. SWALES
14C DATES
POLLEN ZONE
DEPTH cm
2310 ± 50
2920 ± 50
3810 ± 50
4720 ± 50
SFI 5
SFI 4
SFI 3
SFI 2
SFI 1
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
Radiocarbon Year BP
Gramineae
Gramineae > 50µm
Cyperaceae
Calluna
Empetrum
Ericales / Narthecium (N)
Plantago lanceolata
Pteridium
Rumex acetosa / acetosella tp
Ruderal spp
Urtica
Compositae
Caltha
Caryophyllaceae
Cruciferae
Filipendula
Potentilla
Ranunculaceae
Rosaceae
Rubiaceae
Succisa
Trollius tp
Umbelliferae
Grain cm-2 year-1 × 10^3

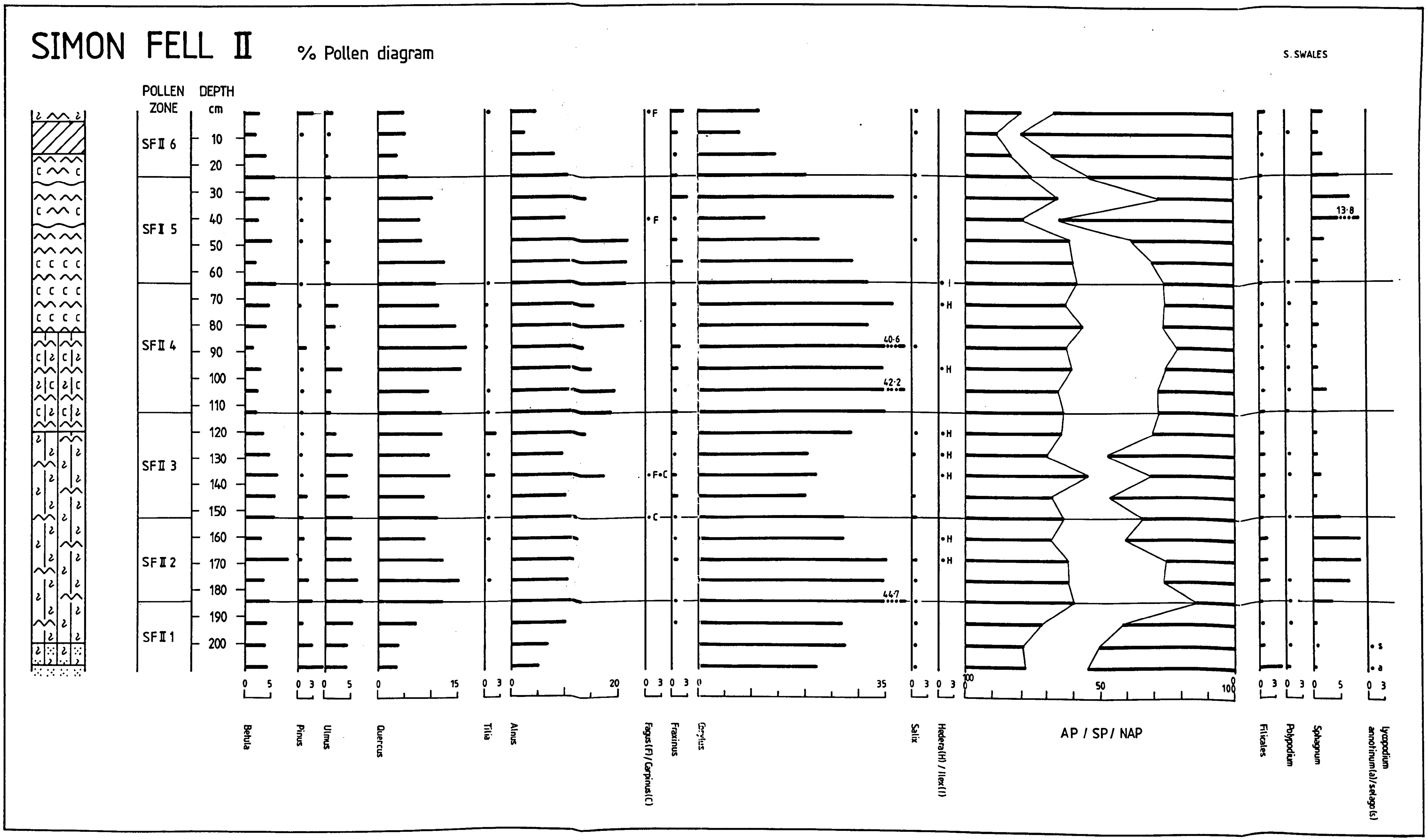

SIMON FELL II
% Pollen diagram
S. SWALES
POLLEN ZONE
DEPTH cm
SFII 6
SFII 5
SFII 4
SFII 3
SFII 2
SFII 1
Betula
Pinus
Ulmus
Quercus
Tilia
Alnus
Fagus (F) / Carpinus (C)
Fraxinus
Corylus
Salix
Hedera (H) / Ilex (I)
AP / SP / NAP
Filicales
Polypodium
Sphagnum
Lycopodium annotinum (a) / selago (s)
40·6
42·2
44·7
13·8

DIAGRAM 7.1

ALLOTMENT SHOOTING BOX

% Pollen diagram

S.SWALES

DIAGRAM 7.2

ALLOTMENT SHOOTING BOX
% Pollen diagram
S.SWALES
¹⁴C DATES
POLLEN ZONE
DEPTH cm
890 ± 60
3650 ± 60
4440 ± 60
5160 ± 60
5740 ± 60
ASB 5
ASB 4
ASB 3
ASB 2
ASB 1
Radiocarbon Year BP
Gramineae
Gramineae > 50µm
Cyperaceae
Calluna
Empetrum
Ericales
Narthecium
Plantago lanceolata
Pteridium
Rumex acetosa / acetosella
Plantago sp (Pm) / Artemisia /
Chenopodiaceae
Rumex sp (R) / Cannabis tp
Urtica
Cirsium tp (Ci) / Aster tp (As) / Compositae liguliflorae (l)
Serratula tp (Se) / Caryophyllaceae (Cy) / Cruciferae /
Filipendula
Helianthemum (H) / Lonicera (Lo) /
Lotus tp
Melampyrum
Potentilla
Ranunculaceae
Rubiaceae
Rubiaceae
Succisa
Umbelliferae
Typha angustifolium (Ta) / Potamogeton

DIAGRAM 4.3


ALLOTMENT SHOOTING BOX
Pollen influx diagram
S. SWALES
14C DATES
POLLEN ZONE
DEPTH cm
890±60
3650±60
4440±60
5160±60
5740±60
ASB 5
ASB 4
ASB 3
ASB 2
ASB 1
15.94
Radiocarbon Year BP
Betula
Pinus
Ulmus
Quercus
Tilia
Alnus
Fagus / Carpinus
Fraxinus
Corylus
Salix
Hedera
AP
SP
NAP
TLP
Filicales
Polypodium
Sphagnum
Lycopodium selago
Grain cm^{-2} year^{-1} × 10^{3}

DIAGRAM 4.4

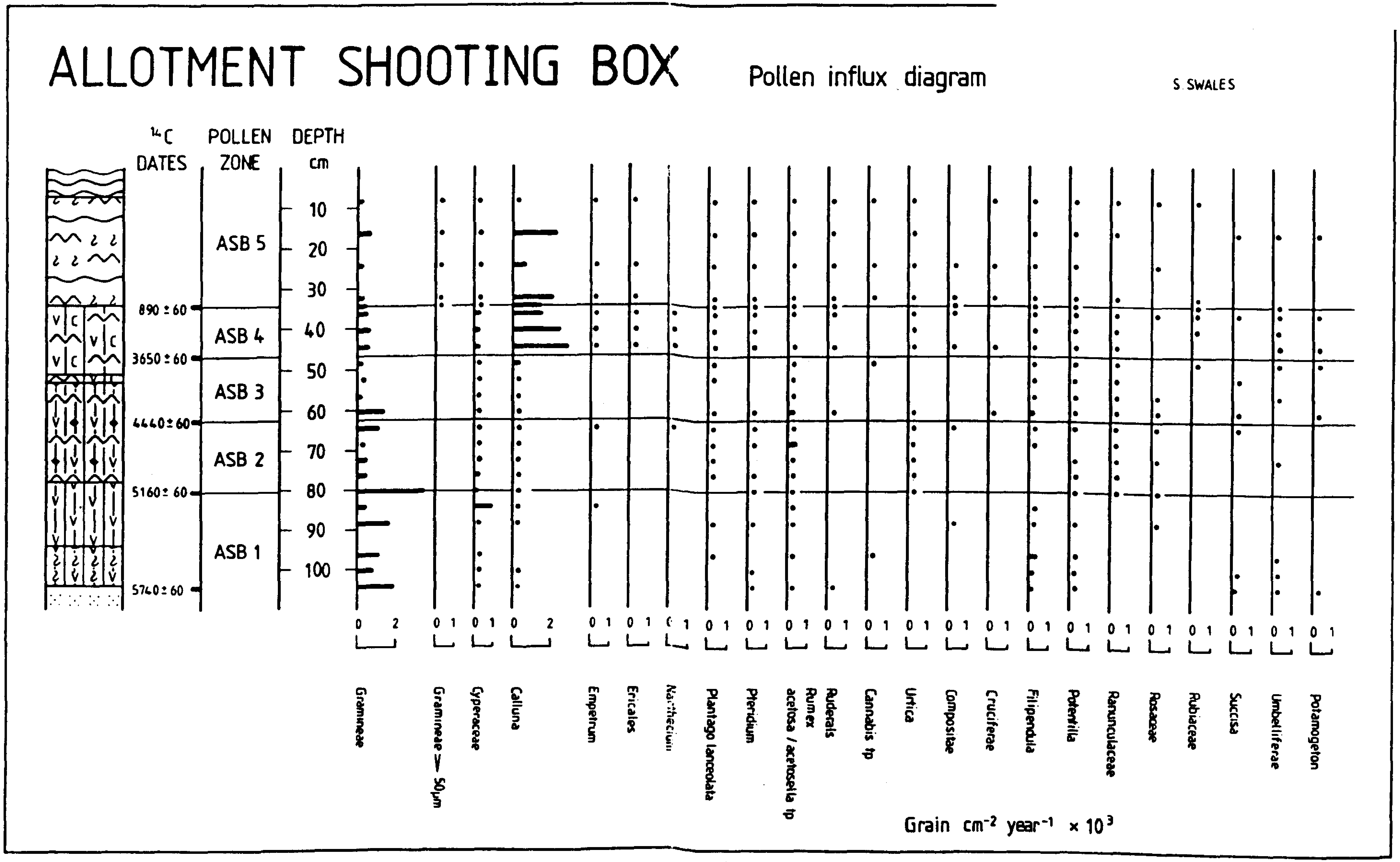
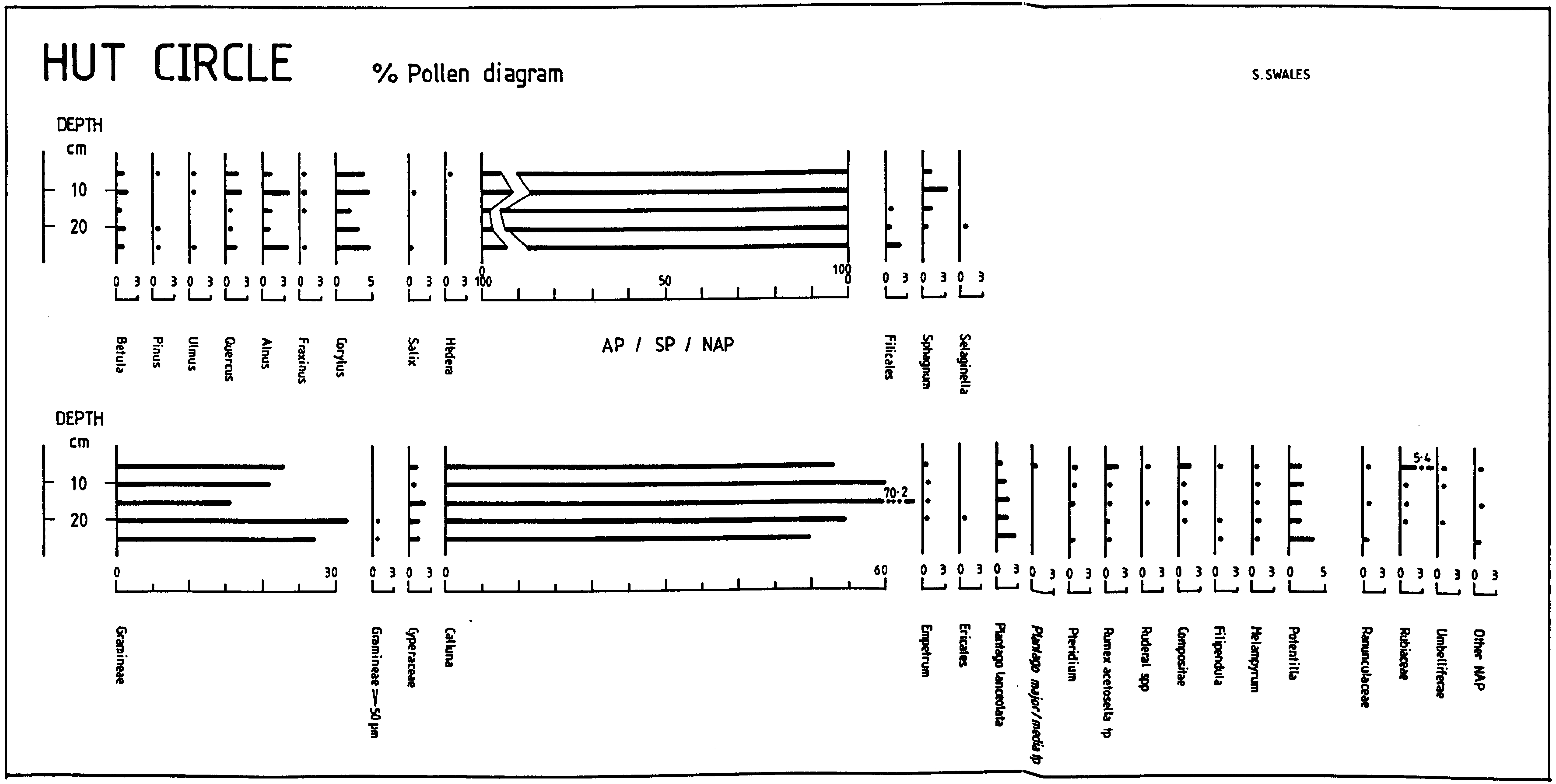

ALLOTMENT SHOOTING BOX
Pollen influx diagram
S. SWALES
14C DATES
POLLEN ZONE
DEPTH cm
890 ± 60
3650 ± 60
4440 ± 60
5160 ± 60
5740 ± 60
ASB 5
ASB 4
ASB 3
ASB 2
ASB 1
10
20
30
40
50
60
70
80
90
100
Gramineae
Gramineae ≥ 50µm
Cyperaceae
Calluna
Empetrum
Ericales
Narthecium
Plantago lanceolata
Pteridium
Rumex acetosa / acetosella tp
Ruderals
Cannabis tp
Urtica
Compositae
Cruciferae
Filipendula
Potentilla
Ranunculaceae
Rosaceae
Rubiaceae
Succisa
Umbelliferae
Potamogeton
Grain cm-2 year-1 × 10^3

DIAGRAM 8.1


SULBER POT
% Pollen diagram
S. SWALES
POLLEN ZONE
DEPTH cm
SP 4
SP 3
SP 2
SP 1
Betula
Pinus
Ulmus
Quercus
Tilia
Alnus
Fagus
Fraxinus
Corylus
Salix
Hedera
AP / SP / NAP
Filicales
Polypodium
Sphagnum
Selaginella


SULBER POT
% Pollen diagram
POLLEN ZONE
DEPTH cm
SP 4
SP 3
SP 2
SP 1
Gramineae
Gramineae > 50µm
Cyperaceae
Calluna
Ericales (Er) / Empetrum (Em) / Narthecium (N)
Plantago lanceolata
Pteridium
Plantago major/media tp
Rumex acetosa / acetosella tp
Chenopodiaceae (C) / Artemisia (A) /
Urtica
Carduus tp (Cu) / Aster tp (As) / Serratula tp (Se)
Compositae liguliflorae (l) / Caryophyllaceae (Cy) / Cruciferae (Cr) /
Filipendula
Leguminosae (L) / Melampyrum (Mp) /
Mercurialis
Potentilla
Ranunculaceae
Rosaceae / Stellaria tp (St)
Rubiaceae
Succisa
Umbelliferae
Trollius tp
Helianthemum
Potamogeton

DIAGRAM 9.1



HUT CIRCLE
% Pollen diagram
S.SWALES
DEPTH cm
10
20
0 3
0 5
0 50 100
100 0
AP / SP / NAP
Betula
Pinus
Ulmus
Quercus
Alnus
Fraxinus
Corylus
Salix
Hedera
Filicales
Sphagnum
Selaginella
DEPTH cm
0 30
0 60
70·2
5·4
Gramineae
Gramineae >50 μm
Cyperaceae
Calluna
Empetrum
Ericales
Plantago lanceolata
Plantago major/media tp
Pteridium
Rumex acetosella tp
Ruderal spp
Compositae
Filipendula
Melampyrum
Potentilla
Ranunculaceae
Rubiaceae
Umbelliferae
Other NAP