The Vegetational and Land Use History of the West of Arran, Scotland.

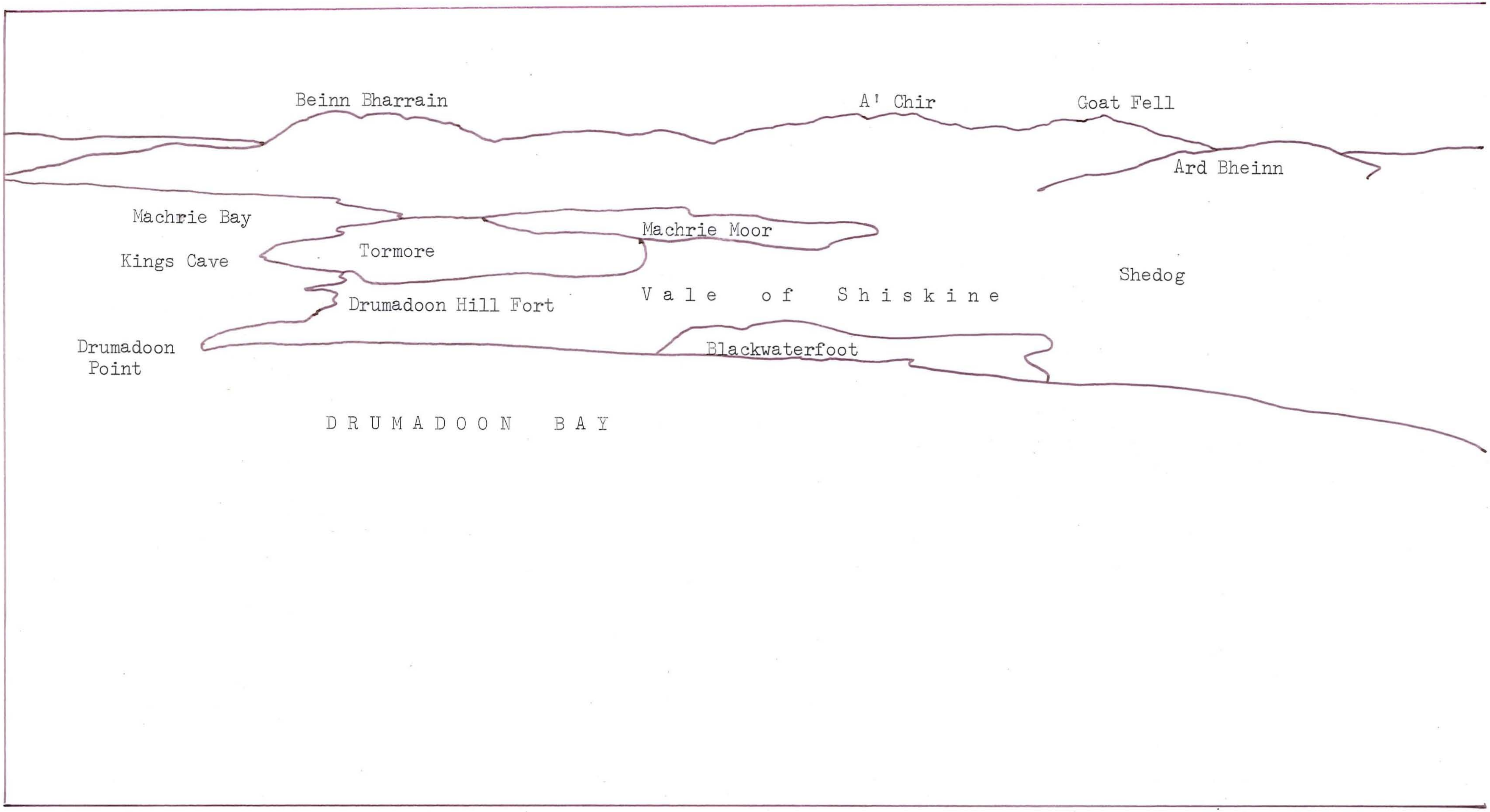
David E. Robinson

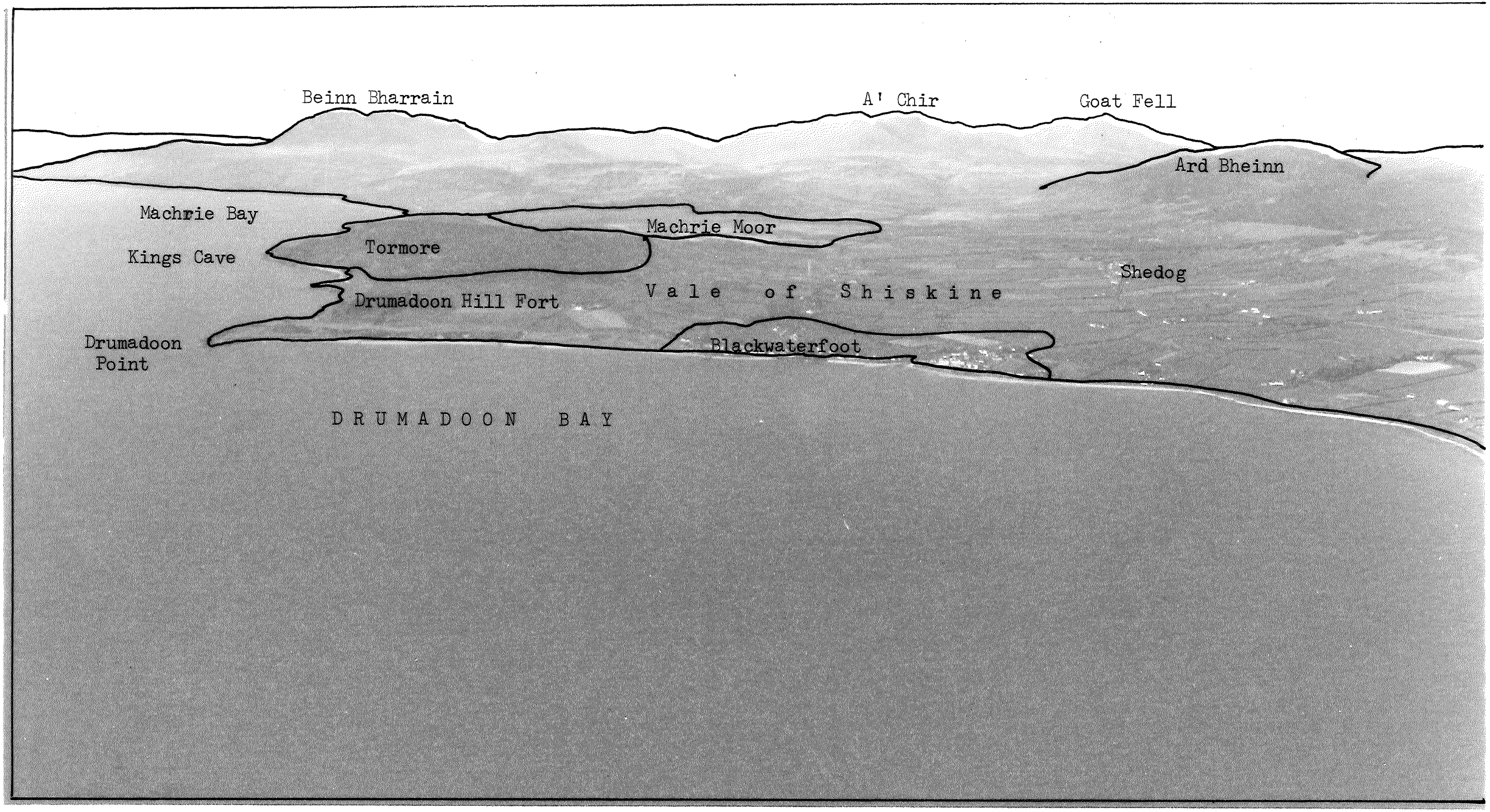
Thesis submitted to the University of Glasgow for the degree of PhD.

November 1981.

Plate I (frontispiece)

Aerial photograph of the study area (the Vale of Shiskine, Arran) looking north from over Drumadoon Bay. (Courtesy C.E.U., Crown Copyright).


Beinn Bharrain
A' Chir
Goat Fell
Ard Bheinn
Machrie Bay
Machrie Moor
Kings Cave
Tormore
Shedog
Vale of Shiskine
Drumadoon Hill Fort
Drumadoon Point
Blackwaterfoot
DRUMADOON BAY



Beinn Bharrain
A' Chir
Goat Fell
Ard Bheinn
Machrie Bay
Machrie Moor
Tormore
Kings Cave
Shedog
Vale of Shiskine
Drumadoon Hill Fort
Drumadoon Point
Blackwaterfoot
DRUMADOON BAY

CONTENTS

LIST OF FIGURES

Figures in Appendices

LIST OF TABLES

Tables in Appendices

LIST OF PLATES

ACKNOWLEDGEMENTS

A great many people have given me encouragement and assistance during the course of this work. In particular I would like to thank the following :-

Dr. J. H. Dickson, for his helpful and enthusiastic supervision.

Mrs. C. A. Dickson, and Miss Mary Fraser, for assistance with pollen and macrofossil identifications.

Dr. D. Breeze (Inspectorate of Ancient Monuments), Mr. J. Barber and Mr. I. Maté (Central Excavation Unit), for invaluable discussion and information concerning the excavations on Tormore.

Mr. M. Brooks and Mr. P. Strong (C.E.U.), for provision of some of the figures and all of the plates in this thesis.

Professor L. Alcock, Dr. L. Slater and Mr. A. Morrison (Archaeology Department, Glasgow University), for advice on ^{14}C dating and archaeological problems.

Professor F. Oldfield (Geography Department, Liverpool University), for the provision of unpublished data concerning the incorporation of pollen into peat deposits.

Bent Aaby (Danish Geological Survey), for the provision of unpublished data concerning the ^{14}C dating of Phragmites peat and permission to use Figure 5.9.

Dr. H. J. B. Birks and Dr. B. Huntley (The Botany School, University of Cambridge), for permission to use their Polldata Mk lV and Mk V computer programmes for the processing of pollen data and the drawing of pollen diagrams.

Mr. A. Alexander (Geography Department, Edinburgh University), for access to his modified Birks/Huntley Polldata programmes and assistance with their use.

Dr. G. L. Jacobson (Department of Botany, University of Maine.) for the provision of unpublished data concerning the non-microscopic measurement of charcoal in sediments.

Dr. M. Stenhouse (Department of Chemistry, Glasgow University), for the ^{14}C dating of all the peat samples.

I would also like to thank Graham and Irene Durant and Jakob and Moira Jakobssonfor the provision of quiet peaceful places to work when they were most needed.

Finally my thanks go to my wife Sarah, who typed the final copy of this thesis, and to my parents. Without their collective support this work would not have been possible.

This research was supported by a research studentship from the Scottish Development Department (Inspectorate of Ancient Monuments) who also funded the radiocarbon dates. It was carried out in the Botany Department, Glasgow University, under the auspices of Professor M. B. Wilkins.

Errata

Page 3, line 18, should read '(Pilcher, 1969, Pilcher and Smith, 1979, Smith and Pilcher, 1973, ...'

Page 4, line 32, should read 'illustrated by Pilcher(1969) at Beaghmore and later at Ballynagilly (Pilcher and Smith, 1979)...'

Page 24, line 25, should read 'Solidago virgaurea...'

Page 49, line 34, should read ' which employs a 9:1 mixture of hot acetic anhydride and concentrated sulphuric acid.'

All references in the text to ' Ritchie, 1978', should read ' Ritchie and Crawford, 1978'.

SUMMARY

Peat sections and soil samples relating to the excavation of a group of Bronze Age monuments on Tormore, in the west of Arran, were analysed for their pollen, charcoal and plant macrofossil content in conjunction with the similar analysis of a long peat section from Machrie Moor, 1 km to the east.

The analyses provided information about the vegetation and land use history of the area during a period from the last glacial until approximately 500 years ago. The vegetation developed along broadly similar lines to that in other areas in south-west Scotland, with any differences being due to the local conditions of climate and exposure and possibly very early interference by human populations.

Mesolithic hunter/gatherers may have been active, at least on a seasonal basis, from as early as 8500 bp. There are also indications of very early Neolithic settlement, with pastoral agriculture and some cereal cultivation becoming established well in advance of the elm decline. Following a reduction in human activity in the late Neolithic there was renewed forest clearance for the purposes of mixed agriculture in the Bronze Age. This reached a climax around 2800 - 2900 bp, resulting in a virtually treeless landscape. The main occupations of the Tormore monuments span the period of the Bronze Age.

In the later Bronze Age soil deterioration and peat growth became serious problems, contributing to a marked reduction in agricultural activity which persisted into the early Iron Age. In the later Iron Age there was a resurgence in pastoralism during which field banks and associated ditches were constructed on Tormore to act as grazing boundaries.

Human activity in the Dark Ages which follow, was confined to isolated episodes of pastoral and arable agriculture. This remained the case until Viking/Mediaeval times when there was a resurgence in mixed farming to levels similar to those in the Bronze Age. These practices continued at a reduced level into the later Middle Ages.

CHAPTER ONE

INTRODUCTION

Archaeological monuments come under threat of destruction almost from the moment at which their construction is underway; from the elements, from various burrowing and grazing animals and from the actions of successive human populations.

Of these three main agents man has been by far the most devastating and as a consequence the better preserved monuments and those representing the earlier periods, tend to be concentrated away from the centres of human population where the pressure on them is proportionately less. This situation has been dramatically reversed in the past three or four decades with the initiation of large-scale afforestation projects in remote upland and outlying areas by the Forestry Commission, and to a lesser extent by land improvement schemes. The combined effect of deep ploughing prior to the planting of trees and the subsequent root development significantly disrupts the internal contexts and stratigraphy of a site, greatly reducing the amount of information retrievable by excavation.

The response to this has been the instigation of a number of 'rescue' excavations by organisations at both national and local levels in cooperation with the Forestry Commission. This has been done with a view to amassing as much information as possible from the threatened sites in the often short time available and to establishing a survey and excavation procedure for similar areas,followed by conservation where necessary.

The Isle of Arran is an example of an area under this kind of threat. The afforestation programme began in 1952 and thirty years on large areas of upland are now planted,with dramatic effects on the landscape as the new forests develop. Arran has a high concentration of archaeological monuments and several of the more obvious and well-known ones have been preserved in small clearings. However many less obtrusive ones, representing periods from the Neolithic onwards, are already lost in the trees.

The initial aims, impetus and material for this study stem directly from the rescue excavation, in June 1978,of a supposed Iron Age settlement site near Tormore, in the mid-west of the island. It was directed by Mr. J. Barber of the Scottish Development Department's Central Excavation Unit. The monuments, a collection of hut circles, cairns and field banks, were concentrated along the 60m contour on the east-facing slope of Tor Righ Mor, and were covered in blanket peat to a depth of between 0.2 and 2metres.

Contrary to the picture which the title 'rescue' might conjure up the excavation was both meticulous and detailed under these difficult conditions. Large amounts of flint, pottery and carbonised plant material, mainly cereal grains, were found and removed.

Once the excavation was underway it soon became apparent that some of the monuments, at least, represented a much earlier period than was originally envisaged. Two cairns and two hut circles from the group were excavated in detail and both cairns plus one of the hut circles apparently had their origins in the Beaker period, ca. 2000 BC. In addition the hut circle had been repeatedly rebuilt and reused, its occupation extending into the late Bronze Age. The field banks seemed to represent even later reuse of the area, possibly in the early Iron Age.

Peat sections were taken from over the monuments, from a ditch associated with a field bank and from a saddle-type depression 30 metres to the west of the site. Soil samples were collected from the various layers encountered during the excavation.

It was hoped that the analysis of these, particularly with reference to the preserved pollen, would give information concerning the status of, and changes in, the local and regional vegetation as influenced by the inhabitants of the site. These data could then be linked with those amassed from the excavation, the analysis of the plant macrofossils, the soils and the artifacts, with a view to unravelling the complicated sequence of occupations. The duration of each occupation phase and the contemporary land use and economy were of particular interest.

Success with respect to the pollen work hinged on the deep peat section from the saddle depression (TM1) being of sufficient age to predate the site thus giving information about the pre-interference vegetation and providing a reference curve for the shorter sections, (TMD1, TMD4, TMD5) and the soil samples. Unfortunately this was not the case, pollen analysis of the basal layers of TM1 revealed that considerable deforestation and interference had already occurred, suggesting that the peat began forming in the later stages of the occupation. This was subsequently confirmed by a ^{14}C date for the base which was statistically inseparable from a date from charcoal contemporary with the destruction of the last hut on the site. Pollen analysis and ^{14}C dating of the shorter sections, TMD1, TMD4, TMD5, showed that they had even later origins and were similarily of limited use as regards the interpretation of the main body of evidence.

It was obvious that if the work was to continue the project would have to be broadened to accommodate the analysis of a longer section from an older deposit. Such deposits were known to exist on Machrie Moor, to the east, (Durno, unpublished) and despite intensive peat cutting in the area 4.5 metres of apparently undisturbed peat were located and sampled. Preliminary analysis of the section (MML80) revealed that the deposit began forming in early post-glacial times, with an unbroken sequence continuing through almost to the present day. Detailed analysis, therefore, would give information about the whole of the occupation period, albeit in a somewhat more general form. However there were added bonuses :-

1. The section would provide a regional pollen diagram for the west of Arran which covered the majority of the post-glacial. This would trace the development of the vegetation prior to the involvement of the prehistoric populations, augmenting the existing vegetational work in the area (Nichols, 1967, Moar, 1969a, Birks, 1972, 1975, Rymer, 1974, 1977, Turner, 1965, 1970, 1975, Durno, in Mercer, 1968).

2. The diagram would also reflect regional events subsequent to the arrival of man and with the emphasis on human impact on the environment, the data would tie in with similar work from Scotland and Northern Ireland (Pilcher, 1969, 1979, Smith and Pilcher, 1973, O'Sullivan, 1974, Davidson et al, 1976, Caseldine, 1979, Edwards, 1979, Keatinge and Dickson, 1979).

3. On a more local front the analysis would provide a framework for the interpretation of data from past excavations on Arran (Durno in MacKie, 1964) and also the recent ones in the Vale of Shiskine area, by the C.E.U. at Kilpatrick and near Auchagallon, and by Dr. Aubrey Burl on Machrie Moor.

1.2 Pollen Analysis and Archaeology in Scotland

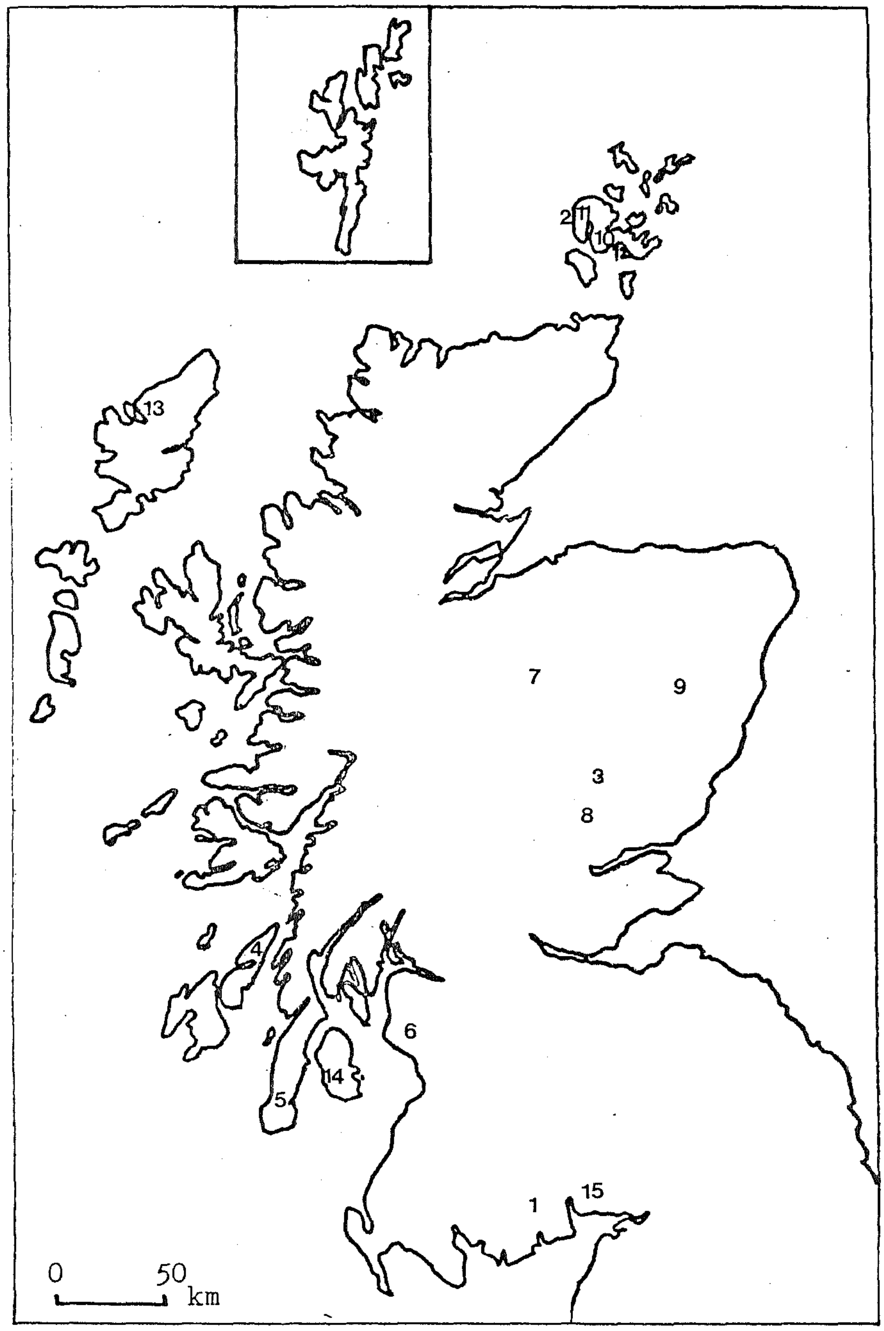
Data concerning the vegetational history of Scotland has been steadily accumulating since the early pioneering work of Erdtman in the 1920's. The similar application of pollen analysis techniques to archaeological problems has a shorter history with the work of Knox (in Piggott, 1953) and Lambert and Godwin (in Childe, 1956) being among the earliest. Until recently these two branches of the discipline have evolved in a somewhat parallel fashion, largely due to the nature of the deposits involved.

Vegetational studies concern in the first instance the migration of tree species following the last glacial and the development of forest patterns (see Section 1.3). The sites for study are chosen accordingly, with a complete sequence of post-glacial and preferably late-glacial deposits being required from a deposit with a regional rather than a local pollen catchment. The resulting diagram is also interpreted in regional terms. Inevitably the

Figure 1.1

Showing the locations of the sites referred to in section 1.2.

1. = Milton Loch, Dumfriesshire , (Knox, in Piggott, 1953).
2. = Maes Howe , Orkney, (Lambert and Godwin, in Childe, 1956).
3. = Dalnaglar, Perthshire, (Durno,1965, Durno, in Stewart, 1964).
4. = Jura (several sites), (Durno, in Mercer, 1968 - 1974b).
5. = Aros Moss, Kintyre, (Nichols, 1967).
6. = Bloak Moss, Ayrshire, (Turner, 1965, 1970).
7. = Speyside (East-Central Highlands), (O'Sullivan, 1974).
8. = Forest of Alyth, Perths. (Caseldine, 1979).
9. = Howe of Cromar, Aberdeenshire, (Edwards, 1979).
10. = Orkney,(several sites), (Davidson et al.,1976, Jones in Renfrew, 1979).
11. = Orkney, (several sites), (Keatinge and Dickson, 1979).
12. = Birsay, Orkney, (Morris, 1979).
13. = Callanish, Lewis, (Cowie, 1980).
14. = Tormore and Kilpatrick, Arran, (Barber,1980a, 1980b).
15. = Racks Moss, Dumfriesshire , (Nichols, 1967).


0 50 km
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15

effects of human disturbance on the vegetation are apparent at some stage. However these are rarely seen before 5000 BP and as the major forest patterns in Scotland were established by 6000 BP (Birks, 1977), detailed discussion relating to any archaeological monuments in the vicinity tends not to be undertaken.

Conversely the pollen in deposits coming from, or relating to, archaeological excavations tends to be very local in origin. The excavator is unable to exercise a great deal of choice over the material available for sample as most of the initial decisions concerning the site are governed by the archaeology. In consequence only a rather limited interpretation is possible which is hard to relate to other work.

Attempts have been made to bridge the gap from both sides. Durno(1965, in Stewart, 1964) attempted to relate a long pollen diagram from a bog at Dalnaglar in Perthshire, both with the excavation of Iron Age hut circles close by and events in the area as a whole. His main interest was in detecting 'landnam' phases. He also prepared a similar reference curve from northern Jura to aid in the interpretation of his work with Mercer on several Mesolithic sites (Durno in Mercer, 1968,1970, 1971, 1972, 1974a, 1974b).

In vegetational studies it was Nichols (1967) and Turner (1965, 1970) following her work at Tregaron in Wales (1964), who first emphasised human influences on Scottish vegetation, although again their sites were not chosen with any particular monuments in mind. That step was taken by O'Sullivan (1974) and later Caseldine (1979) and Edwards (1979) who concentrated on tracing and evaluating the impact that the occupants of certain monuments had on the environment. As Edwards (1979) remarks, "Pollen analysis..... when supported by the increasingly indispensable facility of radiocarbon dating can provide a staggering amount of environmental information". However the real cutting-edge can be supplied when detailed vegetational work is linked directly with modern techniques of archaeological excavation. The "staggering amount of information" which Edwards speaks about can be related to archaeological contexts and economies, and land use can be explored with much greater resolution. This was first illustrated by Smith and Pilcher (1969) at Beaghmore and later at Ballynagilly (Pilcher, 1979), both in Northern Ireland. In Scotland, Jones, in conjunction with Davidson and Renfrew (Davidson et al., 1976, Renfrew, 1979), has been attempting to reconstruct the prehistoric environment on Orkney using regional data from peat bogs and local data from the excavations at Maes Howe and the Ring of Brogar. Also on Orkney, Keatinge and Dickson (1979) have been involved in similar work relating to the re-excavation of Skara Brae (Clarke, 1976).

Projects of this nature have encouraged further work, with the routine collection of material for pollen analysis during excavations and the sampling of nearby deposits to give regional information. The work in this thesis is an example and there are several other studies either imminent or in progress in Scotland (see Morris, 1979, Cowie, 1980, Barber, 1980b, Whittle, 1980). As the information from these becomes available it should become easier to correlate events over a wider area. Also as a framework of regional data builds up the integration of analyses from individual sites will be possible without the provision of a specific regional curve. Indeed, on Orkney this appears already to be the case.

NB. A summary of pollen analysis directly concerned with archaelogical excavations in Scotland is included in Appendix A4 , see also section 2.7.

1.3 The Forest History of the South-West of Scotland

At the present time approximately 10% of land in Scotland is covered by forest of which 95% is coniferous (Gauld, 1980). However the majority of this has been planted during the last 200 years and if these recent plantations are ignored almost the whole of Scotland can be considered to be in a state of deforestation. This is largely the result of the actions of man and his domesticated animals over the past 5000 years. Remnants of natural and semi-natural woodland do occur however, often in inaccessible places such as on cliffs and the sides of deep gorges. The study of these relict woodlands led McVean and Ratcliffe (1962) to divide Scotland into four regions on the basis of the woodland type which each of these could potentially support (see Fig. 1.2.). Arran, being in the south-west of Scotland, lies in the region of potential oak forest with birch. The few woodland fragments presently extant on the island are much the same in composition as those described for the region as a whole (Birks, 1977, 1980), although examples of oak woodland are very small and scattered (see section 2.5).

Several pollen diagrams have been published from the south-west of Scotland tracing the development of the woodland during all or some of the period since the end of the last glacial (Nichols, 1967, Durno in Mercer 1968, Moar, 1969a, Birks, 1972, 1975, Rymer, 1977). Others are available in an unpublished form (Rymer, 1974, Peglar, 1976-77, in Birks, 1980, Dickson, 1980). Birks (1977, 1980) has taken account of these, emphasising those with a good sequence of ^{14}C dates, to produce a regional synthesis

Figure 1.2

Showing the potential distribution of woodland types in Scotland (after McVean and Ratcliffe, 1962, Birks, 1977).

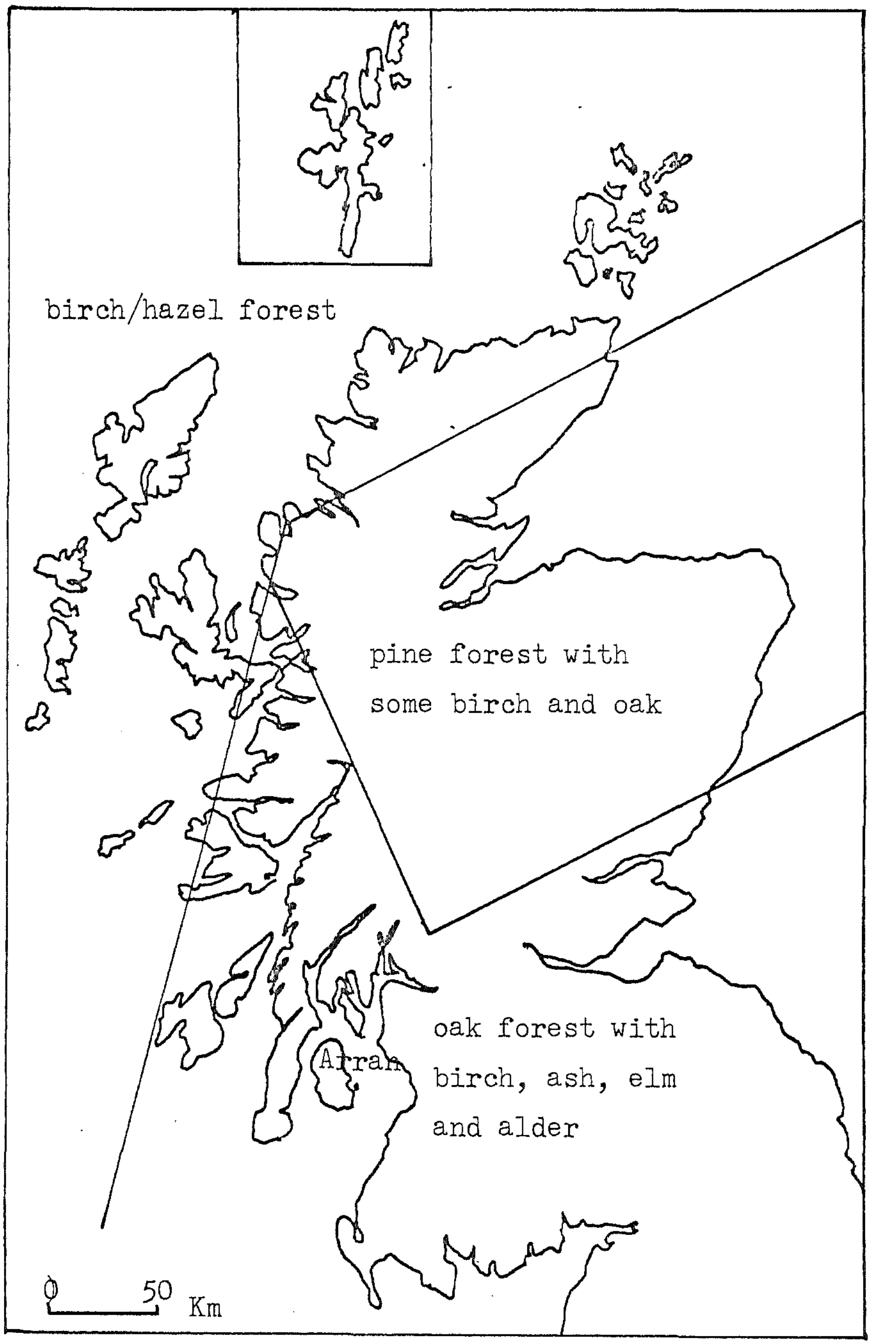

birch/hazel forest
pine forest with
some birch and oak
oak forest with
birch, ash, elm
and alder
Arran
0
50 Km

Table 1.1

Principal Categories of Land Use in Scotland after Gauld (1980).

(Area expressed in MHa).

Land Category	Area	% of Total
Rough Grazing	4.7	57.7
Arable, temporary and permanent grass	1.7	21.8
Forest	0.8	10.0
Urban	0.2	2.5
Miscellaneous	0.2	2.5
Inland water	0.2	2.5
Total	7.8	100

for forest development.

At the end of the last glacial the landscape was dominated by a mosaic of Juniperus/Empetrum heath and herb communities consisting mainly of sedges and grasses, but also containing competition intolerent species such as Thalictrum and Artemisia norvegica.

By about 9800 BP Betula (probably B. pubescens) expanded, forming open birch woodland also containing Populus, several species of Salix, tall herbs such as Filipendula and ferns such as Dryopteris filix-mas.

This was quickly followed by an expansion of Corylus avellana (hazel) around 9500 BP resulting in a mixed hazel/birch woodland with perhaps the hazel occupying the richer soils.

Subsequently this woodland was replaced as Quercus and Ulmus expanded, forming mixed deciduous forest with Hedera, Ilex, Sorbus aucuparia and Lonicera. In Galloway this occurred at 8500 BP, further north in Argyll it took place some 500 years later.

Pine (Pinus sylvestris) was never an important component in the woodland of the south-west, it appeared not to be able to compete with the established deciduous trees and was confined to marginal habitats such as at the tree-line and on dessicated peat bog surfaces. It did however arrive in Galloway around 8000 BP, having a minor presence in just such the habitats mentioned (Birks, 1975). Lime (Tilia cordata) is not considered by Birks to have ever been native in Scotland.

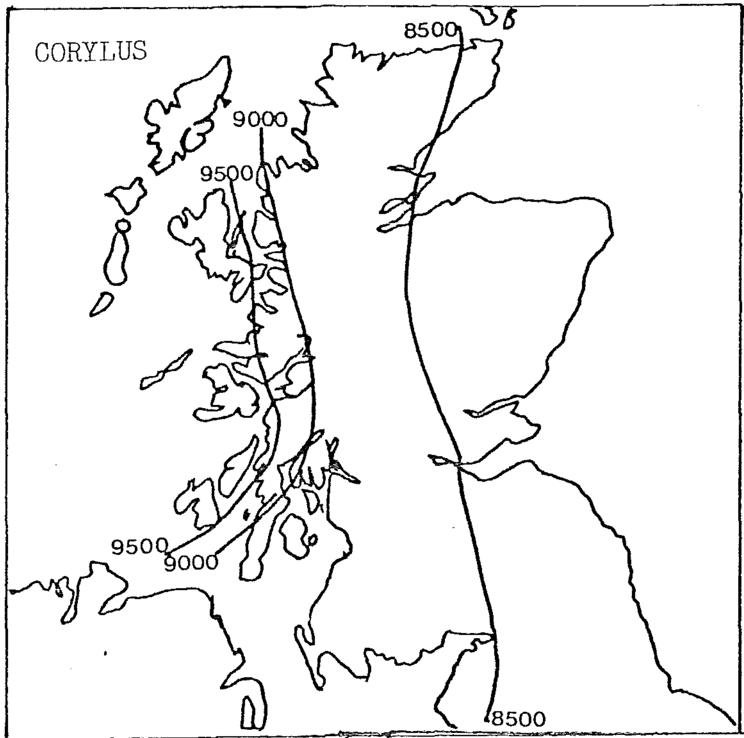
Alder (Alnus glutinosa) expanded about 7500 BP, possibly into the wet habitats previously occupied by Salix and Betula. A similar date is recorded from sites in the north of England, whereas dates from central and northern Scotland tend to be between 1000 and 2000 years younger. Rymer (1974) reports the local abundance of alder in south Argyll 500 years prior to the regional expansion. A small alder peak preceding the main expansion is also a feature of other diagrams (Nichols, 1967, Birks, 1972).

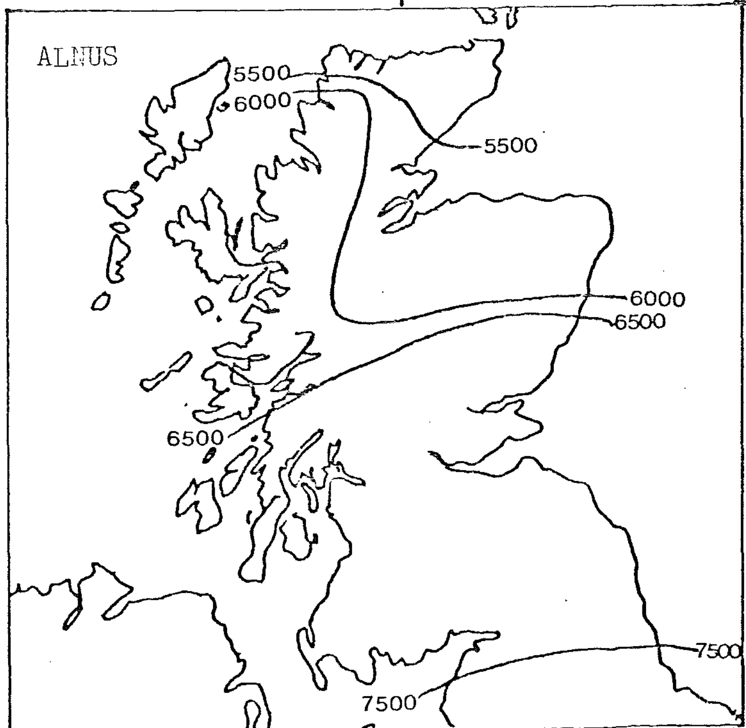
By 6000 BP the major forest patterns were established, the various differences being due to a complex interaction between climate, soil and the migration rates of the various trees, further complicated by geographic obstacles. Change tended to occur at a much earlier date in the south-west due to the mild wet climate and the fact that being further south, the tree species tended to reach it sooner.

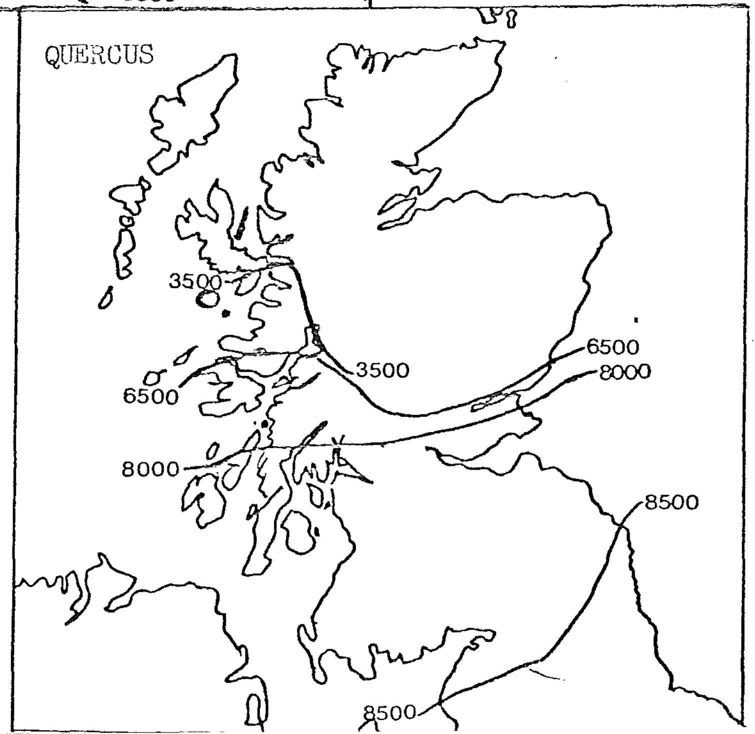
Interference with the forest canopy by prehistoric human populations appears to have begun in earnest around 5000 BP, coincident with the decline in elm (Ulmus). Mesolithic man was present in the area prior to this and evidence for small scale activity is claimed by Nichols (1967) and Dickson (1980). However this is unlikely to have been of the same magnitude as that

Figure 1.3

Isochrone maps showing the times of the major expansions of *Corylus*, *Alnus* and *Quercus* in Scotland (after Birks, 1980).


CORYLUS
8500
9000
9500
9500
9000
8500


ALNUS
5500
6000
5500
6000
6500
6500
7500
7500


QUERCUS
3500
3500
6500
6500
8000
8000
8500
8500

envisaged for the same period in England (Simmons, 1969, 1975a, 1975b, Jacobi et al., 1976) and the overall effect on the vegetation would have been slight.

At the time of the first major Neolithic clearances elm appears to have suffered disproportionately in the south-west of Scotland just as in the rest of north-western Europe. Climatic change, disease and direct human action have all been implicated to some degree in this. Evidence from absolute pollen diagrams, however, is now showing that although elm did suffer a major reduction, other forest species including oak and pine were also affected (Pennington, 1975, Sims, 1973, Beckett and Hibbert, 1976, 1979. This fact was obscured by the method of expressing pollen data in percentage terms. This tends to strengthen the view that the observed elm decline is anthropogenic in origin.

Clearances at this time in the south-west seem to have been small-scale with little permanent effect on the canopy and the general absence of cereal pollen would suggest a pastoral based economy (Turner, 1970, 1975, Nichols, 1967).

This activity was greatly intensified in the Bronze Age and later Iron Age with much more obvious inroads being made into the forest cover (Nichols, 1967, Rymer, 1974). However the extent of this was not uniform over the whole area. Turner (1970) reports from Bloak Moss in Ayrshire that deforestation did not occur until Dark Age times (ca. AD 400).

With the coming of the Iron Age deforestation proceeded apace in much of the south-west. Clearance was no longer just for agricultural purposes but also to provide timber for the making of charcoal for iron smelting. Later, the construction of ships and building made great demands on the native forest. These trends have continued unabated, with the modern open landscape being the end result.

On Arran some extensive forests are reported from medieval times (Anon, 13th cent., Monro, 1703). By the middle of the 18th century, at the latest, these had disappeared and the island was so devoid of timber that trips had to be made to mainland Ayrshire to obtain wood to make ploughshares (New Stat. Acc. 1845). Attempts were made to reverse this situation both on Arran and in the rest of the country through the planting of trees. The Arran plantations began in the late 18th century with the planting of pine (Pinus sylvestris), silver fir (Abies alba), oak (Quercus sp.), ash (Fraxinus excelsior), elm (Ulmus sp.), sycamore (Acer pseudoplatanus), birch (Betula sp.) and also poplar (Populus), walnut (Juglans), chestnut (Castanea) and Laburnum in sheltered areas (New. Stat. Acc. 1845). Various plantations have sprung up since then, the majority being of coniferous species (mainly spruce (Picea) and larch (Larix)) for timber production rather than aesthetic purposes. Many exotic species are present in the grounds of Brodick Castle and in private gardens.

In 1952 the Forestry Commission began operations in Arran and they are still very much involved with the afforestation of large areas of the island. Similar programmes are in evidence throughout the south-west and Scotland as a whole. The development of both coniferous and deciduous plantations can readily be traced in pollen diagrams which extend to recent times for example at Snibe Bog in Galloway, (Birks, 1972) and both Aros Moss on Kintyre and Racks Moss near Dumfries (Nichols, 1967).

1.4 The Origin of Blanket Peat

The peat sections from Tormore and Machrie Moor which form the basis of this study are all made up, to some extent, of blanket peat. The origins of this shallow ombrogenous peat, which covers much of upland and western Britain, is a subject which has prompted much discussion in recent years. Particular attention has been paid to the roles played in its initiation by climate and soil and also by the actions of prehistoric populations.

The first blanket peats began forming in the upland basins and on the plateaux of the British Isles in the early Atlantic period i.e. around 7000 BP (Conway, 1954, Durno, 1958, 1959, Tallis, 1964a, 1964b, Tallis and Switsur, 1973, Hicks, 1971, Moore, 1975). Although Moore (1975) argues that, in the Pennines at least, the basal deposits are due to an original peat-forming woodland with a switch to blanket peat proper occurring nearer to 5000 BP. This would coincide with a phase of initiation throughout Britain, for which the local elm decline is often an accurate marker (Moore, 1975). Initiation continued throughout the prehistoric period, with some deposits forming as late as Medieval times (Radley et al., 1974). Dates for the basal layers commonly coincide with a secondary elm decline and Beaker/early Bronze Age clearances around 4000 BP and with late Bronze Age/Iron Age events in the 1st millenium BC (Moore, 1975, Smith, 1975, Goddard, 1971, Keatinge and Dickson, 1979).

In general the shallower deposits tend to be the most recent, although the depth is also porportional to the slope of the underlying topography (Taylor and Tucker, 1968). Attempts have been made to measure the rate of growth of blanket peat using deposits of considerable age with horizons dated either by the pollen curves (Durno, 1961) or by ^{14}C dates (Pears, 1975). Mathematical modelling of the accumulation has also been attempted on peat which began forming over man-made features of a known historical age (Maltby and Crabtree, 1976). Rates from ^{14}C dated profiles in the Cairngorms varied from 1.4 – 3.4 cm per 100 years (Pears, 1975).

Peat accumulation occurs when the rate of deposition of organic material on to a soil surface exceeds the rate at which that material is decomposed. This situation normally arises when the actions of the soil animals and micro-organisms responsible for this decomposition are inhibited in some way, for example by acid or anaerobic conditions. In the case of peat formation both of these may be involved, although the latter, through the medium of soil waterlogging, is the more important if peat growth is to proceed beyond the acid-humus stage (Pennington, 1975, Taylor and Smith, 1972, Iversen, 1964).

The four main factors involved in soil waterlogging have been outlined by Moore and Wilmott (1976), these are as follows:-

1. The topographic situation being such that drainage water is received by the site.

2. Increased water supply due to climatic change involving an increase in the precipitation : evaporation ratio.

3. Soil maturation leading to the induration of the B horizons and the consequent waterlogging of the A horizons.

4. Alterations in the hydrological cycle produced by changes in the vegetation, for example the replacement of forest by grass-land through the intervention of man.

The first three of these have long been recognised as being involved in the process of blanket peat initiation and growth (Taylor and Tucker, 1968, Taylor and Smith, 1972, Godwin, 1975).

With regard to topography, Bellamy (1972) states that "Anywhere that water collects on its way from the catchment to the sea constitutes a template for peat formation". More particular reference to blanket peat is made in papers such as those by Moore (1972a) and Hafsten and Solem (1976) who recognise the importance of an undulating landscape. Marshy hollows act as point sources and centres of growth leading to the spread of peat over the intervening dry land once the threshold to peat accumulation is crossed.

Climate and soil maturation are undoubtedly important factors in the crossing of this threshold and were for some time considered to be wholly responsible. Increased precipitation in a deteriorating climate accelerates soil leaching and in consequence promotes podsolisation. There may be subsequent pan formation, due to the precipitation of transported iron colloids, which in turn may impede drainage leading to waterlogging and peat formation. Godwin (1975) considered that podsolisation, through the process described above, was a prerequisite for blanket peat formation and that blanket peat could be considered to be the final stage in soil maturation in high rainfall areas (Godwin, in Lamb, 1964). However both Moore (1975) and Smith et al. (1981, p.108) doubt the effectiveness, in all cases, of the sub-surface iron pans as agents of peat formation. In addition other evidence exists which suggests that a straightforward interaction between climate and soil pedogenesis may not be all that is involved. Dimbleby (1965a) remarks that many sub-peat soil profiles are immature and in a similar vein Crampton (1966) mentions that many peats have developed over soils which do not show signs of intensive leaching.

Although wet conditions are undoubtedly necessary for peat formation they do not always lead in that direction. There are many places which are as wet or wetter than upland Britain and yet are peat-free and show signs of only incipient podsolisation (Smith et al., 1981). One example given is the Appalachian mountains which have a similar climate but also have tree-cover up to 1500 metres. However as this is in a different continent, the parallel cannot be drawn too closely.

The fourth factor, hydrological changes brought about by human interference with the vegetation, has been identified for some time but its influence has been somewhat underestimated. In the past decade, Moore (1972a,1973, 1975), Moore and Merryfield (1974), Moore and Wilmott (1976), Smith (1970, 1975), Simmons (1969, 1975a, 1975b) and Pennington (1970, 1975), through their own work and the collation of that of others, have shown that prehistoric man has had a profound effect on the processes leading to blanket peat formation in this country. In addition it has been suggested (Moore, 1975) that many of the features seen in sub-peat profiles are the consequence, rather than the cause, of deforestation and subsequent peat formation.

Human influence has been exerted primarily through deforestation and intensive landuse which dramatically alters both hydrological and nutrient cycles. The initial clearance of the land can be brought about in a number of ways, by felling, by burning and through the grazing activities of animals preventing progressive regeneration of the canopy. The first, immediate, consequence of deforestation is an increase in the surface-water runoff. Trees transpire a great deal more water than the herbaceous or shrubby vegetation which replaces them and hence their removal creates a surplus in the system. Experimental estimates of the increase in runoff vary from 8 - 40%, depending on the methods employed to measure it and the forest composition. The work of Swank and Douglas (1974, in Moore, 1975) extrapolated to British conditions of a woodland in Neolithic times gives a figure of at least 10% (Moore, 1975). An increase of this magnitude would have quite serious effects, promoting soil erosion, increasing leaching and the loss of nutrients and particulate matter from the watershed (Davis, 1976, Culleton and Mitchell, 1976). These effects would be accentuated if the use of fire was involved. Burning removes a great deal of the surface organic material and minerals are in a much more soluble form and are, therefore, more readily leached. The overall effect is a more rapid progression towards the loss of soil structure and stability, with compaction, poorer drainage and gleying (Bridges, 1978).

The partial deforestation of an area alone may raise the water-table so significantly that the remaining trees die. A situation is described from Poland (Skarzynska in Moore, 1975) whereby an Iron Age culture, based in lowlying areas, was swamped by peat-forming vegetation as a consequence of the deforestation of the surrounding catchment.

Complete deforestation and the growth of shallow-rooted shrubs, such as Corylus (hazel), or of herbaceous species also interferes with the nutrient cycle (Dimbleby, 1965a, 1965b, 1975, 1976) and again the effect is amplified by burning. In the absence of deep roots the nutrients which are naturally leached downwards in the soil are no longer returned to the surface and soil conditions become increasingly acid. This alone is not too detrimental but, as mentioned earlier, it does tend to inhibit the activities of soil animals, such as earthworms, and the soil micro-organisms involved in the breakdown of organic material. Accumulation of mor humus is the result and under the favourable conditions produced by a deteriorating climate or forest clearance this may switch to peat formation (Pennington, 1975).

Ungulates grazing in a woodland tend to feed on the leaves and bark of young saplings. If the grazing pressure is sufficiently intense this may result in the opening of the woodland canopy as the older trees die and fall in the absence of replacements. Simultaneous trampling and breaking up of the ground surface may also have serious implications, particularly in wet woodlands. These tend to be in a state of ecological stress and the disruption of what soil structure there is plus the liberation of nutrients and further waterlogging may be sufficient to tip the balance towards premature tree-death and the establishment of peat-forming communities. Moore (1973) sees this as one of the major pathways to blanket peat formation.

Once an area is cleared the subsequent arable and pastoral agriculture can instigate peat forming processes. Dimbleby (1975) writes: "it can be demonstrated that on acidic parent materials, the clearance of primary forest, followed by pastoral or arable agriculture may institute a new process of soil genesis resulting in a different soil, a less biologically active one, compared with the mature soil which preceded forest clearance". A good example of this is seen in the initiation of the peat deposits at Goodland Townland in Ireland (Case et al., 1969). The sequence of events was as follows:-

1. The clearance of forest associated with a brown podsolic soil.

2. The cultivation of a soil in which earthworms were active.

3. The conversion to pasture, the soil progressively acidifying.

4. The disappearance of the earthworms and the development of a leached soil with a thin iron pan.

5. The development of surface wetness, probably due to the deterioration of the soil structure.

6. Onset of peat formation, still within the Neolithic period.

The whole process appears to have occurred very rapidly, over the space of a few hundred years, although Mitchell does stress that there may have been a gap of as long as 500 years between the Neolithic land use and the onset of peat growth.

A similar scheme is inferred by E. E. Evans (1975). He mentions the formation of a fibrous surface layer on heavily grazed outfields in Ireland. This can eventually lead to a loss of contact with the soil, surface wetness and more serious waterlogging. Keatinge and Dickson (1979) suggest that heavy grazing may also have been involved in the formation of areas of blanket peat on Orkney.

Arable agriculture tends to have even more profound effects. A study of the effect of recent cultivation on arable and grassland soils in the period 1945 -1970 (Low, 1972) shows the very rapid deterioration which occurs, albeit under intensive modern agriculture. Although the work is not directly comparable, it is interesting to note that the conversion of grassland to arable purposes markedly decreases the number of earthworms in the soil, increases compaction and the resistance to the passage of water and the soil density increases almost to the point of stopping root penetration

Wet arable loam soils suffer puddling and surface gleying and with repeated ploughing the total nitrogen content of the soil falls.

To return to the involvement of prehistoric agriculturalists, the evidence for this is in the main rather circumstantial:-

1. Periods of peat initiation often seem to coincide with periods of intense prehistoric activity in the forests, such as at the elm decline, during Beaker and later Bronze Age times and in the Iron Age (Moore, 1973, 1975, Smith, 1975, Goddard, 1971, Case et al., 1969, Mitchell, 1972, Ritchie et al., 1974).

2. The basal layers of the peat often contain pollen of ruderal and weed species commonly associated with human clearance and settlement (Moore, 1973, Keatinge and Dickson, 1979, Simmons and Cundill, 1974, Whittington, 1978, Edwards, 1978, Durno in Fairhurst and Taylor, 1971).

3. Charcoal too is often present in the upper soil and lower peat layers(Durno and McVean, 1959, Keatinge and Dickson, 1979, Whittington, 1978).

4. In the absence of either cultural pollen or charcoal artifacts from the various periods are often well represented nearby (Bartley, 1975) or are preserved at or near the soil/peat interface (Jacobi et al., 1976).

As mentioned earlier peat initiation is often marked by the elm decline but in several instances this is not the case. Moore (1975) lists a number of sites where peat began forming at an earlier time. However this is not taken as evidence against the involvement of Neolithic farmers as there is increasing evidence to suggest extensive interference with the environment prior to 5000 BP (Lynch, 1981).

Mesolithic populations may also have played a less than passive role, with intensive local modification of the environment,and they too may have been involved in the initiation of these early deposits (Simmons, 1964, 1969, 1975a, 1975b, Jacobi et al., 1976, Dimbleby, 1962, 1965b). The majority of the evidence comes from Dartmoor and the Pennines. There appears to have been the systematic clearance and burning of areas of forest, increasing the availability and nutritional value of material suitable for grazing and browsing by ungulates. This would tend to concentrate these animals in these areas where they could readily be exploited. The extensive use of fire in game management by hunter/gatherer cultures is well documented and a very comprehensive account is given by Mellars (1976). Smith (1970) speculates that fire may also have been used to increase the frequency and productivity of <u>Corylus</u> (hazel), the nuts being useful food.

In later times animals may have been herded in a semi-domesticated fashion. There is evidence for the use of domesticated dogs (Simmons et al., 1981) and finds of ivy pollen in a Mesolithic context (Simmons and Dimbleby, 1974) may indicate ivy's use as a fodder plant for tethered animals.

Repeated pressure along these lines, especially in exposed areas and at forest margins which tend to be ecologically unstable, could quite rapidly produce permanent deforestation followed by heath or blanket peat formation (Dimbleby, 1976, Simmons, 1975a, Jacobi et al., 1976). The seasonal movement of the hunters with the game would mean that these pressures were exerted on several fronts and the extent of the changes produced may, accordingly, have been quite out of proportion with the small size of the populations involved. It has been suggested that an example of this may be the depressed tree-lines apparent at this time. The forest limits were commonly around 600 metres when climatologically there appears to be no reason why they should not have exceeded 900 metres (Dimbleby, 1975, Grigson, 1981, p.105).

However the importance of human intervention should not be overestimated. Most authors see the pressure exerted by human populations and their animals as tipping the balance towards peat formation in an already stressed environment. The initial stress is exerted by the prevailing climate and soil status and this is readily seen from a simple distribution map of blanket peat in Britain. Soil depauperisation was already well advanced by late Atlantic times (Romans and Robertson, 1975, Mackereth, 1965, Walker, 1966) and both Moore and Chater (1969) and Pennington (1975) report wetter conditions in the uplands of Wales and the Lake District at this time. Similarily another period of peat initiation, the late Bronze Age/early Iron Age, is generally accepted as being one of deteriorating climate (Lamb, 1977, Piggott, 1973).

It is conceded (Smith, 1975) that peat would have developed in any case in many of the basins and on many of the plateaux in upland Britain and indeed instances of this independant development are known from Norway (Hafsten and Solem, 1976). There are still those however who see man's role as purely incidental. Ball (1975) states that 'on balance .... The highland trends in soil formation, due to the climate, geology and relief have been clearly running in the direction of leaching, acidity, podsolisation, gleying and peat formation' and that 'man has only intervened to hasten or slow the rate of these trends'.

As Smith (1981) remarks 'The fossil remains of plant and animal communities are a very poor substitute for a time machine'.

CHAPTER TWO

THE ISLE OF ARRAN

2.1 Location and Geography

The Isle of Arran lies in the Firth of Clyde between latitude $55^{\circ} 26'$N and $55^{\circ} 44'$N and longitude $5^{\circ}5'$ W and $5^{\circ}23'$ W. The Ayrshire coast is approximately 30km to the east and Kintyre is between 5 and 10km to the west. The island is 32km long, from the Cock of Arran in the north to Bennan Head in the south, and 19km wide, from Imachar Point in the west to Clauchlands Point in the east. With an area estimated at $400km^3$, Arran is the largest of the Clyde islands, although in many ways it is more Hebridean in character.

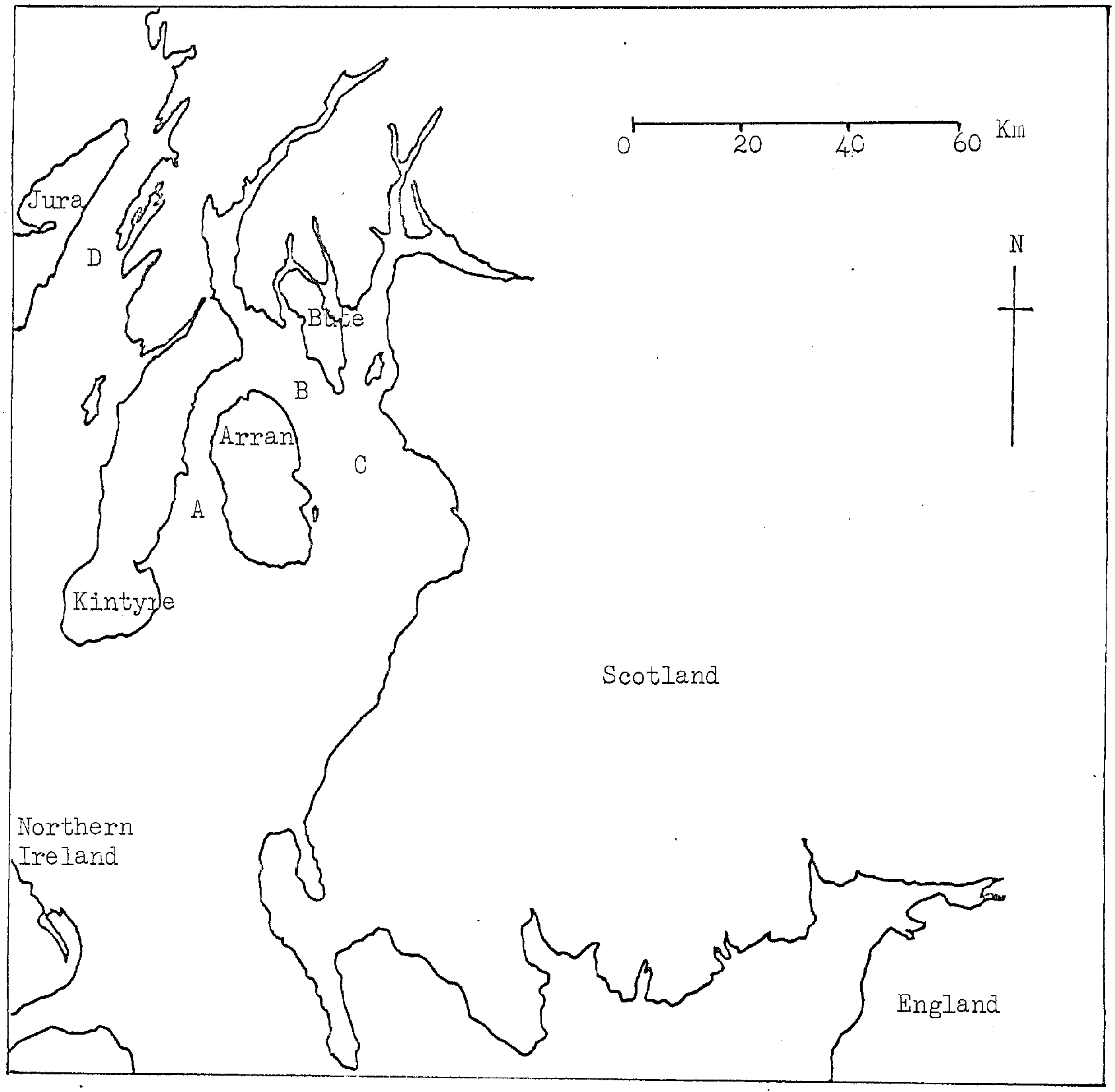
The coastline is regular, broken only by the bays at Brodick, Lochranza and Lamlash. One of its most striking features is the main post-glacial raised beach at approximately 8 metres (25 feet) OD. This is traceable along the whole of the island's coast, apart from in the south at Bennan Head, and it dates from the main Flandrian marine transgression. Traces of raised beaches at approximately 30 metres (100 feet) O.D. and 15 metres (50 feet) O.D., dating from late-glacial sea level changes, are also visible in some areas. The raised rock platform accompanying the 8 metre raised beach is commonly 20 - 30 metres wide, although it occasionally extends to as much as 150 metres. It ends abruptly at the landward edge in steep cliffs, often in excess of 15 metres high. These have been extensively modified by wave action leaving stacks, caves and other undercut features.

Inland, both the geography and topography are complex with a distinct north/south division being obvious along a line from Dougarie in the west to Brodick in the east. In the north the hills are rugged, almost alpine in appearance, showing many glacial features and surrounded by a well developed 1000 foot (300 metre) platform or erosion surface. Several of the peaks exceed 800 metres with Goat Fell, at 874 metres, being the highest.

To the south the hills are much more rolling in appearance, rarely exceeding 450 metres. They extend westward to the sea in long rounded spurs and in the east are characterised by short, deeply incised valleys.

Figure 2.1

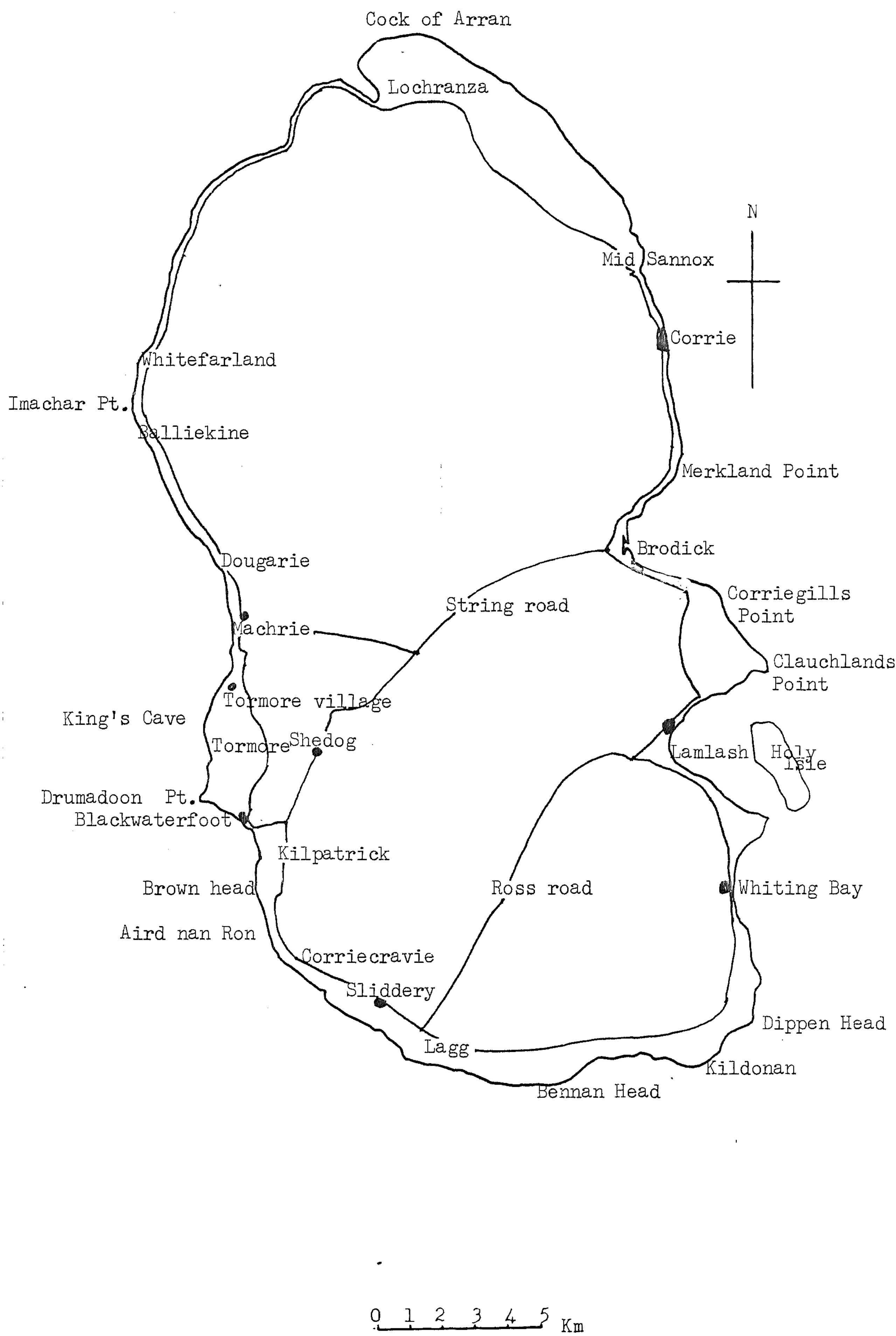
Showing the location of Arran in relation to the Scottish mainland. (A = Kilbrannan Sound, B = The Sound of Bute, C = The Firth of Clyde, D = The Sound of Jura).



0
20
40
60
Km
N
Jura
D
Bute
B
Arran
C
A
Kintyre
Scotland
Northern
Ireland
England

Figure 2.2

Showing the main centres of population on Arran and other locations mentioned in the text.


Cock of Arran
Lochranza
N
Mid Sannox
Corrie
Whitefarland
Imachar Pt.
Balliekine
Merkland Point
Brodick
Dougarie
String road
Corriegills
Point
Machrie
Clauchlands
Point
Tormore village
King's Cave
Tormore
Shedog
Lamlash
Holy
Isle
Drumadoon Pt.
Blackwaterfoot
Kilpatrick
Brown head
Ross road
Whiting Bay
Aird nan Ron
Corriecravie
Sliddery
Dippen Head
Lagg
Kildonan
Bennan Head
0 1 2 3 4 5 Km

Overall the south is more accessible than the north with greater possibilities for communication and settlement.

Flat low-lying land is scarce on the island, tending to be concentrated around the coasts and in the valley mouths. This has resulted in the main centres of population having a similar distribution. All the villages except Shedog, which is in the Vale of Shiskine, are situated on, or very near the coast. The permanent population of the island is approximately 3000, with the majority being concentrated in the south-east of the island in and around the villages of Brodick, Lamlash and Whiting Bay. There has been a shift in population from west to east in the last hundred or so years in response to the decreasing importance of the sea and the land for employment and the growth of tourism and accompanying service industries. However agriculture and forestry are still the main single sources of employment on the island.

2.2 Climate

Arran has a strongly oceanic climate, being both mild and wet. The proximity of the Gulf Stream and the prevailing strong south-westerly winds are largely the cause of this. Winds arriving from over the Atlantic are laden with moisture and unhindered by low-lying Kintyre they encounter the Arran hills, resulting in frequent low cloud and heavy rain. The annual rainfall in the central hills is 80 - 100 in. (203 - 254cm), falling to 65 - 75in. (165 - 178cm) at Brodick in the east and 46in. (117cm) in the west. On average there are about 200 wet days per year, November, December and January being the wettest months, with May and June being the driest and sunniest (McLellan, 1976). Snow is rare, falling mainly on higher ground where it may persist into early summer in north-facing hollows.

The annual temperature range is small, from an average minimum of 36°F (2°C) in January and February, the coldest months, to a July maximum of 64°F (17°C). Frost can occur between mid-November and mid-March but is rarely severe.

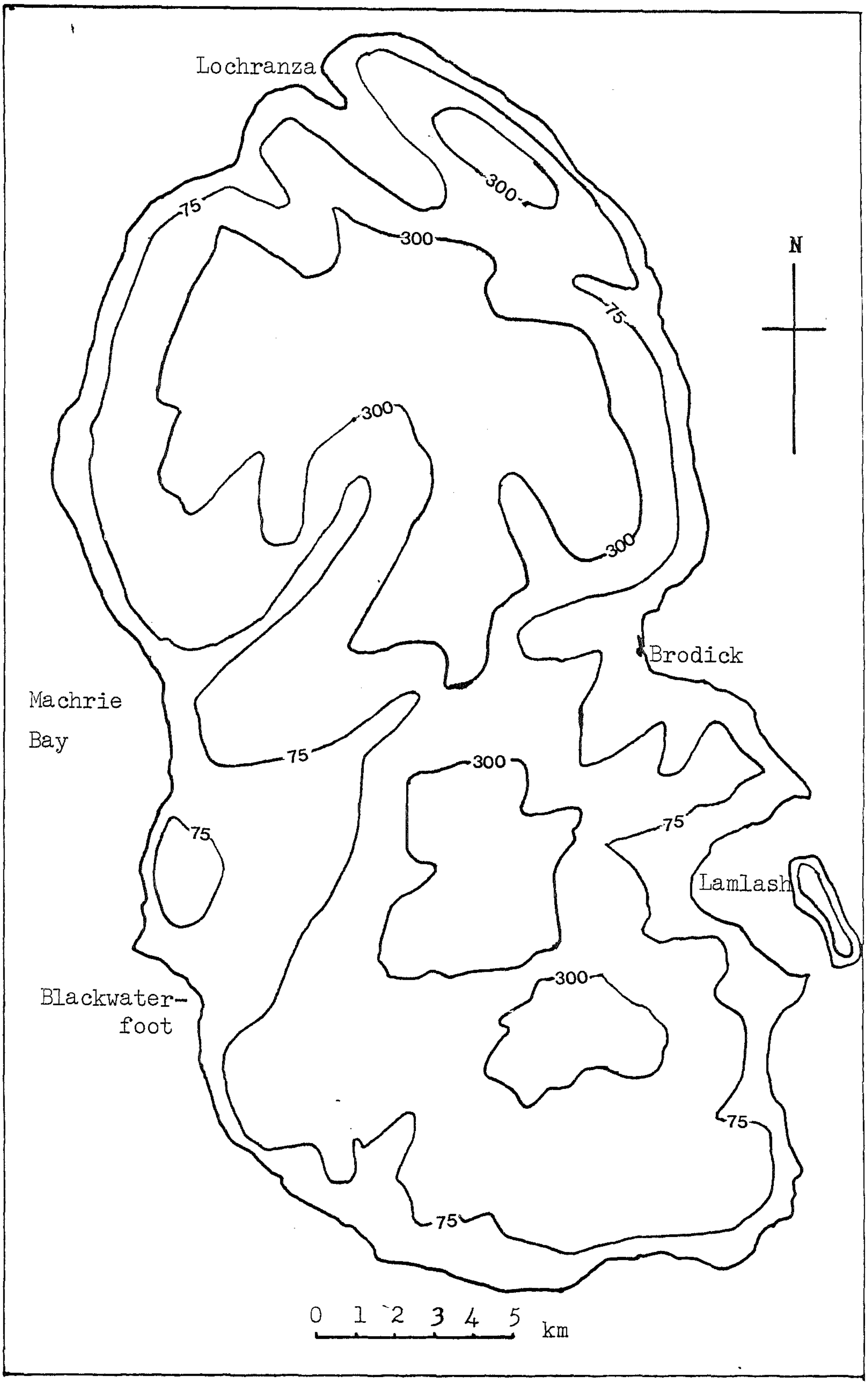
Winds are generally strong and conditions can be very severe in exposed places. Conversely a sheltered valley with a southerly aspect can be almost sub-tropical, allowing the cultivation of exotics such as Cordyline australis and even true palms in some locations, for example at Lagg.

2.3 Geology

The geology of Arran is extremely complex with a great variety of

Figure 2.3

Showing a simplified relief map of Arran (Contours marked in metres). This illustrates the small area of lowlying land on the island. (Adapted from OS sheet 69.)



Lochranza
300
75
300
75
N
300
300
Brodick
Machrie
Bay
75
300
75
75
Lamlash
Blackwater-
foot
300
75
75
0 1 2 3 4 5 km

rocks outcropping on the surface. These range in type from schists and grits to limestone and marls and in age from Dalradian to Tertiary. One of the most recent accounts of the geology is by MacGregor (1965), although works by Tomkieiff (1961), Tyrrell (1928) and Geikie (1910) are still much referred to.

Igneous rocks form by far the most obvious and striking features on the island, Arran being part of the Tertiary volcanic district which includes parts of Northern Ireland, the Hebrides, the Faroes and Iceland.

The north of the island is dominated by a massive eroded granitic boss covering an area of almost $140km^2$, with the smaller central ring complex to the south. Dalradian schists and grits surround the northern granite except at Corrie where they are replaced by Devonian Old Red Sandstone. This continues south to Glen Rosa and Glen Shurig and then westward to Dougarie. Its pebbly grits and conglomerates, laid down under desert conditions, are commonly exposed beyond Machrie. Carboniferous rocks also outcrop in the east with calciferous sandstone, carboniferous limestone, millstone grits and coal measure series all being represented. On Arran the coal measures are a misnomer, being totally represented by clays, shales and sandy beds. At least one coal seam is present in the carboniferous limestone series however, and this was mined for a time in the north of the island.

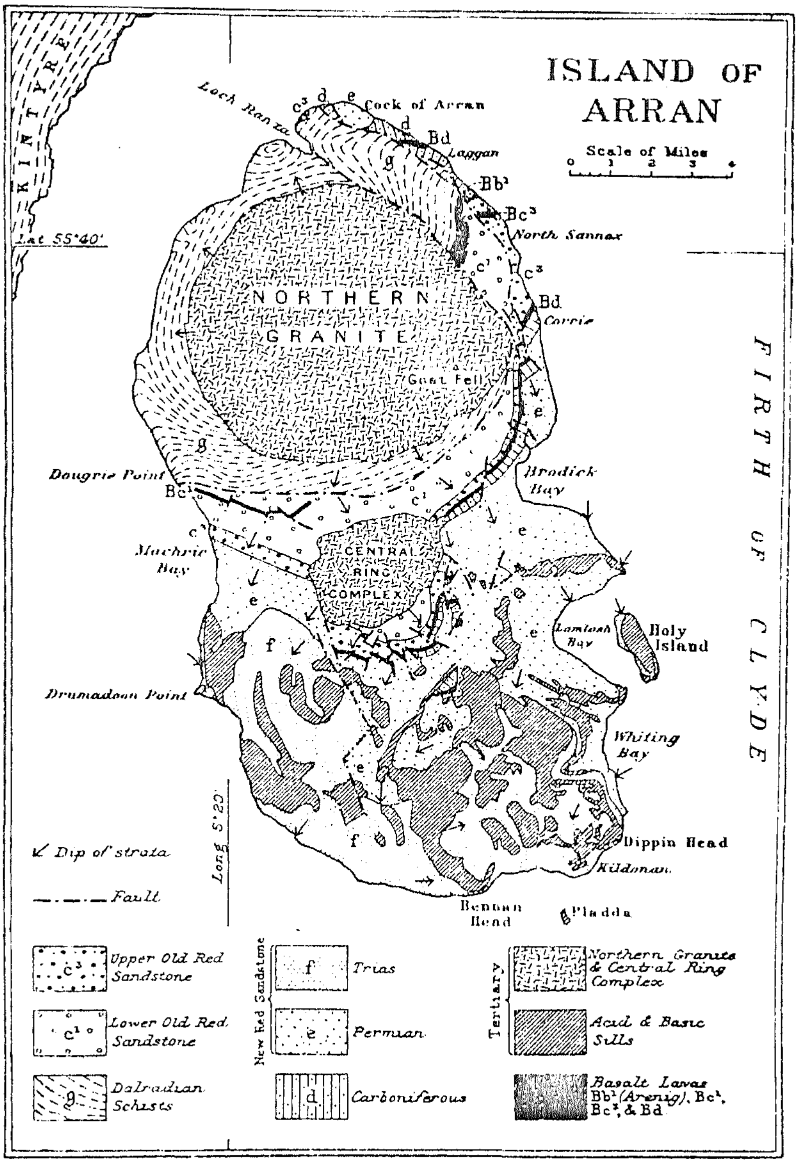
In the south the landscape is characterised by sills and dykes of igneous rock formed by the forcing of molten material through the existing sedimentary rock, ostensibly Permian and Triassic in age. These features are emphasised by the subsequent, more rapid, erosion of the surrounding rock leaving the harder injected igneous material. Around the south coast, Drumadoon Point, Brown Head, Dippen Head and Clauchlands Point are all examples of this. Inland, where the features cross the natural drainage systems, several waterfalls illustrate the stepped landscape which results from the differential erosion of the two rock types. The most spectacular of these is in Glenashdale.

Several other rock types and formations of more minor importance occur at various locations around the island. These are discussed in detail, along with those already mentioned here, in the literature referred to in the opening paragraph.

As was mentioned briefly, Arran has many topographical features of glacial origin, these include corries, glacial troughs, meltwater channels, kames, kame terraces, drumlins, eskers and moraines of various types. Gemmel (1973) considers that the island is "a microcosm of all that may be found in the field of Quaternary research in Scotland". Whilst this is

Figure 2.4

Showing the solid Geology of Arran (reproduced from the Tertiary Volcanic Regional Guide).



ISLAND OF ARRAN
Scale of Miles
0 1 2 3 4
KINTYRE
Lat. 55°40'
Loch Ranza
Cock of Arran
Laggan
North Sannox
Corrie
NORTHERN GRANITE
Goat Fell
Dougrie Point
Machrie Bay
CENTRAL RING COMPLEX
Brodick Bay
Lamlash Bay
Holy Island
Drumadoon Point
Whiting Bay
Dippin Head
Kildonan
Bennan Head
Pladda
Long. 5°20'
FIRTH OF CLYDE
Dip of strata
Fault
Upper Old Red Sandstone
Lower Old Red Sandstone
Dalradian Schists
New Red Sandstone
Trias
Permian
Carboniferous
Tertiary
Northern Granite & Central Ring Complex
Acid & Basic Sills
Basalt Lavas Bb¹ (Arenig), Bc¹, Bc³, & Bd

true, the ice sheet and subsequent late-glacial and post-glacial processes have had a relatively superficial effect on the landscape. The major features of relief and drainage were established prior to the glacial period (Gemmel, 1971, 1973). The opinion is that during the Tertiary Arran was part of an elevated plateau which included most of Scotland. It developed its own drainage system resulting on the westward side in the formation of Kilbrannan Sound, the Sound of Bute, the Firth of Clyde and the main through valleys on Arran. The 300 metre (1000 foot) platform now seen on the island is thought to have been produced by the severe climatic erosion of a high level semi-tropical savanna environment. Although it has been suggested that it may have been due to a period of marine inundation followed by uplift of the land to the present level, the landscape features being modified and accentuated by subsequent ice action. However evidence for this is scant.

2.4 Glaciation of Arran

Ice cover associated with the last glaciation extended to an area including Ayrshire, Arran and Kintyre at about 25000 years BP (Gemmel, 1973, Price, 1980). Prior to this periglacial conditions had prevailed with a tundra vegetation which in central Scotland supported the mammoth (Elaphus primigenius), woolly rhinoceros (Coelodonta antiquitatis) and reindeer (Rangifer tarandus). The mean January temperature was probably of the order of -20°C (Price, 1980).

The build up of ice continued reaching a maximum about 18000 years BP, at which time the ice sheet in Scotland is thought to have been at an altitude of 1600 – 1800 metres. During the early stages the sea-level may have been as much as 100 metres below the present level.

Arran received ice from both the west-central highlands and its own local ice cap centred on the northern hills. Ice from the southern uplands is not thought to have been involved.

Following the glacial maximum at ca. 18000 BP there began a period of downwasting and retreat. Large lobes of ice probably downwasted in situ in the lowland valleys, perhaps in some cases remaining longer than the upland ice. From 15000 – 13000 years BP the climate ameliorated rapidly and by the latter date the temperature may have been much as today's (Bishop and Coope, 1977). The Firth of Clyde was a calving bay for icebergs and this would have greatly accelerated the ice-front retreat. Associated with this retreat was a substantial rise in sea-level which at its maximum left fossil beaches at 27 - 33 metres O.D. (Gemmel, 1973). At the time of this high level the south of the island was largely ice-free although highland and local ice reached down to the sea north of a line from Imachar Point to Corrie. 500 years later only the local ice remained with few, if any, glaciers reaching tidewater.

Despite the fact that the climate was favourable for plant growth the largely inorganic till was a poor substrate. The landscape would have been treeless with patches of pioneer open habitat herbs, scrubby willows, pools and bare till.

The climate deteriorated again after 12000 years BP leading to the onset, at about 11000 BP, of the so-called 'Loch Lomond Readvance' during which ice from the west highlands filled the Loch Lomond Basin and the upper Forth valley. Arran was beyond the full extent of this readvance but the local ice cap is known to have reformed or extended. Only the glaciers in Glen Sannox and Glen Rosa reached tidewater and it is thought unlikely that even small glaciers formed in the south of the island (Gemmel, 1973). The climate began improving again about 10500 years BP (Price, 1980). A very rapid retreat ensued with little downwasting. Arran, along with the rest of Britain, is thought to have been ice-free by 10300 years BP at the latest, although Bishop and Coope (1977) date this nearer to 10000 BP for the south-west of Scotland. By 9500 BP mean July temperatures in central Scotland were about 14^{o}C and by 8000 BP conditions were much as they are today (Price, 1980).

2.5 The Vegetation

Arran is subject to strong oceanic influences and this is reflected in the vegetation and flora of the island. The mildness of the climate is indicated by the presence of several cryptograms of Macaronesian-Tropical affinities (Greig-Smith, 1950), these having their distributions centred in warm oceanic, or even tropical, regions of the world. Examples include Hymenophyllum tunbrigense, Dryopteris aemula and Adelanthus decipiens.

The geology and topography of Arran are both complex and diverse resulting in a broad range of habitats being available to the fauna and flora. Several plant species are present on the island at the limit of their distribution. Trichomanes speciosum, near to its northernmost limit, is known to have grown on the island (Stewart, 1901), but appears to be no longer present. Glaucium flavum and Rhynchosinapsis monensis are near their northernmost British locality. Polypodium australe is near its northern limit, and Juncus trifidus grows in its southernmost British locality. The shingle beaches of Arran provide Mertensia maritima with one of its most southerly locations. Other plants of note include the service trees, Sorbus arranensis and Sorbus pseudofennica. These are endemic to the island and are found in Glen Diomhan and the upper reaches of the North Sannox burn. Sorbus rupicola is also present, being found on the east side of the Holy Isle.

Much of the present vegetation of Arran, like that in the rest of Scotland, is of a derived and artificially maintained nature. Lowland areas, where suitable, are under agriculture, predominately pastoral, although some crops are grown including oats, barley, potatoes, swede, turnips and kale. Higher ground is also grazed, but at a less intensive level, mainly by red deer, Blackface sheep and red grouse, the latter have become less frequent in recent years. Large tracts of marginal upland have been, and continue to be, aquired by the Forestry Commision for afforestation, considerably augmenting the isolated blocks of conifers planted in the nineteenth century.

The majority of deciduous trees and shrubs on the island are also planted or are the result of their recolonisation of cultivated land. Fraxinus, Crataegus, Ilex and Viburnum are common on the margins of fields and in formerly inhabited hollows. Salix and Alnus are also common especially by rivers and in damp areas on the raised beaches. Some fragments of natural and semi-natural vegetation do occur. The only recent attempt to survey and describe these was made during a student field course of the Botany School, Cambridge University in 1974. The vegetation of the saltmarshes, raised beaches, inland mires, dwarf-shrub heaths, mountains and some woodlands was examined and recorded using standard phytosociological methods (Adam et al., 1977). The majority of the following information is summarised from this source.

Plant nomenclature in this and all other relavent sections of the thesis follows Clapham, Tutin and Warburg (1962) for vascular plants, except that Lotus uliginosus is used in preference to L. pedunculatus, Warburg (1963) for mosses, Paton (1965) for liverworts, and James (1965) for lichens.

Saltmarsh Communities

Although not covering a large area, saltmarsh communities are widespread around the coast. In suitable habitats the presence and composition of these appears to be governed by the frequency of tidal immersion, the degree of flushing by freshwater and the degree of nutrient input, particularly from rotting seaweed.

The lowest vascular plant community on the shore consists of isolated eroding patches of vegetation dominated by Puccinellia maritima, and 1 - 2cm high turf fucoids thought to be forms of Ascophyllum nodosum or Fucus vesiculosus., Plantago maritima, Armeria maritima and Glaux maritima are generally present with Festuca rubra and Juncus gerardii occuring higher up the shore.

At the next level the vegetation cover becomes morecomplete, forming a closely grazed sward dominated by Juncus gerardii with Festuca rubra, Agrostis stolonifera, Plantago maritima and Armeria maritima. With increasing distance from the sea Armeria maritima becomes less common and Carex distans, Cochlearia officinalis and Trifolium repens appear. Later Leontodon autumnalis Potentilla anserina, Sagina procumbens, Juncus articulatus and Lotus corniculatus are common, together with several bryophytes.

On some stretches of coast a similar region is dominated by Juncus maritimus. At the seaward edge of the community several halophytes occur, Cochlearia officinalis, Glaux maritima and Plantago maritima. The ground between the Juncus stems here is blanketed by a thick felt of brown and green algae. Further up the shore Agrostis stolonifera and Festuca rubra occur and the vegetation becomes more species-rich with the presence of Galium palustre,Potentilla anserina, Rumex crispus, Leontodon autumnalis, Trifolium repens, Odontites verna and occasionally large clones of Cirsium arvense.

Within the saltmarsh there are areas of gravel subject to flushing by freshwater; these often support stands of Blysmus rufus with Agrostis stolonifera, Festuca rubra and Glaux maritima. Dense stands of Eleocharis palustris may occur in similar situations.

At the highest extent of the saltmarsh at the junction with the raised beach a community dominated by Iris pseudacorus, Filipendula ulmaria and Poa trivialis spans the region from rotting seaweed and shingle to raised beach fen. On the shingle the vegetation is rather species-poor, but several nitrophilous species do occur such as Urtica dioica, Stellaria media and Galium aparine,in response to the nutrient input from the seaweed.

From the saltmarsh/raised beach boundary onto the raised beach proper the vegetation is very species-rich with considerable variation from place to place. Local flushing by freshwater encourages Polygonum hydropiper, Montia fontana and less frequently Catabrosa aquatica. If cattle poaching occurs Ranunculus sceleratus is often abundant.

The suggestion is made by Adam et al. that during the time of maximum forest cover this region,now dominated by Iris etc.,would not have been wooded and may have provided a refuge for several nitrophilous weed species. Later as the forests were opened up they expanded to their present distribution.

Raised Beach Vegetation

With the exception of Bennan Head, the Arran coastline is bordered by the so-called 8 metre (25 foot) raised beach often with an associated fossil cliff to the landward side. Settlers and agriculturalists over the years have been attracted to these flat fertile areas and several townships have built up in this way; drainage and other agricultural improvement ensued. Some stretches of coastline are still largely unaffected by this including those near Corrie and from Lochranza to the Cock of Arran.

To the landward side of the Iris / Filipendula / Poa community shallow largely inorganic peats occur over gleyed mineral soils. The water-table is near or at the surface and the area is flushed by drainage water. This peat supports a mire community dominated by Juncus acutiflorus with Holcus lanatus, Agrostis canina, Sphagnum palustre and frequently Hydrocotyle vulgaris, Potentilla erecta, Lotus uliginosus, Cirsium palustre, Viola palustris and Polytrichum commune. Where the peat is thicker and more organic Molinia caerulea and Myrica gale are the main components of the vegetation with Potentilla erecta, Juncus acutiflorus, Narthecium ossifragum and Erica tetralix.

Locally a mire community dominated by Carex nigra occurs, usually in association with Hydrocotyle vulgaris, Isolepis setacea, Anagallis tenella, Pinguicula lusitanica, Hypericum elodes, Samolus valerandii, Carex hostiana, Drepanocladus revolvens and Sphagnum teres.

The cliff faces usually support woodland as they are rarely subjected to grazing. In exposed sites however the cliffs are treeless, supporting a characteristic range of species including Populus tremula, Luzula sylvatica, Lonicera periclymenum, Digitalis purpurea, Valeriana officinalis, Erica cinerea, Corydalis claviculata, Sedum album, S. anglicum, Lathyrus montanus, Carex laevigata, C. sylvatica, Umbilicus rupestris, Osmunda regalis and Hypericum androsaemum. Bryophytes and ferns are locally frequent and a wide variety of species is present including Hymenophyllum wilsonii, Asplenium trichomanes and Marchesinia mackaii.

Blanket Bog Communities

The Arran blanket bog vegetation is very similar floristically to the Myrica/Molinia community described from the raised beaches. The main difference is the frequent presence in the inland bogs of Trichophorum caespitosum, Eriophorum angustifolium, E. vaginatum, Drosera rotundifolia, Polygala serpyllifolia and Pleurozia purpurea. The overall range of vegetation seen in the blanket bogs is much the same as that seen in the rest of Scotland, although the bogs are not readily assignable to any of the three western associations recognised by McVean and Ratcliffe i.e. Trichophoreto-Callunetum, Trichophoreto-Eriophoretum and Molinieto-Callunetum. There is also a great abundance of Myrica gale on the island and the suggestion is that (Adam et al., 1977) this is related to a particular land use history, but the nature of this is not discussed.

In northern upland areas tracts of blanket bog are occasionally broken by small flushes which are mildly basic and support Schoenus nigricans, Drosera anglica, Carex hostiana, C. dioica, Selaginella selaginoides and Utricularia minor.

Dwarf Shrub Heath

In the north of the island, below 450 metres, well-drained slopes support extensive Calluna heath. This is subject to management in the majority of cases in the form of regular rotational burning or muirburn, as it is known. The heath is dominated by Calluna vulgaris with Potentilla erecta, Hypnum cupressiforme var. ericetorum, Dicranum scoparium and Agrostis canina. Damp north-facing slopes tend in addition to have an abundance of Vaccinium myrtillus and Galium saxatile plus a variety of bryophytes including Mylia taylori, Scapania gracilis, Sphagnum quinquefarium and Plagiothecium undulatum.

Areas less well-drained are characterised by the presence of Erica tetralix, Molinia caerulea, Sphagnum compactum and, surprisingly, Pteridium aquilinum which is normally intolerent of such conditions. Pteridium aquilinum is also found in large stands on slopes all round the island. It often forms a mosaic with the Calluna vulgaris heath and its abundance is a direct consequence of land use involving burning and grazing.

Montane Vegetation

The montane region on Arran is confined to the rugged granitic hills in the north of the island. Few habitats are available for generally basiphilous montane species, the conditions being almost uniformly acid. Sedum rosea and Thalictrum alpinum do occur but are far from abundant, tending to be restricted to cliff ledges and deep gullies.

Vegetation above 450 metres falls into two types. Between 400 and 550 metres wind-clipped prostrate Calluna heath with Hypnum cupressiforme cloaks the cols and ridges. At the highest level from 550 to 874 metres, the latter being the height of Goat Fell, Arran's highest peak, the vegetation is dominated by Vaccinium myrtillus, Rhacomitrium lanuginosum and Alchemilla alpina with Galium saxatile, Carex bigelowii and C. pilulifera. There are local occurences of Salix herbacea and Dicranum fucescens. Persistence of snow cover in some north-facing hollows on Goat Fell is suggested by an abundance of Nardus stricta and Cladonia uncialis.

Woodland Vegetation

Natural and semi-natural woodland is rare on Arran and tends to be restricted to sheltered areas on the cliffs abutting the raised beaches and to areas below these cliffs where grazing is restricted, usually by rough terrain.

Two major woodland types are recognised by Adam et al. (1977), one with Betula pubescens, the other with Corylus avellana, as the main component in the canopy. Oxalis acetosella, Blechnum spicant, Potentilla erecta, Mnium hornum and Hypnum cupressiforme are found in the field and ground layers of both types, but several species are peculiar to one or other of them.

In the birch woods the dominating Betula pubescens has a rather stunted, gnarled growth habit, rarely exceeding 8 metres in height. Constants under the canopy include Anthoxanthum odoratum, Deschampsia flexuosa, Agrostis canina, Dryopteris aemula, Dicranum majus and Scapania gracilis.

There are two variants within the birchwoods. One, occuring on steep north-or east-facing slopes with acid humus-rich podsols or brown earths developed over Permian sandstone, is characterised by an abundance of Luzula sylvatica with Dryopteris dilatata, Hymenophyllum tunbrigense, Vaccinium myrtillus, Calluna vulgaris, Solidago vigurea and Plagiochila spinulosa. Boulders cover a major part of the area, supporting a carpet of Atlantic bryophytes. Damp, periodically flushed, fertile brown earth soils developed over Dalradian schists in the north of the island provide more basic conditions. Several basiphilous species are found under the canopy of the species-rich birchwood including Rhytidiadelphus squarrosus, R. triquetrus, Luzula pilosa and Thuidium tamarascinum. Others including Athyrium filix-femina, Lysimachia nemorum, Viola riviniana, Primula vulgaris, Ranunculus acris, Conopodium majus, Hylocomium brevirostre and Pseudoscleropodium purum are also present in hazel woods. In the absence of grazing pressure several tall herbs including Angelica sylvestris, Epilobium montanum and Hypericum androsaemum are often evident.

The hazel woods are restricted to the steep west-facing slopes near Imachar Point on fertile, clay-rich, brown earth soils, again derived from Dalradian schists.

The canopy is dense and closely spaced, multistemmed trees reach heights of up to 10 metres. Grazing is heavy under the canopy and there is a preponderance of basiphilous species — Primula vulgaris, Ranunculus acris, Deschampsia caespitosa, Geum rivale, Geranium robertianum, Lysimachia nemorum, Anemone nemorosum, Athyrium filix-femina, Prunella vulgaris, Filipendula ulmaria, Valeriana officinalis, Allium ursinum, Sanicula europaea and Carex sylvatica. Bryophytes are less evident than in boulder-strewn birchwoods due to the intense shade and lack of suitable habitats.

Scraps of oakwood do occur on the island often on the cliffs or slopes to the landward side of the raised beach. Those on the cliffs, such as at Aird nan Ron, are probable remnants of natural woodland. Conversely those on the more accessible slopes, for example at Dougarie, are probably planted.

Alder woods too are in evidence being particularly obvious along the Ross road from Lamlash to the west and on the raised beach at Corriegills, south of Brodick. Smaller groups of alder trees are present at various points around the coast.

Both Fraxinus and Ulmus still occur naturally on the island although they can hardly be said to form a woodland. Fraxinus is common growing singly on the raised beach cliffs and is found with Ulmus in a similar situation to the south of Fallen Rocks, on the north-east coast.

The vegetation described from Arran is very western in type, the communities being similar to, or having close affinities with, those in corresponding habitats in the Western Isles, on the west coast of Scotland and in the west of Ireland. Only the inland communities of Calluna heath and blanket bog show any relationship to those on the mainland. Even then the great abundance of Myrica in the latter confuses the comparison.

2.6 The Archaeology of Arran

Arran, in common with many other islands off the west coast of Scotland, is rich in archaeological remains representing, to varying extents, periods from the Mesolithic onwards.

The first attempt at listing and describing these was made by MacArthur in 1861 but it was not until nearer the end of the 19th century that serious excavation and investigation were attempted. Thomas Bryce was responsible for the majority of this which, although valuable, was by today's standards rather crude. His findings, along with the later accounts by Balfour, are included in The Book of Arran (1910). In the period between the publishing of the Book of Arran and the recent series of excavations very little new information was added. Although the passage grave at Carmahome, near Kilpatrick was excavated by Ludovik Mann in 1924, as was the Iron Age fort at An Cnap by V. A. Noel Paton in 1927. More recently a Neolithic cairn at Monamore, investigated by Bryce, was re-excavated by Dr. E. MacKie of the Hunterian Museum in Glasgow (MacKie, 1964).

Comprehensive reviews of the archaeology are available in the form of Scott's regional archaeology for the south-west of Scotland (1966), the relevant chapters of McLellan's book, 'The Isle Of Arran' (1976), and the very recent 'Discovering Arran's Past' by Fairhurst (1981). These basically contain updated versions of the information in the Book of Arran aligned with the authors' own personal views.

Since 1978 there have been two major excavation projects in the west of the island. The first, directed by Dr. A. Burl, concerned the stone circles on Machrie Moor. The second, of which the work in this thesis is a part, was directed by Mr. J. Barber of the Scottish Development Department's Central Excavation Unit. It involved rescue excavations, prior to Forestry Commission ploughing, of sites at Tormore, Kilpatrick and near Auchagallon, to the north of Machrie Moor. Several of the major findings have been incorporated into Fairhurst's book and full reports are in preparation.

The following is a brief summary of the present state of archaeological knowledge regarding Arran. It is gleaned from the available literature, including the works mentioned above, and also in discussion with Mr. J. Barber, Mr. A. Morrison of Glasgow University and several others to whom I would like to express my thanks.

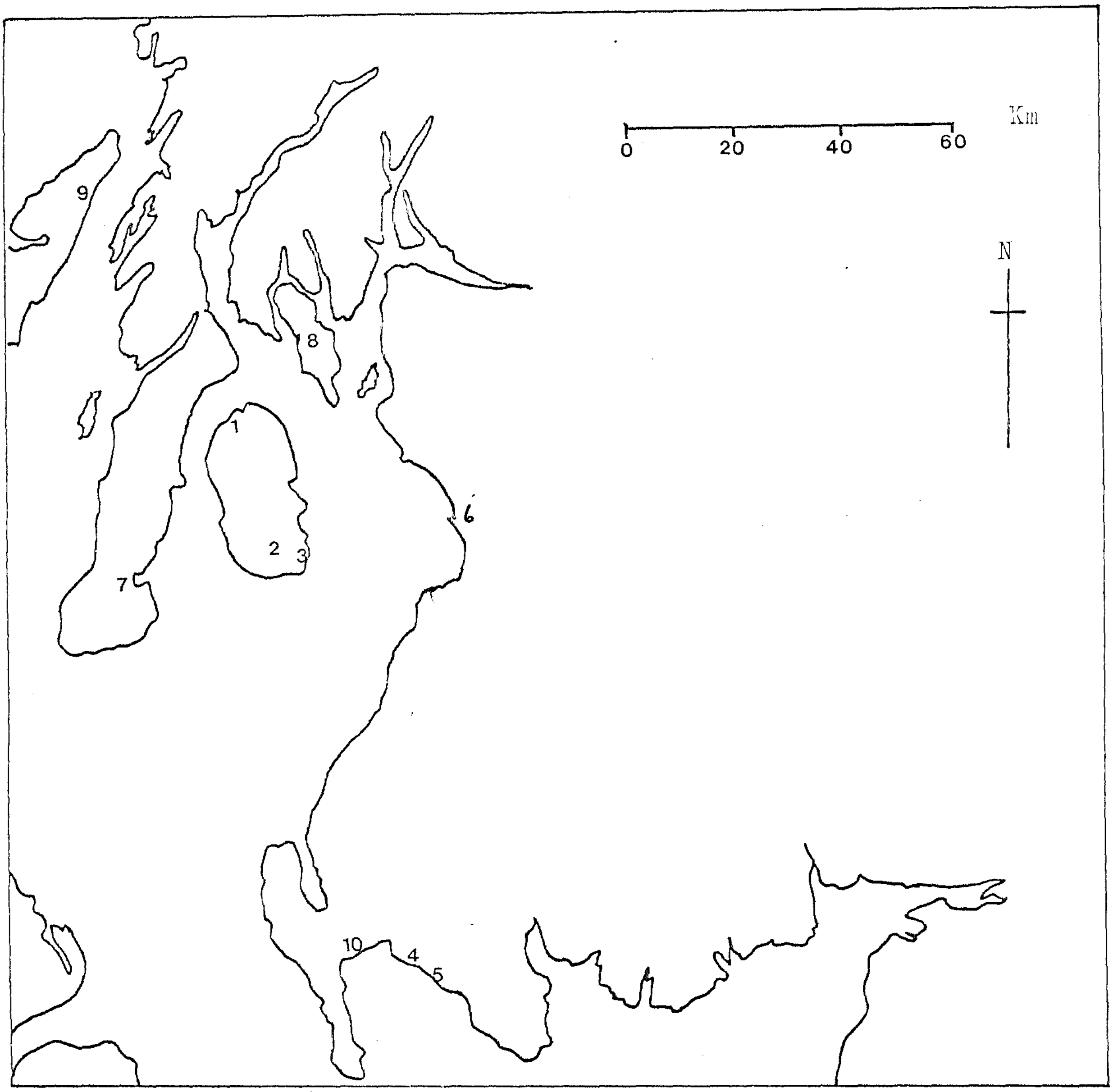
The Mesolithic Period

Material evidence for the occupation of Arran at this time is sparse, the sum total being worked flints from Catacol ascribed to the mesolithic by Lacaille (1954) and from Auchareoch and Knockankelly (Fairhurst, 1981). However in view of the evidence for the occupation of the Ayrshire and Solway coasts, (Cormack and Coles, 1964, Cormack, 1970, Lacaille, 1954, Morrison, 1980) of Kintyre, (McCallien and Lacaille, 1941, Lacaille, 1954) and the coast near Oban, (various authors, summarised by Megaw and Simpson 1979, Morrison, 1980) of the Isles of Bute (Lacaille, 1954, Marshall, 1978) Jura and Colonsay, (Mercer, 1970) and Oronsay (Mellars, 1979, Mellars and Payne, 1971, Jardine, 1977) it seems certain that Arran, which is on the

Figure 2.5

Showing sites of Mesolithic finds mentioned in the text.

1. Catacol, Arran (Lacaille, 1954).
2. Auchareoch, Arran (Fairhurst, 1981).
3. Knockankelly, Arran (Fairhurst, 1981).
4. Low Clone, Wigtonshire (Cormack and Coles, 1964).
5. Barsalloch, Wigtonshire (Coles, 1970).
6. Shewelton Moss, Ayrshire (Morrison, 1980).
7. Campbelltown Moss, (McCallien and Lacaille, 1941)
8. Bute (Marshall et al., 1978)
9. Jura (Mercer, 1968-1974b).
10. Luce Bay (Lacaille, 1954).



Km
0
20
40
60
N
9
8
1
6
2
3
7
10
4
5

sea route to several of these sites, also had a Mesolithic population at some stage. This idea is further supported by finds in Mesolithic contexts of worked pieces of Arran pitchstone, a type of volcanic glass peculiar to the island, notably from the upper Clyde and Tweed valleys and from Ayrshire (Morrison, 1980).

Mesolithic man does not appear to have figured very prominently in Scotland as a whole until later in the period, the earliest dates coming from the Lussa Wood 1 site on Jura (6244 and 6013 bc, Mercer, 1974a). The majority of sites, including those mentioned above, have been dated, at the earliest, to the beginning of the 4th millenium BC. Even at this time the population is likely to have been very small, being measured in hundreds or even tens (Butzer, 1972). Earlier sites may have existed and either lie undetected, or were concentrated on the coastal plain and were subsequently covered and destroyed by the rising sea-level (Lacaille 1954, Scott, 1966). Certainly the coastal sites which have been found tend to be concentrated at the landward side of the raised beach deposits of the main Flandrian marine transgression.

Alternatively Scotland may have been virtually unpopulated until the rising sea-level displaced populations from the game-rich North Sea Plain and similar areas, increasing the pressure on the remaining land and resources. The concentration of Mesolithic sites in Britain as a whole does tend to rise steadily from the time of the transgression onwards (Megaw and Simpson, 1979, p. 64).

Whatever their origins, the people living in the coastal areas of the south-west of Scotland seem to have had an economy firmly in the hunter/gatherer vein. With few exceptions it was based on the exploitation of fish and shellfish, supplemented to varying degrees by chance finds of seal and whale meat and the hunting of game (Scott, 1966). There is evidence from Oronsay (Mellars, 1979) from analysis of the otoliths of a sea fish, the Saithe (Pollachius virens), for seasonal occupation of the sites and for the extensive collection of hazel (Corylus) nuts in the autumn. It is also suggested that other plants, including marine algae, were also important in the diet although no direct evidence exists for this. However the Mesolithic site at Morton in Fife (Coles, 1971) contained remains of several plants which are known to have been used as food plants in later times. These included seeds of Stellaria media, the chickweed, Rubus sp., bramble, plus charred acorn husks and once again, hazel nuts. The presence of these remains could indicate that the plants were being used for food.

The end of the Mesolithic period and the coming of the so-called Neolithic revolution, as in several areas, is far from clear-cut. As yet there appears to be no published evidence in Scotland for very early Neolithic-type interference with the environment by Mesolithic people along the lines of that reported from England by Simmons (1969, 1975a, 1975b) and Jacobi et al. (1976). Unpublished data from the recent excavations on Arran (J. Barber, pers. comm. 1981) do suggest however the involvement of Neolithic people considerably before the elm decline. A feature which is more marked is the length of time which the Mesolithic way of life persisted after the arrival and establishment of the Neolithic agriculturalists. Hunting and gathering appear to have still been major food sources as late as the Bronze Age (Morrison, 1980, p. 172). It may have been that the relatively low population density coupled with the inherent productivity of the natural resources served to encourage this conservatism, particularly in outlying coastal areas.

The Neolithic Period

In the 4th millenium BC, and possibly before, there began an influx of new people and ideas into Britain. The arrival of these immigrants, referred to as 'Neolithic' or 'new stone age' people by virtue of their advanced skills in the working and polishing of stone tools, represented the renewal of the contact severed by the flooding of the North Sea Basin two millenia earlier.

The Neolithic people were, by definition, agriculturalists, originating centuries earlier in the south-east Mediterranean area. They made the short crossing from Europe probably in open, leather-hulled boats, (Case, 1969) bringing domesticated animals and the seeds of crop plants, predominately cereals.

On arrival they would have encountered a small, but well established Mesolithic population, who, in some areas at least, would already have been involved for some time in small-scale modification of the environment. This would have been confined to the use of fire and the axe to clear areas of forest and improve grazing; ungulates may also have been herded along the lines suggested by Simmons (1975a,b, 1969) and Jacobi et al. (1976). Finds of quantities of ivy (Hedera) pollen in Mesolithic contexts (Simmons and Dimbleby, 1974) have raised the possibility that the plant was collected to attract animals, or feed ones already tethered or coralled.

Figure 2.6

Showing the distribution of Neolithic tombs on Arran.

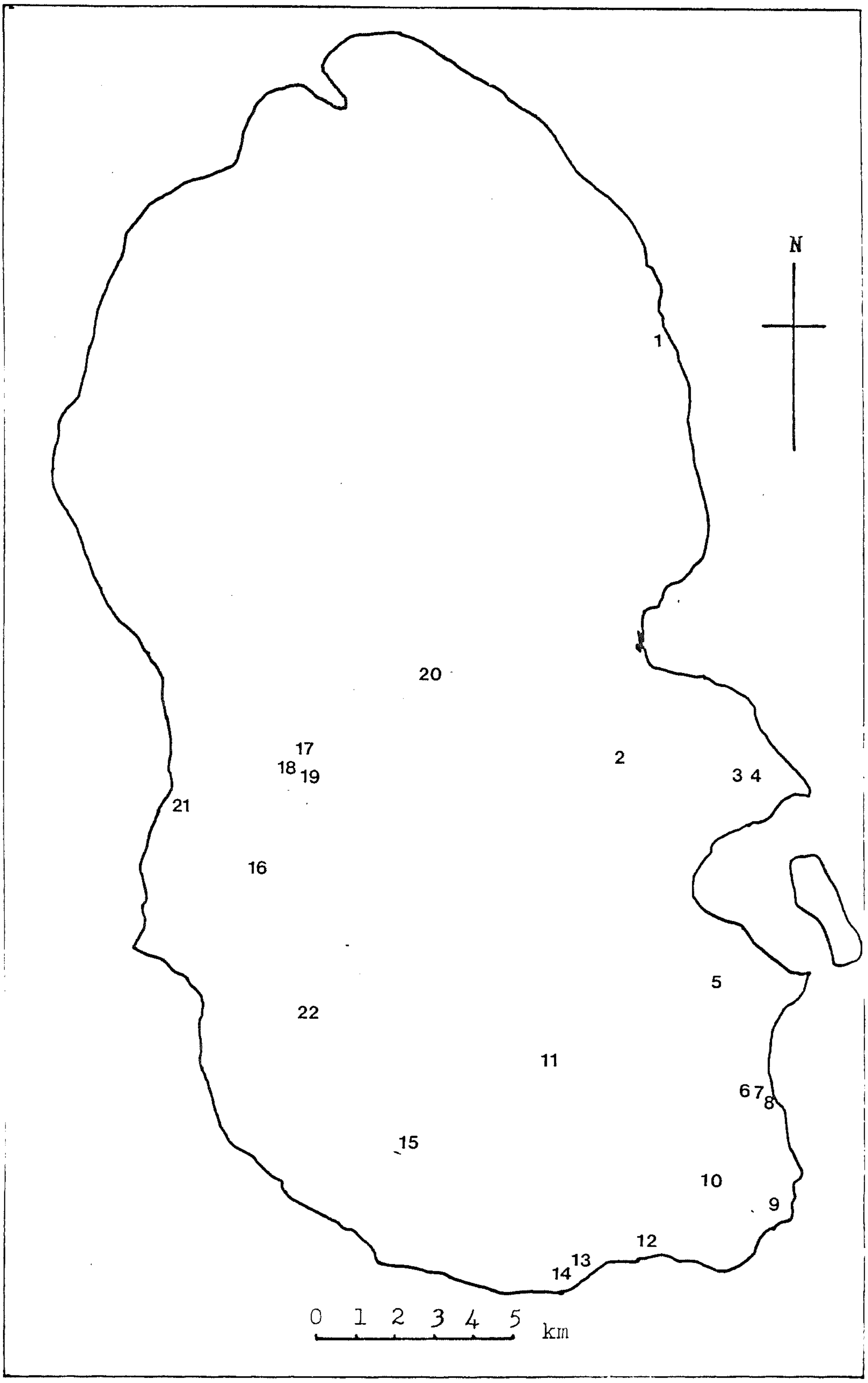
Chambered tombs

1 = Sannox, 2 = Glen Rickard, 3 = Dunan Mor, 4 = Dunan Beag, 5 = Monamore, 6 = Torr an Loisgte, 7 = Giants Grave (north), 8 = Giants Grave (south), 9 = Dippen, 10 = Ballymeanoch, 11 = Carn Ban, 12 = East Bennan, 13 = Torylin, 14 = Clauchog lime kiln, 15 = Sliddery, 16 = Tormore I, 17 = Tormore II, 18 = Moss Farm Road, 19 = Moss Farm Cist, 20 = Monyquil, 21 = Tormore III.

Passage Grave

22 = Carmahome.

(After Fairhurst, 1981, further details in McLellan,1977).


N
1
20
17
18 19
2
3 4
21
16
5
22
11
6 7 8
15
10
9
12
13
14
0 1 2 3 4 5 km

Despite being limited to fairly short sea journeys and the time of year at which they could travel (Megaw and Simpson, 1979, p.78), the Neolithic people rapidly spread all over Britain and Ireland. This was probably in a series of short 'hops' along the coasts and rivers, rarely losing sight of land and avoiding the often dense woodland which covered much of Britain at that time.

The first few generations would have concentrated on establishing their crops and animals, with little attention being paid to the building of permanent structures. Even from later times finds of settlement sites are rare, possibly due to their being wooden constructions of a rather ephemeral nature. The majority of direct evidence from this period comes from funerary monuments dating from the latter part of the 4th millenium BC. They represent the attainment of some degree of stability by the colonists maybe several generations after the first arrivals. They also suggest that the food supply was sufficiently well organised to allow considerable time and effort to be expended on their construction and that there was some sort of religious and social hierarchy and a belief in an afterlife. They do not, however, give much information about everyday life. That information tends to come from rather indirect sources such as chance finds of artifacts and pollen and plant macrofossil analysis.

The monuments are particularly well represented on Arran by a group of chambered cairns which typologically form a group known as the Clyde cairns. Arran is the centre of distribution of this group which has affinities with groups in Ireland (Carlingford), on the Solway and in the west of England (Cotswold-Severn group).

At the last count there were twenty cairns on the island (Fairhurst 1981) and several occur in the Vale of Shiskine, including five near the study sites. These are Tormore 1, Tormore 11 and Tormore 111 (the latter consisting of remnants built into a byre wall) and two sites near to the Moss Farm on Machrie Moor, the Moss Farm Cairn and the Moss Farm Cist. This represents quite an unusually high concentration of monuments, perhaps reflecting the level of usage of the area.

There is considerable diversity of form in the cairns found around the island but all of them have an internal chamber, comprised of more or less imbricate slabs of stone, often divided by transverse septal slabs. Those chambers which were found to still contain skeletal material appeared to represent succesive inhumations. The corpses may have been left until the flesh rotted away with the tomb being re-opened to receive the bones (Fairhurst, 1981).

The first serious excavations were carried out by Bryce in the late nineteenth and early twentieth centuries and the findings reported by him in the Book of Arran (vol 1 1910). Many cairns had been extensively plundered and violated prior to this for reasons of greed and piety and for building stone (McLellan, 1976). Only the relatively isolated Carn Ban in the southern uplands escaped major interference. Bryce was interested in finds of human remains for his anatomical studies but he also came across animal bones and Neolithic pottery, including Beacharra ware. One cairn excavated by Bryce, that at Monamore, was re-excavated by Dr. E. MacKie in the early sixties (MacKie, 1964). This provided material (charcoal) from under forecourt deposits for the only ^{14}C dates for these monuments on Arran. The dates were 3160 ± 110bc and 2240 ± 110bc.

The design of the cairns appears to have developed over a period of a thousand years or more with some of the early cairns being continually re-opened and re-used during that period with usage continuing into the Bronze Age, (Scott, 1966, McLellan, 1976). The earliest structures tend to be associated with the lower, more fertile, land near the coast, they also tend to be the simplest in construction. Later and more complex cairns are found further inland on the poorer upland soils (Scott, 1966). This apparent link with arable land was recognised at quite an early stage (Childe, 1942) and was supported by Renfrew (1973) who saw the cairn as a focus for the ritual activity of a small group who were working the adjacent land. In a later collaboration with Davidson and Jones (1976), however, he recognised that the cairns, in this case on Orkney, do not always lie to the upland of cultivated areas. The slope, aspect and the proximity of the sea also seem to be important factors in determining the location.

As mentioned earlier the Mesolithic way of life in the south-west of Scotland did not just disappear with the advent of these new influences. In Jura for example it persisted well into the 3rd millenium (Mercer, 1970, 1974c). It seems likely that life on Arran was supported by a balanced mix of Mesolithic and Neolithic practices for some period of time. This integration and hybridisation is one source proposed (Scott 1966) for the appearance later in the Neolithic of apparently 'secondary Neolithic' influences, another proposal being that they were due to an influx of people from the Iberian peninsula (McLellan, 1976). The characteristic artifacts of this culture included pottery known as Lyles Hill, Peterborough and Rinyo-Clacton ware, lopsided flint arrow heads, jet beads and discoidal flint knives (Scott, 1966, McLellan, 1976). The most obvious difference was in the burial monuments. These took the form of passage graves, having a corbelled chamber in the centre, reached by a long narrow passage. They are quite distinct from the chambered cairns, although hybrid cairns do exist for example at Achnacree in north Argyll (Scott, 1966).

Whatever its origins this culture appears to have largely by-passed Arran. Only one passage grave has been found on the island, at Carmahome near Kilpatrick, and, although several artifacts have been found, it is thought that these may be later introductions resulting from trade(McLellan 1976).

The Beaker Period

The trade contacts of the Neolithic were carried through to the early Bronze Age, and it is thought likely that this was the medium through which the influences of the Beaker people first became apparent on Arran. Whilst it is clear that they constituted an invasive force in some parts of Britain it may be that their ideas travelled to the west faster than they did (Morrison 1978). The name 'Beaker' is derived from the characteristic beaker-shaped pottery which is so often found associated with sites of this period.

With the transition from the late Neolithic to the Beaker period the basic archaeology appears to, at first, change only slightly. The Neolithic tombs continue in use, with crouched inhumations and Beaker pottery being found set into them for example at Dunan Beag (Fairhurst, 1981) and Clauchog (McLellan, 1976), although Bryce (1910) found no examples of Beaker pottery associated with short cist burials (see later).

The Bronze Age

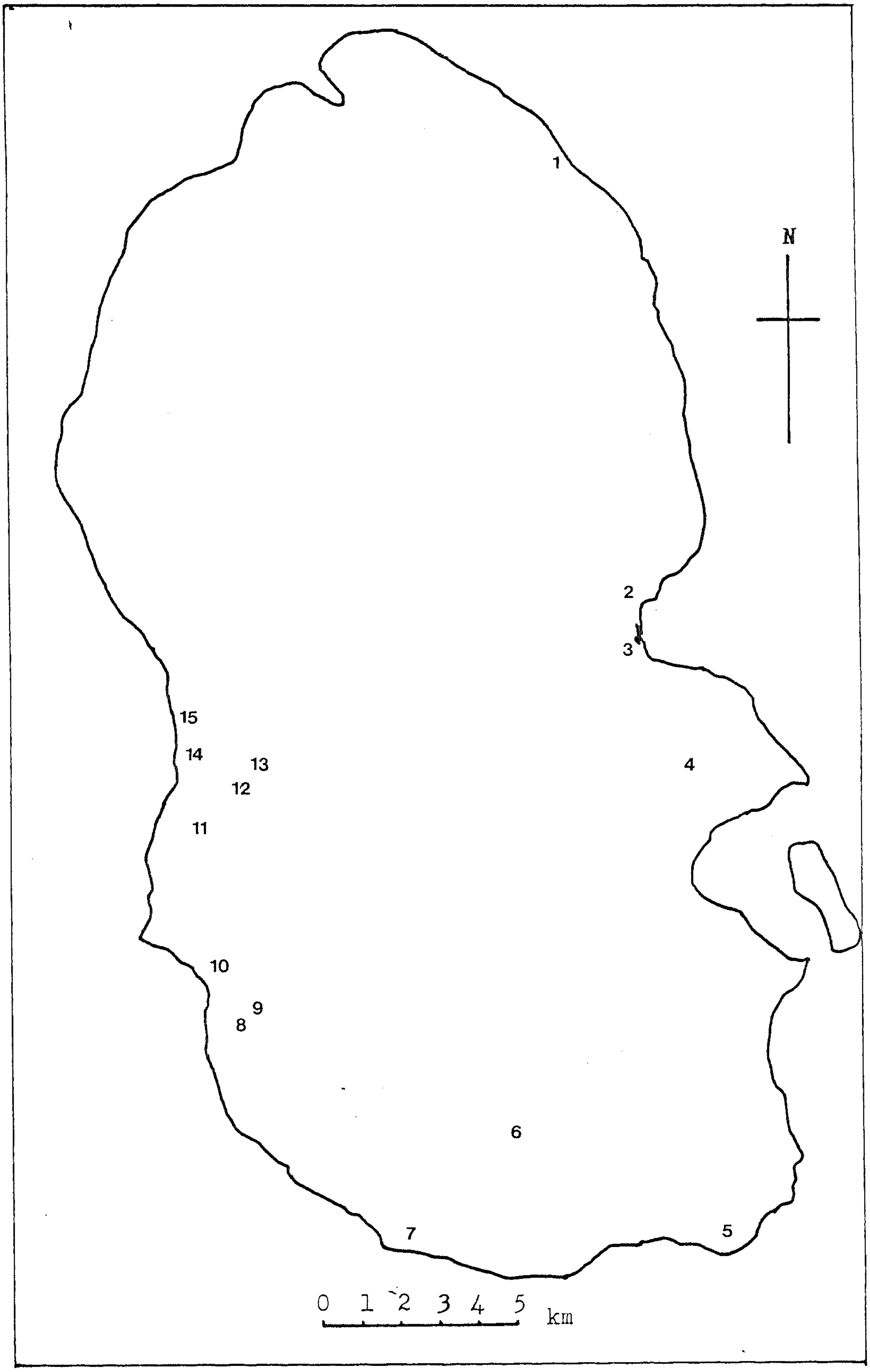
Whilst the Beaker cultures can in some ways be considered transitional at the start of the Bronze Age and bronze working may have started then, the major changes came with the influx of people interested in trade and metal ore prospecting. These people appear to have had links with the Wessex culture in England and the trade established at this time seems to have persisted throughout the period (McLellan 1976). This trade may initially have been based on copper, there being deposits of copper ore in Argyll. Later tin was alloyed with the copper to make the more durable bronze and as these metals were never abundant they were rarely used other than for decorative or ritual purposes. Trade in them must have been very profitable. Changes at this time mainly concerned burial practices. These are characterised by the use of the short cist, made of stone slabs. They were often set into Neolithic tombs, again suggesting some degree of continuity between cultures, or covered by a circular mound of earth

Figure 2.7

Showing the distribution of the main Bronze Age sites on Arran.

1 = North Sannox (cairn), 2 = Brodick old deer park (3 standing stones), 3 = Brodick School(standing stone), 4 = Lamlash/ Brodick hill (stone circle), 5 = Kildonan (standing stone), 6 = Aucheleffan (stone circle), 7 = Clauchog (cairn), 8 = Kilpatrick (field system), 9 = Kilpatrick (cairn), 10 = Cairn Farm (cairn), 11 = Tor Righ Mor (field system and settlement site), 12 = Machrie Moor (1 standing stone and 7 stone circles), 13 = Machrie (field system), 14 = Auchagallon (stone circle), 15 = Auchencar (standing stone).

(After Fairhurst, 1981, further details in McLellan, 1977)



N
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
0 1 2 3 4 5 km

Plate II

Upright stones which make up one of the Machrie Moor stone circles. (Courtesy of the C.E.U., Crown Copyright).

and/or stones. Alternatively they were marked by a monolith or had no above ground indication of their presence. Most of the cists were found to contain a type of pot known as a food vessel (McLellan, 1976).

Both crouched inhumations and cremations have been found from this period on Arran, the former are taken to be the earlier. There are also at least three sites with cinerary urns buried neck downwards with no associated markers or artifacts. These are taken to be later still (McLellan 1976).

Food vessels were found by Bryce in cists associated with the Machrie Moor stone circles confirming that they too were built around this time. There are five circles on the moor and they were first surveyed by James Bryce in 1861. These records were subsequently used by Thomas Bryce in his survey and later in his account in the Book of Arran. Recent meticulous work by Roy et al.(1963) has shown these surveys to be grossly inaccurate. The detailed investigation of the arrangement of the stones within the circles has lead to theories that they had some mathematical, astrological or calendrical purpose. Although Burl (1979) believes that they were just ritual meeting places, the configurations being the consequence of their being laid out at full moon, midday or other time when the likely deities were most apparent.

The circles are significantly close to the area of this study and coupled with information gleaned from the recent excavations of settlement sites at Tormore and Kilpatrick (J. Barber, pers. comm. 1981) suggest that there was a considerable Bronze Age presence. Burl (1979) from his consideration of the function of the circles, the available land in the vicinity and the probable under-use of that land gives a conservative estimate of 20 - 50 people in the Machrie Moor area.

Bronze Age monuments tend to be associated with large tracts of cultivatable land in contrast to the Neolithic where virtually every small valley had an accompanying cairn which is rarely overlain by later material or usage (J. Barber pers. comm. 1981). It may be that there was a shift away from small family groups to those of a size proposed by Burl and as a consequence a shift towards fewer and larger ritual centres such as the stone circles and larger cairns. The Bronze Age, particularly the later part, appears to be a period of great stability with settlement sites such as that at Tormore being occupied for in excess of a thousand years. This too would have encouraged the formation of larger units not only for ritual and political purposes but also for trade and agriculture.

In the later Bronze Age there was a steady rise in population supplemented by immigration, possibly from Ireland (McLellan, 1976, J. Barber, pers. comm. 1981). Arran may have had its largest, most highly organised and efficient prehistoric population at this time.

Craftsmanship in metals too reached a high standard and fine examples of bronze, bronze and gold, and pure gold artifacts have been recovered from various sites on the island, notably the large cairn at Blackwaterfoot, before its destruction, and from Low Whitefarland.

Around the beginning of the 1st millenium BC these trends appear to reverse with both monument building and trade seeming to decline. The full reasons behind this are not known. It may be that the climatic deterioration thought to have occurredat that time (Lamb, 1977, Piggott, 1973) was sufficiently severe to combine with intensive land use in causing crop failure and deterioration of the soil. Certainly podsolisation of soil profiles buried under monuments on Arran becomes quite evident at this time (J. Barber, pers. comm. 1981) although a similar feature was reported from below the forecourt deposits of the Neolithic cairn at Monamore by MacKie (1964) and Romans and Robertson (1975). The soil there was very light and sandy, however, and may have been prone to leaching (Ball, 1975).

Despite this apparent decline it would seem likely that a population of some sort remained as several artifacts and practices were carried over, adapted and used in the ensuing Iron Age (Scott, 1966). The lack of intermediate activity may in part just signal a shift of emphasis.

The Iron Age

Both Scott and McLellan explain the advent of the Iron age in the south-west of Scotland in terms of succesive waves of marauding Celts moving northwards after being displaced from the south of England. This appears to have been a generally accepted view. Fairhurst (1981) however, comments on the fact that in recent years many archaeologists have become sceptical of the 'invasion and subjugation' theory to explain both this and other earlier transitions. They favour instead the view that it was a revolution of ideas and skills which occurred, running ahead of, and far exceeding, the impact of the initial introduction.

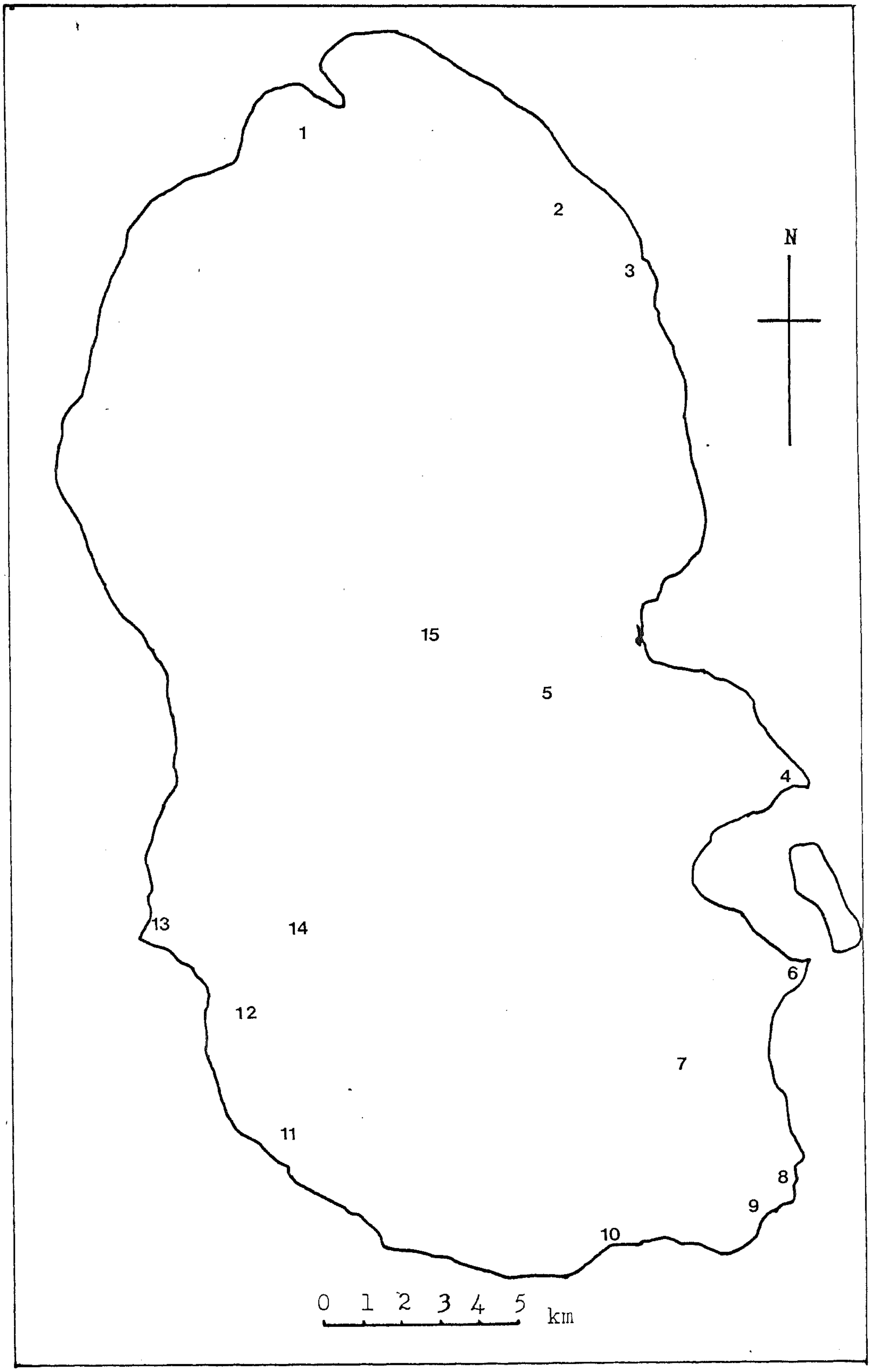
In this case these skills included those of smelting and working iron, which preceding cultures had found beyond them, and the new Celtic designs in metal, stone and other materials. There were also big changes in social organisation and architecture.

Whereas the Neolithic and Bronze Age are characterised by their burial practices, in the Iron Age the salient features are the fortifications. This comes as no surprise as these were violent, unsettled times and the Celts were fanatical warriors (Ritchie and Ritchie, 1981).

Figure 2.8

Showing the distribution of Iron Age hill forts on Arran. 1 = Lochranza, 2 = North Glen Sannox, 3 = An Cnap, Sannox, 4 = Dun Fionn, 5 = Glen Cloy (Bruce's Castle), 6 = Kings Cross Point, 7 = Glenashdale, 8 = Dippen, 9 = Kildonan, 10 = Bennan Head, 11 = Torr a Chaisteil, Corriecravie, 12 = Kilpatrick, 13 = Drumadoon, 14 = Cnoc Ballygowan, 15 = Cnoc a' Clochair, Monyquil.

(After Fairhurst, 1981, further details from McLellan, 1977).


N
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
0 1 2 3 4 5 km

Iron Age forts are scattered all round Arran. They vary considerably in size, shape and construction; fairly simple and small at Bennan Head, massive hilltop enclosures at Drumadoon and Cnoc Ballygowan, timber-laced walls at An Cnap, dry stone, rubble cored duns at North Sannox, Glenashdale, Dippen and Kildonan, and thick-walled towers at Kilpatrick, Corriecravie and Kings Cross Point. These were not all built simultaneously to ward off a mass invasion but at various times from 500BC onwards. Periods of usage may have varied considerably. It is suggested that the fort at Cnoc Ballygowan was never completed or used while others may have had repeated rebuilding and occupation through to Viking times (McLellan, 1976, Fairhurst, 1981). Fairhurst also suggests that they were built mainly for show to ward off potential invaders, as they often have obvious strategic weaknesses which could be exploited by such an enemy.

None of the Arran forts have been excavated recently or in detail. In the absence of the information that such an excavation might yield, it is impossible to construct any kind of chronology. McLellan, from his own observations, the work of Balfour (1910) and a belief in successive Celtic invasions, suggests that the various forts represent a process of integration which was probably repeated more than once. Small groups of Celts arrived in search of northern territories and established small fortifications. Pressure from subsequent invaders forced them to band together into defensible tribal centres such as at Drumadoon. The invaders then built their own fortifications and the process continued with a gradual mixing of the various groups. This is quite a neat explanation and in the absence of any evidence to the contrary seems as valid as any other.

Events in the Machrie Moor-Vale of Shiskine area at this time are likely to have been dominated by the tribal centre at Drumadoon. People from settlement sites all round the valley probably took refuge there in times of trouble.

Settlement sites are a feature of the Iron Age in Britain and the innumerable hut circles scattered round the island are often attributed to this. However if the findings of the Tormore excavations prove to be applicable in general terms some of these may have had their origins and complete periods of usage in much earlier times.

Celtic settlers are unlikely to have found Arran a very attractive place for arable agriculture. Although the climate is thought to have been improving steadily throughout the period, reaching an optimum in the so-called Roman Iron Age (Lamb, 1977), conditions initially may have been far from favourable. As a result of this and the generally unsettled times pastoral farming would have been widespread. Field enclosures were much larger than in the Bronze Age, possibly reflecting the lower productivity of the land and maybe different husbandry practices. The population density of both people and animals was probably, of necessity, much lower.

Areas of rig and furrow or Celtic runrig cultivation have been found dating from this period near Auchagallon, north of Machrie Moor, suggesting that at least some arable farming was practised. Yields may have been somewhat erratic in view of the generally cool wet summers and continued peat growth. Also at Auchagallon (J. Barber, pers. comm. 1981) an area has been found where attempts were made to grow cereals directly on the peat by the addition of shell sand, apparently with little success. Conry (1971) describes various forms of these 'plaggen' or 'man-made' soils from Ireland where they date mainly from the late eighteenth and early nineteenth centuries. The addition of shell sand to peat is a practice thought to extend back to similar pre-Christian times. This practice may also be an alternative explanation for the soil scatters found in the peat at Goodland Townland, Ireland, by Case et al. (1969).

During the later part of the recognised Iron Age there was Roman occupation of Scotland. Evidence for their presence has been found on Kintyre and in Ayrshire but as yet nothing has emerged to suggest that they were ever on Arran. Fairhurst (1981) considers that they probably did know of and visit Arran, possibly using the anchorage off Lamlash, but that any occupation is likely to have been very short, leaving little if any evidence.

The Dark Ages

The period between the departure of the Romans and the coming of the Vikings is often referred to as the Dark Ages and in Scotland it is a period about which little, archaeologically, is known. Arran is not peculiar in this and the Dark Ages represent somewhat of a gap in the archaeological record. Some of the Iron Age forts may have continued in use but evidence for settlement sites and land usage are very sparse, although it is presumed that Celtic runrig system, apparent in later times, persisted throughout.

The little information there is concerning this period on Arran deals almost exclusively with the involvement of the Celtic, and later the Roman, church on the island. The accounts, however, appear to rely rather more

Figure 2.9

Showing the location of the main Dark Age, Viking and Mediaeval sites on Arran.

1 = Holy Isle (cave of St. Molaise and Norse runes)

2 = Lamlash, Blairmore (Old St. Brides church)

3 = Lamlash, St. Brides church (carved stone in churchyard)

4 = Shiskine, St. Molio's church(carving built into wall)

5 = King's Cross Point (Viking Boat Burial)

6 = King's Cave (Pictish carvings)

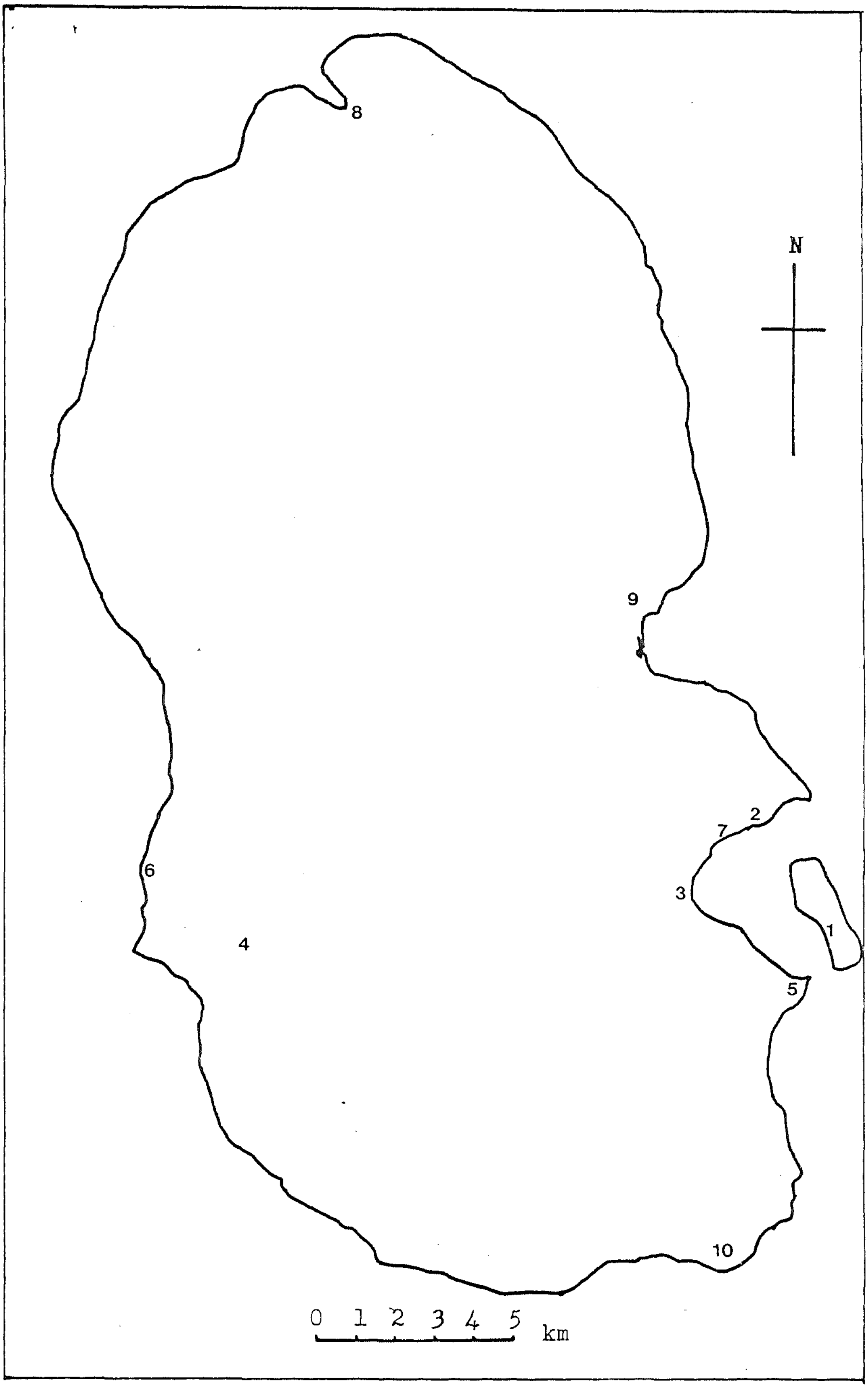
7 = Blairmore Burn (Viking Burial Mound - removed)

8 = Lochranza Castle

9 = Brodick Castle

10 = Kildonan Castle

(After Fairhust, 1981, McLellan, 1976,1977)


N
8
9
2
7
3
1
6
4
5
10
0 1 2 3 4 5 km

on legend than fact. There are two main stories, the first concerns the dun at Kilpatrick. There has been speculation that this was converted into a cashel by St. Brendan in the 6th century AD following the adoption of the Christian faith by a local chief. This idea is based on the fact that St. Brendan, during a voyage to the Western Isles in AD 545, established a monastery of the Celtic church the site of which has never been satisfactorily identified. This, combined with the manipulation of several place names, led to the view that Kilpatrick was a likely site. If this speculation is true it would make Kilpatrick the earliest outpost of the Celtic church, predating even Iona.

The second story concerns the legendary St. Molio or St. Molaise who is reputed to have lived on the Holy Island, leading to it being called 'Eilan nam Molaise' later corrupted to Lamlash. He is said to have been involved with the early Celtic church on the island. Whether this is true, how long the monk stayed and even who he really was are not really known with any certainty (Fairhurst, 1981, McLellan, 1976). It may be that several similar monks came to Arran but whether they were evangelists working among the people or hermits living a lone life of hardship and deprivation again is uncertain.

On a secular front, in the 6th century AD accounts refer to Scots from the kingdom of Dalriada in Northern Ireland entering the south-west of Scotland and joining with the resident Picts in attacking the west end of the Antonine Wall. Later they appear to have displaced the Picts from the area, either by force or arrangement, forming a sister kingdom of Dalriada in Scotland which persisted until Viking times. Pictish carvings which may date from this period have been found at the Kings Cave near Drumadoon.

The Viking Period

The earliest Viking involvement in the Western Isles began around the end of the 8th century AD with piratical raids led by lesser chiefs. Monasteries appear to have been prime targets with their rich pickings of gold, silver and jewels. Occupation and possibly less violent intervention came later and the extent of this on Arran is unclear. One view is that it was restricted to occasional raids and the use of the eastern bays, particularly Lamlash, as a safe anchorage. Conversely it is suggested that the Vikings maintained a prolonged presence, practising their own forms of agriculture, changing the rental systems and having a considerable impact on island life. With the inclusion of Arran in the Viking kingdom of Man and the Sudreyjar and the arrangement between Malcolm of Scotland and Magnus Barelegs in 1098 giving the latter "all the islands that lie to the west of Scotland", it seems likely that the second state of affairs is nearer the truth. This is supported by evidence from place names, chronicles and sagas and the two burial mounds at Blairmore Burn and Kings Cross Point. There also seems to have been intermarrying between the largely male dominated Viking incomers and the females of the native population. This resulted in a race known as the 'gaill-Gaidheil' or 'stranger gaels', Vikings being identified as 'gaill' or 'strangers'. It was this race which was later to be at odds with both their Norwegian rulers and the feudal overlords of mainland Scotland (McLellan, 1976).

The climate at the time of the Viking occupation was particularly favourable, coming as it did in the period often referred to as the 'little optimum' (Lamb, 1977). From about 950 AD to 1300 AD temperatures were at least 1 - 2 degrees C higher than at present and land was cultivated up to previously unheard of altitudes in England and Wales and also, by inference, in Scotland. Many exotic species were grown and vineyards flourished up to 500 km north of their present limit (Lamb, 1977). With the climatic deterioration which came at the end of this period came also crop failure, famine and starvation which had a far greater effect on the population than the Black Death which also occured about this time (Lamb,1977).

Viking involvement in Arran,and the Western Isles generally, came to an end ostensibly with the Battle of Largs in 1263 and the selling of the Sudreyjar to Scotland in 1266. There followed a great period of unrest, hardship and rebellion which persisted throughout the Middle Ages.

The Middle Ages

The Middle Ages in Arran, and the Western Isles generally, are characterised by upheaval and unrest. This may have been accentuated by the various written accounts, emanating from aristocratic and ecclesiastical sources, which become more frequent and detailed, but undoubtedly it was a time of great hardship and uncertainty. The accounts tell of raids, burning, devastation and feuds. For example, MacDonald (n.d.) mentions raiding parties crossing from Kintyre to Arran in 1443 and ravaging the island to such an extent that in the years of 1445, 1446 and 1447 the taxes paid were a fraction of those paid in peace time. It is unlikely that this was an isolated incident.

Political unrest began during Viking sovereignty of the Isles with the fight for independance led by Somerled, a man of gaill-Ghadeil descent and self-styled King of the Isles. It continued under the later Scottish rule and was further complicated by internal feuding and power struggles which began after Somerled's death.

These prevailing conditions prompted the building by the Arran aristocracy of the first castles on the sites at Brodick, Lochranza and Kildonan to protect themselves and their retainers from the attacks which appeared to threaten from every quarter. Little is known of the common people and their everyday existence and this continues to be the case until the more reliable reports which appear after about 1700.

It was probably these ordinary people, working the land, who suffered the most during the later War of Independance against the English and the various other conflicts which occurred up to and including the Improvements and Clearances, although McLellan (1976) considers that the Jacobite rebellion largely passed Arran by.

The situation would have not been helped by a downward trend in climate. This is generally acknowledged to have taken place following the little optimum in Viking times (Lamb, 1977). The same source also speculates that much of the trouble may have been precipitated by the crop failures and food shortages which were a direct consequence of this trend. The steady deterioration of the climate continued, with some minor reversals, throughout the Middle Ages, culminating in the so-called 'little ice age', which lasted from 1550 to 1700. During this time the weather was so severe and food shortages so acute that James 1st shipped Scots to Ireland in an effort to alleviate the situation. Agreements were also made with Baltic ports for them to act as 'emergency granaries' in times of shortfall (Lamb, 1977).

Agriculture throughout this time was dominated by the Celtic runrig system which had persisted virtually unchanged since its introduction in the Iron Age.

Runrig

The runrig system was one of communal farming based on small village communities or clachāns. The name is derived from 'roain', 'share' and 'ruith', 'running', which was later adapted to 'runrig', 'rig' being Scots for 'ridge' (McLellan, 1976).

The area of land worked was rented collectively through a tacksman or tacksmen who in turn paid an annual rent to the estate (Storrie, 1967b). Three divisions were made in the land, in-field or croft-field, out-field and common grazing. The distinction between in-field and out-field was often unclear. The writer of the first Statistical Account (1793) fails to make any mention of it and speaks only of the light crops of barley, oats and occasionally peas and flax, with potatoes being grown in quantity on the sloping ground. He does, however, report the grazing of horses and cattle and the export of the same cattle along with barley, kelp, mutton and linen yarn.

The New Statistical Account of 1845 is more detailed giving the uses and crops of the in-field and out-field. The out-field appears to have been uniformly treated throughout the island. It was broken up and ploughed, then being sown with oats until the yield was less than the seed sown. It was then left for 7 years or more to grow weeds and recover. The treatment of the in-field was not uniform, but it involved generally a rather disorganised rotation of oats, potatoes, peas, beans, barley, mashlam and fallow years when it was heavily manured.

The common grazing was divided into soums based on the area needed to graze a cow, six sheep or half a horse. A family was allocated a certain number of soums determined by the animals owned which in turn determined the rent paid. This was also the basis for the allocation of arable and meadow land. The arable land was ploughed together into ridges or rigs and areas of it were reallocated each year by a process of drawing lots. This, along with the communal working of the land, was organised by the 'fear a bhaille' or 'man of the village'. Allocations were also made to widows, old people, craftsmen such as carpenters and blacksmiths and to labourers or cottars not contributing directly to the rent.

In this form the system seems to have worked very well possibly providing the best level of subsistence for the population under the prevailing conditions. The communities were very closely-knit with the old and infirm being supported by the more able.

Accounts written in the latter part of its usage, however, refer to it as being degenerate and grossly inefficient. It is probable that by this time the system had broken down under estate pressure and that land was no longer reallocated annually with the clachans being overpopulated by tenants and subtenants not directly responsible for the payment of the rent. Also McLellan, (1976) considers that the writers of the reports, such as that by Headrick (1807) and the New Statistical Account (1845), had more than a passing interest in the Improvements and in pleasing the landowners by justifying runrig's demise. The New Statistical Account (1845) reports the people before the Improvements as living in poverty in 'poor hovels' and as having neither carts nor bridges and only crude wooden tools. In contrast the post-Improvement period is described in glowing terms.

The Improvements and Agricultural Reforms

Attempts to reform Arran's agricultural system began in the late 18th century with the commissioning by the trustees of the 7th Duke of Hamilton of John Burrel and Boyd Anderson to plan the improvements on the line of those on the mainland, notably in the Lothians. Burrel's plan provided for each tenant to have his own holding, individually enclosed, with help being given in the planning and erecting of new buildings. The grazing of cattle and sheep was to be strictly controlled and the breaking and improvement of new ground was to be encouraged. Dykes and enclosures and peat and seaweed-cutting areas were all taken into account. The overall plan was to make each holding a viable unit and to eliminate the ineffieiency and overcrowding which had developed, for whatever reason, within the runrig system.

These plans however accomplished little (Mackenzie, 1910). The tenants were understandably uncooperative and Burrel had not taken enough account of the various important factors operating. As a result some of the farms were unworkable, the rents stopped and bankruptcies followed. Many farms reverted to multi-tenancy of an even more impoverished type, others were never enclosed in the first place. The population rise, at the root of the original problems, continued and emigration, both temporarily into the navy or fishing fleet and permanently to the new industries of the mainland, presented a way out.

In 1814 - 1815 a renewed attempt was made to abolish multi-tenancy and common grazing. This time it was rather more successful although the transition was neither swift nor peaceful (Mackenzie, 1910). Runrig persisted in some more isolated places such as Balliekine (Storrie, 1967). In others a type of multi-tenancy continued and the farm units were often much smaller than Burrel envisaged.

With enclosures came the problem of the 'surplus' population, those who were not able to acquire leases to the new farms and who had been removed from their clachans. They were allocated small lots near the shore, one locality being Tormore, here they grew potatoes and were allowed fishing and kelp-curing rights to supplement their subsistence.

The enclosures also saw the end of the closely knit clachan communities. Very few habitable buildings constructed before 1775 are now known on the island (Fairhurst, 1981) and ruined clachans are much in evidence especially along the Ross road and in North Glen Sannox. The present landscape with its large fields and solitary farmhouses dates directly from the enclosure schemes and only in the north are settlements found centred round the old clachans.

With the later clearing of the larger glens of Sannox, Kilmory and Sliddery to make way for sheep, the pressure on the coastal plots became too great. The trickle of a few years earlier turned to a flood as mass emigration to the mainland and to the newly opening Megantic county in Canada became the only available course of action.

Since enclosures and clearance in the late 18th and early 19th centuries the population has steadily declined and today is lower than it was at the end of the 17th century. Agriculture is still by far the largest single employer although, along with maritime related work, it has declined in the last century. Employment now is much more diverse due in the main to the upsurge in tourism and its related and supporting industries.

2.7 Pollen Analysis and Archaeology on Arran

A full account of pollen analysis directly related to archaeological excavations in Scotland as a whole is given in Appendix A4 . On Arran only one excavation has had pollen analysis associated with it, although several projects, other than the work in this thesis, are planned from the recent excavations at Kilpatrick (NR 906 261) and near Auchagallon (N R 902 343).

The published work relates to the re-excavation of the Monamore chambered cairn by Dr. E. MacKie (MacKie, 1964) and the analyses were performed by Dr. S. Durno of the Macaulay Institute in Aberdeen. Pollen analyses have also been published from an excavation of the Hilton cairn on nearby Bute (Marshall et al., 1976). They were carried out by Dr. G. Whittington of St. Andrews University.

Monamore Chambered Cairn, Arran (MacKie, 1964)

The cairn was originally excavated by Bryce at the turn of the century. He dug straight into the burial chamber leaving the forecourt untouched and it was this region which received the most attention in the re-excavation.

Inwashed soil had accumulated in the forecourt to a depth of 30cm. This deposit was analysed by Durno with a view to discovering the period of time over which it had accumulated. A short peat monolith was removed from the hillside above to act as a reference curve. The diagram for the forecourt shows high levels of tree pollen which increase further after the building of the cairn before falling dramatically. At this point there are large increases in grass, heather, plantain, Compositae and other herbs. Overall this appears to represent a reduction in activity following the building of the cairn with an emphatic resumption at a later date, corresponding with events recorded at the base of the hill peat profile. The diagram for this blanket peat deposit as a whole is typical of many which began forming during the last millenium BC. The interpretation from the pollen analysis and the ^{14}C dating of charcoal suggests that the cairn was in use for in excess of 1000 years following its construction ca. 5400 BC.

Hilton Chambered Cairn, Bute (Marshall, 1976)

The Hilton cairn on Bute (NS 067 685) (Marshall et al., 1976) was excavated more recently, in the period 1972 - 76. This Neolithic cairn was on the site of a previously levelled occupation site. It consists of a primary chambered cairn, the contents of which are dated typologically to 2300 BC. Onto this a later secondary Neolithic structure has been added and there is an intrusive Bronze Age cist in this secondary cairn material. Samples were taken for pollen analysis by Whittington of St. Andrews University. There were three from the turf packing surrounding the stones of the primary cairn, one from soil under the cairn and one from turf and clay packing used to level up the occupation site just outside the primary cairn. The samples from under the cairn and the lower levels of the turf packing show that at the time of construction the area was wooded. The woodland is predominately alder and birch with no elm or oak and very little pine. Indicators of agriculture are not well represented. In contrast the sample from the pre-cairn phase and the one from the later stages of the cairn construction both show an open landscape dominated by grass and heather with several agricultural species including plantain and cereals. The sample from the top of the cairn has some birch, alder and hazel whereas the pre-cairn sample has virtually no trees. This could be taken to indicate that the original mixed deciduous woodland was extensively cleared, followed by regeneration by alder, hazel and birch prior to the cairn being built. This secondary woodland was then progressively cleared by the builders of the cairn. However the picture may have been complicated by the transport of turf and other material to the site from an outside area.

Plate III

Aerial photograph of the Vale of Shiskine, looking south from over Beinn Tarsuinn towards Blackwaterfoot and Drumadoon. (Courtesy of the C.E.U., Crown Copyright).

CHAPTER THREE

THE ARCHAEOLOGY OF TORMORE

In April 1976 large portions of the Blackwaterfoot/Machrie area were surveyed by Dr. R. Mercer and students of Edinburgh University prior to ploughing and afforestation by the Forestry Commission (Mercer, 1978). This survey revealed a high concentration of hut circles, standing stones, cists and field banks and provided a basis for the series of rescue excavations which followed. These were carried out by the Scottish Development Department's Central Excavation Unit (C.E.U) under the direction of Mr. John Barber.

The first was at Tormore commencing in June 1978, with the site at Kilpatrick (NR 906 261) being investigated in September of that year and in the following summer, and excavations taking place near Auchagallon (NR 902 344) in 1980.

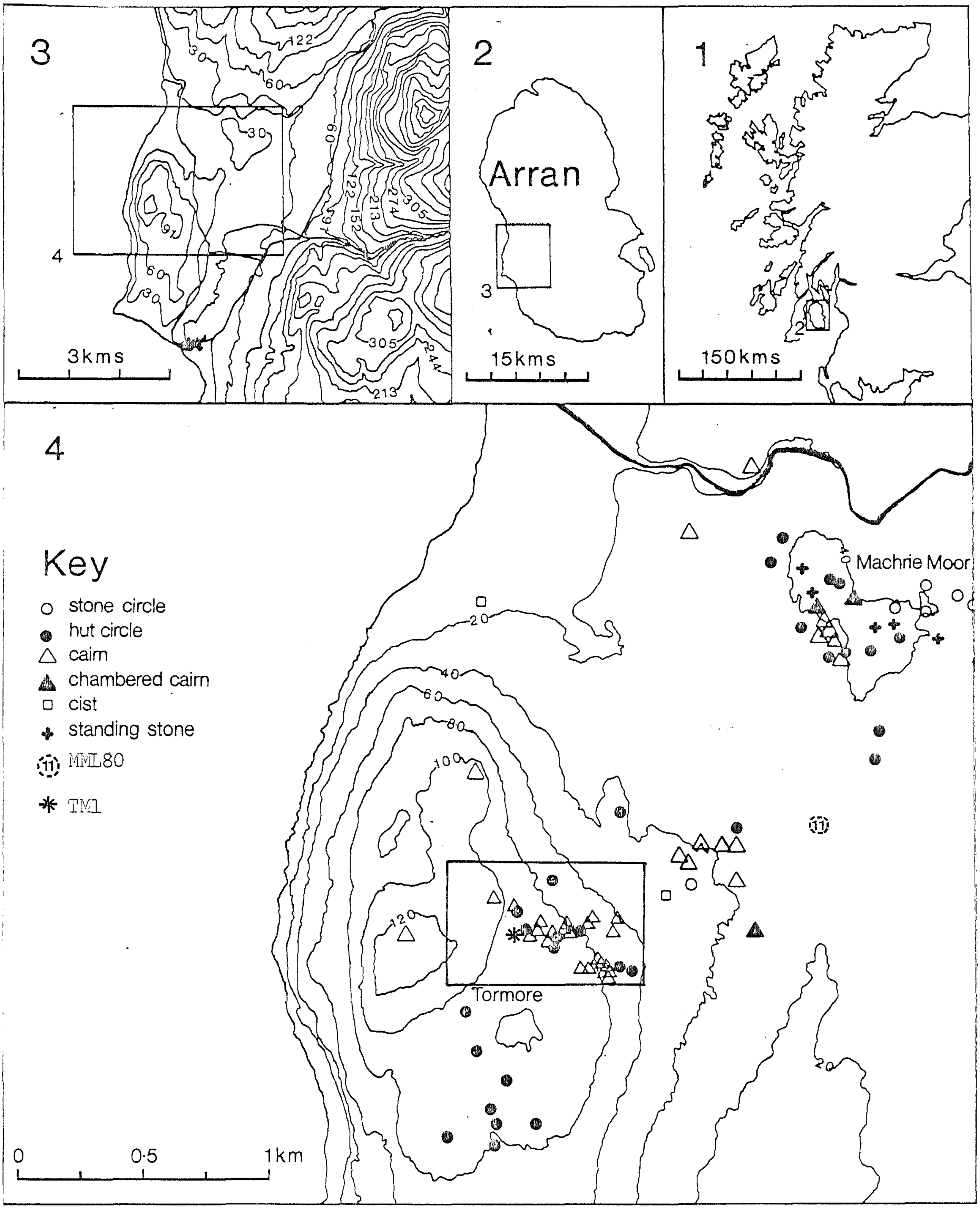
The Excavation at Tormore (NR 896 312)

Originally the excavation at Tormore was scheduled as a short, five-week project but such was the unexpected nature of the findings and the interest which they generated that this was extended to fifteen weeks.

The location of the monuments, as revealed by Mercer's survey, is given in Fig. 3.1. They are ranged along the east-facing slopes of Tor Righ Mor which forms the western side of the basin enclosing Machrie Moor. The sites chosen for excavation form part of a group of eight hut circles, two of which appear to have been superimposed on earlier circles (circles 10 and 14 on Fig. 3.2, the site plan for the Tormore excavation). There are also twenty cairns and ca. 1500 m of tracable pre-peat field bank. The monuments lie between the 60m and 100m contours with the field banks extending beyond these limits. The hut circles are very uniform in appearance, all being ca. 11m in diameter, with an entrance to the south-east. The cairns are more variable, they have a maximum height of one metre and a diameter of 4 - 5m. Less obvious and harder to trace are the field banks, these rarely exceed 0.25m in height and 1m in width and often are only visible for short stretches above the peat. Prior to excavation this collection of monuments was thought to be Iron Age in date, being similar to those at Kilphedir (Fairhurst and Taylor, 1971) and at Dalnaglar (Stewart, 1964). It was presumed that they represented a settlement site and the monuments around the 100m contour

Figure 3.1

Showing the distribution of monuments on Tormore and Machrie Moor and relating to the site plan for the Tormore excavation (Fig. 3.2). The locations of sections MML80 (11) and TM1 (*) are also shown.
(Courtesy of the C.E.U.- Crown Copyright).


3
2
1
Arran
4
3kms
15kms
150kms
Key
stone circle
hut circle
cairn
chambered cairn
cist
standing stone
MML80
TM1
Machrie Moor
Tormore
0
0·5
1km

were chosen for excavation as they appeared to be the most suitable for the investigation of the inter-relations within this.

The Excavated Monuments

The results of the excavation at Tormore are still in the process of being written up by the staff of the C. E. U.. An interim report was produced in 1980 and the majority of the information contained in this chapter is taken from that in addition to published information in 'Discovery and Excavation in Scotland' and information collected in discussion with John Barber over the past three years.

Site One

Site One is a hut circle (see Fig. 3.2). It is touched on the south-west side by a field bank which also appears to emerge from the north-west of the site, being quickly lost in the peat and apparently reappearing and continuing over the hillside further to the north-west. On excavation, site one was revealed as a complicated site. It consisted of two superimposed series of huts, the first, not more than 6m in diameter, was the smallest. It consisted of three superimposed banks preserved as clearly defined buried turf lines. The lower two of the three yielded beaker pottery, including an all-over-cord beaker, and tanged and barbed arrowheads. Charcoal was abundant in the buried soil layers but occurred less frequently in the bank cores. The second hut in the series had a shallow drip trench directly outwith it.

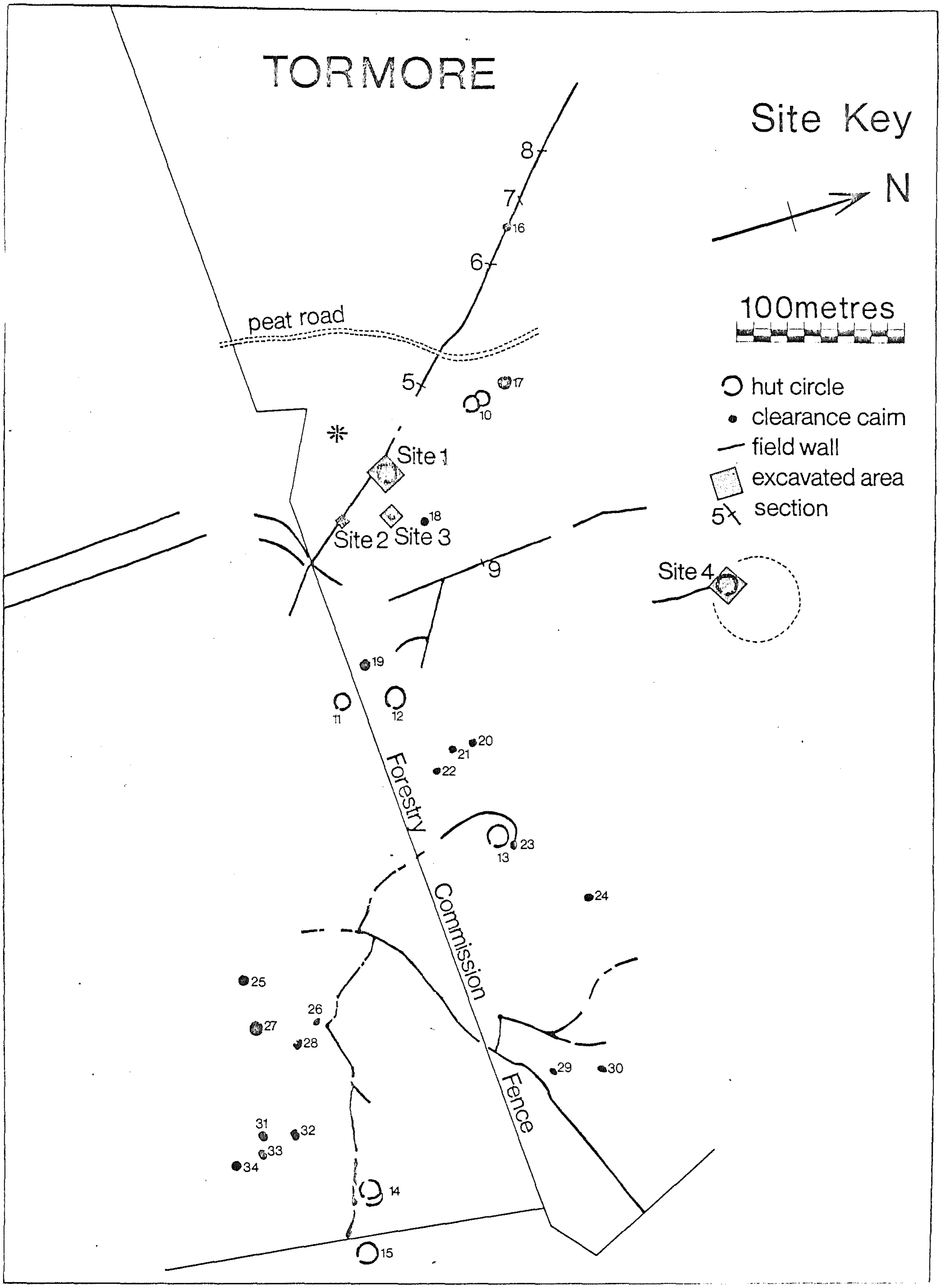
The second series of huts were larger reaching the typical diameter of around 11m. It was only on the north side that they overlaid the earlier huts, preserving the complete sequence. Fig. 6.8 is a drawing of the section cut through the north-east quadrant. Samples of soil were removed from the various layers and some of these were analysed for pollen. The results of this are discussed in full in Chapter 6.

There were at least four banks in the second series of huts and in the course of the construction of each of these material was repeatedly dug out from the interior of the hut circle and incorporated into the banks. The abundant charcoal contained in these banks is, therefore, useless as regards the ^{14}C dating of the sequence. After the last of the four banks had been constructed and had begun to erode, wooden structures were erected within it. These are represented by interval settings of eleven large postholes surrounded by settings of smaller posts at 50cm intervals around the inner

Figure 3.2

Showing the site plan of the Tormore excavation and the location of section TM1 (✱).

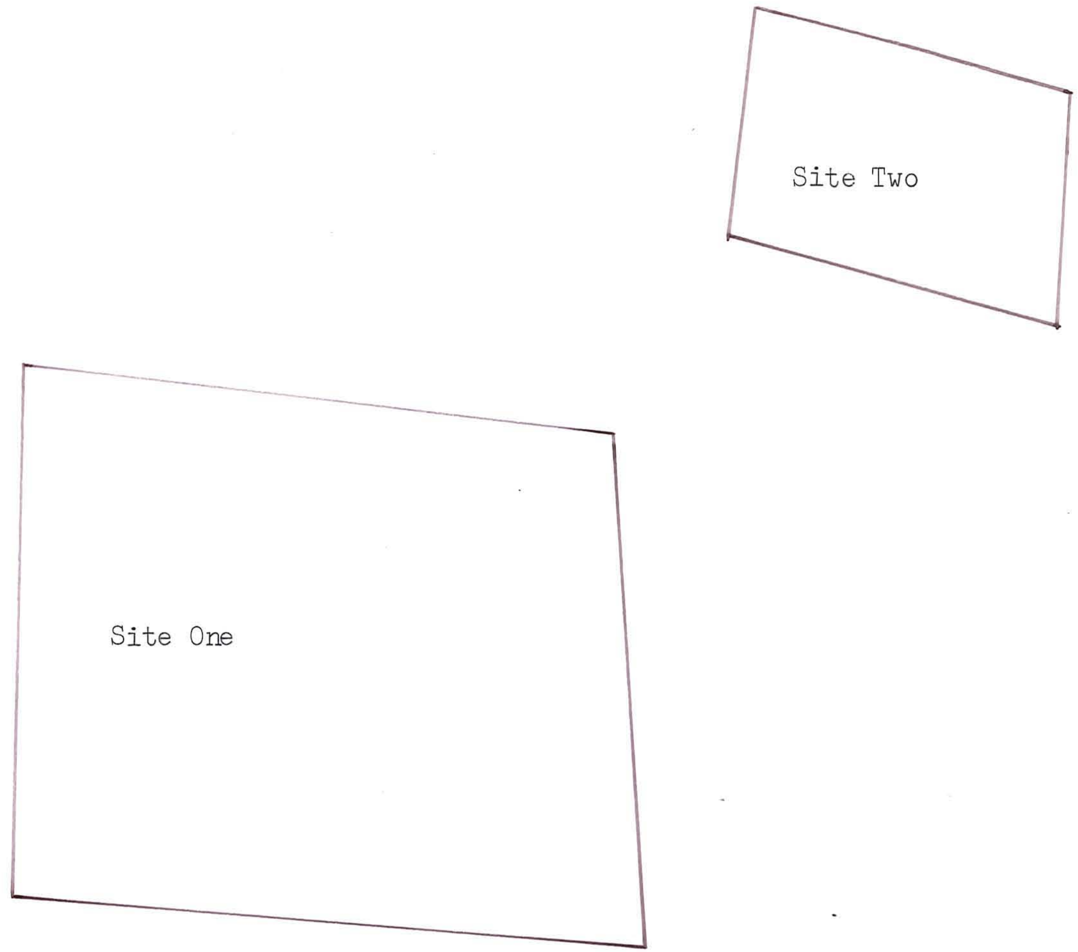
(Courtesy of the C.E.U. - Crown Copyright).

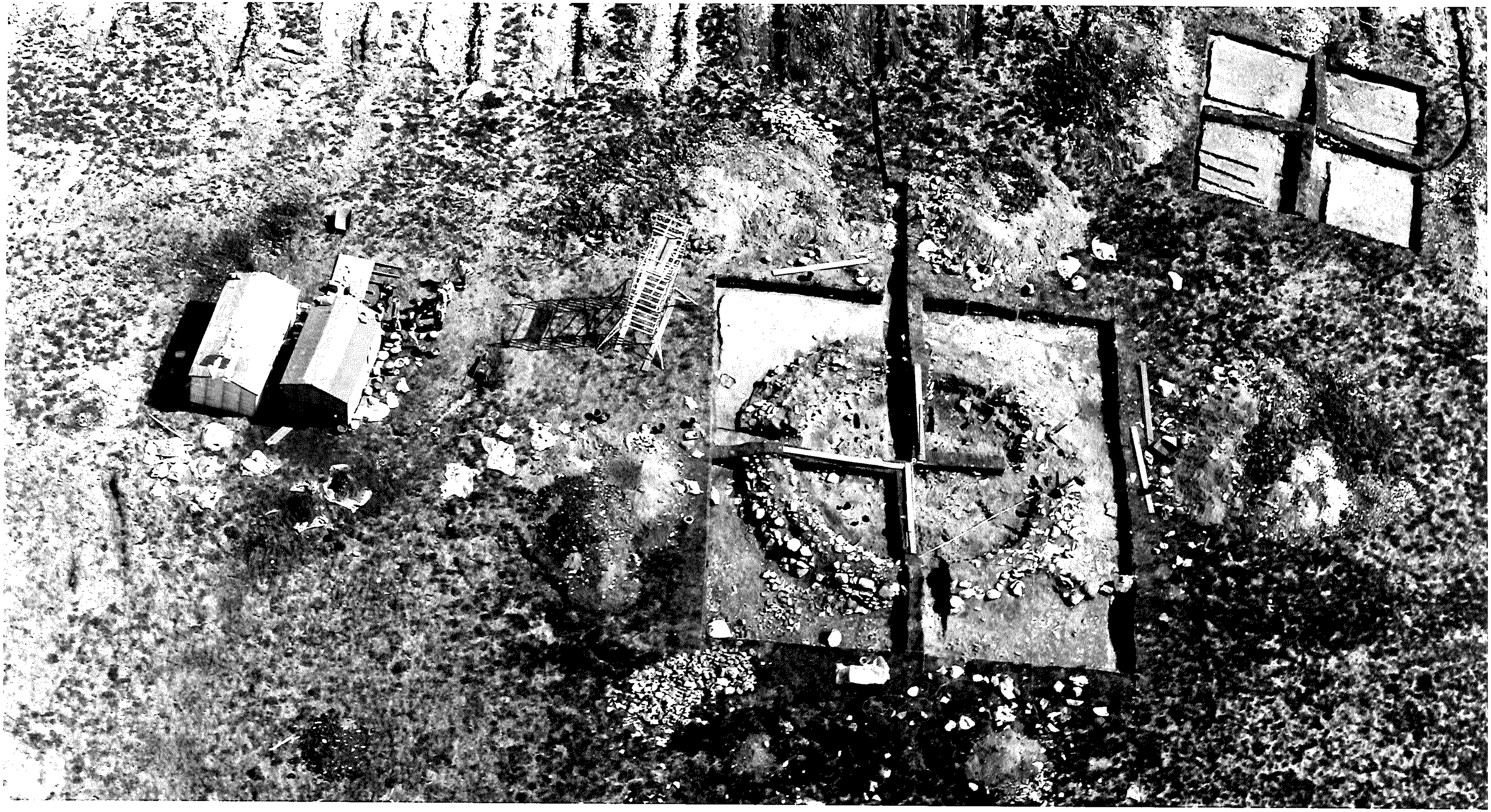


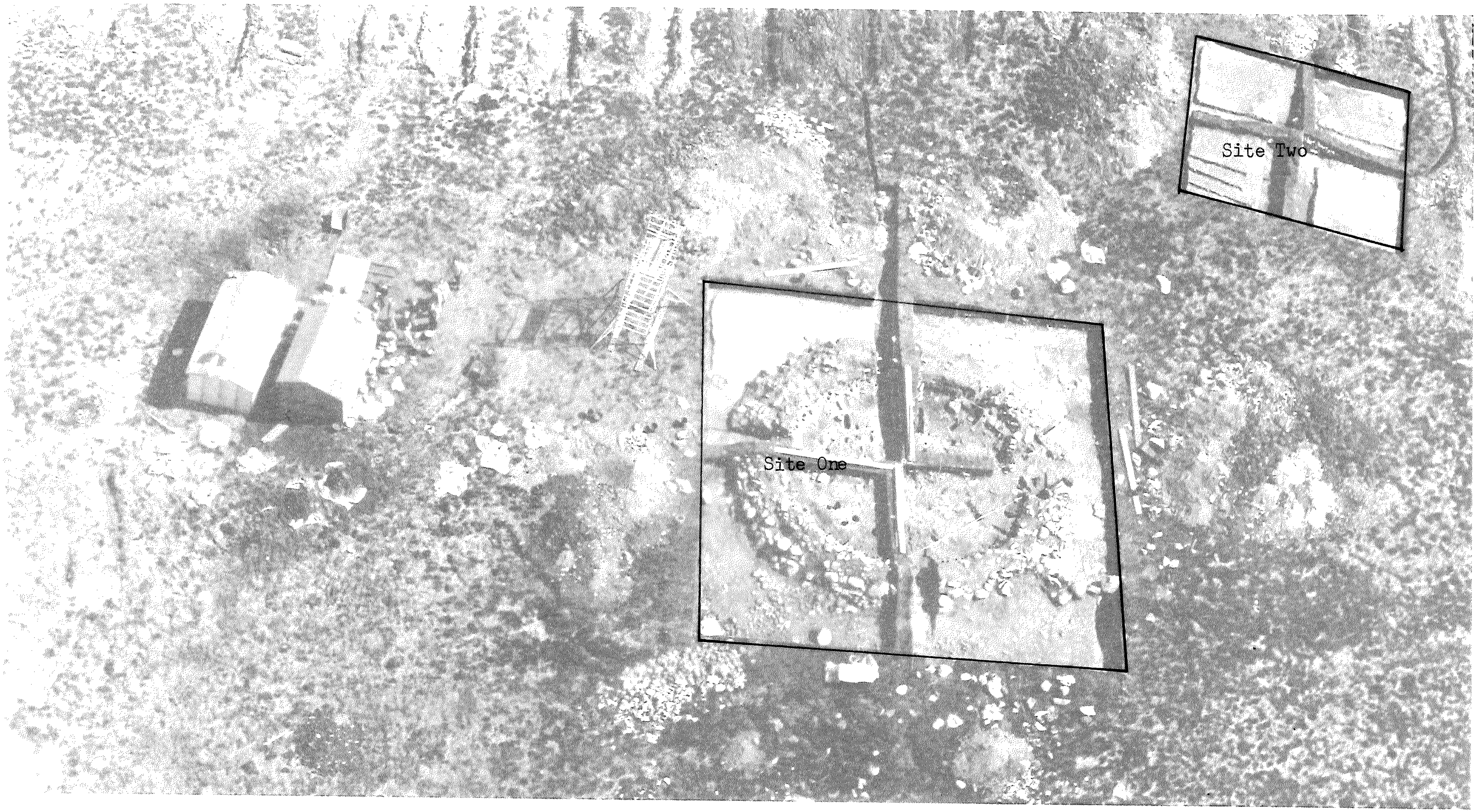
TORMORE
Site Key
N
100metres
hut circle
clearance caim
field wall
excavated area
5 section
peat road
Site 1
Site 2
Site 3
Site 4
Forestry Commission Fence
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34

Plate IV

Aerial Photograph of part of the Tormore excavation, showing Sites one and two and the limit of the Forestry Commision ploughing. (Courtesy of the C.E.U., Crown Copyright.)


Site Two
Site One




Site Two
Site One

shoulder of the bank. The first of these structures was burned down and was almost completely removed before the construction of later buildings. In the interval a layer of silt had washed down. The last hut in the series was also destroyed by fire and from this final structure large volumes of carbonised material were recovered. This included oak posts, carbonised cereals, complete stretches of wattles and material tentatively identified as thatch. Charcoal from this hut was ^{14}C dated to 1029 ± 90bc.

Finds recovered from the second series of huts included several hundred potsherds (some of the flat rimmed form), many flints (the majority of them well made scrapers with a scraping angle) and a single piece of haematite kidney ore. The repeated recutting of the internal faces of the banks complicated the interpretation of the many features found within the circle as these tended to be truncated and superimposed. The entrance to the huts again lies to the south-east but it does not overlie the entrance of the earlier huts. It appears to have been quite an elaborate structure represented by sixteen postholes which were organised in opposed pairs on the inner and outer corners of the entrance and, in one case, at the centre as well. From one of the post holes in the entrance a saddle quern was removed. This had been modified from its original use, a hollow had been chipped in it to enable it to be used as a hinge stone for a door. Its final use had been as a packing stone in the post hole. Ard marks were found on the east side of the hut circle and some of these underlay at least the second series of banks. Soil samples were taken from the fill in these ard marks and analysed for pollen, again the findings are discussed in Chapter Six.

It was clear from the excavation that the field banks which touched the site were built after the hut circle had finally been abandoned. Stones from the hut had been used to construct the bank and peat had infiltrated to the lowest levels of the loosely built structure but did not underlie it. Peat sections were removed from the ditch associated with the continuation of the bank to the north-west. These are discussed in detail in Chapter Six.

Site Two

Barber (1980a) reports that site two "presented an odd appearance on deturfing". It consisted of an annular cairn of small field stones which was touched and partly overlain by the south-eastern extension of the field bank mentioned above. The bank was made up of large boulders at this point and on removal of these a much more carefully constructed bank, constructed of stones identical in size to those of the cairn, was revealed. The inter-

Figure 3.3

Showing an artist's impression of the last strucure built on site one of the Tormore excavation. (Drawn by Peter Strong of the C.E.U. - Crown Copyright).

Note: The tree illustrated closely resembles a species of *Acer*, possibly *Acer pseudoplatanus* which was , of course, not present in Britain in the Bronze Age.

pretation is that the cairn was a simple clearance cairn from which stone was robbed to build the first bank which was later overlain by the boulder bank. Sectioning of the bank revealed that the boulder bank too had been rebuilt and that the original bank had a ditch which was not filled with peat, unlike the final version. When the cairn itself was sectioned an even earlier bank and ditch was revealed suggesting that this was a land division of great antiquity and importance. The finds from this site amounted to a single waste flake of flint.

Site Three

The cairn at site three was a simple clearance cairn overlying the ancient sandy topsoil. Within this were preserved several agricultural furrows. Finds from the site included a 'sickle-like' flint implement and two flint scrapers plus a hoard of sixteen flints, twelve of which were fashioned.

Site Four

Another hut circle was excavated at site four. This was much simpler than the one at site one although the superficial appearance is similar. Greater use was made of stone in the construction of the circle at site four with the banks being delimited by massive boulders. The original structure enclosed an inner circle of postholes but these were not present immediately inside the bank. The finds recovered consisted almost exclusively of scrapers. The whole of site four lies within a ditch which is of earlier construction and about 1.5m deep. This was largely stone filled suggesting that a stone wall once bordered it but no other trace of the wall survives. A hearth site was discovered and charcoal from this collected for ^{14}C dating, but no date is as yet available. The presence of three postholes and a stone wall footing suggests that perhaps there was reuse of the site at some stage. If this was the case it is unlikely to have been a very substantial structure.

The overall conclusions from the evidence as presented so far is that there was settlement on Tormore from at least the Beaker period. There may have been earlier agricultural usage connected with the ard marks and furrows which were found and which was centred on a monument not investigated during the course of the excavation. Repeated settlement followed this early usage culminating in the wooden structures (see Fig. 3.3) the last of which was built with wood with a ^{14}C date in the middle to late Bronze Age. Reuse of the site in the Iron Age is suggested by the presence of the obviously later field banks. Whether an associated settlement was present at this time is not clear. The Iron Age field bahks appear to be the latest structures present.

CHAPTER FOUR

MATERIALS AND METHODS

4.1 COLLECTION OF CORES AND MONOLITHS

Tormore

The four sections from Tormore (TM1, TMD1, TMD4, TMD5) were collected by members of the Central Excavation Unit in June 1978. Sharpened 50cm monolith tins were driven into the cleaned faces of the sections and the samples were removed by cutting away the remaining unsevered peat to the rear of the tin with a sharp knife. TM1 was recovered from almost 2 metres of peat in a saddle-type depression 40metres to the west of site one in the excavation (see Fig. 3.2). TMD1, TMD4 and TMD5 were removed from sections 5,8 6 respectively across the ditch associated with the field bank running north-west away from site 2 and site 1. After collection the monoliths were wrapped in polythene sheet and sealed with adhesive tape before being transported to the mainland. As the samples were collected by the excavators, there was no opportunity to examine the stratigraphy and nature of the deposits in the field.

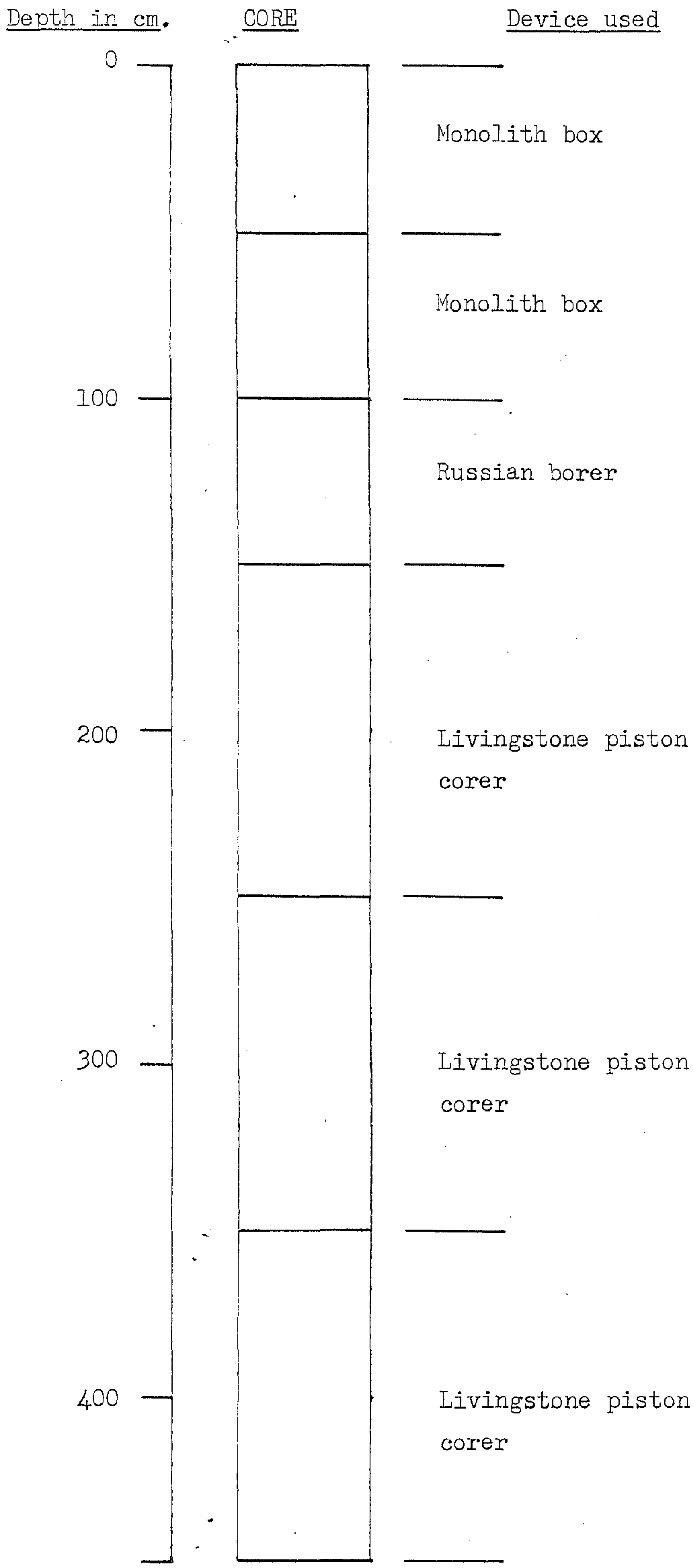
Machrie Moor

The Machrie Moor section (MML80) was collected by Dr. J. H. Dickson, Dr. C. Faseas and myself in January 1980, following the analysis of a preliminary core collected with the help of Dr. P. Jowsey, late of the Macaulay Institute, Aberdeen, in June 1979.

Due to the fibrous nature of the upper 1.5 metres of peat, three separate methods of sampling had to be employed to ensure the collection of a complete section. A hand operated Livingstone corer, which does not perform well in fibrous deposits, was used for the majority of the section, from 1.5 metres to the base of the peat at 4.5 metres. Duplicate 50cm cores were taken from a depth of 1 metre to 1.5 metres using a 'Russian' borer (Jowsey, 1966) and the top metre was collected in two 50cm monolith tins from a cleaned vertical face cut into the peat. All the samples were taken in an area of less than $1m^2$. The Livingstone cores were left in their 5cm (2in) aluminium tubes and all samples were wrapped in polythene sheet and sealed with adhesive tape. At the time of sampling no description of the stratigraphy of the sediment was attempted due to shortage of time.

Figure 4.1

Showing the devices used in the collection of section MML80 from Machrie Moor.


Depth in cm.
CORE
Device used
0
100
200
300
400
Monolith box
Monolith box
Russian borer
Livingstone piston corer
Livingstone piston corer
Livingstone piston corer

Similarily no systematic survey of the peat stratigraphy in the area was attempted other than the cores collected. However the area was extensively probed and sampled in the process of locating the eventual coring site. The surrounding deposits were all shallower than MML80 and the majority were likely to have been disturbed due to the extensive peat cutting in the area. No such interference was obvious in MML80 apart from the possible absence of some relatively recent material.

4.2 Pollen analysis

After collection the peat samples were stored in a cold room at ca. 5^{o}C. The Livingstone cores were extruded in the lab and re-wrapped in clean polythene. Generally all the samples for pollen analysis were removed at the same time and stored in individual, sealed polythene bags until processed. Occasionally it was necessary to remove further samples in order to decrease the sampling interval at crucial levels, however efforts were made to keep the exposure to the air and modern pollen contaminants to a minimum. Material for ^{14}C dating, charcoal analysis and loss on ignition determination was removed as and when necessary with similar precautions being observed. Sediment description by the Troels-Smith (1955) method was postponed until all the material likely to be needed for pollen analysis and dating had been removed as the method demands the destruction of a considerable proportion of the material in its execution.

i) The preparation of samples for pollen analysis

The detailed procedure followed in the preparation of samples for pollen analysis is outlined in full in Appendix Al(a), in brief the samples were treated as follows:-

a. A lcm-thick sample was removed from the pre-cleaned surface of the core or monolith and transferred to a centrifuge tube.

b. The material was broken up in hot 10% alkali (NaOH) and sieved through a 150u mesh sieve to remove coarse plant debris (the sievings were retained in a Petri dish for later examination, see section 4.10).

c. Samples with a high mineral content were treated with cold concentrated (40%) hydrofluoric acid for a period of between 48 - 96 hours with repetition of the treatment when neccessary.

d. Fine plant debris was removed using Erdtman's acetolysis method which employs a 9:1 mixture of hot acetic acid.

e. Staining was carried out in all cases, with aqueous safranin being the staining agent.

f. Following staining the pollen residues were transferred to the mounting medium, silicone oil, via tertiary butyl alcohol (T.B.A.). The merits of silicone oil as a mounting medium are discussed by Andersen (1960).

g. The pollen preparations were mounted on slides of 0.8 - 1 mm thickness with 22 mm number 0 square glass coverslips. Where necessary the residues were further diluted with silicone oil. To prevent movement of the coverslips the corners were tacked down using 'Glyceel'.

ii) The analysis of the slides

All pollen slides were counted at x400 using a Nikon binocular microscope. Critical determinations were made at x1000 using an oil immersion lens with either anisol or cyclohexane as the medium between the objective and the coverslip. In all cases a full slide (or slides) was counted with either 10 or 20 equally spaced traverses being made. This was to avoid the problems created by the non-random distribution of pollen as discussed by Brookes and Thomas (1967). At least 150 tree pollen grains or 500 total land pollen were counted at each level. The counts were recorded on pre-prepared counting sheets and the totals and hand calculations entered on a totals sheet. Later the counts were transferred to computer cards for analysis via the computer programme 'Poldata Mk IV'. The data and calculations contained on the computer files were checked against the total sheets and hand calculations before the diagrams were drawn up by the computer. Poldata Mk IV is a version of the programme written by Dr. H. J. B. Birks and Dr. B. Huntley of Cambridge University, which was adapted for use on the 2980 EMAS system in Edinburgh by A. Alexander of the Geography Department, Edinburgh University.

iii) Pollen identifications

Identification of the various pollen and spore types encountered during the course of the study was achieved primarily through the use of the pollen reference slide collection in the Department of Botany, Glasgow University. This contains material mounted in both silicone oil and glycerine. Reference was also made to several pollen and spore keys, floras and texts including Faegri and Iversen (1974), Moore and Webb (1978), Birks (1973), Andrew (1970, 1980), Erdtman, Berglund and Praglowski (1961), Erdtman, Praglowski and Nilsson(1963), Moe (1974), Reitsma (1966), Sorsa (1964), Beug (1961), Andersen (1979), Andersen and Bertelsen (1972), Johansen (1978) and Oldfield (1959).

All nomenclature regarding the various pollen types follows Moore and Webb (1978) apart from the use of the categories '*Corylus* type' and '*Myrica* type'. The difficulty in separating the fossil pollen of *Corylus avellana* and *Myrica gale*, particularly when the grains are badly preserved, is well known. In this study an attempt has been made to separate the grains into Corylus and Myrica on the basis of comparison with reference material and the photographs, electron micrographs and descriptions of Pilcher (1968), Edwards and Larmour (unpub), Erdtman et al. (1963) and Moore and Webb (1978). No claims are made as to the absolute identification of the two types and the sum of the two is included in the category 'coryloid' as is common practice. However I feel that the separation is a valid and useful one especially in the light of the important part which Myrica plays in the present-day vegetation of Arran. (The two types were not separated in the analysis of the section TM1 because analysis was well advanced before the convention was adopted). NOTE Since writing this section my attention has been drawn to a paper by Edwards (1981). This reaches the conclusion that the separation of Myrica and Corylus grains using the light microscope may produce unreliable results and that a useful check might be performed using a scanning electron microscope. Verification of this nature is not possible at this stage in the project and the results are reported as originally outlined above. The points raised by Edwards have, however, been borne in mind.

iv) Unidentified grains

During the course of any study of this nature pollen grains and spores are encountered which for some reason are unidentifiable. The most common cause is poor preservation. Cushing (1967) deals with this problem, dividing pollen grains and spores into five categories :-

i. Well preserved

ii. Corroded, the exines have distinctive etching.

iii. Degraded, the exine has undergone structural changes such that the individual elements become fused and blurred.

iv. Broken, the exine is split, dividing the grain into two or more pieces.

v. Crumpled, the grains are wrinkled, folded or collapsed.

In this study three categories were used, excluding well preserved :-

i. Corroded - which includes both Cushing's 'corroded' and 'degraded' groups.

ii. Broken - the same as Cushing.

iii. Crumpled - the same as Cushing.

Grains may also be difficult to identify because they are obscured by debris or other pollen grains, these were scored as 'obscured'. Occasionally grains were encountered which, although well preserved, were not able to be identified by the normal methods, these were scored as 'unknown'.

For all diagrams a summary 'unidentified' curve is also included.

v) Presentation of the pollen data

The pollen data is presented in the form of pollen diagrams, the originals of which were all drawn with the aid of the 'Polldata Mk IV' computer programme. The results are expressed in one or more of the following ways:-

1. As a percentage of the total land pollen (i.e. excluding unidentified pollen, spores etc. and obvious aquatics). Taxa not included in the sum are expressed as a percentage of the total land pollen + the relevant sub-sum e.g. Polypodium expressed as a percentage of T.L.P + sum Filicales.

2. As pollen influx (grains/cm^2/year). (See Absolute Pollen analysis).

The method used is clearly printed on each pollen diagram.

vi) Zonation of Pollen Diagrams

Throughout this thesis the emphasis has been very much on the effect which successive human populations have had on the vegetation. This emphasis has been carried through to the zonation of the pollen diagrams.

Sections TM1 and MML80 have been divided into local pollen assemblage zones on the basis of the observed changes in their constituent pollen curves. Where necessary these zones have been further divided into subzones, in the majority of cases on the basis of the changing levels of human activity.

The ditch sections TMD1, TMD4 and TMD5 were zoned almost totally on the basis of human activity because abrupt changes in the local pollen types and the resulting 'depression' of the regional pollen input would have made any other zonation scheme cumbersome and rather meaningless.

No attempt has been made to construct Regional Pollen zones but MML80, which is obviously the most representative of regional events, has been correlated with diagrams from the south-west of Scotland and the rest of Britain where applicable.

4.3 INTERPRETATION OF POLLEN DIAGRAMS

With the work in this thesis being so obviously orientated towards the influence which succesive human populations have had on the vegetation, the behaviour of species indicative of forest clearance, disturbed ground and various agricultural practices is of great importance. Of those indicators, only the pollen of cereals and Plantago lanceolata provide unambiguous evidence of human involvement. Others are only of use when they occur in association with other similar indicators, with cereal or plantain pollen or in periods of obvious forest clearance. In isolation their presence could be independant of human activity.

The indicator species used in the course of this work are listed in Appendix A8 along with brief outlines of the conditions which they are taken to reflect.

With regard to the more technical aspects of interpretation such as factors influencing the production, transport and sedimentation of pollen and spores, these are dealt with in great detail by authors such as Moore and Webb (1978), Faegri and Iversen (1974) and Birks and Birks (1980) to whom reference is made.

4.4 ABSOLUTE POLLEN ANALYSIS

Pollen data expressed in percentage terms are always subject to problems of auto-correlation between taxa and the obscuring and distortion of events by the local over-representation of a certain pollen type or types.

Methods aimed at measuring the *'absolute pollen frequency' of each type, so-called 'absolute pollen analysis', largely overcome these problems by enabling the values of each taxon to be expressed independantly.

The term 'absolute pollen frequency' is equivalent to the 'pollen concentration', which in turn is a measurement of the number of grains per unit volume or mass of wet or dry sediment. (Units - grains/cm^{-3}, grains/gm^{-1}). Pollen data are also expressed in terms of 'pollen influx' which is the number of grains incorporated into a given area of sediment over a given period. (Units - grains/cm^{-2}/year). To enable this to be calculated it is necessary to know the rate of accumulation of the sediment or the 'sediment matrix accumulation rate' (Units - cm/$year^{-1}$), or the amount of time taken to accumulate a given thickness of sediment, he 'deposition time' (Units - year/cm^{-1}). These are generally derived from the time/depth curve produced from a series of ^{14}C dates for the sediment under investigation.

Pollen influx can then be calculated as follows:-

POLLEN INFLUX = POLLEN CONCENTRATION x SEDIMENT MATRIX ACCUMULATION RATE

= POLLEN CONCENTRATION x DEPOSITION RATE

Various techniques have been developed to measure absolute pollen

* All terms expressed after Davis (1969)

frequencies. Direct methods based on known volumes (Davis, 1965, 1966) and weights (Jorgensen, 1967) of sediment have been used with success, although indirect methods involving the addition of known concentrations of either exotic spores or pollen have also been popular and are thought by some to be more reliable (Beckett, pers.comm. 1979). The use of exotic additions stems from the work of Benninghoff (1962) which was refined and tested by Mathews (1969) and Bonny (1972). Suspensions of Nyssa sylvatica, Ailanthus glandulosa and Eucalyptus globulus pollen have all been employed, with the concentration being measured by successive haemocaetometer counts (cf. Bonny, 1972) or a Coulter counter (cf. Stockmarr, 1972, Edwards and Gunson 1978). The main problem encountered in this method has been achieving and maintaining a homogeneous suspension of pollen or spores. Stockmarr (1971) made an effort to overcome this by producing calcium carbonate based tablets containing a known number of Lycopodium clavatum spores, normally 12500 ± 500 per tablet. These are added in appropriate numbers to a known weight or volume of sediment before the normal preparation procedure. They provide a convenient and seemingly accurate alternative to exotic pollen suspensions. However the method of calculating the fossil pollen concentrations from the pollen counts is the same in both techniques, being based on the following equation:-

$$\frac{\text{FOSSIL POLLEN/SPORE}}{\text{CONCENTRATION}} = \frac{\text{FOSSIL POLLEN/SPORES COUNTED}}{\text{EXOTIC POLLEN/SPORES COUNTED}} \times \frac{\text{EXOTIC POLLEN/SPORE}}{\text{CONCENTRATION ADDED}}$$

The inherent errors in the Lycopodium method are discussed in Stockmarr (1971) and Bonny (1972) deals with the errors involved in the use of other exotic pollen. A full account and comparison of the Davis, Mathews and Jorgensen methods is contained in Peck(1974).

Absolute Pollen Analysis on Peat Deposits

To date almost all studies involving the use of absolute pollen analysis have been on material from lakes rather than peat bogs and as a consequence most of the ensuing interpretation, comparison and statistical work has been based on these sediments (see Birks and Birks, 1980, pp. 206 - 230). This is a result of the suitability of lake deposits to the technique. They tend to be fine grained, accumulating at a more or less constant rate, or showing only gradual changes in the rate of deposition, and, especially in large lakes, the effects on deposition of vegetation growing in or around the lake tend to be small. Thus it is easy to obtain a precise volume of sediment,

Table 4.1

Published Absolute Pollen Analysis Data from Peat Deposits

Reference	Site(s)	Method
Hicks (1975)	Kangerjoki, Finland	Jorgensen, (1967)
Hicks (1976)	Kuusamo, Finland	Jorgensen, (1967)
Beckett and Hibbert (1976)	Abbott's Way, Somerset Levels	Jorgensen, (1967)
Beckett and Hibbert (1979)	Abbott's Way, Meare Heath, Somerset Levels	Jorgensen, (1967)
Beckett (1978)	Meare Heath, Somerset Levels	Jorgensen, (1967)
Beckett (1979)	Abbott's Way, Somerset Levels	Jorgensen, (1967)
Davis (1977)	Blue Mounds Creek, Tamarack Creek, Hub City, Wisconsin	?Mathews, (1969) with Lycopodium spores
Mannion (1978)	Threepwood Moss, S.E. Scotland	Stockmarr, (1971)
Huntley (1981)	Caenlochan, N.E. Scotland	Bonny, (1972) as modified by Birks (1973, 1976)

prepare a smooth,linear time/depth curve and discount the effects of local vegetation on the deposition of pollen into the sediment. The only problems tend to stem from the inwash of older carbon, from soil or rocks, which affects the dating, and from the slumping or redeposition of surface deposits.

The analysis of peat sections on the other hand presents a multitude of problems. The stratigraphy of peat bogs is commonly heterogeneous with rapid changes in the peat-forming species and the rate of deposition resulting from small ecological changes. Hiatuses may be present representing the temporary cessation of peat growth. This makes it very difficult to calculate the sediment matrix accumulation rate or the deposition rate, even with a considerable number of ^{14}C dates. Peat also tends to be very fibrous in nature and this can make it difficult to obtain an accurate volumetric sample for analysis. This coarse plant debris also necessitates sieving of the samples during preparation and this may lead to losses of exotic (Mannion, pers. comm, 1979). However if the preparation precedure is the same for all samples then this need not necessarily produce anomalous results. The vegetation growing on and around a bog can profoundly affect the deposition of pollen on to the bog surface. Trees growing on the surface can reduce pollen influx by a filtering effect (Hicks, 1975) and their remains cause problems in sampling and the calculation of deposition rates as discussed above. Oldfield et al. (1979) in work on the incorporation of magnetic particles into peat have shown that there is a marked difference between the number of particles trapped in hummocks and those trapped in hollows on the surface of the bog. They suggest that this has direct implications for absolute pollen studies and that up to 5 times as much pollen may incorporate into hummock material as finds its way into the hollows (Oldfield, pers. comm. 1979). By the same token bogs where the topography is not so obviously varied may also be subject to the differences in the pollen-trapping efficiency of the various constituent peat-forming plants.

Despite these difficulties several authors have been involved in the absolute pollen analysis of peat. The first work was that on a bog at Kangerjoki in Finland by Hicks (1975) and soon afterwards it was used on material from the Somerset Levels (Beckett and Hibbert, 1976, 1979, Beckett, 1978, 1979). Since then several other sites have been examined (see Table 4.1). The consensus of opinion appears to be that it is a worthwhile exercise and that providing the stratigraphy of the peat is fairly homogeneous with no obvious hiatuses, and sufficient ^{14}C dates are available, the results are meaningful. One of the main applications of the method appears to be in the investigation of short-term interference phases, certainly the data from the

Abbot's Way on the Somerset Levels concerning the elm decline and the behaviour of the other tree species at this time are intriguing. Beckett (1979) has also used the data in a comparison with influx data from lake sediments, investigating the differences due to the lack of inwashed or stream-borne pollen in the peat sediments.

Absolute pollen analysis on peat from Tormore and Machrie Moor

Samples were prepared for absolute pollen analysis for the whole of the Machrie Moor section (MML80) and also from the duplicate sampling of the basal 20cm of the Tormore section TM1 which is referred to as TM1AB. The method chosen was that using tablets containing a known number of Lycopodium clavatum spores as described by Stockmarr (1971), the reasons being that the Lycopodium tablets were available, apparently reliable and easy to use. The preparation procedure was identical to that for normal pollen analysis apart from the need to know the initial volume of the sample used. This was measured using distilled water and a calibrated measuring cylinder as described in Bonny (1972). The Lycopodium tablets were added prior to any treatment of the samples. A full account of the method used is given in Appendix A1(b).

When the slides were counted the exotic spores were counted along with the fossil grains up the pollen sum of 150 fossil tree grains or 500 fossil land pollen grains. The totals were included on the totals sheets for the later calculation of pollen concentration and influx using 'Polldata'.

No problems were encountered in separating fossil Lycopodium clavatum spores from those added in the tablets.

The benefits of absolute pollen analysis have already been briefly outlined (section 4.3). The main reason for its application to the material from Arran was to investigate in detail the behaviour of the various pollen types, particularly the trees, during clearance and interference phases.

4.5 SOIL POLLEN ANALYSIS

The analysis of pollen recovered from soils tends to be fraught with problems. Most soils, unlike peat and lake deposits, do not have the benefit of combined anaerobic and highly acid conditions to halt or retard pollen decomposition or inhibit the activities of burrowing soil animals, such as earthworms, whose actions destroy the structural integrity of the deposit. The downward movement of pollen is also a major cosideration in soils that are at all porous. Soils with a pH greater than 5.5 are considered to be particularly prone to the problems of differential preservation and vertical mixing due to earthworm action (Birks and Birks, 1980, Dimbleby, 1961a,1965a). Pollen samples have been prepared from obviously calcareous soils (Dimbleby and Evans, 1974), although this sort of material often produces very strange pollen spectra or is devoid of pollen (Whittington in Ritchie, 1978, Durno, in Coles and Taylor, 1970).

It was Dimbleby (1957, 1961a, 1961b, 1962, 1965a) who pioneered the technique of soil pollen analysis particularly with respect to soils associated with archaeological monuments (e.g. Dimbleby, 1965b) and the formation of heathland. Iversen (1964, 1969), Andersen (1979), Havinga (1963, 1968, 1974) and Godwin (1958) have also been closely involved, with the latter two emphasising the problems inherent in the technique.

Soil Pollen Analysis and the Tormore Excavation

A large number of soil samples were collected during the course of the excavation on Tormore. Several were from layers which appeared to have been effectively sealed and as the majority of them were also acid (J. Barber, pers.comm.1980) it was decided to subsample and pollen analyse them. It was hoped that if problems of differential preservation existed they would be revealed by disproportionately high amounts of Filicales spores or of corrosion-resistant pollen.

The samples came from turf and bank core layers arising from the repeated rebuilding of the hut at site 1 (see Figs 3.2, 6.8) and from the fill of ard marks in the soil underlying site 2.

They were air dried soon after collection and stored in sealed plastic bags. For analysis about 5 cm^3 of dry soil was removed with a teaspoon after the contents of the bag had been thoroughly mixed up. The samples were prepared by the standard procedure (see appendix A1) with the HF treatment being repeated several times in order to produce mineral free slides. No attempt was made to produce data concerning the pollen concentration of the soil as employed by Dimbleby (1957, 1961a, 1961b, 1965a). The data are expressed as percentages of the total land pollen as in the other diagrams, see Fig 6.9.

About 60% of the samples analysed contained sufficient pollen to merit a full count being completed. In most of these the pollen preservation was poor but not so bad as to prevent the identification of the majority of the grains. The proportions of Filicales spores etc. suggested that differential preservation was not a serious problem.

4.6 SEDIMENT DESCRIPTION

All sections were described using the Troels-Smith (1955) system for unconsolidated sediments. By this system the darkness (nig), stratification (strat), elasticity (elas), dryness (sicc), sharpness of the boundary transitions (lim) and humification (humo) are evaluated on a 5 point scale (0 - 4). The structure of the peat (struct) and the composition are described. The description of the composition is in terms of deposit elements (these are fully discussed in Troels-Smith, 1955) and the abundance of these is recorded on a 6 point scale (0, +, 1 - 4) along with the degree of humification of each element. The diagrammatic representation of the descriptions presented along with the pollen diagrams was modified in the light of the recommendations made by Aaby (1979) for a simplified Troels-Smith system. The major changes concern Humositas - the degree of humification, the frequency classes of the deposit elements and the inorganic elements, Argilla and Grana. There are also several symbol changes which will be obvious from the key to the symbols (Appendix A6).

Humositas - the degree of humification

Aaby suggests that instead of the five class Troels-Smith scale of humification (0 - 4), a three class scale (1 - 3) is used in drawing up the description. These would be represented by:-

1. Thin line ..... humo 0 and part humo 1 (TS)
2. Medium line ..... part humo 1 and humo 2 (TS)
3. Thick line ..... humo 3 and 4 (TS)

Deposit elements

A reduction is also recommended for the frequency classes of deposit elements, normally described on a scale 1 - 4 , representing $\frac{1}{4}, \frac{1}{2}, \frac{3}{4}$ and all of the deposit. Aaby's system has three classes:-

First class ..... T-S system 1

Second class ..... T-S system 2

Third class ..... T-S system 3 and 4

In this way the number of ways a single deposit can be expressed is reduced from 20 (4x5) to 9 (3x3) thus making the drawing of the deposit types much easier and quicker.

Substantia humosa.

This term was used by Troels-Smith to represent completely disintegrated organic substances, the origin of which it was impossible to ascertain from field examination. Aaby's scheme allows for Sh in the description but recommends that it should if possible be avoided in the figures, being replaced by an alternative symbol. Preferably this should be as the result of examination in the lab revealing the origins of the material.

Inorganic elements - Argilla and Grana

The Argilla elements remain as in the original T-S system, the major changes involve Grana. The four Grana categories are combined into two :-

G.arenosa 0.06 - 0.6 mm G. subburalia 0.6 - 2.0 mm	....	Grana minora (sand) 0.06 - 2.0 mm
G. glareosa minora 2.0 - 6.0 mm G. glareosa majora 6.0 - 20.0 mm	....	Grana majora (gravel) (20 - 60 mm

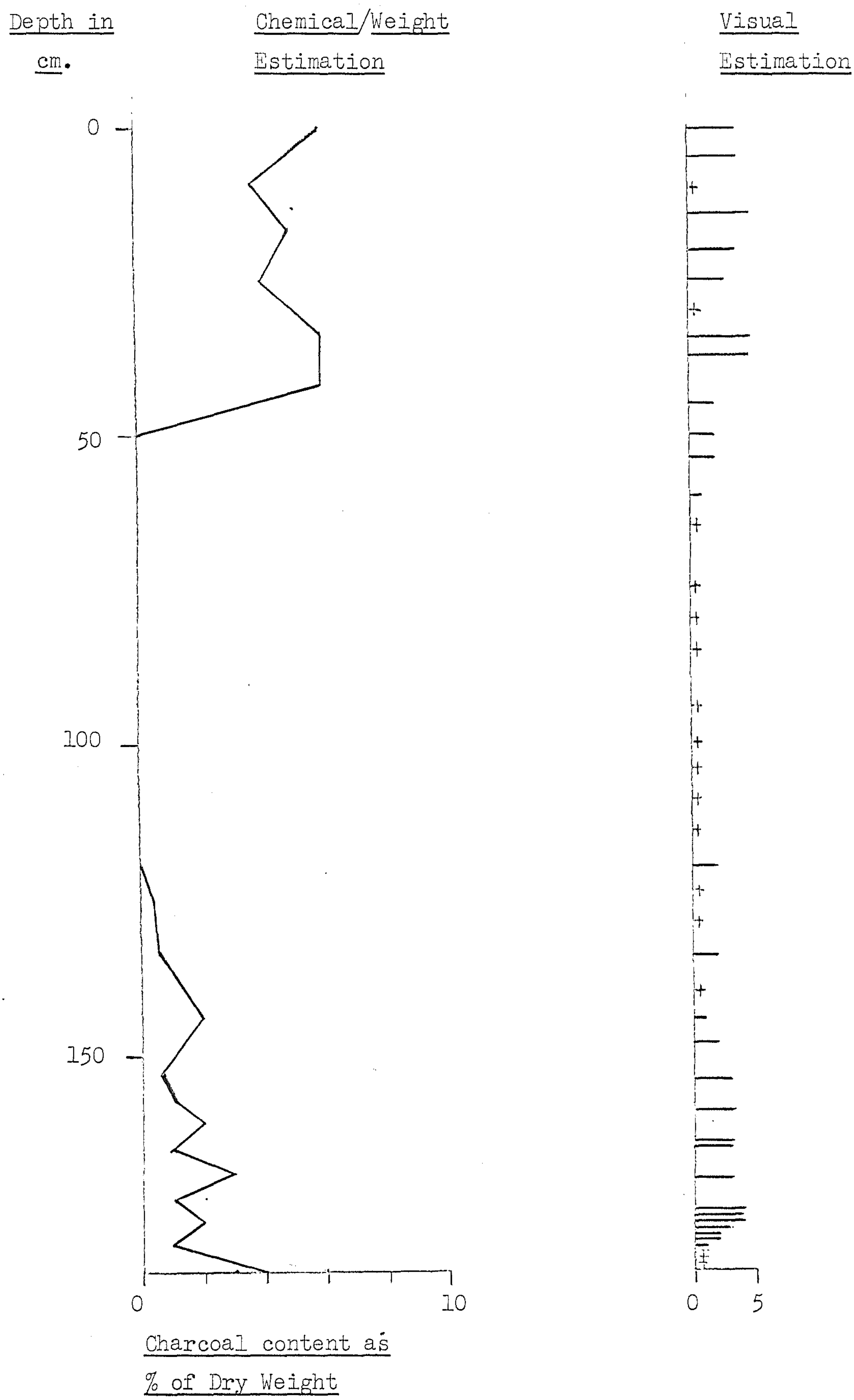
The symbols used to express these modified terms are given in Fig. A6.1.
N.B. In the description of the sediments in the lab microscopic techniques were employed in the determination of the various deposit elements. This too is a modification of the T-S system which is, strictly speaking, a field method. Colour classification of the sediments was according to Munsell's soil colour chart. No classification is given for the Machrie Moor section (MML80) as sediment description was postponed until all other analysis of the section was complete and as a result the peat was fully oxidised and its colour bore little resemblance to the original.

4.7 THE CHARCOAL CONTENT OF SEDIMENTS

Over the years charcoal fragments have been recovered from a large number of both lake and peat deposits in the course of routine analysis. This material originates from both herbaceous and woody species, varying in size from in excess of several centimetres down to a few microns. Generally speaking the larger pieces tend to represent local fires with the smaller fragments arriving as charcoal dust from more distant sources. The possible connection between charcoal layers and prehistoric human activity was recognised at an early stage and their presence is often the basis of interpretations implicating man in the processes leading to heath and blanket bog formation (see section

Figure 4.2

Showing a comparison between the visual and chemical estimations of the charcoal content of section TM1.


Depth in cm.
Chemical/Weight Estimation
Visual Estimation
0
50
100
150
0
10
0
5
Charcoal content as % of Dry Weight

1.4). Methods of recording the presence of charcoal in deposits vary considerably. In many cases just the presence at a certain level is noted (eg. Durno and McVean, 1959, Pilcher and Smith, 1979), in others a visual estimation of the charcoal abundance from pollen slides and sieve washings is plotted (eg. Tallis, 1975). There have also been several attempts at the quantitative estimation of the charcoal present. Swain (1973), working on lake sediments in Minnesota, treated his samples with hot concentrated nitric acid (HNO_3) to oxidise the majority of the non-charred organic material. Then, after washing, he added a known concentration of Eucalyptus pollen, made up slides as for pollen counting and counted the charcoal fragments and exotic grains. The fragments were also measured and put into size categories enabling the total concentration of charcoal in the sample and also charcoal influx to be measured. This method is adapted from Waddington (1969) and a version is also used by Birks (J. Birks, pers. comm. 1979). Following the work of Patterson, who did a critical evaluation of the various methods in use (Jacobson, pers. comm. 1979), several researchers working on fire history in America (including Swain, 1978) adopted a method outlined by Maher (1972). This involved the counting and measuring of charcoal fragments on slides already prepared for 'absolute pollen analysis'. The charcoal fragments are placed in one of 5 - 6 size classes which increase in size geometrically (i.e. each is twice the size of the previous one). For statistical reasons it is important that there is a minimum size below which the fragments are not recorded and it is suggested that this should be of the order of 40 sq. microns.

The resulting data are again expressed as charcoal area/unit pollen concentration and it is particularly useful to plot the changes in the frequency of larger pieces of charcoal which, as mentioned earlier, tend to indicate local fires (Jacobson, pers. comm. 1979). In connection with this it is also necessary to examine the pollen sievings which may contain large pieces of charcoal. The data from this can be tabulated separately, adding to the interpretation.

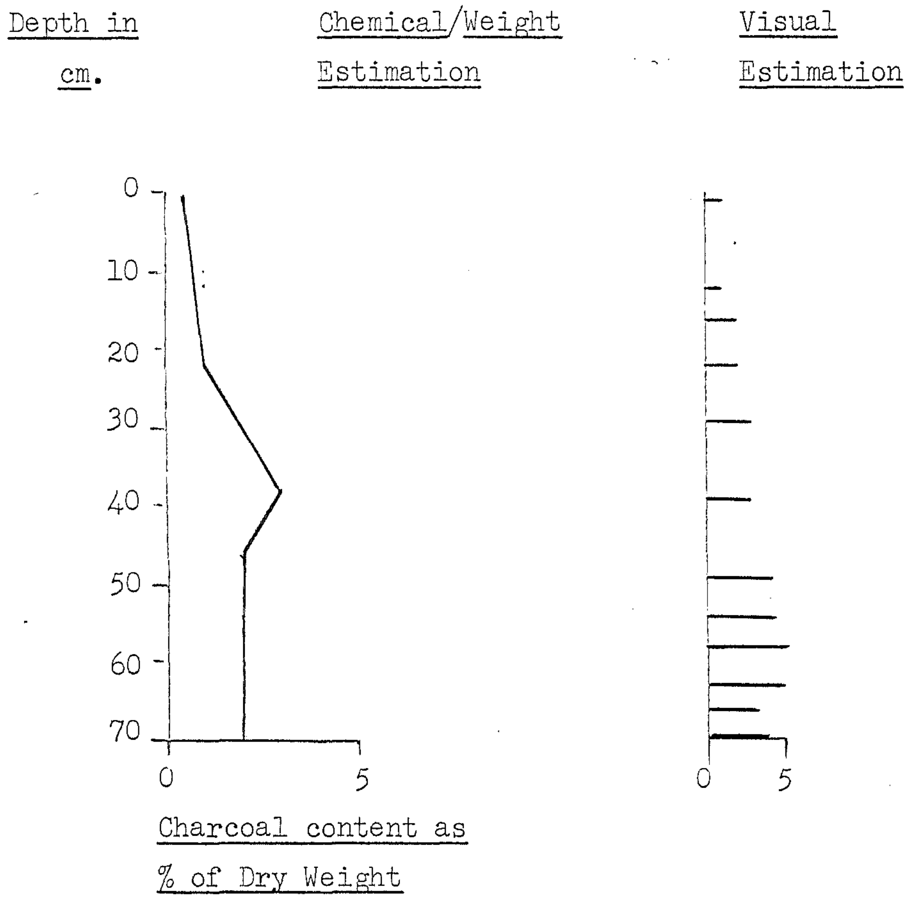
Non-microscopic methods of estimation have also been employed. Tallis (1975) briefly describes a method measuring the residue remaining after the treatment of peat samples with 20% potassium hydroxide followed by concentrated nitric acid. The majority of the material "seems to be carbonaceous" and it is expressed as a percentage of the oven dry weight of the initial peat sample. Visual estimation of the charcoal fragments on the pollen slides on a five point scale is also plotted. There is a fair measure of agreement between the two curves apart from in a particularly mineral rich layer in the peat. No explanation for this deviation is tendered, but it is probably due to the mineral giving the initial sample an artificially

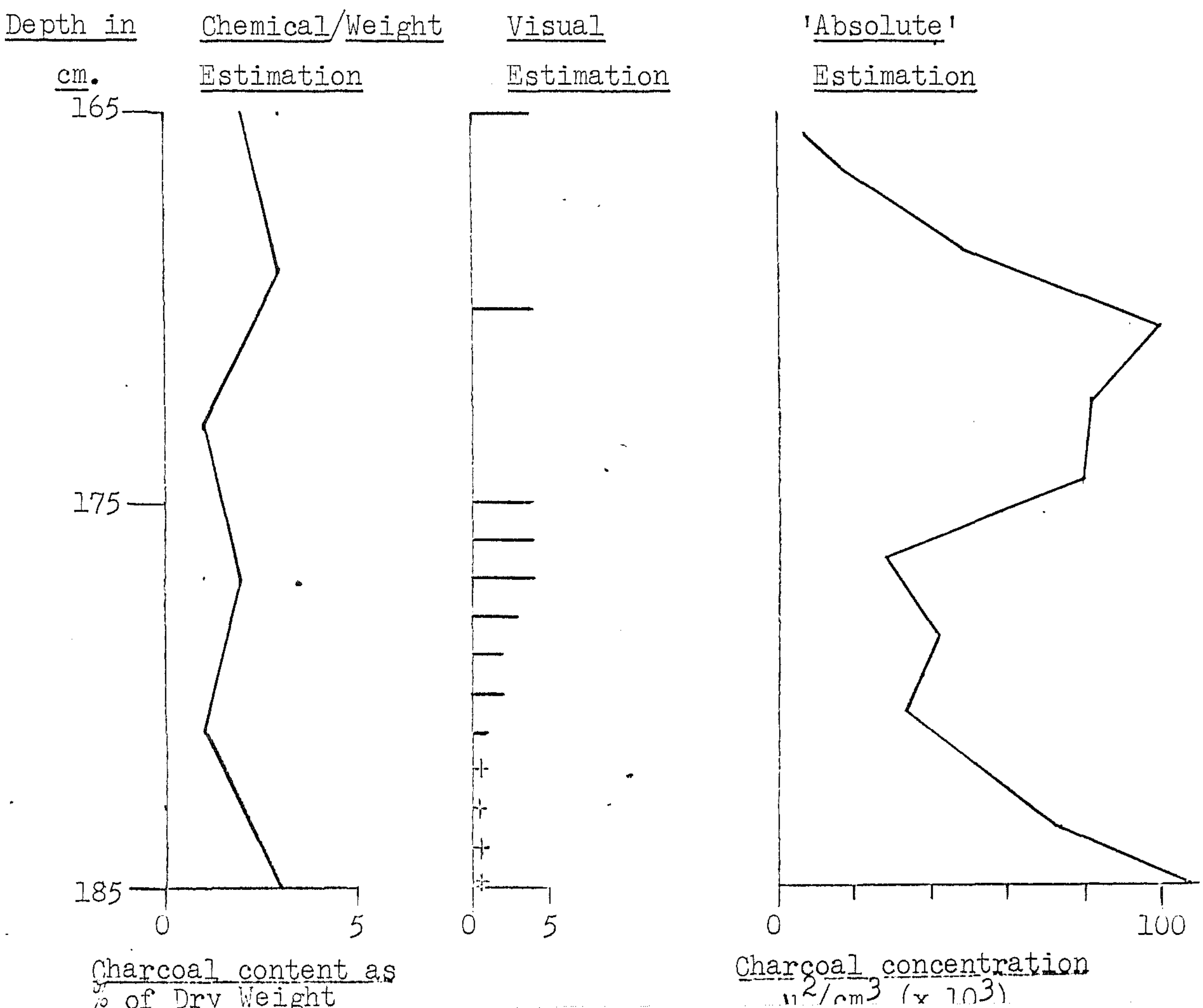
Figure 4.3

Showing a comparison between the visual and chemical estimation of the charcoal content of section TMD1 from Tormore.

Figure 4.4

Showing a comparison between the visual, chemical and 'absolute' estimations of the charcoal content of the basal portion of section TM1.


Depth in cm.
Chemical/Weight Estimation
Visual Estimation
0
10
20
30
40
50
60
70
0
5
0
5
Charcoal content as % of Dry Weight


Depth in cm.
Chemical/Weight Estimation
Visual Estimation
'Absolute' Estimation
165
175
185
0
5
0
5
0
100
Charcoal content as % of Dry Weight
Charcoal concentration μ²/cm³ (x 10³)

high dry weight.

Another method was adapted by Jacobson (1976, unpublished) from one for marine sediments (Smith et al., 1973, 1975). The original method requires the removal of all carbonates, organic carbon and silicates by treatment with HCl, H_2O_2 and HF, leaving elemental carbon i.e. charcoal. Following this pretreatment, small amounts (less than 50mg) of the residue are ground with a stainless steel ball in a high speed mixer for 24 hours, after which the sample is compressed into a homogeneous KBr pellet for analysis. The grinding step produces surface oxidation of the carbon atoms in the sample and it was discovered (Friedel and Hofer, 1970) that activated elemental carbon produces characteristic infrared absorption spectra after such treatment. Preliminary tests on the technique on artificially produced samples containing petroleum/charcoal standards and on several fly ash samples from power stations indicated excellent sensitivity and producibility for the technique. However this method is very time consuming and Jacobson considers that differences in the elemental carbon measured may in part be due to the success with which all the non-elemental carbon has been removed in the pretreatment.

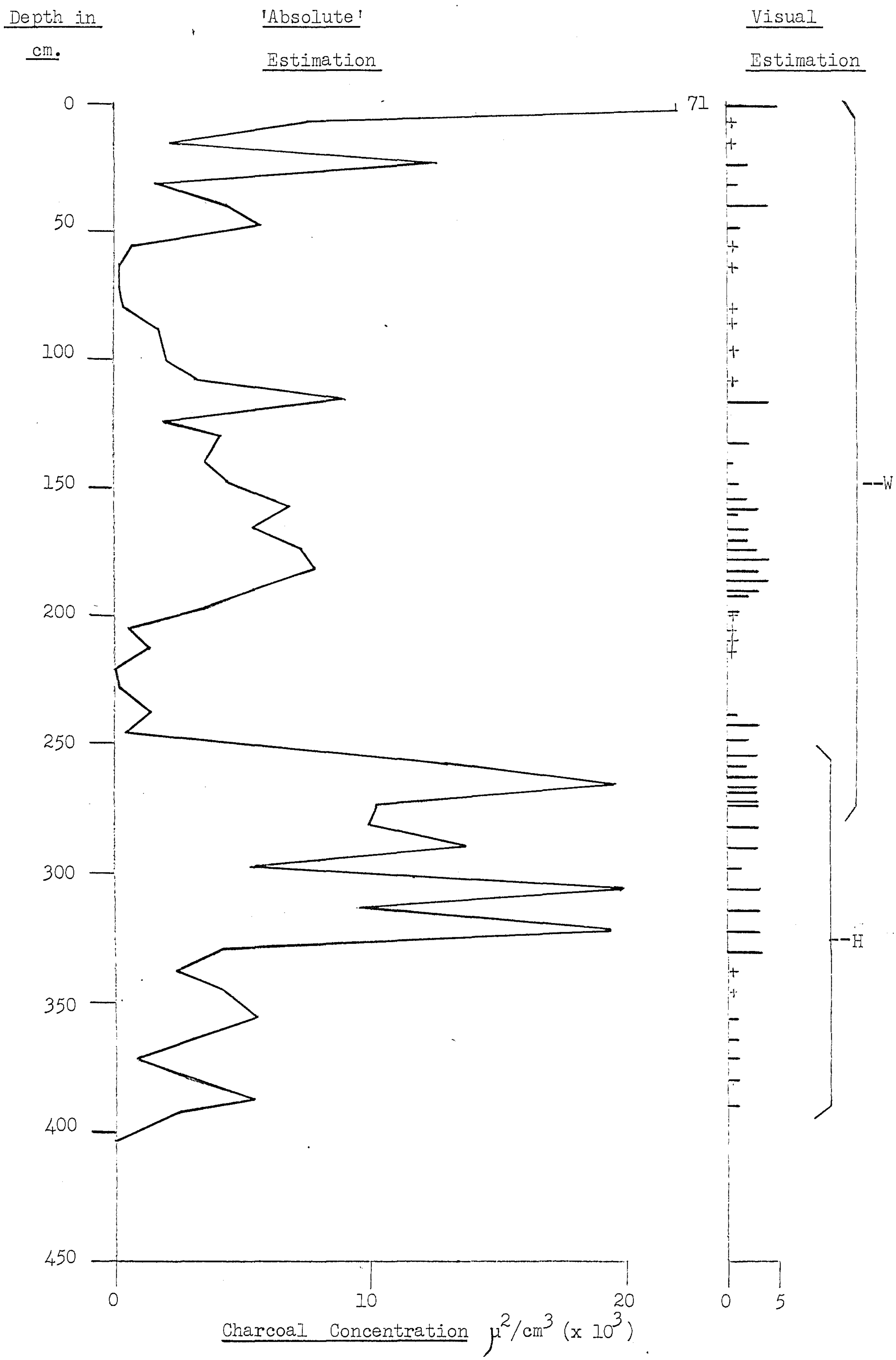
Jacobson's method involved the use of a LECO WR-12 carbon determinator. Samples are burned in an induction furnace, following Smith et al.'s pretreatment with HCl and H_2O_2 (HF is omitted as silicates do not interfere with the measurements in this case). The resulting CO_2 is trapped in a molecular sieve, released by heating and then measured by thermal conductivity. However the method did not prove to be too successful, with samples in cold H_2O_2 still effervescing, i.e. still containing non-charred organic material, after 60 days, and only 2 - 5% of the charcoal in artificially prepared samples being recovered. Fossil sediments also gave inconclusive results with poor reproducibility. Jacobson considers that the chemical pretreatment selectively destroys all but a very narrow size range of the charcoal thus giving these anomalous results and concludes that the microscopic method using slides described earlier is probably the best method available to date.

The Estimation of the Charcoal Content of Peat from Tormore and Machrie Moor

The initial estimates of the charcoal content of the peat sections from Tormore and Machrie Moor were made on a five point scale on the basis of the low-power microscopic examination of the pollen sievings.

Figure 4.5

Showing a comparison between the visual and 'absolute' estimations of the charcoal content of section MML80.



Depth in cm.
'Absolute' Estimation
Visual Estimation
0
50
100
150
200
250
300
350
400
450
71
--W
--H
0
10
20
0
5
Charcoal Concentration μ^2/cm^3 (x 10^3)

When the data from TM1, the first section examined, was drawn up it revealed an interesting relationship between the amount of charcoal present and the degree of human activity as indicated by the pollen diagram. It was decided to look at ways of quantitatively measuring the charcoal content. I decided against the methods of Swain (1973) and Maher(1972) as these would have involved the lengthy preparation either of charcoal plus 'exotic' slides, or 'absolute' pollen slides. I chose instead to design a procedure based on the non-microscopic method as briefly outlined by Tallis (1975) using hot KOH to break up the peat followed by hot conc. HNO_3 to remove all the non-charred organic material. The dry weight of the residue is then presented as a percentage of the original dry weight of the sample (see Appendix A1(c) for the detailed method).

A check was carried out on the method by mixing a known dry weight of charcoal with a peat sample known to be devoid of charcoal and processing it the same way as the experimental samples. The average recovery rate was 90%, the 10% probably being lost due to charcoal floating after the dry weight determination and not, therefore, being collected in the pellet after centrifugation. The problem arises from the difficulty in 're-wetting' the charcoal after the dry weight determination and could probably be avoided by using a wet sample and calculating the neccessary dry weight value from a duplicate sample.

However on the peat samples from the sections the technique appeared to be much less successful. When used on TM1 and the ditch section TMD1 it detected the general trends as regards the presence and absence of charcoal but it lacked the resolution of even the rough estimates from the pollen sievings (see Figs. 4.3 and 4.4). Samples were also analysed from MML80 and no difference could be seen from the data between peat which was known to contain charcoal and that which was charcoal-free. I think the method was not sufficiently sensitive to detect the relatively low concentrations of charcoal in the fibrous peat of MML80 and even with the blanket peat sections, TM1 and TMD1, which have higher concentrations, it was still far from satisfactory. It was obvious that very large samples had to be processed to overcome the errors involved and give even a rough indication of the charcoal content.

At a later stage the whole of MML80 and the base of TM1 were sampled for absolute pollen analysis (see section 4.6) and it was decided to try Maher's method of charcoal estimation as discussed earlier.

Five evenly spaced traverses were made across a slide at each level.

The number of Lycopodium spores encountered was scored and the charcoal fragments were put into one of six size categories by means of an eyepiece graticule. The size categories were 40 μ^2, 80 μ^2, 320 μ^2, 640 μ^2 + 1280 μ^2. The area of charcoal at each level was summed and could be expressed in concentration and influx terms much in the same way as pollen data.

A comparison was made between this 'absolute' method and the visual estimation for MML80 (Fig. 4.5) and the three methods used on the base of TM1 (Fig. 4.3). Of the three methods the 'absolute' one appears to give the greatest degree of definition with the chemical method being obviously inferior. In general the 'absolute' and visual estimations match very closely but there is a deviation between the two at the base of TM1. The visual estimation shows much less charcoal than is detected by the absolute method. The charcoal at this point is in very small fragments and these could have been overlooked in the examination of the pollen sievings.

From these investigations it would appear that the 'absolute' method involving the use of pollen slides prepared for absolute counting backed up by visual examination of the pollen sievings is the best way to measure the charcoal content of the sediments and trace fire history.

4.8 LOSS ON IGNITION

Loss on ignition determinations were made on all sections and a detailed description of the method used is given in Appendix A1(d). These determinations were made primarily to investigate the link between increased agricultural activity and the increase in the amount of airborne mineral incorporated into the peat (Aaby, pers. comm., Mornsjo, 1968).

4.9 RADIOCARBON DATES

Eighteen radiocarbon cates were supplied by the SDD (AM) and the determinations were made by Dr. M. Stenhouse of the Chemistry Department, Glasgow University. All the samples were of peat. Where possible a 2 cm thick slice, weighing in excess of 100 gms, was supplied for dating. With the 5 cm diameter Livingstone cores this volume of material was not available and much larger vertical intervals had to be sampled. Even then it was difficult to obtain 100 gms of peat and smaller weights had to be supplied to the lab. The need to supply such large vertical samples resulted in rather imprecise dating of the events in the pollen diagram and the small sample size also added to the errors in dating this material.

The samples were given an acid pretreatment (2 hrs hot 0.5 M HCl) followed by cold alkali and sieving through a 250 μ sieve. The residue was then treated with cold alkali, resieved and boiled with acid to precipitate out the humic acid fraction 1. A further treatment with hot (70°C) alkali and a hot acid treatment was used to extract the humic acid fraction 2. Occasionally enough material remained for this to be repeated giving humic acid fraction 3. All dates were made on humic acid fraction 2.

The dates are listed in Tables 5.2, 6.2, and 6.6. They are in radiocarbon years before present, based on the Libby half life for ^{14}C of 5568 years, with a quoted counting error of one standard deviation. Uncalibrated ^{14}C dates throughout this thesis are denoted by the use of bp and bc, meaning radiocarbon years before present and before Christ. Any calibrated dates were calculated using the calibration curve of Clarke (1975) and are followed by either BP of BC, or prefixed by AD, signifying calendar years before present, before Christ and after Christ respectively. Some dates, quoted both in radiocarbon and calendar years, were arrived at by extrapolation between dated levels, these are denoted by (e).

4.10 ANALYSIS OF POLLEN SIEVINGS

During the course of the preparation of pollen samples coarse plant debris was sieved off. This material was retained for later examination, any recognisable plant macrofossils were picked out for identification by comparison with a reference collection and texts including Grosse-Brauckman (1972, 1974), Aalto (1970), and Jessen (1955). The resulting data were used in the descriptions of the peat stratigraphy. The data from MM180 were sufficiently detailed to enable the construction of a macrofossil diagram (Fig. 5.4) with abundance on a six point scale being recorded.

CHAPTER FIVE

MACHRIE MOOR (MML80)

5.1 SITE DESCRIPTION

The coring site on Machrie Moor (NR 905 315) is towards the south of the moor, 1 km to the north-east of the Tormore site (see Fig 3.2). The Tormore I chambered cairn is 500 metres to the south-west, Crochandoon is 1km to the north-west and the Machrie Moor stone circles are 1 km to the north-east. A high proportion of the moor is covered by bog, underlain in most places by fen peat. It can be classified as a 'basin mire' within Ratcliffe's (1977, p. 250) category of 'valley bogs'.

Beneath the peat there are areas of dune-bedded sandstone and breccia, boulder clay and deposits associated with the 30 metre (100 foot) raised beach. The latter are present, along with fluvioglacial deposits, at the coring site. The surface vegetation is dominated by _Molinia caerulea_, with some _Calluna vulgaris_, _Erica tetralix_ and _Potentilla erecta_. There are areas of _Phragmites_ reed swamp and _Salix_ scrub close by, and a large area of cut-over bog to the west also supports _Myrica gale_, _Potentilla palustris_, _Potamogeton polygonifolius_, _Eriophorum vaginatum_ and _E. angustifolium_. Quadrat data from Machrie Moor are included in Appendix A2.

5.2 SAMPLING OF DEPOSITS - See section 4.1

5.3 PEAT STRATIGRAPHY AND THE DEVELOPMENT OF THE PEAT DEPOSITS

A description of the peat stratigraphy is given in Table 5.1, and the detailed Troels-Smith analysis is contained in Appendix A5. A diagrammatic representation of the Troels-Smith analysis, modified in the light of Aaby (1979) (see section 4.6), is given alongside the pollen diagrams (Figs. 5.1, 5.2, 5.3).

The macrofossil diagram (Fig. 5.4) records the plant macrofossils recovered from the pollen sievings and from the microscopic examination of the peat during the Troels-Smith analysis. The macrofossils are recorded on a six point abundance scale from 0 - absent, to 5 - a major peat component.

The diagram has been divided into zones on the basis of the observed

Table 5.1

Peat stratigraphy - MML80 (see also macrofossil diagram, Fig. 5.4)

Depth in cm.	
0 - 32	Poorly humified Molinia peat with some Cyperaceous remains, occasional Myrica leaves and twigs, and fruits of Potamogeton c f. polygonifolius. Abundant charcoal.
32 - 41	Poorly humified Molinia/Carex peat with some Phragmites rhizome and fruits of Potamogeton c.f. polygonifolius. Charcoal fragments.
41 - 58	Poorly humified Molinia/Carex peat with Myrica leaves and twigs. Charcoal fragments, with a peak around 41 cm.
58 - 66	Poorly humified Molinia/Carex peat with Phragmites rhizome, Myrica leaves and twigs, Potamogeton c f. polygonifolius fruits and a Calluna twig. Charcoal fragments very sparse.
66 - 79	Poorly humified Carex peat with Phragmites rhizome and occasional Sphagnum sp. leaves. Abundant Myrica leaves and twigs, Potamogeton c f. polygonifolius and Juncus seeds Very few charcoal fragments.
79 - 100	Well humified Carex/Phragmites peat with abundant Myrica leaves and twigs, Potamogeton c f. polygonifolius and Juncus seeds, plus both trigonous and biconvex Carex nutlets. Some charcoal fragments.
100 - 171	Well humified Carex/Phragmites peat with abundant Myrica leaves and twigs. Potamogeton c f. polygonifolius fruits at 158 cm, Menyanthes seed at 150 cm. Juncus seeds also present with abundant charcoal fragments.
171 - 180	Fairly humified Carex/Phragmites peat with Juncus and Erica tetralix seeds, E. tetralix leaves, Myrica leaves and twigs. Abundant charcoal fragments.

Table 5.1.(cont.)

Depth in cm.	
180 - 210	Poorly humified *Carex/Phragmites* peat with *Sphagnum imbricatum* leaves and stems, *Potamogeton* c f. *polygonifolius*, *Juncus* and *Erica tetralix* seeds, *E. tetralix* and *E. cinerea* leaves (carbonised and uncarbonised).Also *Selaginella selaginoides* megaspores, trigonous *Carex* nutlets and some fragments of'woody'charcoal
210 - 270	Fairly humified *Carex/Phragmites* peat with *Juncus* and *Erica tetralix* seeds, *Sphagnum imbricatum* leaves and abundant 'woody' and 'herbaceous' (c.f burnt *Phragmites* leaves) charcoal.
270 - 319	Well humified *Carex/Phragmites* peat with some *Potentilla erecta* achenes at 290 cm. Small fragments of'herbaceous' charcoal, abundant.
319 - 340	Well humified *Carex/Phragmites* peat with a few *Potamogeton* c f. *polygonifolius* fruits Small fragments of 'herbaceous' charcoal.
340 - 366	Well humified *Carex/Phragmites* peat with seeds of *Potamogeton* c f. *polygonifolius*, *Juncus*, and *Eupatorium cannabinum*. Also a *Salix* twig, *Sphagnum imbricatum* leaves and stems and a large *Myrica* leaf fragment at 355 cm.
366 - 379	Poorly humified *Carex* peat with some *Phramites* rhizome, *Sphagnum papillosum* leaves and *Calluna* twigs.Some small fragments of 'herbaceous'charcoal.
379 - 395	Fairly well humified *Carex/Sphagnum* palustre peat with some *Phragmites* rhizome.
395 - 410	Fairly well-humified *Carex/Phragmites* peat with some *Sphagnum* leaves and fragments of *Campylium stellatum* and *Drepanocladus revolvens*.

Table 5.1. (cont.)

Depth in cm.	
410 - 420	Poorly humified moss/*Carex* peat, largely comprised of *Campylium stellatum* and *Drepanocladus revolvens*, with some Cyperaceous remains.
420 - 448.5	Poorly humified *Carex* peat with trigonous *Carex* nutlets, fragments of *Cratoneuron commutatum*, *Cratoneuron filicinum*, *Campylium stellatum* and *Drepanocladus revolvens*. Also a *Salix* twig at 440 cm along with a *Potentilla palustris* achene
448.5 - 452	A mixture of silt, fine and coarse sand, and gravel (mainly quartz and micaceous material) with some Cyperaceous remains.

changes in the frequency of the macrofossils. These zones are numbered from 1 to 7 and are prefixed by 'macro-' to avoid confusion with the pollen zones. In this interpretation use has also been made of data concerning the local peat-forming vegetation from the pollen diagrams.

It appears from the data that the deposits sampled developed initially in rich fen conditions, with a decreasing trend in base status up the section, leading to the development of poor fen communities and culminating in the formation of Molinia dominated blanket peat. These changes and trends are discussed in more detail below. The terms eutrophic, mesotrophic and oligotrophic have largely been avoided in describing the base-status of the deposits as they are rather vague in their definitions and data concerning the pH and $CaCO_3$ content of the peat arenot available. Where they are used it is in the sense of Ratcliffe (1977,p. 251).

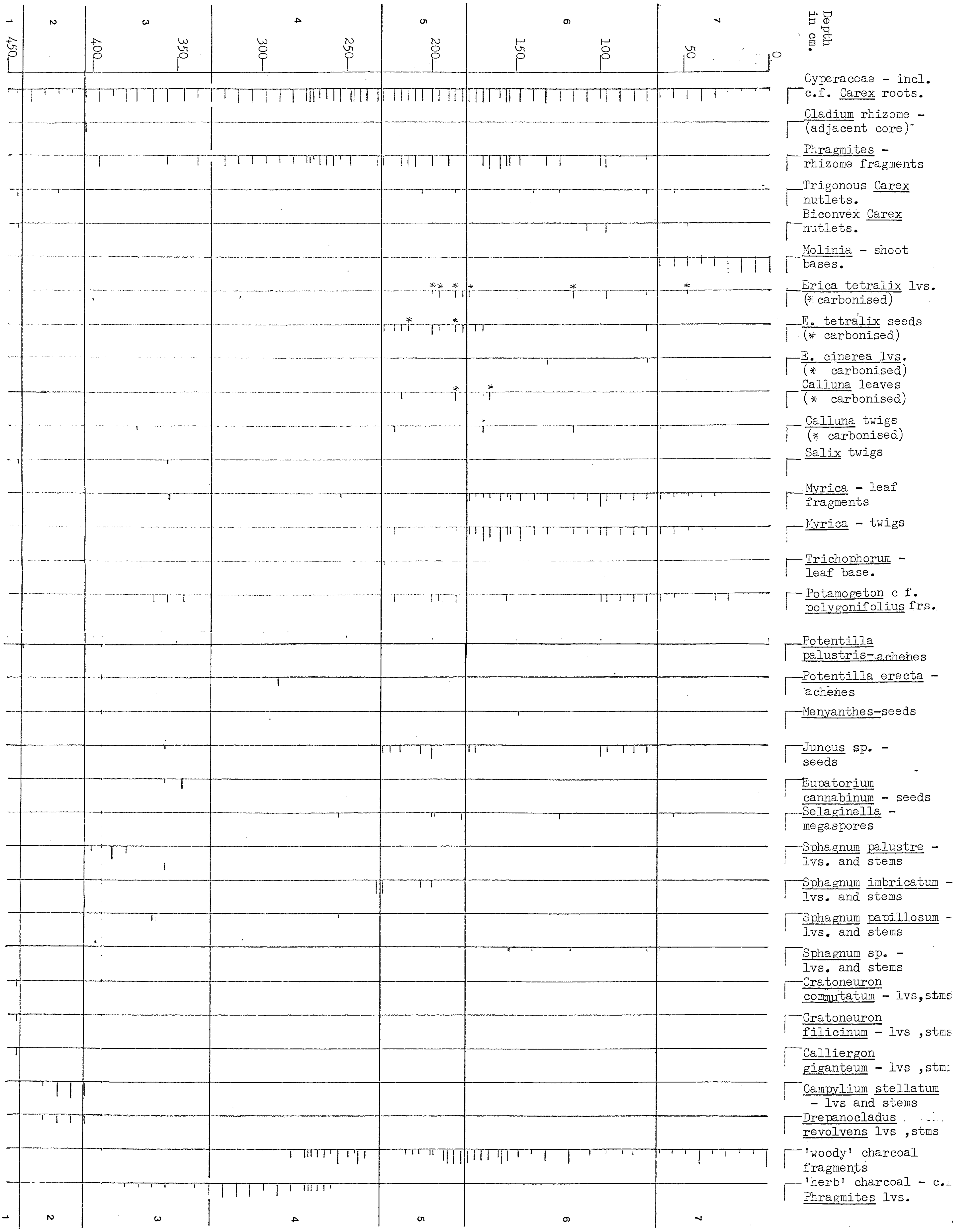
Zone macro-1 (452 - 448.5 cm) (ca. 10000(e)bp)

The base of the section is made up of highly mineral material with particles ranging in size from silts to coarse gravel. This, with its high content of micaceous material, resembles deposits derived from weathered granite found today on the shores of Loch Tanna (NR 920 430) at an altitude of approximately 1000 feet (ca. 335 m). The pollen evidence (see later) suggests that the deposits may be fluvioglacial in origin, originating from the melting of ice at the end of the Loch Lomond Stadial. However as the base of the section is also within the limits of the 100 foot late-glacial raised beach the origins of the material are uncertain.

The organic content of the basal sediment is low, being restricted to a small quantity of herbaceous material which has been identified as coming from species of Carex. A single pollen sample was analysed from a depth of 450 cm and, although the pollen concentration was low (see Fig. 5.3, Influx pollen diagram) and the pollen preservation poor, this revealed a spectrum dominated by Cyperaceae pollen and Equisetum spores. Grass pollen was also present along with that of pioneer open habitat species such as Thalictrum, Rumex, Artemisia and members of the Cruciferae and Compositae. This was a period of colonisation and soil stabilisation by grass and sedge dominated communities. There would have been areas of bare ground between the vegetation and the presence of Potamogeton pollen indicates the presence of shallow open water.

Figure 5.4

Showing the macrofossil diagram for section MML80.


Depth in cm.
0
50
100
150
200
250
300
350
400
450
1
2
3
4
5
6
7
Cyperaceae - incl. c.f. Carex roots.
Cladium rhizome - (adjacent core)
Phragmites - rhizome fragments
Trigonous Carex nutlets.
Biconvex Carex nutlets.
Molinia - shoot bases.
Erica tetralix lvs. (* carbonised)
E. tetralix seeds (* carbonised)
E. cinerea lvs. (* carbonised)
Calluna leaves (* carbonised)
Calluna twigs (* carbonised)
Salix twigs
Myrica - leaf fragments
Myrica - twigs
Trichophorum - leaf base.
Potamogeton c f. polygonifolius frs.
Potentilla palustris-achenes
Potentilla erecta - achenes
Menyanthes-seeds
Juncus sp. - seeds
Eupatorium cannabinum - seeds
Selaginella - megaspores
Sphagnum palustre - lvs. and stems
Sphagnum imbricatum - lvs. and stems
Sphagnum papillosum - lvs. and stems
Sphagnum sp. - lvs. and stems
Cratoneuron commutatum - lvs,stms
Cratoneuron filicinum - lvs ,stms
Calliergon giganteum - lvs ,stms
Campylium stellatum - lvs and stems
Drepanocladus revolvens lvs ,stms
'woody' charcoal fragments
'herb' charcoal - c.f. Phragmites lvs.

Zone macro-2 (448.5 - 404 cm) (ca. 10000(e) - 8775(e) bp)

There is an abrupt change at 448.5 cm from highly mineral sediment to highly organic sediment (Fig. 5.6 Loss on ignition) indicating that, locally at least, soil stabilisation was well advanced and the vegetation was becoming established. Again Cyperaceous material is the main organic component of the peat. The majority of this is from roots and rootlets but in addition both trigonous and biconvex nutlets were recovered. Several species of moss are present. Initially there are leaves and stems of Cratoneuron commutatum, C. filicinum and Calliergon giganteum. Later Campylium stellatum and, to a lesser extent, Drepanocladus revolvens take over from the sedges as the main peat component. All of these mosses to some degree favour eutrophic conditions (Dickson, 1973, Ratcliffe, 1977) and this, together with the presence of Selaginella microspores, leads to the conclusion that the area was subject to base-rich flushing. Ratcliffe (1977, p. 258) recognises this 'brown moss carpet' as being a feature of strongly eutrophic basin mires (rich fens). These are rare in occurrence, being limited by the chance association of calcareous rocks and soils in conjunction with a suitable topographical environment. With this kind of deposit there is typically a succession to willow carr. A small Salix twig was present near the opening of the zone and later Salix pollen rises to a maximum indicating its growth nearby. However it is impossible to deduce which species of Salix was present and the growth form which it adopted. Potamogeton pollen is again present probably originating from plants in shallow pools and possibly streams.

Zone macro-3 (404 - 330 cm) (ca. 8775(e) - 6630 ± 130 bp)

Campylium stellatum and Drepanocladus revolvens are present for the last time at 404 cm. From this level onwards fragments of Phragmites rhizome are evident in the sedge peat, in addition Cladium rhizomes are present in an adjacent core at the same level. Values of Cladium pollen reach a peak and those of Gramineae continue to rise which must, in part, be due to the presence of the Phragmites.

A fragment of Myrica leaf was present at 355 cm and there are corresponding peaks in Myrica type pollen at 356 cm and 380 cm. This is a very early record for a macrofossil of Myrica, being dated to Godwin's zone VI, ca. 7500 bp. Godwin (1975) lists only two records for Myrica macrofossils prior to zone VIIa, one is a doubtful one from zone II (Brook in Kent), the other is from zone IV (Wareham in Dorset).

Twigs of both Calluna and Salix are present in this zone and the pollen of both species is well represented. Sphagnum remains appear for the first time with successive separate presences of Sphagnum palustre, S. papillosum and S. imbricatum. High values of Sphagnum spores coincide with these presences and a peak in the rhizopod Assulina (15%) is also evident coinciding with Sphagnum palustre stems and leaves. A similar peak corresponds with the presence of S. papillosum in TM1 (Chapter Six). Van Geel (1978) takes this to be an indication of local wet conditions.

In the second part of the zone fruit-stones of Potamogeton cf. polygonifolius and seeds of Juncus species are present. These two species are present together at several points in the section suggesting perhaps that they represent a community based around the shallow pools which Potamogeton favours.

Fruits of Eupatorium cannabium are also present in the peat in the latter part of the zone. These probably originated from a tall-herb community on a nearby area of damp ground or streamside.

The presence of several Sphagnum species, the genus as a whole tending to be found in oligotrophic habitats (pH less than 6) (Hill, in Smith, 1978 p. 31), and a Calluna twig does suggest that there may have been a reduction in base-status during this zone. Both Phragmites and Cladium are present, but whilst in the south and east of the country these species are strongly basiphilous, in the north and west they appear to be less exacting in their requirements. Their presence is not inconsistent with increasingly acid conditions and the transition to poor fen (Ratcliffe, 1977 p. 251).

Zone macro-4 (330 - 230 cm) (ca. 6630 ± 130 - 3950(e) bp)

Peat in this zone is very uniform, being comprised of the remains of Phragmites and Carex species and little else. There are minor occurrences of Sphagnum papillosum, Selaginella megaspores, Potentilla erecta fruits and a Myrica leaf fragment.

With regard to the pollen and spores, Myrica type rises steadily as do Calluna, Ericaceae undiff., Potentilla, Narthecium, Potamogeton, Equisetum and Sphagnum towards the end of the zone. It is difficult to know to what extent each of these was involved in the local peat development.

Zone macro-5 (230 - 180 cm) (ca. 3950(e) - 3150(e) bp)

Carex and Phragmites remains continue as the main peat components in this zone but the diversity of accompanying species increases. Fruit-stones of Potamogeton and seeds of Juncus sp. are again present. Selaginella megaspores are quite common and Sphagnum imbricatum is abundant for a time. The values of Sphagnum spores reach high levels but also fluctuate wildly. A great deal has been written concerning the abundance of the sub-fossil remains of Sphagnum imbricatum in Flandrian peat deposits and its relative scarcity as a living plant today. Dickson (1973) summarises the various explanations proposed, concluding that human activity, through peat cutting and drainage, is the most likely cause. There are those, however, who favour an explanation in terms of climatic change.

This zone also sees an increase in the frequency of the remains of Ericaceous species including seeds and leaves of Erica tetralix and Calluna leaves. A large number of these are carbonised and as larger macrofossils are relatively infrequent it could be that the majority of this material was blown in from the surrounding high ground. The pollen diagram indicates an expansion of Calluna heath at this time. Myrica twigs are again present in this zone and Myrica type pollen rises.

Zone macro-6 (180 - 66 cm) (ca. 3150(e) - 1550 (e) bp)

Throughout this zone the dominance of Phragmites and Carex sp. is challenged by the increasing abundance of Myrica leaves and twigs. At certain levels these are very abundant forming dense layers. Values of Myrica type pollen are very high. The presence of Myrica, which tends to be commonly, but not exclusively, found in acid bogs (Godwin, 1975) and the decrease in Phragmites, which on the whole tends to avoid very acid conditions, appears to signal a further move towards more oligotrophic conditions. Burning of the bog surface and surrounding vegetation may also have favoured Myrica. Ratcliffe and McVean (1962) point out that Myrica tends to be more fire resistant than Salix which would otherwise occupy a similar habitat on the bog surface. (Charcoal is present in the peat for the majority of this, and previous zones).

Also present in this zone, although less frequently than in zone 5, are Erica tetralix leaves and seeds and Calluna leaves and twigs. In addition there are leaves of Erica cinerea. Potamogeton and Juncus sp. again occur together at the start of the zone and values of both Potamogeton and Narthecium pollen are high. The latter probably occurs in association with the Myrica dominated community. Sphagnum macrofossils are virtually absent and Sphagnum spores attain more modest values than in the previous zone. Hydrocotyle pollen occurs for the first time.

Zone macro-7 (66 - 0 cm) (ca. 1550(e) - ? 500(e) bp)

Phragmites remains are absent from this zone and first Myrica, then Carex are replaced by remains of Molinia (predominately leaf-base material). Both Sphagnum and Ericaceous remains are rare and the peat is rather uniform, broken only by the occasional presence of Myrica twigs and Potamogeton fruit-stones. Juncus sp. seeds are absent. Falls in Myrica type and sedge pollen reflect the decreased presence of the macrofossils of these species. There is also a rise in grass pollen but it is difficult to say to what extent this is due to the expansion of Molinia or the effect of human agriculture on the abundance of other grass species.

5.4 POLLEN STRATIGRAPHY - MML80

For convenience the pollen diagrams for this section have been divided into zones on the basis of the observed changes in the constituent pollen and spore curves. Where necessary these local pollen assemblage zones have been further divided into sub-zones which are based on smaller scale changes, largely related to human interference (apart from zone 1), occurring within the main zones. The salient features of each zone and sub-zone are described below, further detail is contained in the interpretation and discussion sections.

Local Pollen Assemblage Zones - MML80

Zone MM-1 (452 - 404 cm)

This zone can be divided into three sub-zones, MM-1a, (452 - 436 cm), MM-1b (436 - 420 cm) and MM-1c (420 - 404 cm).

MM-1a is characterised by very high values of Cyperaceae and Equisetum, in excess of 90% and 100% TP respectively. Tree values are very low, with only Betula and Pinus pollen present, the latter, along with Corylus type just reaches 1% TP. Populus pollen is present only in this sub-zone. Accompanying the high sedge values are several herb species some of which reach quite high percentages:-

Thalictrum (3%), Artemisia (incl. A. norvegica type), Urtica (1%), Liguliflorae, Rumex and Potamogeton (3%). Selaginella (2%) and Lycopodium selago(1%) are also present.

MM-1b Cyperaceae values fall to less than 60%, Equisetum falls to less than 10% and Thalictrum and Potamogeton are absent. Tree values are still low, Pinus remains steady ca. 1% and Betula rises to 3% at the end of the sub-zone. Both Corylus type and triporate curves rise in a similar fashion and at this point the majority of undifferentiated triporate grains are likely to be Betula or Corylus rather than Myrica. Juniperus rises sharply to a peak of almost 10% in the middle of the zone. Gramineae rises to 15% and Liguliflorae, Tubuliflorae, Umbelliferae, Filipendula, Empetrum and the fungal spore Gelasinospora also rise to 1%, just less than 1%, 2%, 5%, 1% and 1% respectively. Artemisia, Rumex, Rubiaceae, Potentilla, Lotus, Polypodiaceae and Lycopodium inundatum are also present. Filicales fall from 17% at the start of the sub-zone to 7% at the end.

MM-1c Cyperaceae values continue to fall, reaching 25% TP at the end of this sub-zone. Pinus is steady around 1 - 2% and Betula rises from 3% - 34%. Quercus and Ulmus make their first appearances and levels of Juniperus pollen fall to zero. Both Salix and Corylus type rise steeply at the opening of the sub-zone, the latter falls again slightly whilst Salix reaches 5 - 6% TP. Both Filipendula and Umbelliferae fall from the levels reached in the previous sub-zone. However several other herb species are present including Ranunculaceae, Thalictrum (2%), Chenopodiaceae, Plantago maritima, P. media/major type and Narthecium. Potamogeton re-appears and the rhizopod Assulina reaches 3% TP. Filicales recover to 10%, Equisetum is steady at 3% and both Osmunda and Lycopodium clavatum are present.

Zone MM-2 (404 - 364 cm)

The zone opens with high values of Betula (34%), Empetrum (28%), Cladium (8%), Sphagnum (27%), Salix (6%), Conopodium type (3%) and Filicales (10%). These all fall fairly steeply reaching very low values or zero before the end of the zone. There are rises in Gramineae, Calluna, Corylus type, and triporate to 40%, 16%, 28% and 38% respectively. Ulmus and Quercus pollen becomes more frequent, and Pinus reaches 3%. Filipendula continues to decline and Myrica type pollen is present for the first time. Peaks in Assulina (15%), Gelasinospora and indeterminate grains (30+%) occur midway through the zone.

Zone MM-3 (364 - 330 cm)

Values of Corylus type pollen continue to rise to a new maximum of almost 50%. Triporate values fall. Betula is stable ca. 10% and the Quercus and Ulmus curves become continuous, rising to 6% and 4% respectively. Pinus reaches its highest values (10%) at the MM-3/MM-4a boundary and Myrica pollen is present again, but in greater quantities. Several herb species are represented including Filipendula, Potentilla, Umbelliferae, Lotus and Narthecium (2%).

There are the first occurrences of Plantago lanceolata and Plantago undiff., Sorbus and Fraxinus pollen along with presences of Artemisia, Rumex, Liguliflorae (2%) + Tubuliflorae (3%) at the opening of this sub-zone. Pteridium also rises forming a continuous curve from the same point. Calluna values are still high and both Cyperaceae and Potamogeton have double peaks of 15% and 4% respectively. Sphagnum rises to more than 40% TP, Filicales rise to 6% and Polypodiaceae rises to 3%.

Zone MM-4 (330 - 262 cm)

This zone is divided into two sub-zones, MM-4a (330 - 282 cm) and MM-4b (282 - 262 cm).

MM-4a opens with a dramatic rise in Alnus pollen to over 20% TP. At this point there is a peak in Pinus pollen (ca. 10% TP), Calluna and Corylus type values fall and both Quercus and Ulmus rise to 10% and 8% TP respectively. Myrica type pollen becomes more abundant, and Ranunculaceae and Pteridium rise steadily.

MM-4b Tree values begin to fluctuate somewhat after a steady rise in the previous sub-zone. The Pteridium curve rises to over 5% TP, the Plantago lanceolata curve becomes continuous and there is the presence of a single cereal pollen grain (cf. Hordeum).

Zone MM-5 (262 - 218 cm)

Zone MM-5 contains two sub-zones, MM-5a (262 - 238 cm) and MM-5b (238 - 218 cm).

MM-5a opens with a very sharp fall in Ulmus, the 'elm decline', with an accompanying fall in Pinus. There is a sharp rise in Calluna and Ericaceae pollen and the Plantago lanceolata curve is continuous around 1 - 2% TP. All the tree species fall and fluctuate later in the sub-zone and a single cereal pollen grain (cf. Hordeum) is present towards its close.

MM-5b Both Pinus and Ulmus recover, the latter to pre-decline levels. The other tree species also increase with Quercus reaching its highest value of 15% TP, albeit temporarily. The Fraxinus curve becomes continuous and at the beginning of the zone Pteridium, Ranunculaceae and Plantago lanceolata show a slight decline, before rising again.

Zone MM-6 (218 - 100 cm)

This zone is subdivided into three sub-zones, MM-6a (218 - 170 cm), MM-6b (170 - 160 cm) and MM-6c (160 - 100 cm).

MM-6a opens with a secondary elm decline with pine again falling to very low values. Quercus, Alnus and Corylus type fluctuate on a downward trend, as do Betula and Calluna after an initial rise. Gramineae reaches a peak of 35% TP. There is a gradual increase in Plantago lanceolata pollen, reaching consistent levels of 2 - 3%, and a peak in Pteridium of almost 10%. There are also two isolated occurrences of cereal pollen (cf. Hordeum). Narthecium reaches very high values (almost 15% TP).

MM-6b This sub-zone is characterised by low values of tree pollen (less than 10% TP), and very high percentages of Plantago lanceolata and Plantago undiff. (48.5% and 15% respectively). Accompanying this are peaks in Trifolium, Urtica, Rumex acetosa/acetosella, Compositae and cereal (cf. Hordeum) pollen. There are also presences of a large number of other herb species.

MM-6c Plantago lanceolata values fall to around 2 - 3%, with Rumex and Urtica maintained at somewhat lower level. Tree values recover slightly, then all but Alnus show a steady decline towards the end of the sub-zone. Cereal pollen is absent and Myrica type reaches in excess of 50% TP.

Zone MM-7 (100 - 48 cm)

In this zone all the tree species stage a recovery with the increase being most obvious in Betula and Alnus. There appears to be a general reduction in herb species indicative of an open landscape; the situation is reversed towards the end of the zone. Myrica type is high at the start of the zone, declining later, and values of both Gramineae and Cyperaceae are high.

Zone MM-8 (48 - 0 cm)

There are three sub-zones in this zone, MM-8a (48 - 36 cm) and MM-8b (36 - 24 cm) and MM-8c (24 - 0 cm).

MM-8a Tree values are low (less than 5%) and continue to decline. Cereal pollen (cf. Hordeum) is present again and there are increases in Plantago lanceolata, Gramineae and Calluna with an accompanying further fall in Myrica type pollen to less than 10% TP.

MM-8b Tree values, particularly Alnus and Betula recover from the start of the sub-zone. There are peaks in Plantago lanceolata, Rumex, Filipendula and Trifolium and several other open habitat and agricultural indicator species. Cereal values are in excess of 1% TP, with Gramineae percentages high and both Calluna and Myrica type fairly low.

MM-8c Betula and Alnus continue to rise before falling off towards the end of the zone, other tree species have very low values. There are high values of both Calluna and Myrica type pollen, but these are replaced by high Gramineae at the close of the zone. The Plantago lanceolata, Rumex and Pteridium curves diminish slightly but continue to the top of the zone, where cereal pollen appears again.

5.5 RADIOCARBON DATES

Ten ^{14}C dates have been obtained for material from section MML80, these are listed in Table 5.2. As outlined earlier (section 4.9) problems were encountered with the dating of events in the lower 3.5 metres of the core due to the low sample weights of peat available and the large vertical interval of peat which had to be removed.

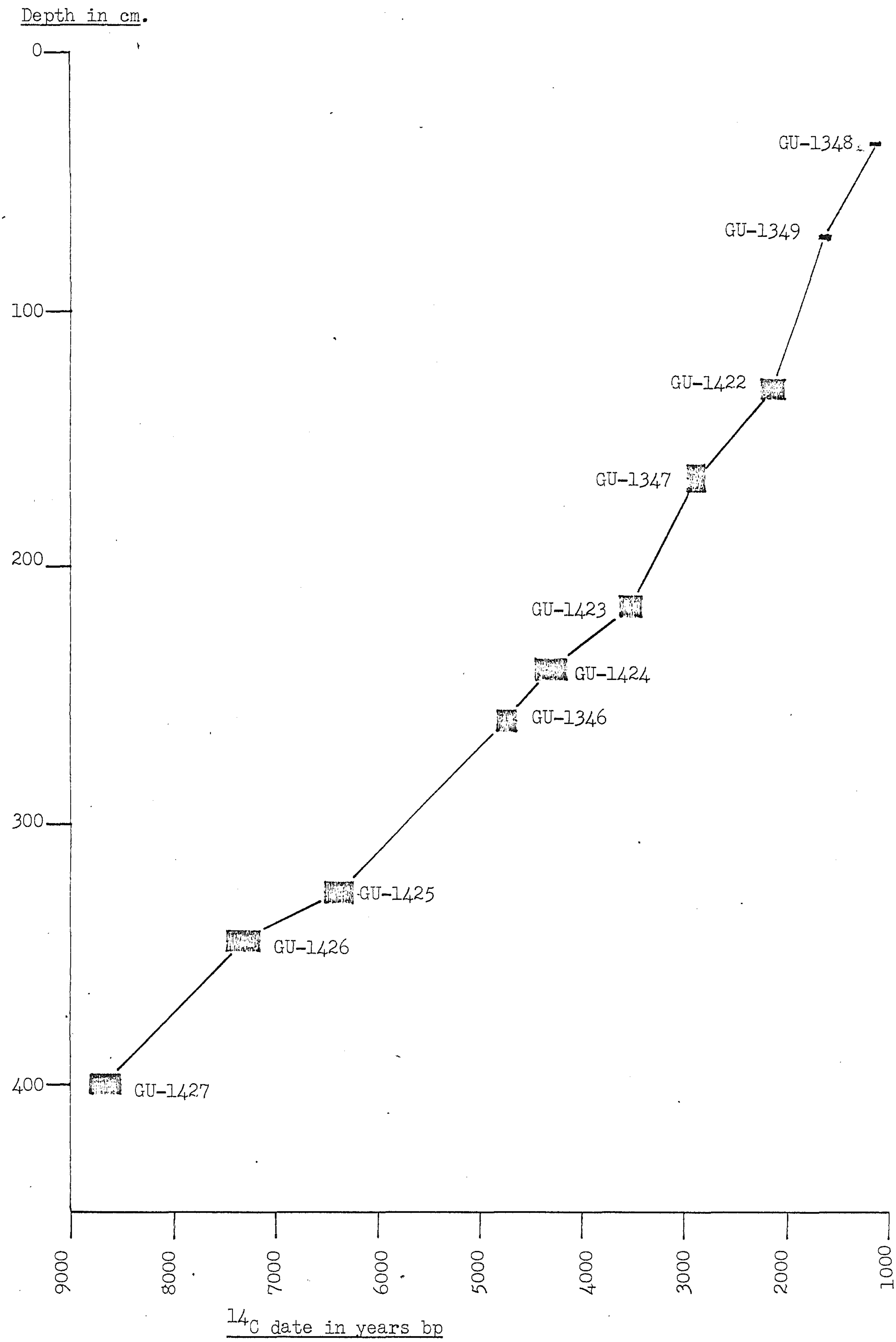
Table 5.2

Radiocarbon Dates from Section MML80

Lab. N°	Sample Depth in cm	^{14}C Dates years bp
GU-1348	35 - 37	1120 ± 60
GU-1349	70 - 72	1615 ± 55
GU-1422	126 - 134	2115 ± 55
GU-1347	160 - 170	2880 ± 80
GU-1423	211 - 219	3535 ± 115
GU-1424	236 - 244	4310 ± 155
GU-1346	256 - 264	4740 ± 85
GU-1425	322 - 330	6630 ± 130
GU-1426	341 - 349	7320 ± 155
GU-1427	396 - 404	8665 ± 155

Figure 5.5

Showing the time/depth curve for section MML80.
(The shaded area represents the sample size in the vertical axis and the quoted error range of one standard deviation in the horizontal axis.)



Depth in cm.
0
100
200
300
400
GU-1348
GU-1349
GU-1422
GU-1347
GU-1423
GU-1424
GU-1346
GU-1425
GU-1426
GU-1427
9000
8000
7000
6000
5000
4000
3000
2000
1000
^{14}C date in years bp

The dates for events in the period 10000 - 4000 bp appear to be consistently younger than those from comparable sites in north-west Britain and Ireland. This could be for a number of reasons. One may be that events took place on Arran at a later date due to the restrictions imposed by it being an island. Another relates to the composition of the peat, all the 'young dates' are from sedge/Phragmites peat. After a change to peat containing a high proportion of Myrica fragments the dates are much more in line with those generally obtained and this is the case for the remainder of the section.

Aaby (pers. comm. 1981), working in Denmark, has carried out ^{14}C analyses of sieved fractions from various types of peat including some in which Carex and Phragmites remains are the main constituents. A 2 mm sieve was used to divide the samples and the results of the dating are given in Fig. 5.9. It can be seen that in the Carex peat the dates for the two fractions are very similar, whereas with the Phragmites peat the 'greater than 2mm' fraction is up to 400 years younger than the 'less than 2 mm' fraction. Aaby explains this in terms of the penetration of the deposit by living Phragmites rhizomes being greater than that of living root systems of Carex species.

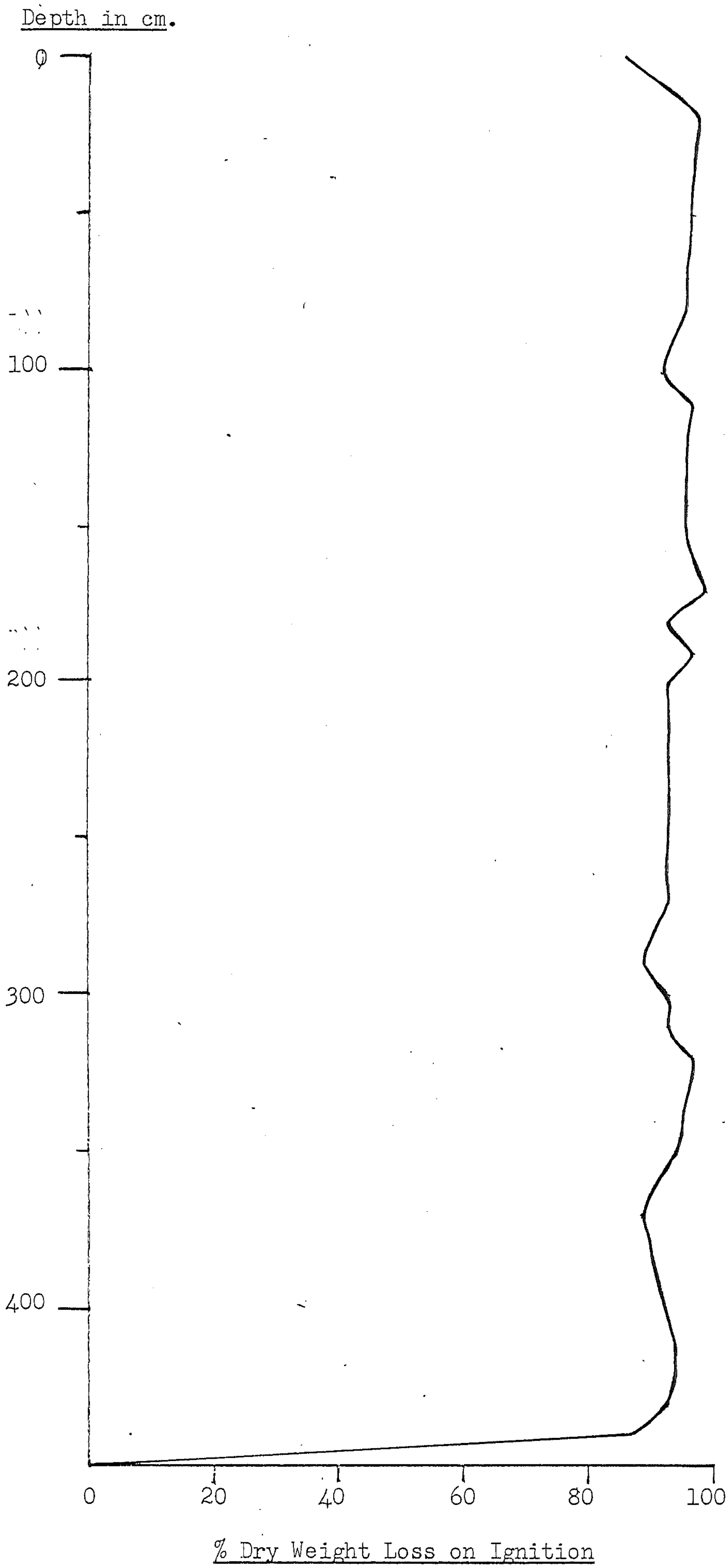
Smith, Pearson and Pilcher (1971a, 1971b) also experienced problems with reedswamp peat at Sluggan Bog in Co. Antrim. One sample (UB-223) gave a date for whole peat of 8195 ± 65 bp, with the water soluble fraction (UB-223B) being dated to 7975 ± 70 bp and the residue (UB-223D) being dated to 8360 ± 60 bp. A second sample from a different level (UB-225) gave two dates for whole peat with a quoted mean of 9655 ± 115 bp. The water soluble fraction (UB-225B) was dated to 8895 ± 125 bp, the humic acid fraction (UB-225C) to 9415 ± 130 bp, the particulate 'more than 250μ' fraction (UB-225D) to 9130 ± 135 bp and the particulate 'less than 250μ' fraction (UB-225F) to 9475 ± 145 bp. The authors consider that fraction F can be taken to be the most reliable.

It is obvious from these examples that there are several problems involved in the dating of this type of material. The majority of these appear to stem from the downward movement of organic material in solution and the penetration of the deposits by living roots and rhizomes of plants growing on the peat surface.

In the dating of the samples from Machrie Moor by the dating lab in the Chemistry Department, Glasgow University, the second humic acid fraction was used (see section 4.9) as opposed to the 'less than 250μ'

Figure 5.6

Showing the % dry weight loss analysis for section MML80. The fluctuations at ca. 370, 290, 180 and 100 cm may be due to increased airborne mineral input resulting from human interference with the vegetation.


Depth in cm.
0
100
200
300
400
0
20
40
60
80
100
% Dry Weight Loss on Ignition

particulate fraction recommended by Smith et al.(1971b). The water soluble fraction, apparently the most 'unreliable ' fraction for dating, was removed in an acid pretreatment and routine sieving through a 250μ sieve similarily eliminated the problem of contamination by younger root and rhizome fragments. If these dates are indeed artificially young then this must be due to the downward movement of humic acids in solution through the relatively open and fibrous matrix of reedswamp peat. However Carex/Myrica peat at a higher level in the section is also fairly open and fibrous, containing quite large Myrica twigs, but dates from this region are not obviously in error.

Peat, on the whole, is not a very suitable material for dating because of the many variables which are involved in its formation. It is clear that more work needs to be done regarding the pretreatment and fractionation of samples in order to produce the 'most reliable date' for each of the many types of peat sample which are submitted.

5.6 ABSOLUTE POLLEN ANALYSIS

The influx diagram resulting from the absolute pollen analysis of the peat section MML80 from Machrie Moor is shown in Fig. 5.3. Only the main taxa have been plotted and the zones on the diagram correspond to those of the relative diagram (Figs. 5.1 and 5.2) and are drawn to aid comparison.

Bearing in mind the fact a sharp change in peat deposition rate between ^{14}C dates in not detectable and that the peat stratigraphy of the section is far from uniform, the overall picture obtained from the two diagrams is very similar. As a consequence I do not intend to discuss the influx diagram in detail. There are however several points which proved to be of interest.

There is very close agreement between the relative and absolute diagrams at the elm decline. Both show a sharp fall in both Pinus and Ulmus. Betula, Alnus and Quercus rise slightly only to fall one sample later. There are accompanying rises in Gramineae, Calluna, Plantago lanceolata and Pteridium. From this it would appear that initially elm alone was affected shortly before a period of more general forest clearance. However all the tree species had suffered some reduction prior to this in an extended period of 'pre-elm decline' interference (section 5.8).

The major difference between the two diagrams is obvious after the

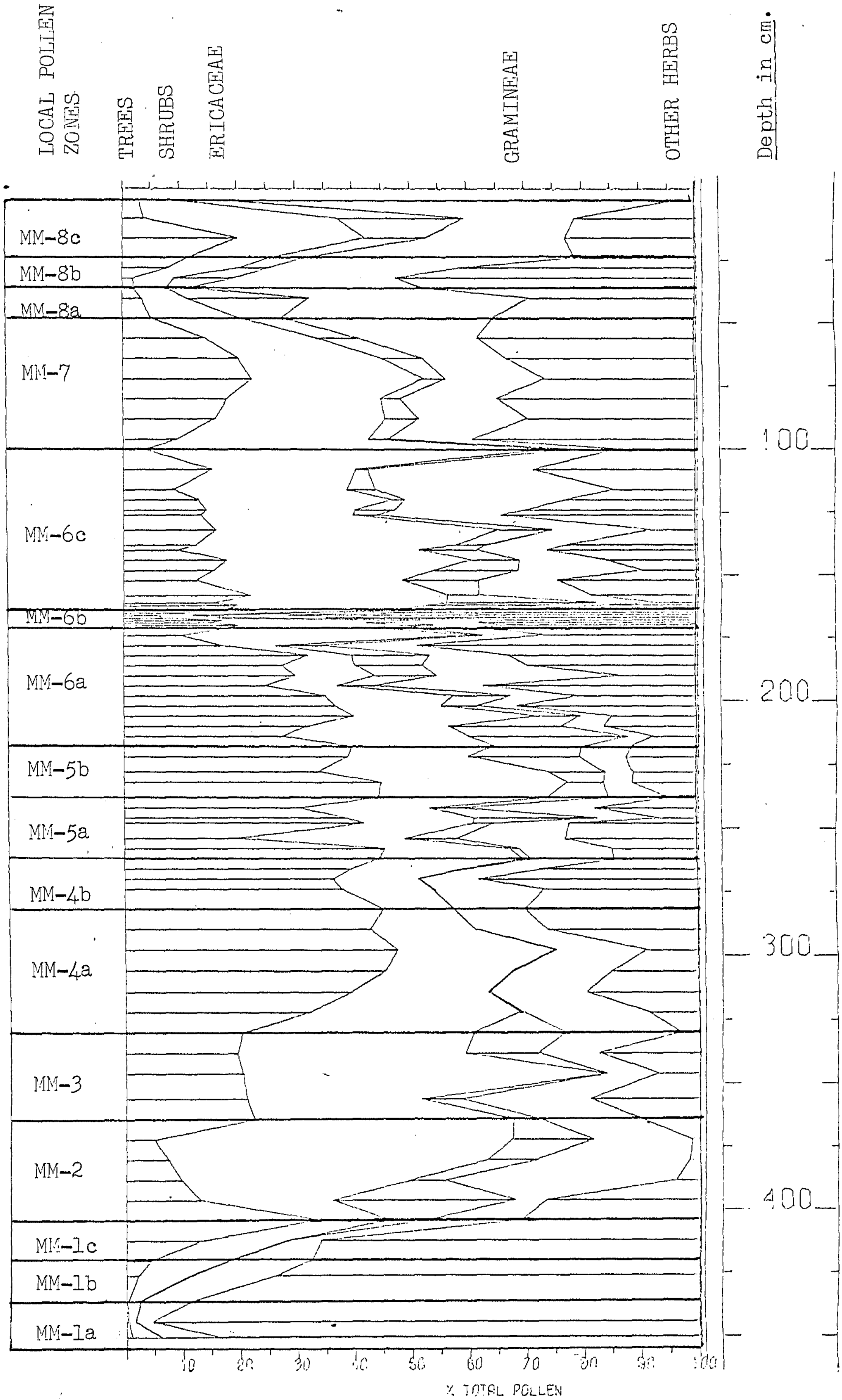
Table 5.3

Peat Deposition Rates for Section MML80

Depth in cm.	Deposition Rate (in radiocarbon years/cm^{-1}).
0 - 71	14.1
71 - 130	8.5
130 - 165	22.0
165 - 215	13.0
215 - 240	31.0
240 - 260	22.0
260 - 326	29.0
326 - 345	19.0
345 - 452	25.0

Figure 5.7

Summary pollen diagram from section MML80, showing the total tree, shrub, Ericaceae, Gramineae and other herb values. The zones (1 - 8) are also shown.(see Figs. 5.1, 5.2 for the full diagrams).



LOCAL POLLEN ZONES
TREES
SHRUBS
ERICACEAE
GRAMINEAE
OTHER HERBS
Depth in cm.
MM-8c
MM-8b
MM-8a
MM-7
MM-6c
MM-6b
MM-6a
MM-5b
MM-5a
MM-4b
MM-4a
MM-3
MM-2
MM-1c
MM-1b
MM-1a
100
200
300
400
10
20
30
40
50
60
70
80
90
100
% TOTAL POLLEN

elm decline, in later Neolithic and Bronze Age times. The relative diagram, as discussed earlier, shows a secondary rise in Ulmus and Pinus in the later Neolithic with accompanying high values of Quercus, Betula and Alnus. Ulmus and Pinus suffer a secondary decline in the early Bronze Age and after an initial rise the other tree species follow a general downward trend. In the influx diagram the recovery in Ulmus and Pinus and the high values of the other tree species are not shown. The rises in Betula, Alnus and Quercus in the early Bronze Age are accentuated, with tree values reaching higher levels than at any time prior to this. This deviation may be largely due to a change in the peat deposition rate between the ^{14}C dates which has affected the calculation of the influx values. Conversely it may indeed reflect events which were not revealed in the relative diagram. Further dating and analysis would be needed to resolve this question.

Subsequent to the Bronze Age there is again close agreement between the two diagrams with much the same pattern of events being revealed. Tree pollen influx values in the upper part of the section are greater, relative to those of earlier periods, than is the case with the percentage diagram. This is likely to be a direct consequence of the high pollen production of the local peat-forming plants such as Myrica and Molinia which depresses the tree pollen values when they are calculated on a percentage basis.

5.7 COMPARISON WITH REGIONAL POLLEN ZONES

As mentioned earlier, Machrie Moor has not been proposed as a type site and regional pollen zones have not been described. However the diagram does show a marked resemblance to the regional zonation of the diagram from Loch Dungeon (Birks, 1972) on which the relevant part of Birks' (1980) regional zonation is based. A comparison of these regional zones with the local pollen zones from Machrie Moor is given in Fig. 5.8.

5.8 Interpretation and Discussion

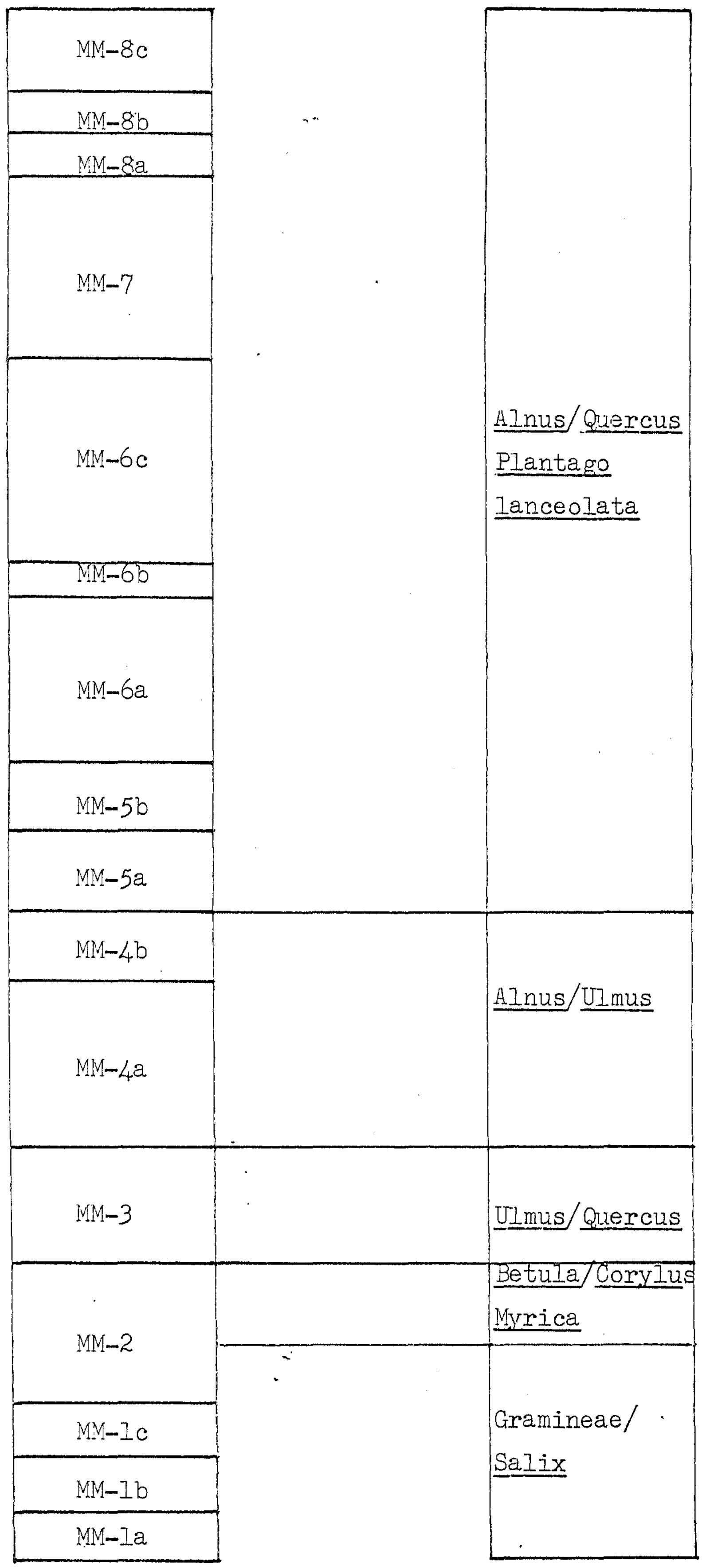
Zone MM-1

Sub-zone MM-1a (ca.10000(e) - ca.9650(e) bp)

Sub-zone MM-1a spans the transition at 448.5 cm between the highly mineral material at the base of the section and highly organic Carex

Figure 5.8

Showing the comparison between the local pollen assemblage zones from Machrie Moor (MML80) and the regional pollen zones proposed for Galloway by Birks (1972).



Machrie Moor

Loch Dungeon-
(Birks, 1972).

peat (see Fig. 5.6). There are two samples in the zone, one from the mineral and one from the peat. They show a treeless landscape, (the few tree pollen grains present are likely to be the result of long-distance transport of pollen) with a mosaic of plant communities, bare ground and shallow water, representing the various stages of plant colonisation and soil stabilisation. The communities may, in part, have resembled Scottish montane vegetation with Artemisia cf. norvegica, Lycopodium selago and a predominance of sedge and grass species. Potamogeton pollen indicates the presence of pools of shallow water and pollen of Compositae, Cruciferae and Artemisia may have been derived from pioneer communities on bare mineral soil. Lowlying sheltered areas would have supported more extensive vegetation with Rumex acetosa/acetosella, Thalictrum, Caryophyllaceae, Urtica, Polystichum and Selaginella, some of which may have formed early tall-herb type communities.

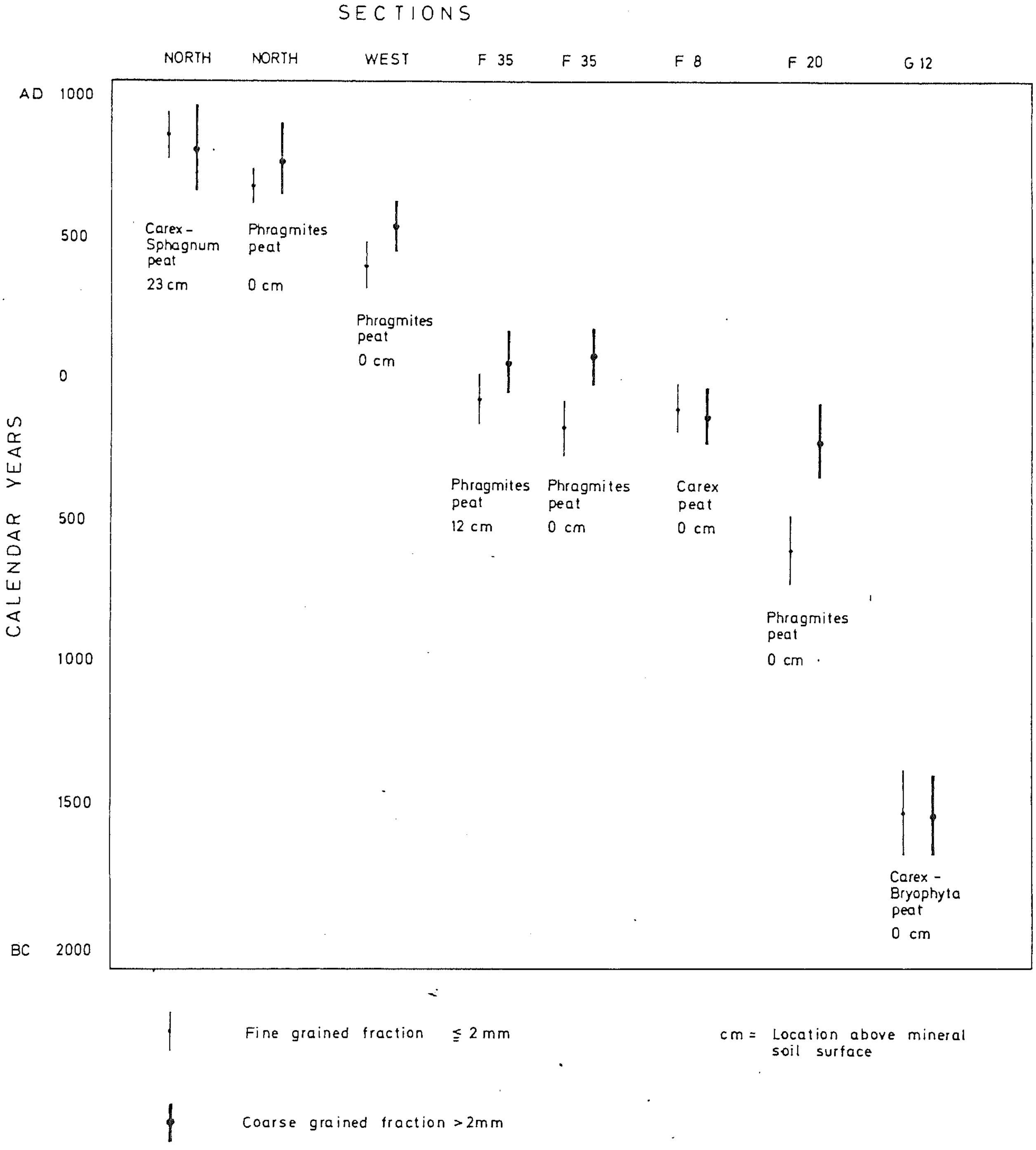
Pollen identified as that of Populus is present in this sub-zone alone. It is probably pollen of Populus tremula (the aspen) which has a far northern distribution and would be able to withstand the harsh conditions at this time. There are records of Populus pollen from Britain in the Late Devensian and throughout the Flandrian period (Godwin, 1975). It seems strange that the pollen is not present in later zones, which precede the development of the forest canopy.

Several criteria have been used by various authors to delimit sediments from the late-glacial (ie. Late Devensian) period from those of the Flandrian period, most of these stem from work done on lake sediments. Donner(1957) places the limit of the Late Devensian at the transition from highly mineral to organic sediment ie. on the basis of soil stabilisation in the absence of severe frost action. Simpkins (1974) makes the division where Betula values begin to increase and Lowe and Walker (1977), Rymer (1977) and Moar (1969a)use the point where the pollen of woody plants, in particular Juniperus, begins to rise. Sissons et al.(1973) define a Juniperus/Betula zone as their first biostratigraphical unit and Pennington et al.(1972) use the top of their Artemisia zone. Peglar (1979) draws the boundary of the Late-glacial deposits at the Loch of Winless in Caithness using a combination of these, the division being made at the point where Betula values rise as Juniperus values fall, Artemisia pollen is absent for the first time and the sediments show a marked reduction in mineral content.

Figure 5.9.

Showing the results of dating the > 2 mm and < 2 mm fractions of various peat types from St. Vildmose, Denmark. The largest discrepancies are seen in *Phragmites* peat with *Carex* and *Carex*/Bryophyta peat showing much closer dating. (Unpublished data courtesy of Bent Aaby, Danish Geological Survey.)

ST. VILDMOSE C 14 DATES



It would appear that late-glacial deposits are present at the base of this section and using the criteria of Lowe and Walker (1977), Rymer (1977) and Moar (1969a) the limit of these seems to be at the close of MM-1a sub-zone. MM-1a, therefore, represents the end of the late-glacial cold phase, the Loch Lomond 'Readvance' or 'Stadial' and corresponds closely to the end of Godwin's zone III, the 'transition zone' of Pennington et al. (1972), Pennington (1977), the III/IV zone of Moore (1970, 1972b) and the end of the 'Stadial period' as used by Lowe and Walker (1977). The mineral material which makes up a large part of the sediment within this sub-zone appears to be largely composed of fragments of weathered granite containing a great deal of micaceous material. It is not unlike the mineral material found today on the shores of Loch Tanna and is probably of fluvioglacial origin, being derived from the melting of the ice at the end of the Loch Lomond Stadial. The ice cap on Arran is known to have extended or reformed at this time (Gemmel, 1971, 1973, and Chapter Two) and although the ice cover was not as extensive as in full-glacial times considerable material must have been deposited at its close. These fluvioglacial deposits probably overlay raised beach deposits from the late-glacial 100 foot raised beach which are present in the area of the coring site on Machrie Moor.

The dating and comparison of dates of these early events on Arran is difficult because the earliest dated level is at 396 - 404 cm and events prior to this have to be dated by extrapolation of the time/depth curve. This method is clearly unsatisfactory as it is impossible to be sure that the earlier deposits formed at the same rate as later ones. This is particularly so with the basal deposits which represent the early stages of soil stabilisation and peat formation and which have a different compostion to those dated (see macrofossil diagram, Fig. 5.4).

Using the method of extrapolation, the date for the bottom of the section is ca. 10000 bp, and the late-glacial/postglacial boundary is ca. 9650 bp. By comparison with other data these dates are rather young. The Loch Lomond Stadial is thought to have lasted from approximately 10,800 bp to 10300 bp (Lowe and Walker, 1977). The post-glacial/late-glacial boundary has been dated by Vasari (1977) at six sites to the north of Arran and the range of dates from these sites is from 10280 to 10010 bp, with an average of 10141bp. This corresponds closely with the idea of the Flandrian (ie. post-glacial) beginning ca. 10000 bp and is in agreement with Godwin (1975) and Berglund (1966). However a date from Bigholm Burn in Dumfriesshire (Moar, 1969a, Godwin and Willis, 1964) for an assemblage similar to that of the first Flandrian zone in MML80 has been dated to 9590 ± 170 and 9470 ± 170. Overall there are not very many dates for this transition but according to Smith and Pilcher (1973) the majority of these from Scotland and Ireland tend to be clustered around 10000 bp.

Sub-Zone MM-1b (ca. 9650(e) - 9250(e) bp)

Sub-zone MM-1b is characterised by a large peak in Juniperus pollen, suggesting that the climate had improved sufficiently to allow the plant to colonise the area or, as suggested by Iversen (1954), to allow the existing population to expand and flower more proficiently (Rymer, 1977). Small amounts of Empetrum pollen are present indicating areas of Empetrum heath, probably in association with the juniper. Sedges and grasses are again the dominant pollen types and both Artemisia cf. norvegica and Lycopodium selago are absent. There appears to be the further development of tall-herb communities with rises in Filipendula, Umbelliferae, Tubuliflorae and Liguliflorae. Values of ferns and Equisetum are high and Polypodium spores are present. These communities were widespread in Scotland at this time in the absence of extensive tree cover. A very similar development is also seen in the Elan Valley Bog in Cardiganshire (Moore, 1970). Today true tall-herb communities tend to be rather scarce, being confined to places inaccesible to grazing animals such as islands in lochs and on cliffs and ledges (Birks, 1973).

Areas of grassland were also present with Rumex acetosella/acetosa, Artemisia sp.,Rubiaceae (probably Galium), Potentilla, Lotus and Ranunculaceae. Birch values begin to rise at 425 cm reaching 3% by the end of this zone. The rational limit (sensu Smith and Pilcher, 1973) for birch is estimated at ca. 9350(e) bp. This rise may represent the first local colonisation by birch but could also be accounted for by transported pollen. According to Birks (1977, 1980) Betula (probably B. pubescens) had extended rapidly into the south-west of Scotland by about 9800 bp. The date for the 'empirical limit' (sensu Smith and Pilcher, 1973) of birch on Arran is estimated at ca. 9650(e) bp. It could be, as mentioned earlier, that the estimated dates from this part of the section are artificially young. Alternatively with Arran being an island there may have been a delay in the migration of birch. The 'empirical limit' for birch at Bigholm Burn (above) tends to argue against regional synchrony.

NB No attempt was made, in these early samples, to distinguish pollen of B. nana from the pollen of the tree birches.

Sub-zone MM-1c (9250(e) - 8665 ± 155 bp)

In sub-zone MM-1c juniper values fall and Betula, Salix, Corylus type and triporate values rise sharply. The continued rise in Betula appears to represent the local expansion of birch woodland on the island in association with ferns, Equisetum and a number of tall-herb species such as Filipendula, Umbelliferae, Urtica, Trollius, Tubuliflorae (possibly Cirsium/Carduus) and Osmunda. Juniper would also have been present in the understory, with the initial reduction in its pollen values being due to decreased flowering as it was shaded out by Betula. The large amount of pollen produced by birch would also depress juniper values (Birks, 1973). Salix expanded into wetter areas again with a number of the tall-herb species and local wet conditions are also suggested by the presence of Potamogeton. Despite the spread of birch woodland areas of grassland were still present with associated species including Rumex acetosa/acetosella, Chenopodiaceae, Plantago media/major and Plantago maritima and possibly Thalictrum (although the latter may also be present with the tall herbs). These grassland communities are likely to have been concentrated near the sea and in exposed areas.

The rise in the Corylus type curve which begins in this zone is rather hard to interpret because of its 'stepped' appearance. Corylus type pollen is present in small, but continuous amounts from the base of the section probably as a result of long-distance transport. In this sub-zone it rises to about 5% TP, and it is unlikely that this represents local expansion. Certainly these low values, even if allowance is made for some of the triporate grains being Corylus, would argue against the extensive presence of Corylus which is such a prolific producer of pollen (Birks, 1973). However it may have been present but in a poorly flowering form due to the ecologically unsuitable conditions which prevailed.

A similar pattern is seen in the Corylus curves of a number of other diagrams from Scotland, northern England and Wales (Peglar, 1979, Hibbert and Switsur, 1976, Rymer, 1974, Hibbert et al., 1971, Nichols, 1967). Several of these have also been closely dated enabling direct or estimated ages of the two rises to be obtained. These dates for the initial rise range from 9798 ± 200 to 9870 ± 200, and for the main rise from 8810 ± 170 to 8940 ± 170. The dates from Arran are slightly younger, being 9250(e) and 8665 ± 155 respectively. Birks (1977) estimates the date for the local expansion of hazel as being around 9500 bp in south-west Scotland.

The history of Corylus in Britain has been discussed by Moore (1972b) and Deacon (1974). Moore comments on the increasing time-lag between the expansion of juniper and that of Corylus following the Loch Lomond Stadial in sites further to the north of the country. He attributes this to there being small prostrate examples of juniper present throughout the cold period which enabled it to expand rapidly when the climate improved. The distribution of Corylus was much less extensive, being confined to refugia in the south of the country. The expansion of hazel was governed, therefore, by its rate of migration from these refugia, which Deacon (1974) and Rymer (1977) consider may also have existed in the far-west of Scotland.

Zone MM-2 (8665 ± 155 - ca. 7825(e) bp)

Zone MM-2 opens with a sharp rise in Corylus type pollen and a sharp fall in Betula, corresponding to the expansion of hazel into large areas of rather more basic soil which formerly supported birch. The two species may have existed in pure stands, but it is also likely that there were areas of mixed birch/hazel woodland.

Both Ulmus and Quercus are present in this zone but both have rather low values and tend to occur rather infrequently, suggesting that the pollen was not of local origin.

As the forest cover developed tall-herb communities diminished, particularly where they were the most abundant, in damper habitats, where they were replaced by Betula and Salix. This reduction is reflected in the decrease or absence of Filipendula, Umbelliferae, Urtica, Filicales and Equisetum during this zone. Adam et al. (1977) suggest that as the forests developed these communities may have been restricted to small areas to the landward side of saltmarsh and shingle communities and that these may also have provided a refuge for nitrophilous and 'weedy' species. However as the main Flandrian rise in sea-level was beginning around this time it is difficult to know to what extent these habitats existed.

The first presences of Myrica type pollen along with that of Narthecium and the presence of Potentilla pollen suggest the development of Myrica dominated communities similar to the ones seen today on the raised beaches (Adam et al., 1977). The association of these pollen types occurs commonly throughout the section, with increasing frequency towards the top, reflecting the expansion of Myrica mire communities and the very similar blanket bog communities. Indeed a large part of the section (180 cm - 66 cm) is made up from peat formed from just such a community.

A peak first in Empetrum and then Calluna indicates the spread of heathland at the opening of this zone. Listera pollen present at this level is likely to originate from this source. Charcoal is also present from the opening of the zone and together these two events may indicate the first interference with the vegetation by Mesolithic populations (Dimbleby, 1965a, Smith, 1970). Whether the fires are of natural or anthropogenic origin is uncertain. The charcoal present in the peat at this time is herbaceous rather than woody in origin and microscopic examination led to the conclusion that it represented fragments of burnt Phragmites. Phragmites became a major constituent of the peat at this time (hence the rise in grass pollen) and it is probable that the charcoal originated from local burning possibly of dry, dead reeds. If large areas of these reeds were present they would have acted as cover and a refuge for game and wildfowl.. Fire may have been used to drive these out to the waiting hunters (Mellars, 1976). Durno and McVean (1959) report the finding of charcoal in peat from Beinn Eighe in north-west Scotland throughout the Boreal period. The fires which produced the charcoal also caused progressive deforestation. Durno and McVean favour Mesolithic human populations as a possible cause of the fires particularly as they considered the climate to be so wet at that time. On Arran however, little archaelogical evidence exists to support this. Natural fires could have occurred and both Birks (1972) and Peglar (1979) report the expansion at this time of Calluna onto dry well-drained soils which were already becoming leached and acidified.

Zone MM-3 (7825(e) - 6630 ± 130 bp)

The Ulmus and Quercus curves become continuous and rise together reflecting the spread of deciduous forest. This rise is dated to 7825(e) bp, comparing with :-

7640 ± 160 (Quercus and Ulmus) Bagholm Burn Dumfriesshire (Moar, 1969a)

8880 ± 170 (Ulmus), 8742 ± 170 (Quercus) Red Tarn, Lancs. (Hibbert et al., 1971)

8095 ± 80 (Ulmus and Quercus), Ballynagilly, Ireland (Pilcher and Smith, 1979) and the estimate of Birks (1977, 1980) of 8500 - 8000 bp for the south-west of Scotland. Corylus type pollen continues to rise as hazel expands along with oak and elm.

The pattern of development of the deciduous forest is very similar to that seen in the diagram from Loch Dungeon in the Galloway Hills (Birks, 1972). Birks considers that Quercus petraea is likely to be the most common species present in view of its greater tolerance of oceanic conditions and acid soils than Q. robur. She also suggests that Ulmus glabra, the most northerly and cold-tolerant of the elms, is the species present.

Betula, which has fairly low, steady values throughout this zone, was most likely restricted, along with Salix, to wet rather acidic habitats and to higher ground. Pine is present right from the bottom of the section but it is only in this zone that it shows a major increase, rising steadily and reaching a peak of 10% TP and almost 50% AP by the close of the zone. The low values in the earlier zones were almost certainly the result of long-distance transport of grains reflecting the post-glacial expansion of pine elsewhere. This zone covers the time period when pine could have possibly been present on Arran. It was never common in the south-west of Scotland as a whole, with the Galloway hills providing the only macrofossil remains (pine stumps). Even there it is not considered to have been an important component of the canopy (Birks, 1972, 1975). It is thought that pine was restricted to marginal habitats such as the surfaces of dried-out peat bogs and upland areas where the soil was too thin or acid to support oak or elm ie. where competition was low. If pine was present on Arran it seems likely that it occupied similar habitats.

At the opening of the zone there is further possible evidence for Mesolithic interference with the vegetation. Calluna values are still high and charcoal is still present in the peat. In addition to this there are the first occurrences of Sorbus type, Fraxinus and Plantago lanceolata pollen, and Rumex acetosa/acetosella and Ranunculaceae are present, suggesting a small scale opening of the canopy. Pteridium is also present for the first time and it rises to moderately high values, forming a continuous curve. It could be that this represents small scale forest clearance perhaps through the use of fire to drive game or even the more conscious manipulation of the environment suggested by Simmons (1975a, 1975b, and Jacobi et al, 1976). Nichols (1967) reports a similar occurrence from Aros Moss in Kintyre where there are coincident peaks of

Calluna and/

other Ericaceae, Pteridium, Coryloid and Rumex, plus the presence of Fraxinus and Urtica pollen. However he does consider the possibility that the Fraxinus and Coryloid pollen represents natural openings in the forest and that the other species may also have occurred naturally on the dried-out surface of the bog for example.

The event on Arran is dated approximately to 7825(e) bp and this is of the same order as dates for the first Mesolithic occupation of Jura (Mercer, 1970). It seems likely that Arran too had a Mesolithic population at this time (see Chapter 2.6) and that the changes in the vegetation may reflect the activities of this population. However they may also be explained in terms of natural rather than man-made vegetation. Both Fraxinus and Sorbus could be present in the developing deciduous woodland and the herb species mentioned could be present in exposed areas or along the coast. Pteridium is often taken as an indicator of open ground but it can be commonly found in the understorey of deciduous woodland, albeit in a subordinate form. It appears however that in this habitat Pteridium tends to reproduce vegetatively via its tough rhizome and that spore production is depressed. The opening of the forest canopy may be a stimulus to both expansion and sexual reproduction (Conway, 1957).

Within this zone there is quite a substantial rise in Alnus, dated to ca. 7825(e) bp, followed by a decline to very low values before the main regional expansion at 6630 ± 130, the opening of Zone MM-4. This is a common feature in pollen diagrams from the south-west of Scotland, being present at Aros Moss (Nichols, 1967), on Jura (Durno, in Mercer, 1968) and to a lesser extent in the Galloway Hills (Birks, 1972). Rymer reports a local expansion of alder, dated to ca. 7985 bp, 500 years before the main rise in North Knapdale, Argyll. It seems likely that this represents the same event. Interestingly, in another diagram from Argyll, from Loch Cill An Aonghais (Peglar, in Birks, 1980), this feature is hardly present. Durno (in Mercer, 1968) and Rymer (1977) attribute the local rise in alder to the increasing sea-level which also caused a rise in the water-table, and made overall conditions wetter. Indeed the relevant part of the Racks Moss diagram from Dumfriesshire is obscurred by a layer of carse clays resulting from the marine incursion. In the Galloway Hills, where the initial rise is less obviously separate than elsewhere, Birks cites the increasing oceanity of the climate as being the primary cause of the expansion in alder.

Zone MM-4a (6630 130 - ca. 5375(e) bp)

It is at the opening of this zone that the main regional expansion in Alnus occurs. The rise is very dramatic and it is probable that at this time alder colonised all suitable habitats at the expense of birch and Salix, even moving onto areas of damp mineral soil where it displaced oak and elm. Certainly the values of oak and elm fall slightly as alder rises but this may be due to possible human interference (discussed later). The chemical analysis of lake sediments (Pennington et al., 1972) and study of peat stratigraphy (Lamb, 1964, Birks, 1975) suggest that the climate became wetter around this time, enabling alder to colonise these mineral soils. The wetter conditions were also probably responsible for the demise of pine, the values of which fall sharply at the alder rise. The date for the alder rise on Arran is 6630 ± 130 bp. The same event took place in north-west England at about 7500bp (Smith and Pilcher, 1973) and Birks (1977) estimates the date for Galloway to be 7000 bp, with it occurring in Argyll at ca. 6800 bp. However he later revises this (Birks, 1980) to 7500 bp and 7000 bp respectively with the latter date coming from Loch Cill An Aonghais (Peglar, in Birks, 1980). The Arran date is younger, being similar to one from Bigholm Burn (Moar, 1969a). However the overall dating of this site appears a little confused and Moar suggests that there may have been large-scale contamination.

Two isolated grains of Tilia occur in this zone and similar quantities appear later in the diagram. It is very unlikely that these represent the local growth of lime and Birks (1977,1980) considers that it was never native in Scotland. Also accompanying the alder rise is an increase in Myrica type pollen along with Narthecium. The development of Myrica communities was discussed earlier and here it may reflect the increasingly wet conditions. Hedera pollen is present for the first time and in view of its sensitivity to temperature (Iversen, 1944, 1960) this may indicate that conditions were warmer as well as wetter.

The subject of Hedera as a climatic indicator is also discussed in detail by Godwin (1975). He raises the point that forest clearance with the resulting opening of the canopy is likely to have produced an increase in the frequency of Hedera pollen. Reductions in the frequency of this pollen type may also be attributed to human interference, with the autumn gathering of Hedera to feed cattle (Simmons and Dimbleby, 1974).

Mention was made earlier of possible human interference with the vegetation during this sub-zone. At 298 cm values of oak fall, and one sample later at 290 cm elm and birch also decrease. Accompanying this there is a temporary levelling off of the decline in Corylus type pollen (and a peak in Coryloid pollen), the presence of Hedera and Fraxinus, which both tend to respond to an opening of the canopy, and several herb species, including Plantago lanceolata, Urtica, Rhinanthus, Ranunculaceae, Tubuliflorae, Rumex acetosa/acetosella, Lotus and Labiatae. There is also a marked rise in the Pteridium curve. Together this strongly suggests a period of forest clearance. Unfortunately the sampling interval does not enable any precise indication of the duration of this event to be calculated but as the majority of the taxa are present only in the one sample it is likely to be less than 200 years. This sample is dated to ca. 5750 bp (3800 bc) and clearances of a similar date are known from Ireland, (Newferry, Smith and Collins, 1971, Ballyscullion, Smith, 1975, Ballynagilly, Pilcher and Smith, 1979, and Cashelkeelty, Lynch, 1981). The Newferry episode is thought to be due to a Mesolithic population but the others are recognised as being early Neolithic. At Cashelkeelty, further weight was given to this diagnosis by the presence of cereal pollen grains (Hordeum type and Triticum type).

From mainland Britain there are also examples of clearances at this time. Pennington (1975) discusses traces of small forest clearances prior to the elm decline between 3700 and 3100 bc in the English Lake District, attributing them to Mesolithic populations. Other examples are contained in papers by Walker (1966) and Birks (1972) although these are not dated. In Ireland the evidence is supported by settlement structures dated to the same period (Pilcher and Smith, 1979) and it seems likely that these may come to light in other locations. Clearances of this type are probably the work of the first Neolithic settlers who were in advance of the later, possibly more settled, people responsible for the building of the permanent monuments of earth and stone.

These observations apart, by the end of the zone the major forest patterns were well established. The brown earths of the valley floor and lower slopes which existed around the Vale of Shiskine at this time are likely to have supported deciduous forest composed primarily of oak, elm, birch and hazel. There would also have been a large proportion of alder with, to a lesser extent, Salix in wetter areas and along the banks of streams and rivers such as the Clachan Burn, the Machriewater and the Blackwater. Hedera is likely to have been present in the canopy and, although no pollen is present, Ilex too may have been present. Small natural openings in the woodland would provide suitable habitats for Sorbus and Fraxinus. Herbs present on the woodland floor would have included various ferns, including Polypodium and Pteridium, Filipendula and other tall herbs. The tree-line, probably the limit of the birch woodland, is likely to have reached the summits in the south of the island and would have been well advanced up the hills of the north apart from where it was modified by exposure. With large areas of the island being close to the coast and also in high relief, exposure is an important factor in determining vegetation types. Areas of naturally open ground would have existed explaining the occasional occurrence of shade intolerant species such as Artemisia, Lycopodium alpinum, L. clavatum and the various plantain species.

The coring site for MML80 lies in one of the lowest areas of the valley floor in the Vale of Shiskine and it seems likely that a large part of the area was given over to treeless mire. If this was the case then dense woodland would never have been in close proximity perhaps providing one of the reasons why even when the deciduous forest was 'fully developed' tree pollen values did not exceed 45% TP. Birks (1972) mentions the occurrence of similar mires in Galloway and suggests that as conditions became wetter and both leaching and soil acidification became prevalent the mire communities extended over areas which were formerly forest.

Zone MM-4b (5375(e) - 4740 ± 85 bp)

At the opening of this sub-zone there is another period of human activity, apparently discrete from that of the last zone. Values of oak, alder and pine fall slightly, there is a rise in Corylus type pollen and charcoal levels are very high. It is at this level that the first cereal pollen grain (cf. Hordeum) is present and there are accompanying rises in Plantago lanceolata, Pteridium and Ranunculaceae with the presence of Tubuliflorae, Rumex acetosa/acetosella, Urtica and Labiatae pollen. Later in the zone Calluna and Ericaceae pollen appear and increase, indicating the expansion of heath probably onto cleared areas of soil which would have become more acid. Tree values, although remaining relatively high, start to fluctuate as might be expected under a scheme of shifting slash and burn agriculture, or, as Pilcher and Smith (1979) suggest at Ballynagilly, regular coppicing or pollarding of trees.

They apply this interpretation to the apparently cyclical behaviour of oak pollen values subsequent to the elm decline. Very similar behaviour is exhibited here by the oak, alder and, to a lesser extent, birch curves, in this and later zones.

The date for the opening of this sub-zone with the presence of the cereal pollen grain is estimated at ca.5375 bp. This corresponds very closely to the dates for similar events in Ireland at the sites already mentioned and also at Beaghmore (Pilcher, 1969) and Sleive Gullion, (Smith and Pilcher, 1972, Pilcher, 1973). The major difference is however that at these sites the event accompanies the elm decline, here it is some 600 years in advance of it. The events in this sub-zone appear to represent an initial short arable phase, virtually represented by one sample, followed by a period a pastoral agriculture of 5 - 600 years duration, prior to the elm decline. During this time tree pollen values are not greatly affected (although there may be indications of pollarding or lopping) with no apparent selective destruction of elm. Cereal cultivation may have continued but with the inherent poor distribution of cereal pollen and the probable distance from the coring site this may have gone undetected. Conversely after the initial clearance for cereal cultivation it may have been abandoned due to the lack of suitable ground. The lowlying alder-bearing land may have been too heavy and higher ground with lighter well-drained soil may have very quickly become acid and infertile, hence the spread of <u>Calluna</u> heath. Sims (1973) describes a gradual decrease in elm values with evidence of clearance prior to the elm decline and Smith (1981) states that this gradual fall in elm with evidence of clearance, followed by a steep decline is likely to have occurred at many sites. It is not clear whether such a long period of clearance as this is envisaged.

It is at this time that the first chambered cairns would have been built on the island. The only one which has been dated is at Monamore near Lamlash (MacKie, 1964). The forecourt deposits associated with the cairn were dated at the base to in excess of 5110 ± 110 bp (3160 ± 110 bc). Pollen analysis was also carried out on these deposits by Durno (in MacKie, 1964). From the published diagram it is not clear exactly how the material analysed relates to the ^{14}C dates. It seems almost certain however that accumulation began after the primary elm decline as values of elm pollen are low.

Zone MM-5a (4740 ± 85 - 4310 ± 155bp)

This zone begins with a very sharp fall in values of elm, within a sampling interval of 4 cm the fall is from 5% to 1% TP (13% - 2% AP). With the sampling interval being 4 cm it is impossible to estimate the duration of the decline other than to say that it occurred in a period of less than ca. 120 years. Pilcher (in Garbett, 1981) suggests a time scale of 1 - 50 years and Garbett himself (1981) gives a period of less than 20 years for the initial decline.

The elm decline is the most commonly dated and discussed event in Flandrian vegetational history (Smith, 1961,1970, 1981, Iversen, 1944, 1960, Troels-Smith, 1960, Seddon, 1967, Frenzel, 1966, Ten Hove, 1968, Godwin, 1975). The reasons for its fascination and the attention it attracts are :-

1. In contrast to other major vegetational events it displays remarkable synchrony across most of north-western Europe, generally falling in the period between 3400 and 2800 bc (Sims, 1973).

2. The decline is apparently selective, affecting elm preferentially.

3. The date of the decline coincides with the advent and expansion of Neolithic cultures and its affect tends to be greater near centres of Neolithic population (Pennington, 1975).

In the past twenty years or more a large number of theories and variations on theories have been forwarded as to the cause of the elm decline. Most of these are centred on the idea that the frequency of elm pollen was reduced through the action of some agency or agencies such as climate, disease or human intervention. Tauber (1965), however, proposes a scheme whereby Salix bushes growing on the margins of lakes and bogs were responsible for a filtering effect, thus reducing the amount of elm pollen reaching the sediment. This idea is very hard to apply to all sites which show an elm decline.

A climatic cause was favoured by Iversen (1944, 1960) in terms of a spell of cold winters adversely affecting the elm population. The idea found support because it explained the observed synchrony of the decline. It has since been discussed and rejected by a number of authors including Troels-Smith (1960), Walker (1966), Rackham (1980) and to a lesser extent Smith (1970, 1981).

The idea of human involvement in the elm decline was championed by Troels-Smith (1960), who undertook archaeological, historical and pollen analytical research to further his case. He argues that the decline was due to bands of 'semi-agriculturalists' collecting leaves and branches of elm for feeding tethered animals. Simmons and Dimbleby (1974) describe a similar usage of ivy to explain high concentrations of <u>Hedera</u> pollen found in Mesolithic contexts. Support is also given by Heybroek (1963) who draws the parallel between the elm decline and the drastic effects which farmers in the Indian Himalayas have on the elm population through the lopping of the branches for animal fodder. Other authors (Mitchell,1965, Morrison, 1959) favour a rather more direct approach by man. They suggest that the decline was due to the ring barking, burning and felling of pure stands of elm to produce agricultural land, elm being an indicator of fertile basic soils. Smith and Willis (1962) see this as possibly following from an earlier fodder gathering. Bark could also have been removed, incidentally or intentionally, for food purposes in times of hardship (Nordhagen, 1954, Smith 1975, 1981) by both human and animal populations.

An attempt was made to investigate these hypotheses by Garbett (1981) in his very detailed work at Ellerside Moss. Analysis was performed on contiguous 2 mm samples across the elm decline, cut from a frozen core using a microtome. On the basis of his findings he divided the elm decline into five phases.

The first represents the fully developed deciduous forest with high values of elm and other tree species. There then follows a period of twenty to thirty years when the haphazard lopping of leaves and branches from oak, lime and elm was practised. Garbett attributes this to the activity of an inexperienced indigenous population, rather than an influx of new settlers.

In the next twenty to thirty years elm was selectively lopped suggesting the attainment of a degree of sophistication by the farmers. However this resulted in the over-exploitation of elm leaving a population of damaged and under-productive trees. These were then cleared along with oak and lime by felling and the extensive use of fire. It is suggested that this would have involved the progresssive clearance of small areas along the lines suggested by Turner (1964, 1970) and Iversen (in Smith, 1981). The final phase was one of regeneration when all the woodland tree species almost reached predecline levels.

This sequence may provide the basis for the interpretation of events at a number of sites. However in view of the variation in the type and extent of agricultural activity prior to, during and after the elm decline it is apparent that it is a phenomenon which disguises a range of human activity and natural events which as yet are not fully understood.

A selective elm disease, such as Dutch Elm Disease, as the cause of the elm decline is also a very plausible proposal, but it is very hard to prove or disprove. It was first forwarded by Watts (1961) who did not believe that human interference as outlined by Troels-Smith (1960) adequately explained the decline. Smith (1961) expanded the idea, suggesting that clearance or thinning of the forest would have speeded up the movement of a disease vector. Heybroek (1963) argued against this, his main objection being that there are no records of elm epidemics prior to the beginning of this century and if such diseases were endemic then living trees would be expected to have some form of resistance. Rackham (1975) and Gibbs (1978) however, suggest that Dutch Elm Disease may be considerably older than Heybroek states and also that living elms do have some form of resistance to the disease. It is also possible that elms suffered from a disease to which they are now immune.

Garbett (1981) considers that a wide spread elm disease would result in a large number of standing dead trees covered with living ivy (<u>Hedera</u>) and that there would be a subsequent increase in the level of <u>Hedera</u> pollen. He detects no such increase in his detailed pollen analyses over the period of the elm decline at Ellerside Moss in southern Cumbria. However he admits that an insufficient number of grains were counted for his findings to be statistically significant.

Rackham (1980), in a recent evaluation of possible causes of the elm decline, favours an explanation which jointly implicates both prehistoric man and a selective elm disease. Lynch (1981) reaches a similar conclusion in explaining the reduction in elm values at Cashelkeelty in south-west Ireland. Rackham's hypothesis is that Neolithic agriculturalists were involved in the pollarding and lopping of elms associated with some clearance and bark stripping. This would have produced some reduction in the values of elm pollen but he calculates that it would have taken 0.5 million adults (10 times the estimated Neolithic population) working throughout the summer to produce the effect seen at the elm decline by these methods. It seems much more likely that the decline was due to the spread of a fatal disease epidemic through an elm population rendered susceptible by repeated removal of leaves and branches. In the wake of the disease there would have been large areas of dead elm trees and these would have been used for pasture and cultivation, being more easily cleared than living trees.

Later as the population grew these areas became less productive and other woodland would have been cleared, resulting in the reduction of pollen from the other forest trees as reflected in many pollen diagrams.

This hypothesis neatly explains the synchrony and selectivity of the elm decline and also to an extent why it tends to be greater in areas of Neolithic settlement. However some recent work involving absolute pollen analysis shows that the decline may not be confined solely to elm. Other species including oak, birch and pine decrease too, although elm does appear to suffer the most drastic reduction (Sims, 1973, Pennington, 1975). The most striking example of this is from the Abbot's Way in the Somerset Levels (Beckett and Hibbert, 1976, 1979, Beckett, 1978, 1979) where the absolute diagram shows that the influx of all tree pollen declines simultaneously, with the exception of birch. The possible explanation of this could be that the 'lag' between the use of land occupied by dead elms and the clearance of living woodland is of variable duration. Its length may be determined by the size and rate of growth of the human population. A high population density would exert heavy pressure on the available resources perhaps causing the similtaneous clearance of dead elms and healthy woodland.

On Machrie Moor the elm decline is dated to 4740 ± 85bp which is towards the most recent end of the range given by Sims (1973), and is 200 to 400 years younger than the majority of published dates from north-western Britain and Ireland. However the date from just above the elm decline at Flanders Moss in Perthshire (Godwin and Willis, 1962) is 2620 ± 120 bc (4570 ± 120bp) and the level at Ballyscullion in Northern Ireland (Pilcher et al., 1971) has a date of 2890 ± 60 bc (4840 ± 60 bp). The dating of the event at Machrie Moor is not very 'precise' in that a large increment of peat (8 cm) had to be used to obtain a sample which was still rather lighter than preferred by the dating lab and this makes comparison difficult.

With regard to the other events in the pollen diagram at this level, *Pinus* values fall along with elm and this may reflect the situation in Irish pine woods rather than suggesting that pine was suddenly reduced on Arran. In addition to this the *Fraxinus* curve becomes continuous and *Salix* values increase. As discussed earlier the influx of the tree species fall. There is also the presence of several agricultural indicator species including *Plantago lanceolata*, *Rumex acetosa/acetosella*, *Urtica*, *Succisa*, *Pteridium* and Ranunculaceae. Towards the close of the sub-zone there is the presence of a single cereal pollen grain (cf. *Hordeum*). As the tree values decline the increase in *Calluna* and Ericaceae pollen which began in MM-4b accelerates sharply, indicating the further spread of acid heath.

Rackham's theories concerning the sequence of events at the elm decline are attractive ones which can be readily applied to the data from Arran. Evidence for forest clearance and pastoral farming is present in excess of 600 years prior to the elm decline, there may also in addition have been small arable plots. It is possible that during that period the practices of pollarding, lopping etc. of elm and other species was being practised. Some species such as elm and ivy may have been preferentially gathered as animal fodder. Although this would have produced some reduction in pollen values, clearance and burning would have been on a limited scale sufficient to provide small areas for cultivation. The overall effect on the values of tree pollen appears to have been slight.

Trees which have been repeatedly cut, exposing large areas of tissue to the air are more susceptible to fungal diseases (such as Dutch Elm Disease)(Rackham, 1980). It may be, therefore, that the prolonged management of elm for food purposes rendered it susceptible to a fatal elm-specific disease which resulted in the observed elm decline. If the disease proceeded on similar lines to the recent outbreak of Dutch Elm Disease, then the elm population would have been drastically reduced over a very short period of time. Areas of woodland would be occupied largely by dead trees, and these areas would have proved attractive to the Neolithic farmers as they would have been easier to graze, or clear and cultivate. However under a regime of primitive agriculture these areas would soon have a much reduced productivity and it would have been necessary to open up living woodland. This may explain the slightly later fall in the pollen values of the other woodland tree species. There is also a rise in heath pollen at this time suggesting that some of the areas cleared following the death of the elms were colonised by Calluna and other acid-heath species. To summarise, it is suggested that the elm decline was the result of an outbreak of an elm-specific disease, the spread of which was aided by human interference with the woodland in a period when the population was increasing.

The pastoral period which follows the elm decline lasts of the order of 400 - 500 years, a similar duration to that of similar events in Ireland (Pilcher and Smith, 1979, Lynch, 1981), and northern England (Pennington, 1975). It appears to have some relationship to the landnam phases described by Iversen which he sees as essentially for pastoral purposes with only a low level of cereal cultivation (Iversen, in Smith, 1981, p 155). However with a time-span of this magnitude it must represent a series of clearances, rather than the single event followed by variable land use as outlined by Iversen.

Zone MM-5b (4310 ± 155 - 3535 ± 115 bp)

In this sub-zone there are indications that human activity was less intense. Elm values recover to pre-decline levels. There is a slight recovery in *Pinus* and, apart from a sharp decline and recovery at 228 cm, oak reaches its highest values. Tree pollen overall is approximately 40% TP.

Although agriculture was less intense, it does not appear to have ceased completely. *Urtica* is less abundant than in the previous zone and *Rumex acetosa*/*acetosella* is absent, but apart from slight declines at the opening of the zone both *Plantago lanceolata* and *Pteridium* have substantial continuous curves. There are presences of Compositae (Liguliflorae) pollen and the Ranunculaceae curve rises. *Calluna* and Ericaceae also continue to rise indicating the continuing spread of *Calluna* heath, presumably reflecting the similar spread of acid soils. Charcoal values are, however, low at this time.

The occurrence of this regeneration phase again outlines the close parallels with events in Ireland, as it corresponds closely to the summary of events at Beaghmore, Ballynagilly and Ballyscullion (Smith, 1975), at Cashelkeelty, (Lynch, 1981) and several other sites. As to the reasons for this apparent decline in the late Neolithic several suggestions have been made. Lynch (1981) speculates that the early farming populations would have been very susceptible to disasters such as crop failure, with only one poor season or period of disease needed to drastically reduce the population. Bradley (1978), Bradley and Hodder (1979), Whittle (1978) and to some extent Garbett (1981) argue along the lines of the available resources being over-exploited with a marked effect on environmental conditions, particularly soil fertility. As Bradley says 'Neolithic expansion outstripped the capacity to support it'. Smith (1981, p 206) raises the question of whether a change in climate may have precipitated this. There is no strong evidence from Machrie Moor to confirm or refute this. However values of *Potamogeton* pollen do rise and there is a small peak in the rhizopod *Assulina* which is taken to indicate local wet conditions (van Geel, 1978). In addition both Juncus seeds and Sphagnum imbricatum are present in the peat, which may indicate increased wetness.

On Arran this period of inactivity appears to have been short-lived, with elm and alder values declining mid-way through this sub-zone ca. 3950(e) bp (2000(e) bc). Corylus type and Fraxinus pollen increases and several agricultural indicator species reappear or increase. These events correspond to a resumption or increase in human activity in Beaker times again an event which seems to be common to much of north-western Britain and Ireland. No cereal pollen is present however, and there are no other indications of cereal cultivation.

Zone MM-6a (3535 ± 115 - 3050(e) bp)

Zone MM-6a opens with a further sharp decline in elm and pine, almost certainly as a result of human interference. After an initial rise Betula falls too and the values of both oak, Corylus type and ferns decrease. Calluna values rise at first in response to this and then are later replaced by grass. Charcoal values increase as those of the trees fall. Mixed farming appears to have been practised with cereal pollen (cf. Hordeum) present along with pollen of Chenopodiaceae, Caryophyllaceae and Umbelliferae. Plantago lanceolata pollen is abundant, Rumex acetosa/ acetosella increases throughout the zone and several other indicator species are present including Ranunculaceae, Vicia type and Pteridium. Again this sequence corresponds very closely with events reported from Ireland. The intensification of forest clearance first for arable, then for pastoral agriculture, followed by a period of abandonment and forest regeneration is thought to have occurred repeatedly throughout the Bronze Age with the achievement of a fair measure of social and economic stability, (Lynch, 1981, Smith, 1975). However continued pressure of this nature was not without its consequences and it is in the Bronze Age that widespread soil deterioration and podsolisation occur. Upland and more marginal soils would have been the most susceptible to this with regeneration phases producing scrub rather than secondary woodland and later forming heath. As discussed earlier these processes (section 1.4) can also lead to blanket peat formation particularly in topographically suitable locations. Goddard (1971) gives three main periods of peat initiation during the Bronze Age in Northern Ireland, they are centred on the dates 1800 ± 200 bc, 1200 ± 100 bc, and 800 ± 100 bc. The change from heath to grass domination in this sub-zone may correspond to the spread of Molinia blanket bog ca. 1300 - 1400(e) bc and the blanket peat at the excavation site on Tormore is known to have begun forming around 1200 bc (see Chapter Six).

Zone MM-6b (3050(e) - ca. 2700(e) bp)

This zone is characterised by very intense human activity indicated by extraordinarily high values of Plantago lanceolata and Plantago undiff. (which probably includes quite a large number of corroded P. lanceolata grains), with the presence of cereal pollen (cf. Hordeum) and a large number of agricultural indicators including Artemisia, Caryophyllaceae, Umbelliferae, Labiatae, and Mentha type, Tubuliflorae, Liguliflorae, Rumex acetosa/acetosella, Urtica, Trifolium (including T. repens), Papilionaceae, Ranunculaceae and Pteridium. In addition to this tree values are very low. It is hard to conceive of a landscape which would produce such a spectrum. There must have been very extensive agricultural activity around the whole of the valley. One possible reason for the very high indicator levels may be that with such large areas being cleared and so obviously under both arable and pastoral agriculture there may have been problems of soil erosion by wind. Agricultural soil, which tends to have a high concentration of agricultural pollen, may in this way have been deposited on the bog surface artificially raising the indicator levels. However there is no indication in the pollen slides or pollen sievings of there being increased mineral in the peat at this time, although the loss on ignition curve (Fig. 5.6) does fluctuate slightly.

Activity in this sub-zone is the culmination of the steady increase in clearance and land use which occurred throughout the Bronze Age. Again it is an event which has been recognised from Ireland (Smith, 1975, Lynch, 1981) and it is also reported by Nichols (1967) from Kintyre and Dumfriesshire. Turner (1970) reports the first significant clearances at Bloak Moss in Ayrshire as being from this time. Activity prior to this appears to have been restricted to small-scale clearance with little overall effect on the canopy. It could be that as more accessible areas became less productive there were moves to exploit the denser woodland inland.

Zone MM-6c (ca. 2700(e) - 1850(e) bp)

The agricultural activity of sub-zone MM-6b persists into MM-6c, albeit at a much reduced level. Several indicator species are present including Compositae (Liguliflorae and Tubuliflorae), Rumex acetosa/acetosella, Urtica, Trifolium, Papilionaceae , Plantago lanceolata, Plantago undiff., Caryophyllaceae, Artemisia, Umbelliferae and Chenopodiaceae. Although this list contains several arable weeds, cereal pollen itself is absent and this may indicate a shift towards pastoral agriculture. Values of Calluna and Ericaceae rise indicating a renewed expansion in heathland and as in previous similar episodes, the heath species appear later to be replaced by grass. Tree pollen values also reflect the reduced pressure on the vegetation increasing slightly in this sub-zone, with Fraxinus reaching its highest values so far. Charcoal values fall steadily apart from a peak just before the close of the zone.

Another interesting feature of this zone is the first presence of Cannabis/Humulus pollen (two isolated grains). Unfortunately it was not possible to determine which of the two species the grains represent.

The records of Humulus/Cannabis pollen and their significance have been discussed by Godwin (1967a, 1967b, 1975) and he concludes that there is no clear evidence to suggest that there was cultivation of either Humulus or Cannabis prior to the Birth of Christ.

Humulus lupulus (the hop) is a plant of wet marshy hollows, fen carr and moist alder woods, native to England and Wales (Clapham et al., 1962, Perring and Walters, 1976). Its frequency has been much reduced by forest clearance and drainage but it does occur today in thickets and hedgerows, either as a relict or as an escape. The history of its early usage by human populations has been dealt with in detail by Wilson (1975, 1978). She discusses the use of Humulus for brewing, in medicine, as a fibre plant and for food, with these practices stretching at least as far back as the ninth century AD. It is thought that originally wild hops were collected, with the later cultivation of the species as demand increased.

Cannabis sativa (hemp) is not a native plant; it is thought to have been introduced in Anglo Saxon times being cultivated as a source of fibre for rope making rather than for its narcotic purposes (Godwin, 1975). It was a widely cultivated crop until relatively recently and for a time it was compulsory for a certain acreage to be planted by each farmer (Godwin, 1978).

In this zone both grains of Humulus/Cannabis pollen occur in a period prior to the birth of Christ(ie. the time at which the earliest cultivation is thought to have possibly taken place). This suggests that the grains originated from wild populations and raises a number of questions as neither species is thought to be native to Scotland, and only Humulus is native to England and Wales. One possible explanation is that Humulus was able to grow wild in the mild south-west of Scotland (it is present on Arran today) and that this was the source of the pollen. Another is that Cannabis may have been introduced much earlier than Anglo Saxon times perhaps as a contaminant in the seed of another crop. Thirdly, either one of these species may have been in cultivation for a longer period than envisaged by Godwin or Wilson. However it is difficult to reach any firm conclusions on the basis of the presence of two isolated grains.

The marked decrease in human activity in the later Bronze Age and early Iron Age again illustrates the strong parallel between events on Arran and those in Ireland. A similar, but even more striking, decline is seen at this time at many Irish sites with very little agricultural activity recorded between 500 bc and ad 500 (summarised by Lynch, 1981). After the cultural and social development which occurred through much of the Bronze Age it seems strange that such an event should happen. A number of factors are thought to have contributed to the demise, not least of these was the climate which was steadily deteriorating (Lamb, 1977, Piggott, 1973). The combination of this with periods of intense forest clearance and land use resulted in widespread soil acidification and podsolisation and the spread of heath and blanket bog (Goddard, 1971, Moore, 1975), making the land less productive. Primarily this would have affected cereal cultivation, later grazing too would have of necessity been less intense and the food production would have been insufficient to support the level of population which had been attained.

The human population would have been more susceptible to disease in colder and wetter conditions with respiratory infections and parasitic infestation posing major problems.

Animal health may also have suffered severely under a regime of deteriorating climate. Diseases caused by parasites such as liver fluke (Fasceola hepatica) and lungworms (nematodes) would have greatly reduced the productivity of animals and in most cases would have been fatal.

These and other parasites flourish in wet conditions and both improved and poor pasture would have provided ideal habitats. It is suggested (Mitchell, 1965) that the late Bronze Age may have reached economic stagnation.

Another important factor may have been the threat posed by Celtic invaders which are thought to have arrived in successive waves in the late Bronze Age/early Iron Age (McLellan, 1976, Scott, 1966) although Fairhurst (1981) favours an invasion of ideas rather than of people. There is no doubt that these were violent times and that this could have led to the breakdown of Bronze Age society and culture leading ultimately to the building of the fortified dwelling places and tribal centres so characteristic of the Iron Age. On Arran this transition appears to have been accomplished without the total suspension of agricultural activity with a deep recession effectively not occurring until the end of the Iron Age.

Zone MM-7 (ca. 1850(e) - 1250(e) bp)

Whilst sites in Ireland show a marked increase in activity around this time, corresponding to activities in the early Christian period (Lynch, 1981, Pilcher, 1969), on Arran the reverse appears to occur. Reduced human pressure is indicated by rise in tree pollen values to maximum of almost 25% TP. Salix and Corylus type also rise and charcoal levels fall. Agricultural activity does not cease completely, however, and was probably in the form of episodes of small-scale arable and pastoral farming. These are represented by the continued presence of Tubuliflorae, Rumex acetosa/acetosella, Urtica, Plantago lanceolata, Pteridium and Ranunculaceae, in substantial amounts. There are also minor presences of Succisa, Caryophyllaceae, Artemisia and Labiatae and a peak of Plantago media/major pollen mid-way through the zone. Humulus/Cannabis pollen is again present and a single cereal grain (cf. Hordeum) occurs towards the close of the zone where tree pollen values are falling again. From this it would appear that agriculture continued throughout this period but it was severely limited by continued peat growth, with possibly both human and animal health again being major considerations.

The main clearances at Bloak Moss (Turner, 1970) occur in the early part of this zone and similar events are suggested from the Galloway Hills by Birks (1972). It could be, as suggested earlier, that areas such as those found on Arran were largely abandoned as being unproductive with inroads being made into the tracts of largely untouched woodland on the mainland. Certainly the Machrie Moor area, which by this time would have suffered human interference for in excess of 3000 years, under conditions of exposure and an increasingly oceanic climate, would have had few areas which were not covered in acid heath or blanket bog.

Zone MM-8a (ca. 1250(e) - 1120 ± 60 bp)

The decrease in tree pollen values which began at the end of the last zone is maintained and an increase in human activity is suggested by a sharp climb in charcoal values. However indicator species are not particularly common although cereal pollen (cf. Hordeum) and a few grains of Artemisia, Umbelliferae and Plantago lanceolata are present. This zone may represent the breaking of new ground with associated burning. In the first instance this appears to have been for cereal cultivation and it might be in response to an improvement in climate. Levels of both Calluna and grass rise at this point.

Zone MM-8b (1120 ± 60 - ca. 900(e) bp)

In this sub-zone agricultural activity intensifies and there appears to be more evidence of mixed, rather than the predominately arable, farming which was found in MM-8a. Grazing land is indicated by the presence of peaks in Rumex acetosa/acetosella, Plantago lanceolata, Liguliflorae, Tubuliflorae, Urtica, Trifolium, Lotus, Vicia/Lathyrus type, Ononis type and several other herb species. Cereal pollen (cf. Hordeum) is again present along with Artemisia, Umbelliferae, Chenopodiaceae, Caryophyllaceae and Labiatae. The values of these fall towards the end of the sub-zone as values of birch and alder pollen rise suggesting a period of reduced activity and woodland regeneration ca. 1000 bp.

The high level of activity which follows a period of virtual abandonment appears to relate closely to the Viking involvement in Arran, suggesting that there was Viking settlement and coexistence on the island as opposed to the continual raiding and looting which did so much to disrupt Irish agriculture at this time (Lynch, 1981). It also corresponds with the amelioration in climate which occurred during Viking times, the so-called 'little optimum' (Lamb, 1977). It was during this period that the whole of Britain enjoyed temperatures in the warmest months 1 - 2° higher than at present, cultivation reached unheard of altitudes and many exotic species such as grapes and figs were grown in monastery gardens. Exact correlation with this is difficult because calibration of ^{14}C dates with time is rather problematic and imprecise (Clarke, 1975, Alcock, pers.comm. 1981). However on the basis of the pollen evidence it does seem likely that this is the period represented.

Zone MM-8c (ca. 900(e) - ?ca. 500(e) bp)

Levels of birch and alder pollen fall again and there is the continued presence of several indicator species with pastoral agriculture the most prominent. Species present include *Plantago lanceolata*, Liguliflorae, Tubuliflorae, *Rumex acetosa*/*acetosella*, *Urtica*, Papilionaceae, *Pteridium*, Ranunculaceae, cereal pollen (cf. *Hordeum*), *Artemisia*, Chenopodiaceae and Labiatae.

Initially this must represent events in the later Middle Ages but how far the record extends towards the present day is unclear. On the basis of the time/depth curve the top of the section is dated to ca. 500(e) bp. However in the top two samples there are grains of *Pinus* and *Fagus* pollen. These may represent initial plantations on the island which began less than 300 years ago.

5.9 SUMMARY

Zone MM-1 Late-glacial and early post-glacial deposits at the base of the section represent soil stabilisation and colonisation with the development of *Empetrum*/juniper heath and grass/sedge communities. Later there is an expansion in tall-herb vegetation and birch woodland and a reduction in open habitat species.

Zone MM-2 The rapid expansion of *Corylus* results in a reduction in *Betula* and the formation of hazel and birch/hazel woodland. The first indication of possible interference by Mesolithic populations, in the form of charcoal in the peat and pollen of heath species, occurs in this zone. It is dated to 8665 ± 155 bp.

Zone MM-3 Rises in *Ulmus* and *Quercus* herald the development of mixed deciduous woodland, in which hazel is still a major component. There is a possible Mesolithic event involving opening of the canopy, probably by burning. The evidence is stronger than in MM-2 and the event is dated to 7825(e) bp.

Zone MM-4 Further development of the woodland occurs with the regional expansion of *Alnus*. A clearance, possibly early Neolithic, occurs early in the zone (ca. 5800(e) bp) with much more definite activity, including cereal cultivation, being present later (ca. 5400(e) bp). These events are well in advance of the elm decline and the farming appears to be mainly pastoral.

Zone MM-5 The elm decline, at the opening of this zone, is dated to 4740 ± 85 bp and it is followed by an intense period (ca. 600 years) of pastoral agriculture. Tree species other than elm suffer a later decline but evidence for cereal cultivation is slight. Agricultural activity suffers a reduction in the later Neolithic with a resumption, again pastoral in nature, in Beaker times.

Zone MM-6 A period of sustained mixed agriculture begins in the early Bronze Age and is maintained through to the end of the Iron Age. A peak is reached in the later Bronze Age with a phase of very intensive agriculture. Tree values fall until this time, staging a recovery subsequent to it. Cereal cultivation declines in importance in the latter part of the zone and heath and blanket bog species expand.

Zone MM-7 Agricultural activity, declining at the end of MM-6, is further reduced in the pre-Viking Dark Ages, being restricted to isolated episodes of pastoral and, to a lesser extent, arable farming. Tree values recover significantly before declining at the end of the zone as human activity intensifies.

Zone MM-8 An emphatic resumption of human activity in the shape of mixed agriculture occurs in Viking and later Mediaeval times. Agriculture appears to have flourished under a favourable climate and apparently settled conditions.

CHAPTER SIX

TORMORE

6.1 SITE DESCRIPTION

The sampling at Tormore (NR 896 312) was based on the C.E.U. excavation site at a height of approximately 100 metres on the east-facing slope of Tor Righ Mor, which forms the western side of the basin enclosing Machrie Moor (see Chapter Three). The village of Tormore is 1km. to the north, the King's Cave is the same distance to the west and the Iron Age hill fort at Drumadoon is 2km to the south-west.

Tormore itself consists of Triassic red marls with cornstones and sand-stone into which Felsite dykes and sills have been intruded. These are patchily overlain with boulder clay. The whole of the hillside is covered with blanket peat ranging in depth from 20cm to almost 2 metres. The surface vegetation consists largely of _Molinia caerulea_, _Myrica gale_, _Calluna vulgaris_, _Erica tetralix_ and _Erica cinerea_. Quadrat data from Tormore are included in Appendix A2.

6.2 SAMPLING OF DEPOSITS

See section 4.1.

6.3 SECTION TM1

6.3.1 Peat Stratigraphy and the Development of the Peat Deposits

Section TM1 is from a saddle-type depression 40 metres to the west of site one in the C.E.U. excavation (see Chapter Three and Fig. 3.2). A description of the peat stratigraphy is given in Table 6.1 and the detailed Troels-Smith analysis is contained in Appendix A5. A diagrammatic representation of the Troels-Smith analysis is given alongside the pollen diagram (Figs. 6.1 and 6.2).

The deposits at the base of this section are atypical in that they began forming well in advance of the general spread of peat growth over the hillside. The organic material at the base is very highly humified and contains a high proportion of mineral. These facts, coupled with

Table 6.1

Peat Stratigraphy - Section TM1

Depth in cm.	Description
0 - 25	Poorly humified *Eriophorum* peat with *Calluna* roots and some *Sphagnum* leaves, also intrusive living roots.
25 - 40	Very humified *Eriophorum* peat with a few *Sphagnum* leaves and carbonised *Calluna* and *Erica tetralix* leaves.
40 - 74	Well humified *Eriophorum* peat with some trigonous *Carex* nutlets, no charcoal.
74 - 86	Well humified *Sphagnum papillosum*/*Eriophorum* peat with leaves of other *Sphagnum* species, charcoal absent.
86 - 159	Highly humified *Eriophorum* peat containing both fibres and spindles. Also present were *Sphagnum* leaves and *Myrica* leaf fragments, carbonised seeds and leaves of *Erica tetralix* and *Calluna vulgaris*, biconvex *Carex* nutlets and a few charcoal fragments. Bands of poorly humified *Eriophorum* remains were present at ca. 128 and 90 cm.
159 - 176	Very humified peat with Cyperaceous remains and some charcoal fragments.
176 - 181	Very humified peat with some fine mineral, Cyperaceous remains and abundant charcoal. Both *Juncus bufonius* and *J. effusus* seeds were recovered.
181 - 185	Very humified peat with a great deal of coarse and fine mineral, most of it quartz-like. Some Cyperaceous remains and abundant charcoal were also present. *Juncus bufonius* seeds recovered from 181 cm.

the presence of seeds of Juncus bufonius and Juncus effusus, and the pollen of Potamogeton and Hydrocotyle, suggest that it formed rather slowly in a 'marshy hollow' probably surrounded by drier ground. This may have remained the case through a period when, the pollen record indicates, there was widespread development of Calluna heath in the vicinity.
It is probable that the depression then acted as a centre of growth for the blanket peat which expanded, replacing the Calluna, and eventually covered the whole hillside. The blanket peat which developed at the sampling site is largely composed of Eriophorum remains but a band of Sphagnum does occur between 86 cm and 74 cm perhaps suggesting local wetter conditions. This is centred on a date of 1550 ∓ 80 bp.

6.3.2 Pollen Stratigraphy

As with MML80 this section has also been divided into local pollen assemblage zones on the basis of the constituent pollen and spore curves. Further subdivisions were made according to changes in the level of human activity. Some difficulty arose in the zonation of the upper part of the diagram due to the over-representation of local pollen types.

Zone TM1-1. (185 - 165 cm)

This zone begins with a dramatic fall in tree and shrub pollen, Betula falls from 10% to 2%, Quercus from 17% to 2% and Coryloid from 47% to 5%. Alnus remains stable around 5 - 7% before falling later in the zone. Pinus, Ulmus and Fraxinus have very low values. Calluna, Gramineae, Plantago lanceolata (plantain), Cyperaceae, Potentilla and Sphagnum values rise as the trees fall, reaching 47%, 50%, 6%, 25%, 6% and 22% at their respective maxima. Cereals (cf. Hordeum), Rumex, Liguliflorae, Tubuliflorae, Chenopodiaceae, Urtica, Papilionaceae and Ranunculaceae are all well represented. Filicales and Polypodiaceae values are modest but are the highest encountered in this section.

Zone TM1-2. (165 - 115 cm)

This zone is divided into two sub-zones on the basis of the behaviour of the species indicative of human interference. Sub-zone TM1-2a (165 - 135 cm) and sub-zone Tml-2b (135 - 115 cm).
TM1-2a Tree values recover somewhat, although they continue to fluctuate considerably, Fraxinus becomes more common and Coryloid pollen reaches a peak of 62% TP. Calluna has modest values of 2 - 4% after the peak

in the previous zone and Gramineae (ca. 40%) and Cyperaceae (ca. 25%) dominate the spectrum. Plantain, Rumex, Compositae, Papilionaceae and Ranunculaceae are less common, Urtica rises towards the end of the zone and both Pteridium and the fungal spore Gelasinospora rise to small peaks.

TM1-2b Tree values are similar to those in TM1-2a, apart from those of Fraxinus and Ulmus, which fall. Coryloid and Cyperaceae are slightly lower (ca. 25% and 15% respectively) and Gramineae rises to a peak of 57% TP. Calluna also shows a steady rise and Sphagnum reaches a peak of 27%. Herb species, including plantain and Rumex, are more common and there is a peak in Pteridium.

Zone TM1-3 (115 - 60 cm)

All the tree species stage a minor recovery, with Betula reaching 8% TP, Quercus 3%, Alnus 5%, and the Ulmus and Fraxinus curves become almost continuous. Gramineae is high throughout and the early high values of Coryloid pollen are later replaced by high Cyperaceae. Calluna and Sphagnum values are very low and herb species such as plantain, Rumex, Papilionaceae and Urtica are infrequent. Between 75 and 85 cm there are peaks in the rhizopods Assulina (12%) and Amphitrema (3%). Towards the end of the zone there is a renewed decline in tree pollen.

Zone TM1-4 (60 - 35 cm)

Tree values continue to fall with a slight recovery in Betula and Alnus towards the end of the zone. Coryloid pollen falls from over 65% at the opening of the zone toca. 5% near its close. Calluna is high (20%) at both the opening and close of the zone, falling to less than 10% in the middle. Ericaceae undiff. values reach a peak of 5% early in the zone with Gramineae reaching 65% later. Cyperaceae values are low, ca. 3% - 7%.

With regard to agricultural indicators, cereals (cf. Hordeum), Ranunculaceae, Artemisia, Rumex, Succisa, Urtica, Plantago lanceolata, Tubuliflorae, Cruciferae, Papilionaceae, Chenopodiaceae and Pteridium are all present.

Zone TM1-5 (35 - 15 cm)

Both Alnus and Betula values fall, Quercus increases slightly and other trees are rare. Coryloid rises to a peak of 30% and Calluna and Ericaceae undiff. to 50% and 10% respectively. Gramineae falls to less than 15% and Cyperaceae reaches a peak of 20%. There are peaks in Rumex (3%), Plantago lanceolata (4%) and Pteridium (1 - 2%), plus presences of cereal pollen (cf. Hordeum), Ranunculaceae, Artemisia, Succisa, Caryophyllaceae, Urtica, Liguliflorae and Tubuliflorae.

Zone TM1-6 (15 - 0 cm)

Tree pollen is virtually absent apart from a few grains of Alnus. Cyperaceae and Coryloid pollen fall to almost zero, Gramineae rises to 20%, but the zone is dominated by the rise in Calluna and Ericaceae undiff. to 78% and 10% respectively. Agricultural indicators are less frequent although low levels of Rumex, Plantago lanceolata, Liguliflorae and cereals do persist. The rhizopod Hyalosphenia reaches a peak of 12% TP before falling to zero at the close of the zone.

6.3.3 Radiocarbon dates

Five ^{14}C dates were obtained for material from section TM1, these are listed in Table 6.2. As the section was in the form of a monolith abundant material was available for dating and none of the problems experienced with MML80 were encountered.

6.3.4 Interpretation and Discussion

Zone TM1-1 (185 - 165 cm) (3130 ± 70 - 2450 ± 60 bp)

This zone appears to represent the clearance, in the middle to late Bronze Age, of fairly open and possibly secondary woodland for the purposes of both arable and pastoral farming. This part of the section was studied in greater detail when the duplicate samples which make up section TM1AB were analysed. The overall interpretation of the two sets of analyses is very similar (see Figs. 6.2 and 6.3) and this, along with a discussion of the minor differences which did arise, is contained in section 6.4.5.

Zone TM1-2a (165 - 135 cm) (2450 ± 60 - ca. 2200(e) bp)

At the end of zone TM1 agricultural activity was decreasing and there

Table 6.2

Radiocarbon Dates from Section TM1

Lab. N°	Sample Depth in cm.	^{14}C Date years bp
GU-1223	51 - 49	1105 ± 60
GU-1224	81 - 79	1490 ± 70
GU-1265	125 - 123	2225 ± 85
GU-1189	165 - 163	2450 ± 60
GU-1137	183 - 185	3130 ± 70

was some degree of woodland regeneration. This trend is maintained into zone 2a and, although the tree species fluctuate, charcoal is less abundant and species indicative of agriculture, such as plantain and Rumex acetosa/acetosella, are less frequent. There is, however, a rise in Urtica and a peak in Pteridium but these may indicate abandoned, rather than occupied, land and settlements. Agriculture may have persisted but if it did it was almost certainly confined to pastoralism. The pollen spectrum is dominated by blanket bog species and this type of vegetation must have been expanding.

The recession in agriculture appears to have been more severe in the vicinity of the sampling site on Tormore than in areas surrounding the Machrie Moor sampling site. Certainly there seems to be clearer evidence of abandonment which parallels events recorded at Beaghmore (Pilcher, 1969) and Sleive Gullion (Smith and Pilcher, 1972, Pilcher, 1973). The reasons for the apparent reduction in agricultural activity in the later Bronze Age/early Iron Age have been discussed in Chapter Five. The evidence here supports the idea that soil fertility was reduced by over-use in a deteriorating climate and that the human and animal population fell, with the survivors moving to lower less vulnerable land.

Zone TM1-2b (135 - 115 cm) (ca. 2200(e) - 1900(e) bp)

Plantain, Rumex acetosa/acetosella, Compositae and Artemisia become more abundant again in this sub-zone. Coupled with another peak in Pteridium this tends to indicate a phase of renewed or increasing activity, corresponding to a period of pastoral agriculture and the building of the field bank on Tormore (see section 6.5) and perhaps connected with the occupation of the Drumadoon Iron Age hillfort. Cereal pollen is absent at this point and tree values, apart form the virtual disappearance of Fraxinus and Ulmus, show little change from TM1-2a. Cyperaceae, Gramineae and Coryloid pollen still dominate the spectrum and a peak in Sphagnum spores corresponds with a few leaves of the moss in the peat. Both Calluna and Ericaceae pollen show a slight rise which may indicate a response to increased grazing pressure. Again there are very close parallels with Sleive Gullion and Beaghmore.

The fact that it was possible for the Iron Age population to submit the area to, what appears to be, quite heavy grazing suggests that up to this time blanket bog vegetation, although quite abundant, was still localised and that there were still areas of potential grazing land available. It was perhaps at this time that the blanket peat began to spread from the hollows onto the intervening dry land causing the reduction in activity which is indicated at the close of this zone.

Zone TM1-3 (115 - 60 cm) (ca. 1900(e) - 1200(e) bp)

The opening of this zone sees the end of the Iron Age pastoral phase and agricultural indicator species, although present, occur much less frequently. There is a slight rise in all tree species indicating reduced pressure on the remaining woodland but as tree pollen never reaches more than 15% TP this woodland is hardly likely to have been extensive and the rise may reflect events at some distance from the site. The fact that agricultural pollen is not totally absent suggests that some farming may have continued. However the almost complete absence of charcoal from the peat at this point strongly indicates that, locally at least, activity was very low.

Towards the end of the zone tree values begin to fall, indicating renewed human pressure. Calluna values throughout this zone are low and the pollen of blanket bog species is in great abundance. At first high Coryloid accompanies the high grass values, later this is replaced by high Cyperaceae.

An interesting feature of the zone is the presence of the rhizopods Assulina and Amphitrema which, according to van Geel (1978), indicate local wet conditions. Their presence corresponds exactly to a band of Sphagnum remains in the peat at a point where surprisingly the level of Sphagnum spores is low. This illustrates how unreliable counts of Sphagnum spores can be as indicators of the abundance of the living moss.

Overall this zone shows a great similarity to zone MM-7 from Machrie Moor which covers a similar period and which also shows greatly reduced human activity.

Zone TM1-4 (60 - 35 cm) (ca. 1200(e) - ca. 900(e) bp)

The fall in tree pollen which began in zone TM1-3 continues and apart from minor recoveries in Alnus and Betula this situation prevails to the end of the zone. Renewed human activity is heralded first by a sharp rise in the amount of charcoal present in the peat and later by the more frequent occurrences of agricultural indicator species including cereals (cf. Hordeum), Ranunculaceae, Artemisia, Rumex, Succisa, Urtica, Plantago lanceolata, Tubuliflorae, Cruciferae, Papilionaceae , Chenopodiaceae and Pteridium. This resurgence appears to have taken place in later Dark Age/early Viking times. Absolute dating of the events is difficult because of problems with the calibration of ^{14}C dates from this period (Clarke, 1975, Alcock, pers. comm. 1981). The pollen from locally abundant species (Myrica, Calluna, Gramineae and to a lesser extent Cyperaceae) dominates the pollen spectrum.

Zone TM1-5 (35 - 15 cm) (ca. 100(e) - ca. 650(e) bp)

Alnus and Betula decline again and other tree species are rare. Coupled with peaks in plantain and Rumex and the presence of cereal pollen (cf. Hordeum), Ranunculaceae, Artemisia, Succisa, Caryophyllaceae, Urtica, Liguliflorae and Tubuliflorae this suggests a further intensification of activity based around a mixed farming economy. This apparent period of expansion may correspond to a time of climatic improvement in the early Middle Ages referred to as the 'little optimum' (Lamb, 1977). Again however, absolute dating is difficult. Certainly the pollen evidence is consistent with the level of land use which an amelioration of climate of that nature might allow. Lamb (1977) speaks of land cultivation up to an altitude of 300 metres in England and Wales.

Zone TM1-6 (15 - 0 cm) (ca. 650(e) - ca. 450(e) bp)

Pollen from tree species is virtually absent in this zone and Calluna heath replaces blanket bog communities as the main local pollen producer. Levels of agricultural indicator species decline again although presences of cereals, Plantago lanceolata, Rumex and Liguliflorae are maintained. This tends to suggest the continuation of farming practices through the later Middle Ages and into later times as would be expected. How far the section extends towards the present day is uncertain without further ^{14}C dates. The top of the deposits is estimated at 450 bp from extrapolation of the time/depth curve. The presence of a peak in the rhizopod Hyalosphenia in this zone indicates disturbance of the peat (van Geel, 1978), which could be due to burning (charcoal levels are high in the upper peat) or to peat cutting which was extensive in the area at one time. Alternately the peat surface may have dried out resulting in very slow growth and even erosion of the peat. Hagged peat does occur near the summit of Tor Righ Mor .

6.4 SECTION TM1AB

The pollen diagrams for section TM1AB (Figs. 6.3 and 6.4) represent the analysis of duplicate samples from the base of the main Tormore section, TM1, corresponding to zone TM1-1. The purpose of this duplicate sampling was to enable the section to be subjected to absolute pollen analysis thus removing the problems of autocorrelation of the pollen curves which may have adversely affected the interpretation. It was also hoped that the more detailed analysis would enable a more comprehensive interpretation to be achieved. Both these objectives were satisfactorily fulfilled.

Samples of peat $\frac{1}{2}$ cm thick were removed at $\frac{1}{2}$ cm intervals from the basal 20 cm (165.5 - 185 cm) of TM1 approximately 8 cm distant, laterally, from the original samples. These samples were prepared and analysed for absolute pollen analysis as described in section 4.4 and Appendix A1. The results are expressed in relative terms in Fig. 6.3 and in terms of pollen influx in Fig. 6.4. In the calculation of the influx rates only two ^{14}C dates were used, one corresponding to the lowest samples, 185 and 184 cm, and the other corresponding to the uppermost ones, 164 and 165cm. This in itself is rather unsatisfactory in that the accumulation rate is quite likely to have changed in the intervening distance and there is no way of detecting this. However in the absence of further ^{14}C dates I felt that the resulting influx curves were still useful for monitoring the behaviour of the individual pollen curves.

6.4.1 PEAT STRATIGRAPHY

The peat stratigraphy is identical to that described from the corresponding part of TM1 (6.3.1)

6.4.2 POLLEN STRATIGRAPHY

Section TM1AB corresponds stratigraphically to zone TM1-1 (165 - 185 cm) of section TM1. If the relative diagram from TM1AB (Fig. 6.3) is compared with Fig. 6.2 which is zone TM1-1 expanded to the same scale, it is clear that there is agreement between the two in terms of the percentages attained by the various taxa and the behaviour of the pollen curves. This says a great deal for the reproducibility of pollen analysis data over a short lateral distance.

Two differences between the two diagrams are obvious however. One concerns the number of pollen taxa recorded in each case, the other a large peak in the plantain pollen with associated presences of other ruderal species which is seen between 169 cm and 170 cm in TM1AB, but which is absent from TM1.

The first difference is explicable in terms of the increased proficiency in pollen analysis which is attained with time. The basal samples of TM1 were some of the first analysed, whereas TM1AB was analysed at a much later date. The absence of the large plantain peak in TM1 is explained by the sampling interval adopted. The peak occurred around 168, 169 and 170 cm, these levels were not sampled for TM1. In TM1AB the sampling interval was $\frac{1}{2}$ cm and the peak was detected. This illustrates the fact that even with sampling at intervals of only 2 — 3 cm, important events may lie undetected.

6.4.3. RADIOCARBON DATES

The two ^{14}C dates from the base of TM1 (GU-1189, GU-1137) were used to date this diagram. They are included in Table 6.2.

6.4.4 ABSOLUTE POLLEN DATA

The influx data from TM1AB mirrors the relative data even more closely than was the case in MML80. No major deviations are observed and the influx diagram largely confirms the interpretation arrived at from the relative diagram. Autocorrelation of the curves does not appear to have seriously distorted the record of events.

One point which the influx diagram does raise concerns the high values seen at the base of the section. These reflect the inadequacy of the dating interval on the section which resulted in it being impossible to calculate accurate deposition rates for each portion of the section with an average value having to be used. Thus the high influx values at the base of the section are more likely to be due to the slower than average accumulation of the peat due to the rather different conditions under which it formed. With a shift to the formation of true blanket peat the deposition rate is likely to have increased.

6.4.5 INTERPRETATION AND DISCUSSION

The interpretation of zone TM1-1 has already been briefly outlined in section 6.3.4. The greater detail available from this duplicate analysis enables further observations to be made. For ease of discussion the diagram has been divided into four sub-zones (A - D). The progressive changes seen through these sub-zones illustrate very well the processes leading to blanket peat formation.

Sub-zone A (183 - 185 cm)

This sub-zone represents the later stages of a Bronze Age clearance phase. Tree pollen values at the opening are 35 - 40% TP and these two levels have been dated to 3130 ± 70 bp. Quercus falls and Ulmus is absent, Filicales and Polypodiaceae are low. The high values of Corylus type and the slight rises in Alnus and Betula suggest a degree of regeneration. As Dimbleby (1965b) points out, the replacement of deep-rooted forest tree species by shallow-rooted shrubs such as Corylus interferes with the recycling of leached nutrients within the soil. This may lead to soil acidification which inhibits the activities of earthworms and other soil animals and promotes a changeover to heath-type communities. Further nutrient loss and accelerated soil podsolisation ensue and the formation of an iron pan may impede drainage resulting in surface waterlogging and ultimately peat formation (section 1.4). An indication of the onset of these processes is given by the small but increasing presence of both Calluna and Potentilla pollen.

Also present throughout the sub-zone are Ranunculaceae, Plantago lanceolata, Urtica, Rumex, Succisa and Pteridium. Trifolium pollen is slightly less abundant. This tends to suggest, along with the low and decreasing tree values, that agriculture was being practised in close proximity to the sampling site prior to the formation of the deposits. It would appear likely that the woodland being cleared was secondary rather than primary in origin.

Goddard (1971) showed in Northern Ireland that the vegetation present immediately prior to blanket peat formation at the sites she examined was either secondary woodland composed largely of Betula and Alnus or that of land heavily used for agriculture. She also recognised three main periods of peat initiation centred on the dates 1800 bc, 1200 bc, and 800 bc. The date for the base of this section corresponds very closely to the middle period of these three.

Mention was made earlier of the fact that the deposits at the base of this section are not true blanket peat and that they are more likely to have formed in a marshy hollow, possibly in pasture. If this is the case then there is a very close parallel with Goddard's areas of heavily used agricultural land and secondary woodland. Lynch (1981) also discusses this subject and talks of peat forming in locations of suitable topography during the middle to late Bronze Age, largely as a result of the deteriorating climate and agricultural malpractice.

Sub-zone B(183 - 176 cm)

In sub-zone B clearance of tree species continues with Quercus, Filicales and Polypodiaceae reaching very low values. Betula and Corylus type also suffer a marked decline. The maintainance of Alnus values ca. 10% TP and the small rise in Salix pollen, may indicate the regeneration of these species in wetter areas, or just that their presence is accentuated in the absence of other trees (Tauber, 1965). Agriculture appears to become more intensive and diverse with cereal pollen (cf. Hordeum) being present. Plantago lanceolata and Ranunculaceae rise to 5% and there are the continued presences of Urtica, Rumex, Trifolium and Pteridium with Plantago media/major type, Liguliflorae and Caryophyllaceae. Fraxinus, a tree often associated with human settlements following clearance, has its first occurrence and Gramineae values rise. It is impossible to say whether this is due to the increase in agriculture or the increase in species such as Molinia or Nardus with the spread of heathland and blanket bog communities. With reference to the latter, Calluna and Potentilla continue to rise along with Cyperaceae and presences of Ericaceae undiff. indicating the further acidification of the soil and spread of Calluna heath.

Sub-zone C(176 - 173 cm)

Sub-zone C corresponds to a period of very intensive mixed agriculture which, as mentioned earlier, is not detected in TM1. Tree values are very low with both Alnus and Salix suffering reductions. Cereal pollen is again present, Plantago lanceolata reaches 15% TP and there are presences of Ranunculaceae, Urtica, Rumex, Plantago media/major type, Trifolium, Liguliflorae, Chenopodiaceae and Pteridium.

The estimated date for the peak of this is 2790(e) bp. A similar phase with even higher values of plantain and other indicator species is seen in Zone MM-5c of MML80 from Machrie Moor. This has been ^{14}C dated to 2880 ± 80 bp and it seems very likely that they represent the same period. For such levels to be reached there must have been intensive land use throughout the Vale of Shiskine. The estimated duration of the period is around 100 years from both sections.

During this sub-zone the increase in Calluna values is temporarily halved around 15% TP. However at the end of the sub-zone Calluna rises to a peak of 55%, Potentilla continues to rise and there are presences of Jasione and Campanula which tend to be found on 'grassy-heaths'. The fall in agricultural indicator species which also occurs towards the close of the sub-zone may have been due to the difficulties and declining productivity which resulted from the increasingly acid soils and the spread of Calluna heath.

Sub-zone D(173 - 165 cm)

Throughout this sub-zone both Calluna and Ericaceae undiff. decline and later Potentilla behaves in a similar fashion. Gramineae and Cyperaceae rise and Betula and Alnus recover slightly. Plantago lanceolata and other indicator species are quite abundant in the early and middle parts of the sub-zone but their frequency decreases towards the end. It appears that after the spread of Calluna heath there is a switch to blanket peat vegetation dominated initially by Eriophorum. As with the spread of Calluna it is impossible to be sure of the extent of this vegetation. It may just represent the immediate locality of the hollow or a more widespread change. It is known from the excavation of the field bank, which lay on mineral soil (see 6.5.4 later), that blanket peat had not covered the whole of the hillside some 500 years later. However it appears probable that soils generally were deteriorating resulting in agriculture becoming less and less productive. The estimated date for the local change to blanket peat (ie. in the depression) is 2700(e) bp.

6.5 THE TORMORE DITCH SECTIONS (TMD1, TMD4, TMD5)

All three ditch sections were removed from a ditch associated with the field bank which runs north-west over the hill from sites one and two of the C.E.U. excavation (see Fig. 3.2). The sections referred to here correspond to the sections on Fig. 3.2 as follows :-

TMD1 - section five

TMD4 - section eight

TMD5 - section six

6.5.1 Peat Stratigraphy

A description of the stratigraphy of the sections is given in Tables 6.2 , 6.3 and6.4, and the detailed Troels-Smith description for each section is in Appendix A5. As with the other sections a diagrammatic representation of the Troels-Smith analysis is given alongside the pollen diagrams (Figs. 6.5, 6.6, and 6.7).

The deposits in the three sections are basically very similar. The base of each one is composed to some degree of inwashed material. This is overlain by fairly well humified Cyperaceous peat possibly with some Molinia remains too.

6.5.2 Pollen Stratigraphy

As the sections are so similar the pollen stratigraphies are listed together below. The zonation of the diagrams is almost totally on the basis of changes in human activity as regional events are obscured by the massive input of local pollen and local events are too erratic to enable sensible zonation to be applied (see later 6.5.4).

Local Pollen Assemblage Zones - TMD1

Zone TMD1 (50 - 40 cm)

The opening of the zone is ^{14}C dated to 2100 ± 220 bp. At the opening,tree pollen values (mainly Alnus and Betula) are 4% TP, later rising to 6% TP. Corylus type and Myrica type pollen are steady around 4% and 8% respectively. Calluna (ca. 30%) and Gramineae (35%) are high and Cyperaceae is steady ca. 5%. Polypodium values fall from 2.5% early in the zone and other ferns are rare. Several herb species are present including indicators of pastoral farming Plantago lanceolata, Rumex acetosa/acetosella and Ranunculaceae.

Plates Va and Vb

Showing the sampling of the field bank ditch section TMD1, (section 5 in Fig. 3.2). Note the coloured laminations at the base of the section, these disappeared in storage.

(Courtesy of the C.E.U., Crown Copyright).


50
CM


50
CM

Table 6.3

Peat Stratigraphy - Section TMD1

Depth in cm.	Description
0 - 12	Well humified Cyperaceous peat with intrusive living roots, charcoal is very abundant.
12 - 22	Well humified Cyperaceous peat with moderately abundant charcoal.
22 - 34	Well humified Cyperaceous peat with some fine mineral, charcoal slightly less abundant.
34 - 50	Very humified peat with a high proportion of both coarse and fine mineral. Abundant charcoal.

Table 6.5

Peat Stratigraphy - Section TMD5

Depth in cm.	Description
0 - 14	Well humified Cyperaceous peat with abundant charcoal, no mineral.
14 - 24.5	Well humified Cyperaceous peat with some mineral particles, abundant charcoal.
24.5 - 28	Very humified peat which makes up a small part of a mineral band, charcoal is abundant.
28 - 34	Very humified Cyperaceous peat with a predominance of coarse and fine mineral. Some charcoal fragments present.
N.B.	Intrusive *Calluna* roots and other living roots are present almost throughout this section.

Table 6.4

Peat Stratigraphy - Section TMD4

Depth in cm.	Description
0 - 7.5	Well humified Eriophorum/Sphagnum papillosum peat with Juncus bufonius seeds and Potentilla erecta achenes. Some charcoal fragments present.
7.5 - 20	Well humified Eriophorum peat with Juncus bufonius seeds and some charcoal, mainly Calluna leaves.
20 - 29	Very humified Eriophorum peat with a sandy inwash stripe at ca. 22 cm. Charcoal not very abundant.
29 - 42	Well humified Eriophorum peat with very abundant charcoal including carbonised Erica tetralix and Calluna leaves.
42 - 47	Very humified Cyperaceous peat with some mineral. Charcoal present.
47 - 52	A predominantly mineral layer containing some very humified peat. The mineral is a mixture of gravel, coarse and fine sand.
52 - 56	Very humified Cyperaceous peat with some mineral, abundant Juncus cf. effusus seeds and some J. bufonius seeds. Charcoal is moderately abundant.
56 - 63	Very humified Cyperaceous peat with a high mineral content. Abundant charcoal including carbonised Calluna twigs and leaves.
63 - 74	Well humified Cyperaceous peat with a large proportion of coarse and fine mineral. Abundant charcoal including carbonised Erica tetralix leaves.

Zone TMD1-2 (40 - 12 cm)

Betula and Quercus values fall, Alnus remains steady ca. 3 - 4%, Corylus type pollen falls to zero and Myrica type is steady ca. 8%. Calluna rises to 55% TP and Potentilla to 2% as Gramineae falls to 23%. There is a peak in Cyperaceae of 11%. Herb species such as Plantago and Rumex are less common, one grain of cereal pollen (cf. Hordeum) is present.

Zone TMD1-3 (12 - 0 cm)

Alnus falls almost to zero with the other tree species and Corylus type pollen being virtually absent. Calluna reaches 67% TP and Gramineae is steady at 23%. Cyperaceae decreases to almost zero. With regard to agricultural indicator species, 1% cereal pollen (cf. Hordeum) is present at 10 cm along with Plantago lanceolata (1%), Compositae (2%), and Plantago undiff., Urtica, Ranunculaceae and Pteridium.

Pollen Stratigraphy TMD4

Local Pollen Assemblage Zones TMD4

Zone TMD4-1 (74 - 57 cm)

The opening of this zone is ^{14}C dated to 1940 ± 65 bp, tree values (mainly Betula and Alnus) rise reaching 10% TP. Betula then falls and Alnus continues to rise to 5% TP. Corylus type pollen falls from 11% to 2% and Myrica type rises sharply. The spectrum is dominated by Calluna (rising to 40%) and Gramineae (35%). Heath species including Galium (Rubiaceae) and Potentilla are present.

Plantago lanceolata and Rumex rise towards the end of the zone, with coincident occurrences of Liguliflorae, Artemisia, Succisa and Umbelliferae. Filicales are low throughout.

Zone TMD4-2 (57 - 19 cm)

Tree and Corylus type values fall again, there being an absence of tree pollen in the middle of the zone. The Myrica type curve fluctuates in a series of peaks from less than 1% to 10% TP. Calluna reaches 89% in the middle of the zone and Gramineae has values of ca. 17% TP at both the opening and the close of the zone. Plantago lanceolata, Rumex and Compositae are less frequent than in the previous zone, although two cereal pollen grains (cf. Hordeum) are present.

Zone TMD4-3 (19 - 0 cm)

Tree values are very low. Betula stages a minor recovery but the occurrences of the other trees and Corylus type pollen are very infrequent. Myrica type pollen falls to 3%, Calluna to 9% and Gramineae and Cyperaceae rise to 45% and 17% respectively. The zone is characterised by very high percentages of Plantago lanceolata (8%), Plantago undiff. (8%), Rumex (4%), Liguliflorae and Tubuliflorae (7%), Papilionaceae (including Trifolium, Lotus and Ononis type) (7%) and presences of cereals (cf. Hordeum), Urtica, Artemisia, Chenopodiaceae and Carophyllaceae. These are then absent at the close of the zone when Potentilla, Narthecium and the rhizopod Hyalosphenia rise to 4%, 10% and 2% respectively.

Pollen Stratigraphy TMD5

Local Pollen Assemblage Zones - TMD5

Zone TMD5-1 (34 - 22 cm)

The opening of the zone is ^{14}C dated to 2224 ± 100.bp, tree values (mainly Betula, Alnus and Quercus) are in excess of 23% TP. These curves drop sharply to 2%, 1% and 2% respectively. Corylus type pollen falls in a similar fashion and both Calluna (64%) and Gramineae (32%) rise to peaks. Polypodiaceae falls sharply from 5% TP and other ferns are rare here and throughout the section. Plantago lanceolata and Rumex are present at the opening of the zone, falling towards its close. There are also presences of Plantago undiff, Papilionaceae , Ranunculaceae and Succisa.

Zone TMD5-2 (22 - 10 cm)

Alnus and Betula values rise slightly before falling again, Myrica type reaches 26% TP and high Calluna (50%) alternates with high Gramineae (63%). Cyperaceae reaches its highest value (9%) at the close of the zone. Plantago lanceolata, Plantago undiff, Rumex, Compositae and Papilionaceae are less common than in the previous zone.

Zone TMD5-3 (10 - 0 cm)

Tree values fall to almost zero, Myrica type, Gramineae and Cyperaceae fall from high values to 0%, 10% and 1% respectively. Calluna replaces them, rising steadily to 85% TP. Plantago lanceolata rises to 2% and Plantago undiff., Rumex, Compositae, Chenopodiaceae and Ranunculaceae are present in small amounts.

6.5.3 RADIOCARBON DATES

Three ^{14}C dates were obtained for material from these sections. In each case the base of the section was dated. The dates are listed in Table 6.6.

6.5.4 INTERPRETATION AND DISCUSSION

The interpretation of the data from the ditch sections TMD1, TMD4 and TMD5 proved difficult for two main reasons :-

1. The large amount of inwashed material which was undoubtedly present in these sections, particularly at the base. When the sections were collected the basal deposits were very obviously laminated with coloured bands being visible (see Plates Va/Vb). Probably these represent very rapid initial accumulation after the cutting of the ditch. These laminations were not obvious when I removed samples for pollen analysis so it was not possible to record them accurately in the description of the peat stratigraphy, presumably the colour differences had disappeared in storage .

This inwashed material, almost certainly derived from the surrounding soil, must contain 'older' carbon and derived pollen and spores (ie. not contemporary with the date of construction of the ditch). Its presence brings into question the results of both the ^{14}C dates and the pollen analysis. However by reference to the data from TM1 and from the excavation I think it is possible to arrive at a measured interpretation.

2. The predominance of pollen from very local sources which was present in the peat. Pollen from the peat-forming surface vegetation is present in vast quantities in the slowly accumulating blanket peat of these sections. The presence of this tends to 'dilute' the pollen input from regional sources, with minor changes on the bog surface obscuring more widespread events. This tends to make meaningful zonation of these diagrams difficult because of the under-represented regional factor and it also complicates the comparison of diagrams.

The diagrams were examined with these problems in mind and broadly speaking there is a fair measure of agreement between the three with regard to both ^{14}C dates and the pollen record. They appear to record the same sequence of events as regards human activity. The ^{14}C dates for the basal deposits are within two standard deviations of each other,

Table 6.6

Radiocarbon Dates from the Tormore Ditch Sections

Lab. N^{o}	Ditch Section	Sample Depth in cm	^{14}C Date years bp
GU-1266	TMD1	50 - 47	1885 ± 120
GU-1264	TMD4	74 - 72	1895 ± 70
GU-1263	TMD5	34 - 31	2225 ± 90

TMD4 being the youngest at 1940 ± 65 bp and TMD5 the oldest at 2224 ± 100 bp. The pollen evidence tends to support these relative ages with tree values at the base of TMD5 being in excess of 23% TP then falling rapidly to the levels seen at the bases of TMD4 and TMD1.

However the relative differences in the age of these deposits may also be attributed to the sampling technique rather than a real difference in the time of accumulation. As the mineral soil was not included in the monolith boxes it is impossible to be certain that a complete set of the deposits was collected in each case.

The diagrams were divided into three equivalent zones largely on the basis of changes in human activity and ignoring changes which were obviously of local origin. Complete matching of the zones was not possible due to the problems already outlined.

Zone One

The main reason for the initial collection of these ditch sections and their subsequent analysis was to date the field bank with which they are associated and to throw some light on its function. The field bank is built over the mineral soil (see Chapter Three) and it was hoped that the basal deposits in the ditch would give information about the land use immediately following construction. Bearing in mind the problems of interpretation already outlined, the pollen analysis and the ^{14}C dates suggest that construction was in the early to middle Iron Age preceding, or in the early stages of, a phase of pastoral agriculture. This phase, Zone 1 in all the diagrams, appears to correspond directly with Zone TM1-2b from section TM1, which also represents an event of this kind. It seems likely, therefore, that the bank was a field boundary delimiting a grazing area. Whether the bank was large enough to physically prevent animals from entering another area is uncertain.

The evidence from this field bank supports the idea that in the Iron Age peat was not yet widespread over the hillside and that the land provided quite good grazing rather than rough forage. It also suggests that the changes discussed in the interpretation of relevant portion of TM1 (6.3.4) were local ones confined to its immediate vicinity although undoubtedly the bog communities were spreading.

It is not possible to discern exactly at which point inwashed material is replaced by peat formation in these sections but I think it is likely that peat formation over the hillside as a whole did not occur until towards the end of the Iron Age, perhaps in the first or second century AD.

Zone Two

This zone shows decreasing agricultural activity, perhaps as a direct consequence of the spread of peat suggested in the previous zone. In this respect the zone is very similar to MM-7 from MML80 and TM1-3 from TM1 although the evidence for abandonment is not as strong in this case. The values of the tree species do not show the same recovery and grains of cereal pollen (cf. Hordeum) are present in its later stages. (These are also present to some extent in TM1 and MML80). In addition charcoal values do not show such a marked reduction. However this may in part be due to the very local nature of the events that these deposits record rather than a major deviation from the sequence of events already outlined.

Zone Three

This zone shows a marked resurgence in agricultural activity which appears to have commenced in the later stages of Zone Two. A mixed farming economy is represented with the evidence being particularly marked in section TMD4. It has massive percentages (in view of the nature of the deposit) of Plantago lanceolata (8%), Plantago undiff. (8%), Rumex acetosa/acetosella (4%) and Compositae (Lig. 2%, Tub. 6%). This zone broadly corresponds to Zones TM1-4, TM1-5 and TM1-6 from TM1 and Zones MM-8a, MM-8b and MM-8c from MML80, which represent a high level of agricultural activity in Viking and later Mediaeval times. As with the other sections mentioned it is uncertain how far towards the present day these deposits extend. The high charcoal levels and the presence of the rhizopod Hyalosphenia at the top of the sections suggests that some disturbance of the peat has taken place.

6.6 SUMMARY OF THE TORMORE PEAT SECTIONS

1. Deposits begin forming in a marshy hollow, recording the clearance of secondary woodland (mainly oak, birch and hazel) in the middle/late Bronze Age for the purposes of mixed agriculture. The hut at site one is occupied for the last time. Clearance, agriculture and soil deterioration are well advanced, generally, prior to this.

2. A reduction in agricultural activity accompanies a switch to predominately pastoral farming in the late Bronze Age.

3. Activity is further reduced in the early Iron Age corresponding to a lull period with a steady expansion in blanket bog vegetation.

4. A resumption of pastoral activity in the later Iron Age connected with which is the construction of the field bank which probably delimited grazing areas on the hillside.

5. Agriculture declines again in the pre-Viking Dark Ages perhaps as a consequence of peat development which is now widespread.

6. Resurgence of agricultural activity in Viking and later Mediaeval times. Crops and animals appear to flourish in a favourable climate.

6.7 SOIL POLLEN ANALYSIS

Soils are generally subject to a very local pollen input (Berglund, 1979) and the analysis of the preserved pollen can give a very detailed picture of conditions in the immediate vicinity of the sample. By the same token the local nature of the pollen spectrum may make comparison difficult with regional data say from peat deposits.

Pollen spectra from soils are also much more subject to modification than peat or lake deposits due to vertical movement of pollen and the differential preservation of grains (see section 4.5). This too makes interpretation and comparison difficult although indicators of differential preservation such as high levels of Filicales and of Coryloid pollen tend to identify altered spectra. On this basis the samples which yielded sufficient pollen for analysis in this study to not appear to have been significantly affected.

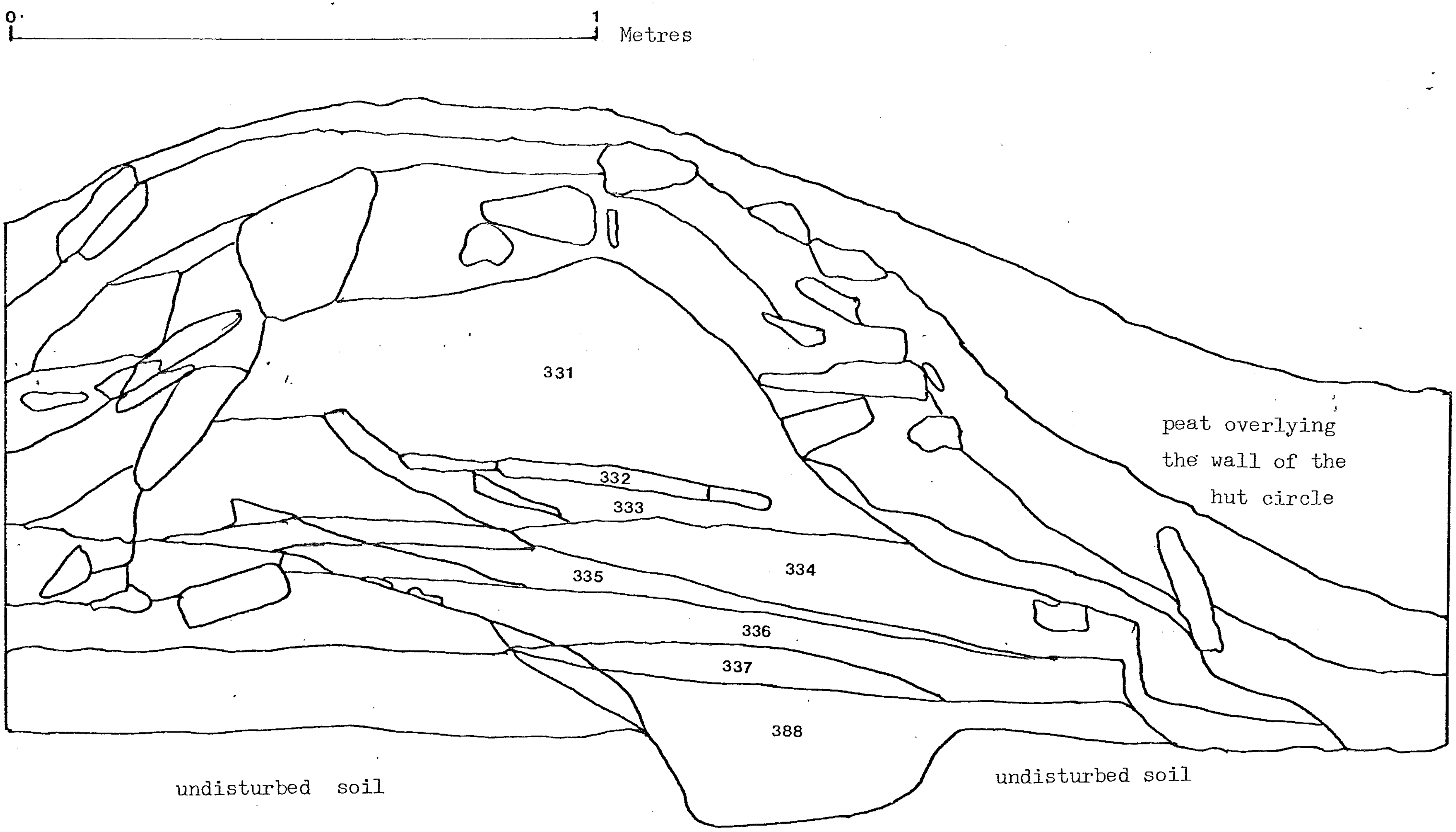
The results presented here represent the analysis of pollen from:-

1. Soils within ard marks under the cairn at site two (Fig. 3.2) which are thought to represent the initial breaking up of the ground after clearance.

2. Bank core material and turf layers from a section through the north-east quadrant of site one (Fig. 6.8). This section represents the complete series of hut walls (banks) from Beaker times (ca. 1850 bc) to the final wooden structure built in the middle to late Bronze Age. The soil samples are only from the first series of banks however and they correspond to the first series of huts (see Chapter Three) constructed in Beaker and early Bronze Age times. The aim of the analysis was to ascertain, if possible, the environment and land use in the immediate

Figure 6.8

Showing part of the section through the hut circle wall (N.E. quadrant, site one) relevant to the soil pollen analysis. Only the layers which were sampled or are mentioned in the text are numbered.
(Original drawing courtesy C.E.U.).


0
1
Metres
331
332
333
334
335
336
337
388
peat overlying the wall of the hut circle
undisturbed soil
undisturbed soil

vicinity of the site from the earliest clearances onwards. As yet it is not possible to correlate fully the findings with the archaeology as this is not comprehensively reported. Fig. 6.8 is adapted from a working diagram and it may not represent the final interpretation. Accordingly only general observations are possible as regards linking the pollen analysis with the archaeology. Attempts to provide dates for samples and layers have largely been avoided for this reason.

All the samples contained charcoal and a report on this along with a general report on the soils is in progress at the C.E.U. Unfortunately the results are not as yet available.

The samples are bulk samples and as such represent periods rather than specific points in time, another reason for detailed dating having been avoided. The results of the analyses are presented in the form of a pollen diagram (Fig. 6.9) and are expressed as a percentage of total land pollen. 500 total land pollen was the pollen sum used although in some samples this was not reached. Cereal pollen grains are categorised on size (40µ - 50µ and 50+µ) because the state of pollen preservation made identification to generic level impossible.

6.7.1 DESCRIPTION OF POLLEN SPECTRA

Samples from Ardmarks under Site Two

Sample 436 - south-east quadrant

Alnus is the dominant tree (5% TP) with some *Betula* and *Salix* and a high proportion of Coryloid (*Corylus* type) and triporate pollen. Gramineae is very high (almost 50% TP) with modest values of *Calluna*. Cereal grains in the 40µ - 50µ range are present along with *Artemisia*, Chenopodiaceae and Umbelliferae. Indicators of pastoral agriculture and occupation generally include *Plantago lanceolata*, *Urtica*, Ranunculaceae, *Pteridium*, Liguliflorae, Tubuliflorae, Papilionaceae and *Succisa*. *Botrychium* is also present and although fern values are fairly high they do not suggest that there has been significant modification of the spectrum.

Sample 438 - south-east quadrant

This sample, also from the south-east quadrant, surprisingly contained very little pollen, just an occasional *Corylus* type grain and *Pteridium* spore. For this reason a full count was not carried out. Whether this lack of pollen was due to conditions at the site since the building of the cairn or degradation after collection is unclear. The former seems more likely as all the soils collected were treated in an identical fashion.

Sample437 - north-east quadrant

Tree pollen in this sample is exclusively Alnus (5% TP) with some Salix and high values of Coryloid and triporate pollen. Grass values are very high but Calluna is modest (5%). Cereals in the 40µ - 50µ range are present along with Artemisia, Chenopodiaceae, Caryophyllaceae and Cruciferae. Indicators of pastoral agriculture and settlement include Plantago lanceolata, Ranunculaceae, very high Pteridium, Liguliflorae, Rumex and Succisa. Fern values are again fairly high and both Botrychium and Ophioglossum are present.

Samples from the Section through the Bank of Site One, North-East Quadrant. (Sample numbers refer directly to Fig. 6.8)

Sample 388

Low tree values with only Betula (1%), Alnus (5%) and Ulmus (1%) represented. Coryloid and triporate are both quite high. Grass dominates the spectrum and Calluna is also very high (36% and 26% respectively). One cereal grain in the 50+µ range is present and there are no other indicators of arable agriculture. Indicators of pastoral agriculture and settlement include Ranunculaceae, Plantago lanceolata, Urtica, Pteridium and Succisa. Ferns are present but have modest values.

Sample 337 - bank core

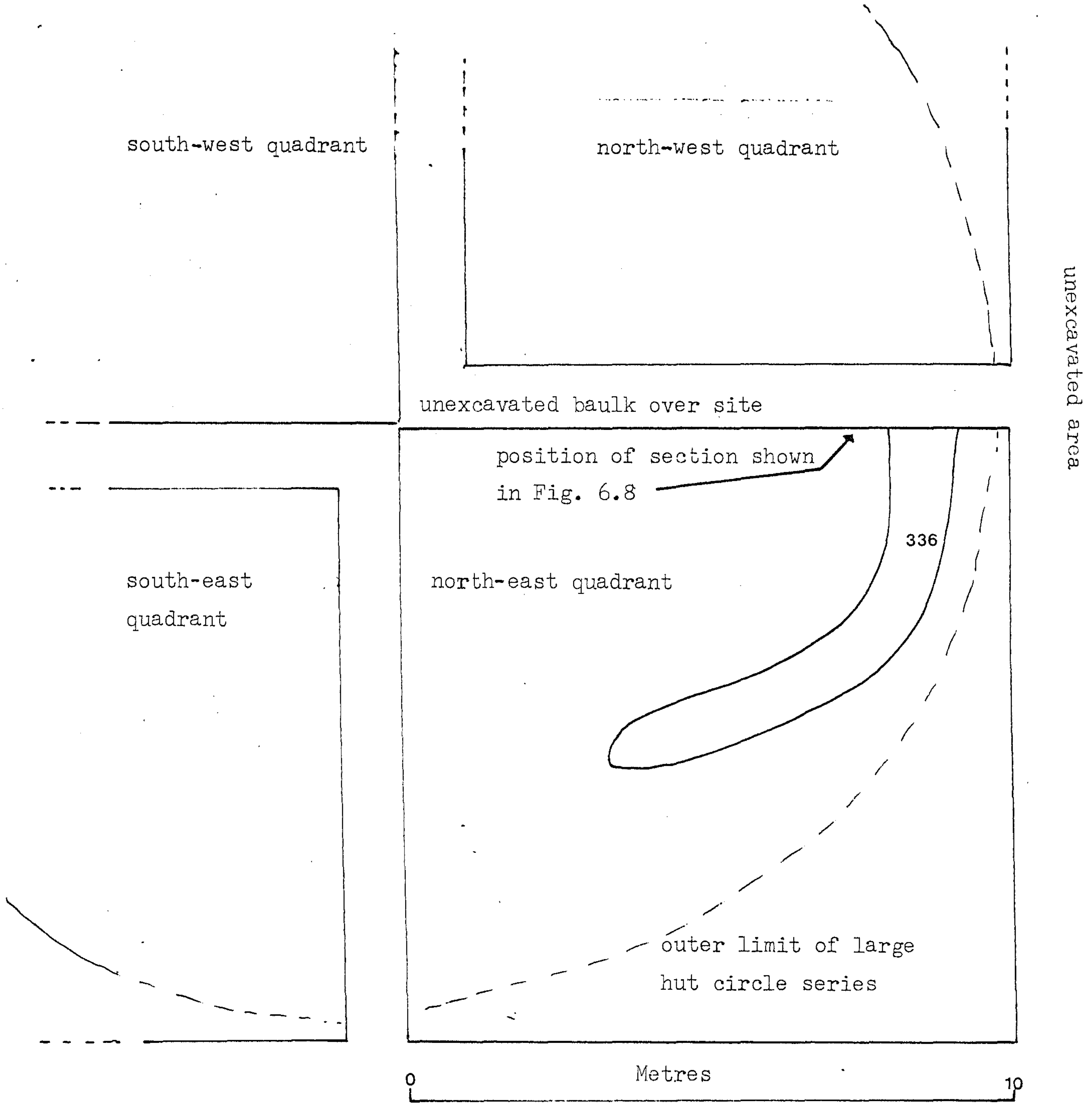
Tree pollen is predominately Alnus (9%) with a little Betula and Quercus. Salix is also present with very high values of Coryloid and triporate. Grass has high values but Calluna is low. One cereal grain is present in the 40µ - 50µ range; there are no other indicators of arable agriculture. Pastoral and settlement indicators include Ranunculaceae, Plantago lanceolata, Urtica, Tubuliflorae, Trifolium, Pteridium, Rumex and Succisa. Fern values, particularly Polypodiaceae, are high.

Sample 336 - turf layer

Five samples have been analysed of the six taken from layer 336 along its length running to the south, away from the section (see Fig. 6.10). The exact sampling points are not known.

Figure 6.10

Showing the extension of layer 336 (see Fig. 6.8) away from the section through the north-east quadrant of site one. The layer was sampled at six points along the length illustrated.



south-west quadrant
north-west quadrant
unexcavated area
unexcavated baulk over site
position of section shown
in Fig. 6.8
336
south-east
quadrant
north-east quadrant
outer limit of large
hut circle series
0
Metres
10

336/2 *Alnus* is the main tree species but *Quercus* reaches 2% and both *Betula* and *Pinus* are also present. A grain of *Ilex* pollen occurs in this sample along with high values of Coryloid and triporate pollen. Grass dominates the spectrum and cereal pollen is very abundant (40µ - 50µ range - 17% TP, 50+µ - one grain). In addition there are presences of Chenopodiaceae and Caryophyllaceae. Pastoral indicators are also common with *Plantago lanceolata*, Ranunculaceae, very high *Pteridium*, Liguliflorae, Tubuliflorae, *Succisa* and *Rhinanthus*. Values of *Calluna* and other heath species are low. Fern values are modest.

336/3 Pollen was absent from this sample.

336/4 *Alnus* (9%) is again the main tree species with *Quercus* (1%) being the only other representative. *Salix* is present and Coryloid and triporate values are high. Grass is the main herbaceous species and *Calluna* is low. Cereals in the 40µ - 50µ range are present (2%) along with Caryophyllaceae. Indicators of pastoral agriculture include Ranunculaceae, *Plantago lanceolata*, *Urtica*, *Pteridium*, Liguliflorae, *Lotus*, *Succisa*, *Rhinanthus* and *Polygonum bistorta*. Filicales values are modest.

336/5 *Alnus* is the main tree species (7%) with *Quercus* (1%). Coryloid and triporate values are very high, grass is 18% TP and cereals (40µ - 50µ) are 5% with the presence of Cruciferae, Caryophyllaceae and Chenopodiaceae. Pastoral indicators include Ranunculaceae, *Plantago lanceolata*, *Pteridium*, Tubuliflorae, *Succisa* and *Rhinanthus*. Fern species have modest values with Polypodiaceae being the highest.

336/6 *Alnus* is the most abundant tree species (2.6%) but *Betula* (0.6%), *Quercus* (1.3%) and *Ulmus* (0.4%) are also represented. Coryloid and triporate values are high and *Salix* is present. Grass is 26% TP and cereals (40µ - 50µ) are 18.5%. Accompanying this is the presence of Cruciferae, Umbelliferae, Caryophyllaceae and Chenopodiaceae. Pastoral indicators include *Plantago lanceolata*, *Urtica*, *Rumex*, *Pteridium*, Liguliflorae, Papilionaceae and *Succisa*. *Conopodium* type pollen is also present. *Calluna* values are low and Polypodiaceae reach 6.4% TP.

Sample 335 - bank core

Not available from the excavators.

Sample 334 - turf line

Alnus again provides the most tree pollen (8%) with some *Betula* (1.3%). Coryloid and triporate pollen makes up a large proportion of the total pollen. Grass is 21.5% TP and cereals are 1.5% (50+µ) and 6.8%

(40 - 50µ) with both Caryophyllaceae and Chenopodiaceae also present. Plantago lanceolata, Pteridium, Tubuliflorae, Trifolium and Papilionaceae indicate pastoral agriculture. Calluna is low (2%) and fern values are quite high.

Sample 333 - bank core

Tree values are very low in this sample although Alnus is again the most abundant. Coryloid and triporate values are relatively high, grass is 11% and Calluna 0.6%. These percentages are depressed by the massive percentage of cereal pollen, 72.5% for the 40µ - 50µ range and 0.8% for the 50+µ range. Chenopodiaceae and Caryophyllaceae pollen is present along with this. Pastoral agriculture is indicated by Ranunculaceae, Plantago lanceolata, Urtica, high values of Pteridium, Liguliflorae and Rumex. Values of ferns are modest and both Ophioglossum and Botrychium are present.

Sample 332 - turf layer

Tree values are low and Betula not Alnus is the most abundant species. Quercus, Ulmus, Ilex and Salix are also present with high values of Coryloid and triporate pollen. Grass is 43% TP and Calluna values are low. Cereals are quite abundant, 40µ - 50µ —3.2% and 50+µ-0.8%. Other arable indicators include Artemisia, Chenopodiaceae, Cruciferae, Caryophyllaceae and Labiatae. Urtica, Pteridium, Liguliflorae, Rumex, Papilionaceae, Trifolium, Succisa and Rhinanthus are also present. Fern values are modest.

Sample 331 - bank core

Layer 331 was sampled at two points and the samples analysed to investigate how the pollen spectrum differed within a layer.

331/1 Alder is the dominant tree with associated presences of Pinus and Ulmus. Both Coryloid and triporate pollen are abundant, Calluna values are low (2%). Grass dominates the spectrum with 40% TP, cereals are abundant and Chenopodiaceae and Caryophyllaceae are present. Indicators of pastoral agriculture include Ranunculaceae, Plantago lanceolata, Pteridium, Tubuliflorae, Liguliflorae and Papilionaceae. Polypodium values are high.

331/2 Alnus is the main tree species present with some Betula. Ilex is also present along with high values of Coryloid and triporate and low Calluna (2%). Grass is the dominant herbaceous taxon and cereals

(40μ - 50μ) are 4% TP. Artemisia, Caryophyllaceae and Labiatae are also present. Pastoral indicators include Ranunculaceae, Pteridium, Trifolium and Papilionaceae. Polypodiaceae values are high.

6.7.2 INTERPRETATION AND DISCUSSION

Ard Mark Soils

Both of the soil samples from ard marks which contained pollen had a very similar pollen spectrum, confirming to some degree that they are contemporary. They appear to represent an open landscape, with woodland represented by alder trees, perhaps in wetter areas. Mixed farming was being practised and it seems probable that the initial forest clearance was made for arable purposes with a change of use to grazing when the soil fertility began to deteriorate. The low Calluna values suggest that heath development was not widespread and that soil acidification had not reached serious levels. It is impossible to deduce the state of the woodland which was cleared. The high levels of Coryloid and triporate pollen may represent a degree of regeneration, largely with hazel, but problems of differential preservation must be considered.

Samples from the Section through the Bank of Site One, North-East Quadrant

Sample 388

This is the lowest sample in the sequence and is very different from the rest in several ways. Firstly its composition, the other soils from the section are essentially podsols (J. Barber pers. comm) but this sample is very sandy with very little organic material, low iron content and a high phosphate content. It also appears as if it has been burnt at some stage. Secondly it has a very high Calluna count, another feature which is absent from all the other samples, even the most recent ones. These two points apart, the spectrum does resemble that of the other samples with evidence of arable agriculture, a single cereal pollen grain (50+μ), and pastoralism. The presence of 1% elm may indicate that this sample represents a very early period in the Beaker occupation before elm values were completely reduced. It may represent an even earlier event but in the absence of ^{14}C dates it is impossible to support this. This layer could represent the site of a cremation or burial followed by burning (hence the high phosphate) followed by local heath development but without further archaeological evidence this is just speculation.

Sample 337 - bank core

This sample is very similar to the ard mark samples in many ways, with alder again being the major tree species and indications of mixed, but predominately pastoral, agriculture. It probably represents the same period of forest clearance for cereal cultivation followed by stock-rearing and a period of regeneration with *Corylus*.

Sample 336 - turf line

Apart from sample 336/3, which contained no pollen, all the samples from layer 336 show a similar pollen spectrum. Woodland appears to have been sparse, being composed mainly of alder with some birch and oak. It was probably centred on wetter and less accessible areas. There also appeared to be abundant hazel scrub, corresponding to regeneration on cleared land. Mixed agriculture is indicated, much the same as in 337, but in this layer the emphasis seems to be much more on arable farming with high levels of cereal pollen being recorded.

Sample 334 - turf line

This sample is from a layer of stacked turves and it too has a similar spectrum showing an open landscape with mixed farming in which arable farming is well represented.

Sample 333 - bank core

The cereal values in this sample are remarkable and must represent some form of onsite storage or processing of cereal grain, straw or chaff. Even if prehistoric cereals are taken to have released pollen more freely than modern ones it is hard to believe that percentages such as these could have occurred in soil in close proximity to an arable field. Robinson and Hubbard (1977) report the concentration of cereal pollen in the bracts etc. of cereal grains and offer this as an explanation of the often high values of cereal pollen found in soils from archaeological sites.

In this sample the high values of cereals depress the values of the other taxa and if their influence is removed a similar spectrum to the other samples is revealed, apart from the fact that other indicator species are generally higher than in the other samples.

Sample 332 - turf line

Although tree values are low in this sample there is an indication that the regeneration of secondary woodland was occurring with the appearance of more tree species such as birch, oak, elm and holly. In addition alder was not the dominant tree species. Coryloid and triporate were still important, representing hazel scrub, and again a system of mixed farming operated.

Layer 331 - bank core

The two samples from this layer, which were analysed to examine variation in the pollen spectra within layers, are basically very similar. The main differences can be attributed to differential preservation of pollen rather than differences in the original pollen input. High values of *Polypodium* spores give an indication that the samples may have been prone to this. As for the interpretation of the spectra that is much the same as for the preceding samples, an open landscape with mixed agriculture and areas of regenerating woodland dominated by hazel. The fact that *Calluna* pollen is virtually absent strongly suggests that these samples, the uppermost of the ones analysed, represent a period prior to the spread of *Calluna* heath over Tormore and therefore almost certainly before the formation of the peat deposits on Tormore. This finding is consistent with the archaeology as outlined so far.

6.7.3 SUMMARY OF SOIL SAMPLE DATA

This collection of soils from the Beaker and early Bronze Age periods on Tormore gives an insight into events on the hillside despite the fact that the analysis has such local implications. The ard mark soils and the sample from the lowest layer of site one (disregarding 388) appear to represent clearance and small scale cultivation but with the main emphasis on pastoral agriculture. Some regeneration was taking place.

Later samples show a definite move towards arable agriculture possibly indicating the existence of large arable field systems. A large proportion of the cereal pollen present may be due to the processing of crops in the immediate vicinity of the site (Robinson and Hubbard, 1977). In addition, thatch may have been used for roofing or as a floor covering along with the chaff. However if this was the case no cereal debris remained in the soils. Pastoralism is also well represented and it appears that this system of mixed agriculture persisted into the middle Bronze

Figure 6.11

Showing the interpretation summary for soil samples from the section through the N.E. quadrant of site one, (see Fig.6.8).

Soil Sample	Summary
331 - Bank Core	Mixed agriculture - possibly with some woodland regeneration.
332 - Turf Line	Mixed agriculture - possibly with some woodland regeneration.
333 - Bank Core	Mixed agriculture with strong evidence for the growth of cereals nearby and/or on-site cereal processing.
334 - Turf Line	Mixed agriculture, with both arable and pastoral farming well represented.
335 - Bank Core	Not available from excavation.
336 - Turf Line	Mixed agriculture, with pastoralism slightly more in evidence than cereal cultivation.
337 - Bank Core	Predominantly pastoral agriculture with some evidence of cereal cultivation.
388 - ?Bank Core ?Ditch.	Open heathland with pastoral agriculture and possibly some cereal cultivation.

N.B. all samples suggested a very open landscape.

Age. Samples from reconstructions subsequent to this were not analysed so nothing can be said of later events.

Sample 388 is very different from the rest. It may also represent a Beaker clearance phase with the pollen spectrum being modified by localised heath formation following fire or the downwash of pollen. Certainly the sandy nature of the sample would facilitate the latter.

A final point concerns pollen preservation. In general pollen from the bank cores was less degraded than that from the turf lines. This is probably a consequence of the bank core material being exposed to the actions of aerobic micro-organisms for a shorter time than that which accumulated in the turf covering the banks. No other major differences were observed between the two types of sample.

Figure 6.12

Showing the time/depth curve for section TM1.
(The shaded area represents the sample size in the vertical axis and the quoted error range of 1 standard deviation in the horizontal axis.)

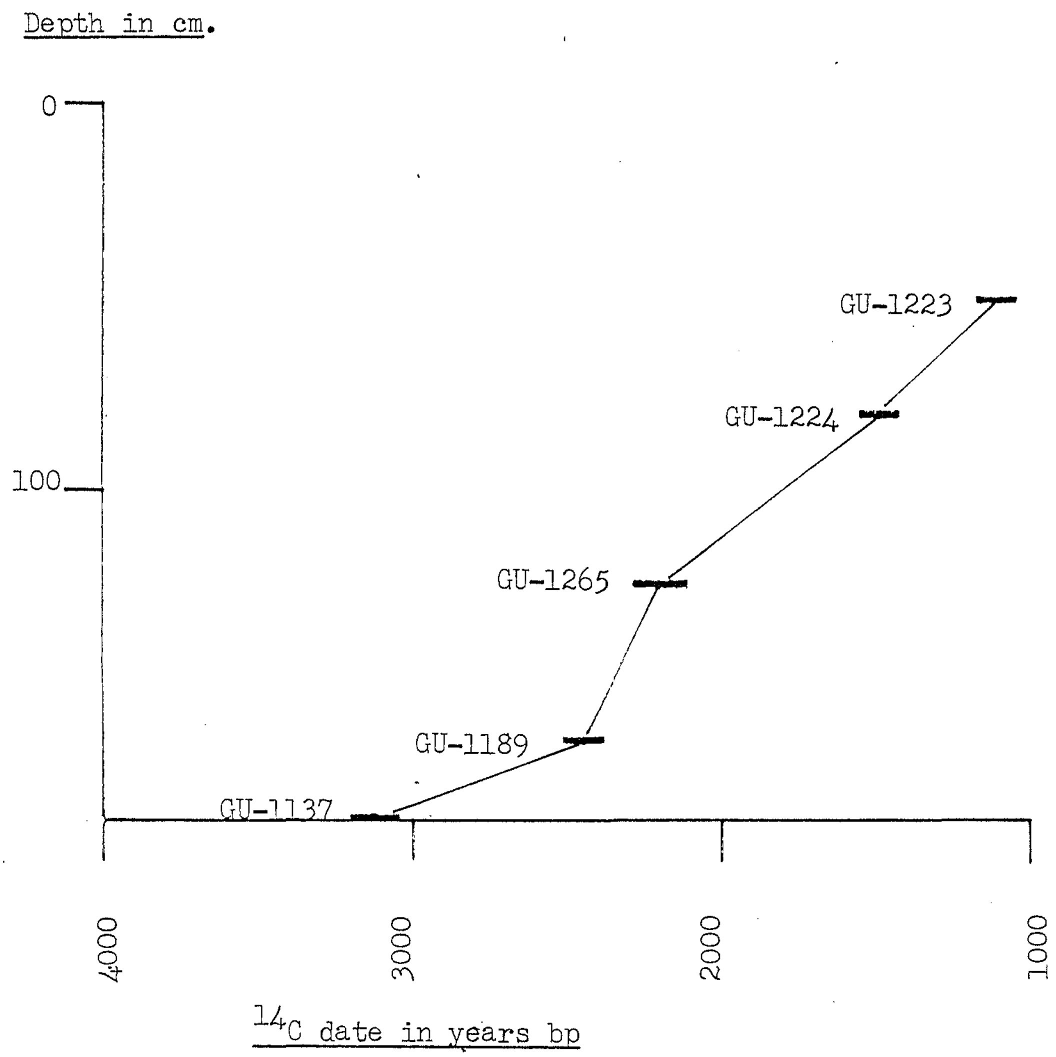
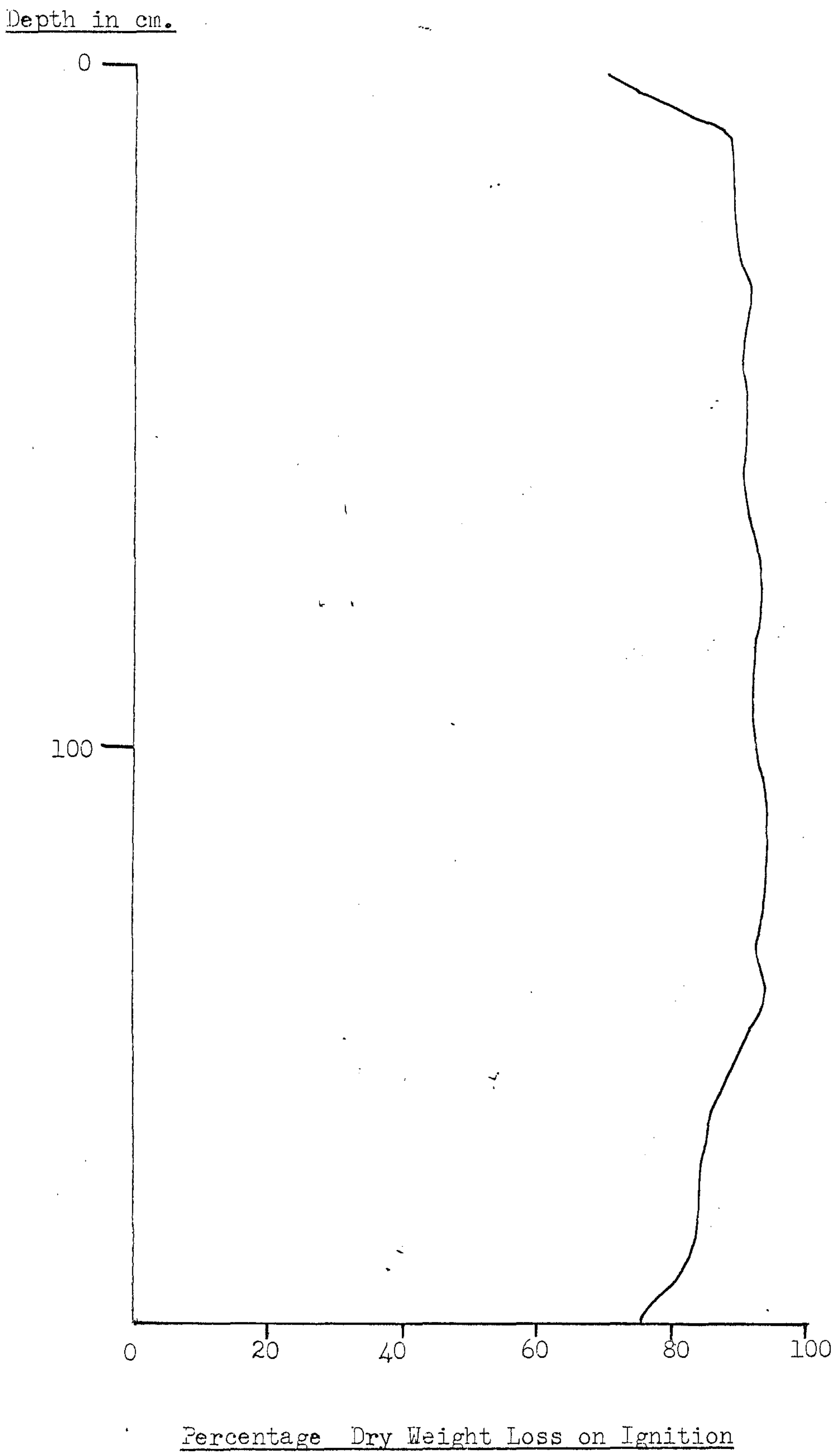

Depth in cm.
0
100
GU-1223
GU-1224
GU-1265
GU-1189
GU-1137
4000
3000
2000
1000
^{14}C date in years bp

Figure 6.13

Showing the percentage loss on ignition analysis for section TM1.


Depth in cm.
0
100
0
20
40
60
80
100
Percentage Dry Weight Loss on Ignition

CHAPTER SEVEN

DISCUSSION AND CONCLUSIONS

7.1 INTRODUCTION

The main aim of this study, at its inception, was to provide information about human economy and land use during the extended period of occupation of the settlement site on Tormore. This approach was later broadened, with the sampling of deep deposits on Machrie Moor, to include the more general aspects of the archaeology and vegetational history of the island.

To a great extent these original aims have been fulfilled. Analysis of MML80, the section from Tormore, whilst being of direct relevence to the Tormore excavation and the archaeology of the island as a whole, has also provided valuable information about the vegetation of the island throughout the Flandrian period. Comparisons were possible with pollen diagrams from other British sites, including those in the south-west of Scotland, these have been discussed in preceding chapters.

Local information about the Tormore site was provided in the earliest instance by the analysis of soil samples taken from the earliest (early Bronze Age) earthworks. Despite the inherent difficulties in interpreting such samples it was possible for some conclusions to be drawn and these were consistent with the more general picture recorded in MML80. At a later date peat formation began in the vicinity of the site, subsequently covering the monuments. Analysis of these deposits provided further information, albeit largely about the post-occupational period. TM1, the two metre peat section from a depression 40 metres to the west of the site, began forming in the middle to late Bronze Age (ca. 3100 bp) with deposition continuing well into historical times (? ca. 500 bp). Its resemblance to the equivalent portion of MML80 is striking. For example :-

1. Both show extensive forest clearance in the later Bronze Age, with a short (ca. 100 year) period of particularly intense activity around 2800 - 2900 bp.

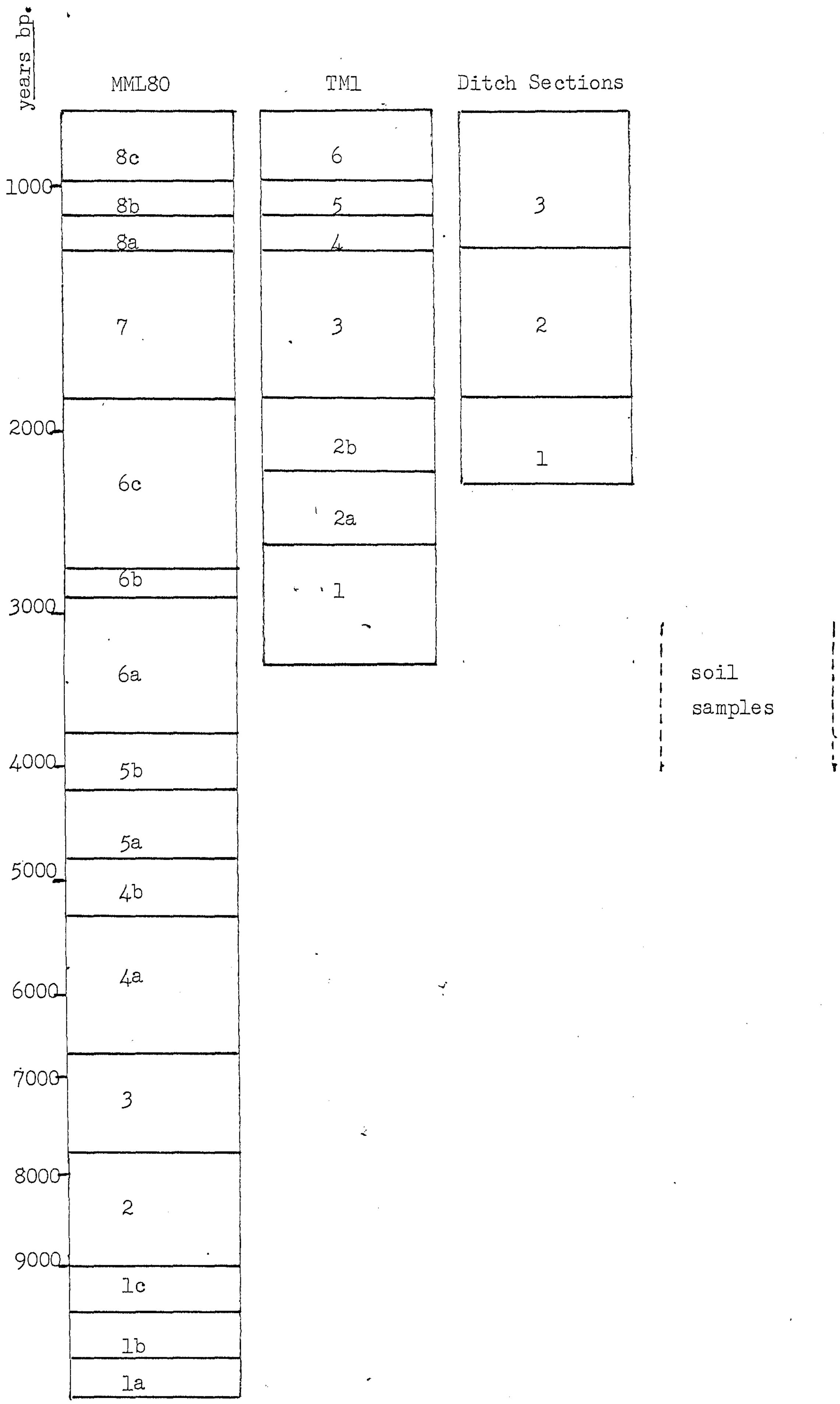
2. They also show very little human activity in the Dark Ages, which allows a certain amount of forest regeneration.

3. In both sections there is evidence of a marked resurgence in agricultural activity which corresponds broadly to the Viking/early Mediaeval period.

The field bank ditch sections, TMD1, TMD4 and TMD5, began forming at a time of more general peat growth around 2000 bp and in most respects they correspond closely to the relevent portions of TM1 and MML80.

Figure 7.1

Showing the correlation between the peat sections and soil samples analysed during the course of this study. The timescale on the left of the figure is estimated from the Time/Depth curve (Fig. 5.5).


years bp.
MML80
TM1
Ditch Sections
8c
8b
8a
7
6c
6b
6a
5b
5a
4b
4a
3
2
1c
1b
1a
6
5
4
3
2b
2a
1
3
2
1
1000
2000
3000
4000
5000
6000
7000
8000
9000
soil
samples

The 'Dark Age Lull' is less evident, but this and other small differences are largely due to the nature of the ditch deposits which accumulated slowly and had a pollen input dominated by the local peat-forming vegetation (see section 6.5.4.). The sharp increase in agricultural activity in Viking times is however, very obvious, particularly in TMD4.

The close agreement which exists between the deposits analysed with respect to the effect of successive human populations on the vegetation has enabled a composite interpretation to be presented. Where small anomalies did occur these provided a further insight into the effects of altitude and other factors on land usage.

7.2 THE ARCHAEOLOGICAL SIGNIFICANCE OF THE FINDINGS

The data resulting from the analyses performed on the samples from Machrie Moor and Tormore have been reported and discussed in detail in Chapters five and six. It is not intended to repeat those discussions here, but rather to summarise the implications which the data have regarding the archaeology of the Tormore site and the island as a whole.

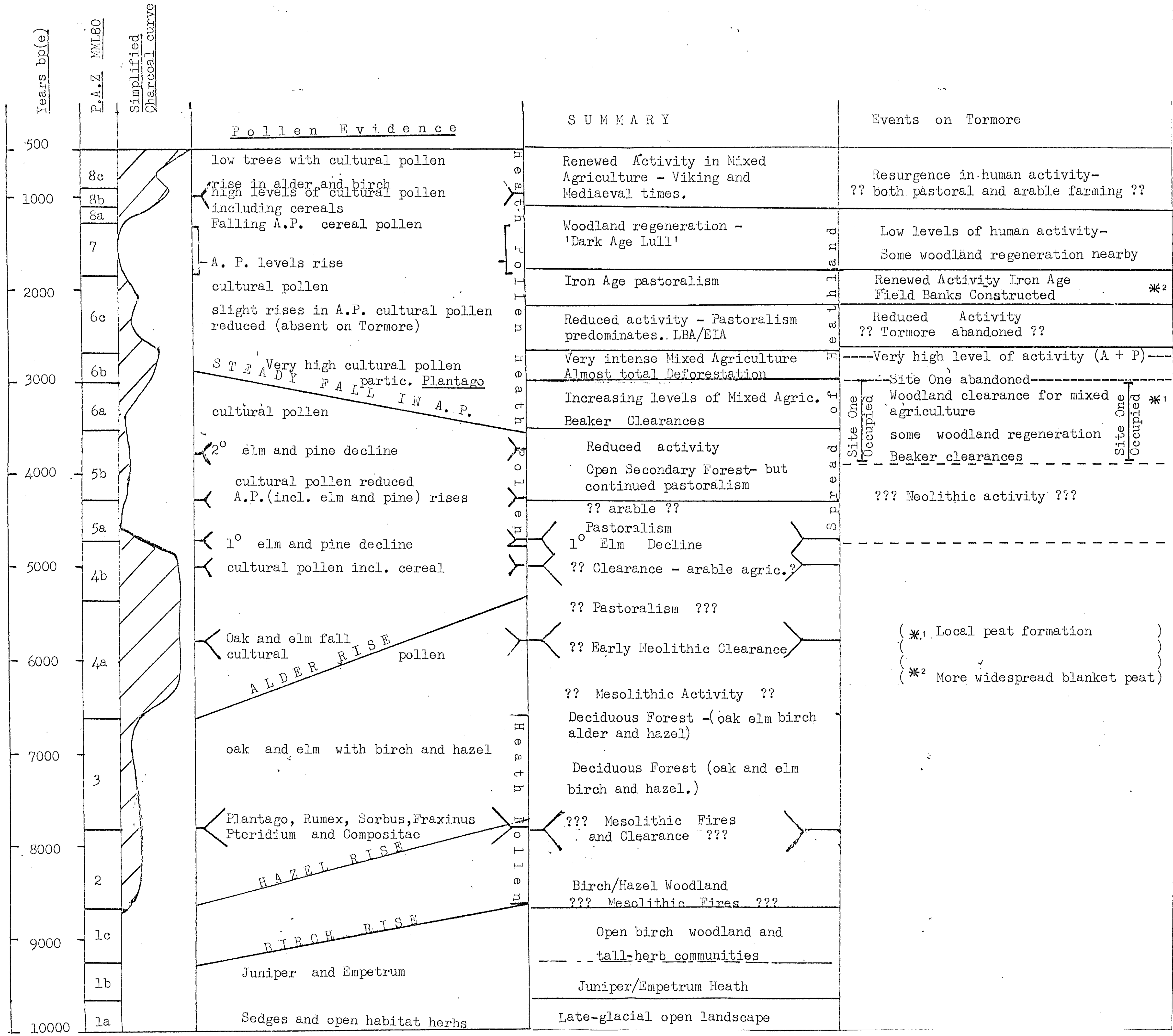
Only MML80, the section from Machrie Moor , covers the whole of the period discussed and it is from this diagram that the majority of the information is taken. A considerable body of local data was also provided by the Tormore peat and soil samples and this has been referred to, where relevant. The summary has been organised on the basis of the recognised archaeological periods and it is acknowledged that there is considerable overlap between these. A summary is also provided in the form of Fig.7.2.

The Mesolithic Period

Arran would have proved very attractive to a Mesolithic population, offering abundant freshwater and sea fishing, plus a wide variety of easily accessible habitats for the hunting of game and wildfowl and collection of wild plant foods. It is also on the main coastal and sea routes to Northern Ireland and the west coast of Scotland, providing an obvious passage which would avoid the dense woodland on most mainland areas. Although finds of Mesolithic artifacts are far from abundant from the island there are many sites in the south-west of Scotland which confirm a Mesolithic presence. Perhaps the most important of these are those on Jura, the earliest of which has been dated to in excess of 8000 bp (Mercer, 1970).

Figure 7.2

A summary diagram showing the pollen evidence and interpretation for Machrie Moor and contemporary events on Tormore.



Years bp(e)
P.A.Z MML80
Simplified Charcoal curve
Pollen Evidence
SUMMARY
Events on Tormore
500
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
8c
8b
8a
7
6c
6b
6a
5b
5a
4b
4a
3
2
1c
1b
1a
low trees with cultural pollen
rise in alder and birch
high levels of cultural pollen
including cereals
Falling A.P. cereal pollen
A. P. levels rise
cultural pollen
slight rises in A.P. cultural pollen
reduced (absent on Tormore)
Very high cultural pollen
partic. Plantago
STEADY FALL IN A.P.
cultural pollen
2° elm and pine decline
cultural pollen reduced
A.P.(incl. elm and pine) rises
1° elm and pine decline
cultural pollen incl. cereal
Oak and elm fall
cultural pollen
ALDER RISE
oak and elm with birch and hazel
Plantago, Rumex, Sorbus, Fraxinus
Pteridium and Compositae
HAZEL RISE
BIRCH RISE
Juniper and Empetrum
Sedges and open habitat herbs
Heath Pollen
Heath Pollen
Heath Pollen
Heath Pollen
Renewed Activity in Mixed
Agriculture - Viking and
Mediaeval times.
Woodland regeneration -
'Dark Age Lull'
Iron Age pastoralism
Reduced activity - Pastoralism
predominates.. LBA/EIA
Very intense Mixed Agriculture
Almost total Deforestation
Increasing levels of Mixed Agric.
Beaker Clearances
Reduced activity
Open Secondary Forest- but
continued pastoralism
?? arable ??
Pastoralism
1° Elm Decline
?? Clearance - arable agric.?
?? Pastoralism ???
?? Early Neolithic Clearance
?? Mesolithic Activity ??
Deciduous Forest -(oak elm birch
alder and hazel)
Deciduous Forest (oak and elm
birch and hazel.)
??? Mesolithic Fires
and Clearance ???
Birch/Hazel Woodland
??? Mesolithic Fires ???
Open birch woodland and
tall-herb communities
Juniper/Empetrum Heath
Late-glacial open landscape
Spread of Heathland
Resurgence in human activity-
?? both pastoral and arable farming ??
Low levels of human activity-
Some woodland regeneration nearby
Renewed Activity Iron Age
Field Banks Constructed
*2
Reduced Activity
?? Tormore abandoned ??
Very high level of activity (A + P)
Site One abandoned
Woodland clearance for mixed
agriculture
*1
some woodland regeneration
Beaker clearances
Site One Occupied
Site One Occupied
??? Neolithic activity ???
(*1 Local peat formation)
(*2 More widespread blanket peat)

The first hint in the peat of possible Mesolithic activity occurs at a level dated to 8665 ± 155 bp. It is at this point that charcoal is present for the first time and there is evidence for the spread of Calluna heath. Later ca. 7800(e) bp there is a possible clearance episode, again there are high Calluna pollen values and the presence of charcoal. The charcoal fragments at this point have been tentatively identified as resulting from the burning of Phragmites, the common reed, and this form of 'herbaceous charcoal' is common well into the fourth millenium. The evidence for early human activity is however equivocal and the observed changes could be explained in terms of natural fires and clearings. If human populations were involved, it is likely that at first this was on a seasonal basis followed by more permanent occupation. Fires may have been accidental, or deliberately started to drive game (from the reedswamps for example), rather than to create cleared areas for agriculture or husbandry. If activity of this nature occured regularily then it may partially explain why dense woodland apparently never fully developed on the island. Even at the maximum of the Flandrian forest, tree pollen values do not exceed 45% TP. This suggests that a very open woodland canopy must have been maintained throughout (Peglar, 1979). Similar peat deposits from Northern Ireland contain in excess of 80% TP for an equivalent period (Smith, 1975). As discussed earlier (Chapter five) a large area of mire vegetation on Machrie Moor may also have contributed to the depressed tree pollen levels and climate and the degree of exposure would also have been involved.

More advanced forms of human manipulation as outlined by Simmons (1975a, 1975b, 1981,),Jacobi et al. (1976) and Mellars (1976) are unlikely to have occured in earlier times but may have been practised later. The clearance attributed to early Neolithic settlers in the next section may have alternatively been the work of late Mesolithic populations. It contains no indication of arable agriculture to confirm it as Neolithic. The devision between the Mesolithic and Neolithic periods is a very difficult one and it is obvious that the elm decline can no longer be taken as a valid marker. There are indications that Neolithic populations arrived in Britain possibly prior to 6000 bp and that the Mesolithic way of life persisted in one form or another into the Bronze Age and possibly later periods (see Chapter two).

The Neolithic Period

More convincing evidence of forest clearance occurs at a level corresponding to ca. 5750(e) bp, which in this diagram is approximately 1000 years prior to the primary elm decline. Clearances of a similar date are known from Ireland and northern Britain (Pilcher and Smith, 1979, Smith, 1975, Lynch, 1981, Smith and Collins, 1971, Pennington, 1975), with the majority of these being attributed to the earliest Neolithic. The lack of archaeological evidence from this time is probably a consequence of the fact that the activities of the early settlers would have been concentrated on survival. All their resources would have been required solely to to establish an agricultural base, there would have been little opportunity for the building of permanent settlement sites or large burial monuments. It is also possible that slash and burn agriculture along with stock-rearing only provided some of their food requirements and that there was still a heavy reliance on hunting and gathering wild foods. It was not possible to accurately date this clearance phase due to the sampling interval at this level. The indications are that it lasted considerably less than two hundred years.

Slightly later, ca. 5400 bp, there is another clearance phase and it is during this that the first cereal grain is present, confirming the activity as being Neolithic. Whether this represents a continuation of the earlier activity or renewed colonisation following the migration or demise of the first population is not clear. However the levels of cultural pollen do tend to suggest a more intensive involvement. The initial arable phase is shortlived, giving way to a period of pastoral farming which lasts for more than 1000 years. Arable farming probably persisted on a small scale during this time although it is not detected in the pollen diagram, possibly because it was practised at some distance from the sampling site. The elm decline occurs at a level dated to 4740 ± 155 bp and it is suggested that it was the result of a selective elm desease acting on a population rendered susceptible by prolonged exposure to human management practices (lopping and pollarding). Subsequent to the elm decline the intensity of the agriculture appears to increase although it is still largely in the form of pastoralism. Areas easily cleared of dead elms would have accommodated an apparently increasing population and as these became less fertile further inroads were made into the living woodland. Increased levels of Calluna pollen signal the spread of heath plants onto cleared areas which were becoming increasingly acid.

The duration of the agricultural activity in the Neolithic suggests that once the settlers were established on the island there followed a period of relative stability based on regular food supplies. This would have freed some resources for other projects such as house and monument building. Settlement sites have not as yet been discovered from Arran but they are known from Bute. Elaborate burial monuments are however in evidence on the island with more than twenty chambered cairns being known. The distribution of these, with each small valley virtually having its own tomb , has led John Barber (pers. comm. 1981) to conclude that the population was in the form of small 'family' based units. It appears likely that there was activity on Tormore at this time as there is a chambered tomb nearby on Machrie Moor (see Fig. 2.6). However no indication of this activity was found during the course of the excavation.

In the later Neolithic agricultural activity is reduced. At a level dated to 4310 $\pm$ 155 bp agricultural indicator species are reduced for a short time and tree species, including elm,are allowed to recover to preclearance levels. The idea of a lull in the activity is also supported by the archaeology, with passage graves and artifacts generally associated with the secondary (late) Neolithic cultures being virtually absent from Arran. Similar reductions have also been noted in the late Neolithic at a number of other sites,particularly in Ireland, and also on Kintyre (Nichols, 1967). Two main theories have been advanced as to the cause of this depopulation :-

1. The people migrated,prompted either by choice or necessity.
2. The was the occurrence of some great catastrophe such as crop failure or disease.

These two events are not mutually exclusive and it is quite possible that a combination was involved. Under stable conditions, with a regular food supply,both human and animal populations would tend to increase thus exerting a greater pressure on the available resources. A point may have been reached where the available resources and technology were no longer sufficient to support the population, resulting in food shortages. The larger populations would also be more susceptible to the spread of disease and a combination of disease and food shortages may have resulted in the death of some people and prompted the migration of others. Complete depopulation of the island is unlikely to have occured as agricultural indicator species are present,albeit at a reduced level,throughout the later Neolithic. The archaeological evidence also suggests a measure of continuity in the usage of the chambered cairns through to the Bronze Age.

The Bronze Age

Following the reduced activity in the late Neolithic there is a resurgence in human activity in the early Bronze Age, corresponding initially to the advent of the influence of the Beaker culture. The earliest structures discovered during the course of the Tormore excavation have been dated to this time on the basis of the artifacts recovered. The combined evidence from the excavation and the analysis of the soil samples from the site, plus the information contained in MML80, suggests that there was clearance of woodland for the purposes of both arable and pastoral farming. The mixed farming economy supported a small stable population. The soil samples are of particular interest in that some of them have a very high content of cereal pollen which may represent the onsite processing of cereal crops (Robinson and Hubbard, 1977). Unfortunately it was not possible to identify the cereal pollen to species level but on size alone the majority is probably from barley (Hordeum), with some wheat (Triticum).

The level of interference during the early Bronze Age was such that it allowed a fair measure of woodland regeneration and, although there is an overall downward trend in tree pollen values, there are periods when quite a large proportion of the area would have been under open secondary woodland. Lull periods ca. 1100 - 1000 bp as described by Lynch (1981) and Smith (1975) are not obviously present.

In the later Bronze Age there is a marked increase in the intensity of forest clearance and agriculture. This is clear from MML80 and TM1 which both show a sharp decline in tree pollen and a rise in agricultural indicator species late in the second millenium. Presumably this represents an increase in population, possibly augmented by immigration from Ireland (Barber, pers. comm. 1981). The later series of occupations of the Tormore site are contemporary with this increased activity although site one was apparently abandoned before the activity reached its peak ca. 2800 - 2900 bp. The ^{14}C date for the base of section of TM1 is statistically inseparable from the one for charcoal from the destruction of the last structure on site one. However these basal deposits are very highly decomposed and obviously formed very slowly; it is likely that the 2 cm sample removed for dating represented in excess of 100 years, therefore representing the later occupation(s).

The peak in activity ca. 2800 - 2900 bp is evident in both MML80 and TM1 and must represent the usage of all available land around the valley, perhaps in response to the enlarged population and the decreasing fertility of higher ground. It is possible that Arran had its highest prehistoric population at this time and that the island's resources were fully stretched to support it.

The Bronze Age was a period of great stability. Settlement sites such as the one on Tormore were occupied for in excess of 1000 years and the late Bronze Age in particular saw highly sophisticated and accomplished metalworking, pottery, building and other skills. Trade links also flourished leading to the development of an urban society. All this was made possible through the provision of a regular and reliable food supply from a mixed farming system. There are indications in the archaeology that the social and agricultural units were larger than in the Neolithic, with burial monuments being associated with larger tracts of agricultural land. As mentioned earlier this suggests the development of urban centres, i.e. settlements larger than family units, with a social hierarchy (Barber, pers. comm. 1981).

Interference with the environment on this scale was not, however, without its consequences. Problems of soil fertility which led to the spread of Calluna heath in the Neolithic would have been more severe in the Bronze Age. Soil deterioration would have been prompted by the intensive land use and an increasingly wetter and cooler climate. Peat deposits such as the one sampled in TM1 began forming in locations where the drainage was impeded and it is obvious from the pollen data that there was a shift from mixed agriculture to a more pastoral based system. Widespread blanket peat formation probably did not occur until around 2000 bp, but prior to this the soil fertility would have been reduced with a direct effect on yields and the available food supply. This is likely to have been a major factor in the apparent collapse of Bronze Age society ca. 500 bc, although the deteriorating climate may also have increased the the incidence of debilitating disease and parasite infestations in both human and animal populations.

The outcome at the end of the Bronze Age appears to have been that there was a much reduced population concentrated on the lowlying, more fertile land around the valley floor with the higher ground being temporarily abandoned. The indications from TM1 are that there was little or no activity on Tormore at this time.

The Iron Age

Activity on the valley slopes resumed in the Iron Age and it appears to have been exclusively in the form of pastoralism. It was during the Iron Age ca. 2000 bp, that the field bank and ditch (from which TMD1, TMD4 and TMD5 were removed) were constructed over Tormore, apparently as a boundary marker for grazing areas. Blanket peat began forming over the hillside shortly after its construction. It is probable that this renewed activity was associated with the people responsible for the building of the hillforts on the island, with the one at Drumadoon being the obvious candidate for the tribal centre in the west of Arran. (The fort at Cnoc Ballygowan is not thought to ever have been completed or inhabited (McLellan, 1976). In times which were obviously violent and unsettled, arable agriculture would have tended to be concentrated on lowlying land close to the fortified centres with the outlying land being used for grazing. The arable areas may have been rather small as it would have been very difficult to grow cereal crops in soil which was in the main wet and heavy. Cool, wet summers would also have made for late harvests and possibly frequent crop failure. There are indications that attempts were made to improve the soil by the addition of shell sand, but this appears to have been unsuccessful (see Chapter two). Cereal cultivation may have been easier in the later (Roman) Iron Age when there was a temporary improvement in climate (Lamb, 1977).

<u>The Dark Ages</u>

A 'Dark Age Lull' period is evident in both MML80 and TM1. Agriculture appears to have declined to a low level, being confined to isolated episodes. Within these episodes there is evidence of both arable and pastoral agriculture, although there is nothing to suggest that the population was very large. Archaeological evidence for occupation during this time is also rather scant, and it could be that most of the population either moved away or were reduced in some other way. Arran would not have been very attractive to an agriculturaly based community. Large areas of land would have been covered by blanket bog and heath and any other lowlying land is likely to have been unproductive in terms of crop yields and stocking-rates. It would have been more profitable at this time to break new ground on the mainland, which still had potential for intensive usage under the systems available. It is interesting to note that at Bloak Moss on the Ayrshire mainland (Turner, 1970, 1975) intensive clearance did not occur until ca. ad 400 (Godwin and Willis, 1962), although there had been some activity in the vicinity prior to this in late Bronze Age and possibly Neolithic periods. It may be that this was a general phenomenon, with easily accesible island and coastal areas, which were inhabited from a very early time, being abandoned as their resources were expended, in favour of newly cleared inland areas. Technological developments during the Iron Age would have provided the means for clearance on the required scale.

The Viking and Mediaeval Periods

A resurgence in agricultural activity is evident at a level roughly corresponding to the first involvement of the Vikings in Arran. There is a rapid expansion in arable and pastoral farming to levels which suggest the influx of a large population. The factor which most obviously influenced this was climate. There was an amelioration of the climate in the centuries around 1000 bp referred to as the 'little optimum'. It enabled the cultivation and stocking of land which probably had not been used intensively since the Bronze Age and possibly earlier times. Accordingly the island was able to support an increased population. However large areas would still have been under blanket peat and heath and it is difficult to imagine much improvement in the productivity of these.

The activity appears to persist at a reduced level into Mediaeval times although the dating of the section at this point is rather unclear. The reduction in activity in these later times may represent a response to a decline in the climate following the 'little optimum', which led up to the 'little ice age'.

It has not been possible to reliably date the upper limit of the sections.

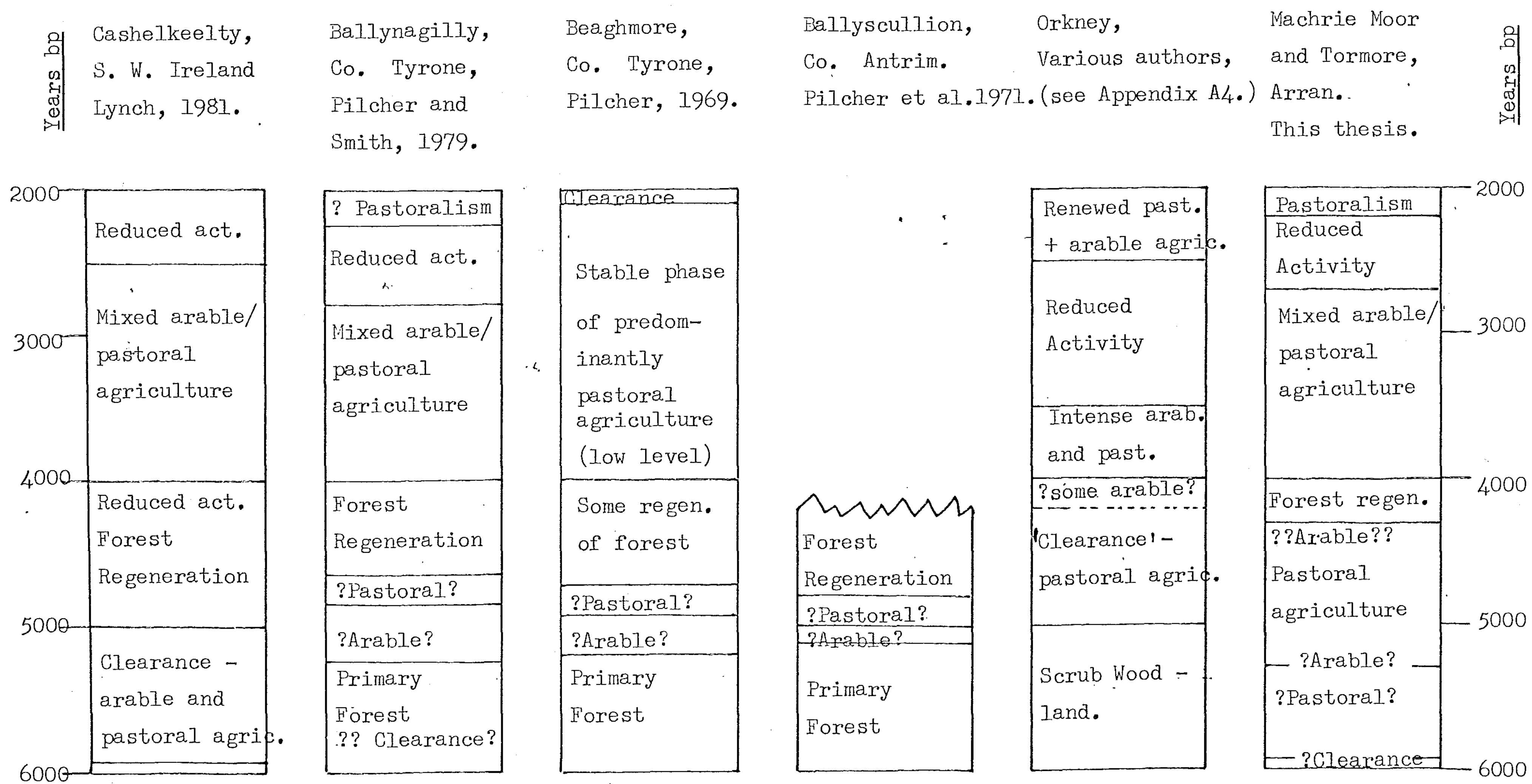
7.3 COMPARISONS WITH OTHER WORK FROM IRELAND AND ORKNEY

Several references have already been made to the similarity between the events recorded in the peat sections from Arran in the prehistoric period and those in Ireland, particularly in the north. Figure 7.3 contains summaries of pollen analysis associated with archaeological excavations in south-east Ireland (Lynch, 1981), northern Ireland (Pilcher, 1969, Smith, 1975, Pilcher and Smith, 1979), Orkney (various authors, see Appendix A4) and Arran (this thesis). It is clear from this figure that the general sequence of events from the earliest Neolithic up to the late Bronze Age is very similar for the diagrams from Ireland and Arran, whereas the Orkney summary is very different. Whilst it is dangerous to draw conclusions from the comparison of such a small number of sites, it does appear that there were close connections between the south-west of Scotland and Ireland. These connections are also suggested by comparisons of the archaeology and in view of the geography of the area they are hardly surprising.

The Arran data does not however match exactly with that from Ireland; the dates and durations of the events and phases are somewhat different and on Arran there is much less evidence of arable agriculture, particularly in the Neolithic. Some of these differences can be explained in terms of

Figure 7.3

Showing a comparison of the data for the prehistoric period on Arran with that from Orkney, south-west and northern Ireland.



Years bp
Cashelkeelty, S. W. Ireland Lynch, 1981.
Ballynagilly, Co. Tyrone, Pilcher and Smith, 1979.
Beaghmore, Co. Tyrone, Pilcher, 1969.
Ballyscullion, Co. Antrim. Pilcher et al.1971.
Orkney, Various authors, (see Appendix A4.)
Machrie Moor and Tormore, Arran. This thesis.
Years bp
2000
3000
4000
5000
6000
Reduced act.
Mixed arable/ pastoral agriculture
Reduced act. Forest Regeneration
Clearance - arable and pastoral agric.
? Pastoralism
Reduced act.
Mixed arable/ pastoral agriculture
Forest Regeneration
?Pastoral?
?Arable?
Primary Forest
?? Clearance?
Clearance
Stable phase of predom- inantly pastoral agriculture (low level)
Some regen. of forest
?Pastoral?
?Arable?
Primary Forest
Forest Regeneration
?Pastoral?
?Arable?
Primary Forest
Renewed past. + arable agric.
Reduced Activity
Intense arab. and past.
?some arable?
'Clearance' - pastoral agric.
Scrub Wood - land.
Pastoralism
Reduced Activity
Mixed arable/ pastoral agriculture
Forest regen.
??Arable??
Pastoral agriculture
?Arable?
?Pastoral?
?Clearance
2000
3000
4000
5000
6000

the ^{14}C dating method. All dates have a quoted error determined by the dating lab. The dating errors on the Machrie Moor samples are large, bringing them within two standard deviations of the main of the Irish dates in the majority of cases. There are also problems inherent in the dating of peat samples as discussed in Chapter five (5.5). If the Arran dates are 'corrected' into line with those from Ireland there are some important consequences. The early Neolithic clearances become very early indeed, occuring at the end of the fifth millenium bc and a stable pastoral phase is preceded by a short arable episode with a cereal pollen grain dated to ca. 5700(e)bp. This 'correction' is based on conjecture however, and for that reason its effects have been omitted from the main body of the discussion and interpretation.

As for the lack of evidence for arable agriculture throughout the Neolithic period, there are two possible explanations :-

1. Cereal cultivation was practised, but due to the poor dispersal of the cereal pollen, or the distance from the sampling site of the arable plots, this is not represented in the pollen record.

2. Conditions on Arran may have been such that pastoral agriculture was favoured above arable, and that it became the mainstay of the economy.

The Iron Age and later times are dealt with in less detail in the reports from the Irish sites which makes comparison difficult. However the overall picture for the Iron Age does appear to be superficially similar, apart from at Cashelkeelty in the south-west of Ireland where there are virtually no indications of agricultural activity between 500 bc and ad 300. Subsequent to the Iron Age widespread forest clearance is evident in Ireland, in early Christian times. Arran by this time was almost completely deforested and was undergoing a period of reduced agriculture with some woodland regeneration.

CHAPTER EIGHT

REFERENCES

Aaby, B. (1979). A simplified Troels-Smith system for the characterising of unconsolidated sediments. In '_Palaeohydrological Changes in the Temperate Zone in the last 15000 years. Subproject B. Lake and Mire Environments. Vol. I_' Ed. Berglund, B.E., International Geological Correlation Programme, Project 158. 80 - 93.

Aalto, M. (1970). Potamogetonaceae fruits 1. Recent and Subsossil Endocarps of the Fennoscandinavian species. _Acta. Bot. Fennica_. _88_, 1 - 85.

Adam, P., Birks, H. J. B., and Huntley, B. (1977). Plant communities of the Island of Arran, Scotland. _New Phytol_. _79_, 689 - 712.

Andersen, S. T. (1960). Silicone oil as a mounting medium for pollen grains. _Danm. Geol. Unders_. _4_ (1), 1 - 24.

Andersen, S. T. (1979). Identification of wild grass and cereal pollen. _Danm. Geol. Unders_., _Arbog 1978_, 69 - 92, København.

Andersen, S. T. and Bertelsen, F. (1972). Scanning electron microscope studies of pollen of cereals and other grasses. _Grana_ _12_, 79 - 86.

Andrew, R. (1970). The Cambridge pollen reference collection. In '_Studies in the Vegetation History of the British Isles_', Ed. Walker, D. and West, R. G., Cambridge University Press, London. 225 - 232.

Andrew, R. (1980). _A practical pollen file of the British Flora_. Sub- Department of Quaternary Research, Botany School, Cambridge.

Anon. (13th Century) _Arran_ - A Gaelic Prose Poem (see Appendix A9).

Balfour, J. (1910). _The Book of Arran_. The Arran Society of Glasgow.

Ball, D. F. (1975). Processes of soil degradation. In '_The Effects of Man on the Landscape_ : _The Highland Zone_.' Ed. Evans, J. G., Limbrey, S., and Cleere, H. (1975). C. B. A. Res. Rep. 11, 20 - 27.

Barber, J. (1978). The excavations at Tormore, Arran. _D. E. S._, 28.

Barber, J. (1980a). _The Excavations at Tormore, Arran_. Unpublished interim report.

Barber, J. (1980b). Kilpatrick, Arran. _P. P. S._ _46_, 367 - 368.

Barrett, J., Hill, P., and Stevenson, J. B. (1978). Second millenium BC banks in the Black Moss of Achnacree : some problems of prehistoric land use. _B. A. R._ _33_, 283 - 288.

Bartley, D. D. (1975). Pollen analytical evidence for prehistoric forest clearance in the upland area west of Rushworth, West Yorkshire. _New Phytol_. _74_, 375 - 381.

Beckett, S. C. (1978). The palaeobotanical background to the Meare Lake Village sites. Somerset Levels Papers 5, 18 - 24

Beckett, S. C. (1979). Pollen influx in peat deposits:values from raised bogs in the Somerset Levels, S.W.England. New Phytol. 83, 839 - 847.

Beckett, S. C. and Hibbert, F. A. (1976). An absolute pollen diagram from the Abbot's Way. Somerset Levels Papers 2, 24 - 27.

Beckett, S. C. and Hibbert, F. A. (1979). Vegetational changes and the influence of prehistoric man in the Somerset Levels. New Phytol. 83, 577 - 600.

Bellamy, D. (1972). Templates of Peat Formation. Proc. 4th Int. Peat Congr. Vol I, 7 - 16.

Benninghoff, W. S. (1962). Calculation of spore density in sediments by additions of exotic pollen in known quantities. Pollen Spores 4, 332 - 333.

Berglund, B. E. (1966). Late Quaternary vegetation in eastern Blekinge, south-eastern Sweden. I. Late-Glacial Time. Opera botanica 12, 1 - 180.

Berglund, B. E. (1979). Guidelines for investigations of terrestial soils. In 'Palaeohydrological Changes in the Temperate Zone in the last 15000 years. Subproject B. Lake and Mire Environments. Vol. 1.' Ed. Berglund, B. E., International Geological Correlation Programme, Project 158. 69 - 76.

Beug, H. J. (1961). Leitfaden der Pollenbestimmung. Gustav Fischer Verlag, Stuttgart.

Birks, H. H. (1972). Two pollen diagrams from the Galloway Hills, Kirkcudbrightshire. J. Ecol. 60, 183 - 218.

Birks, H. H. (1975). Studies in the Vegetational History of Scotland IV. Pine Stumps in Scottish Blanket Peats. Phil. Trans. Roy. Soc. Lond. (B) 270, 181 - 226.

Birks, H. J. B. (1973). Past and present vegetation of the Isle of Skye. Cambridge University Press, London.

Birks, H. J. B. (1977). The Flandrian forest history of Scotland - a preliminary synthesis. In ' British Quaternary Studies-Recent Advances. Ed. Shotton, F. W., Clarendon Press, Oxford. 119 - 136.

Birks, H. J. B. (1980). Quaternary Vegetational History of West Scotland. Excursion Guide, Vth Int. Palyn. Conf. Cambridge (1980).

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

Bishop, W. W. and Coope, G. R. (1977). Stratigraphical and faunal evidence for the late-glacial and early Flandrian environments in S W Scotland. In 'Studies in the Scottish Late-Glacial Environment'. Ed. Gray, J. M. and Lowe, J. J. , Pergamon Press, Oxford. 61 - 88.

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

Boulet, J. (1939). The ecology of a welsh mountain sheep walk. Unpublished PhD thesis. University College of Wales, Aberystwyth.

Bradley, R. (1978). The Prehistoric Settlement of Britain. Routledge and Kegan Paul, London.

Bradley, R. and Hodder, I. (1979). British prehistory:an integrated view. Man 14,1, 93 - 104.

Bridges, E. M. (1978). Interaction of soil and mankind. J. Soil Science 29, 125 - 139.

Brookes, D. and Thomas, K. W. (1967). The distribution of pollen grains on microscope slides. Part 1. Non-randomness of distribution. Pollen Spores 9, 621 - 629.

Bryce, T. H. (1910). The sepulchral remains. In 'The Book of Arran' Vol 1. Ed. Balfour, J. , The Arran Society of Glasgow.

Burl, H. A. W. (1979). The Stone Circles of the British Isles. Yale University Press, New Haven and London.

Butzer, K. W. (1972). Environment and Archaeology. Methuen, London.

Case, H. J. (1969). Neolithic explanations. Antiquity 43, 176 - 186.

Case, H. J. et al. (1969). Land use in Goodland Townland, Co. Antrim from Neolithic times until today. J. Roy. Soc. Antiq. Ireland 99, 39 - 53.

Caseldine, C. J. (1979). Early land clearance in S E Perthshire. Scott. Arch. Forum 9, 1 - 15.

Childe, V. G. (1931). Skara Brae. K. Paul, Trench, Trubner, London.

Childe, V. G. (1942). The chambered cairns of Rousay. Antiq. J. 22, 139 - 142.

Childe, V. G. (1956). Maes Howe. P. S. A. S. 88, 155 - 172.

Clapham, A. R. , Tutin, T. G. and Warburg, E. F. (1962). Flora of the British Isles. Cambridge University Press, London. (2nd Ed.)

Clarke, D. V. (1976). The Neolithic Village at Skara Brae, Orkney, excavations 1972-1973, an interim report. H. M. S. O. , Edinburgh.

Clarke, R. M. (1975). A calibration curve for radiocarbon dates. Antiquity 23, 251 - 266.

Coles, J. M. (1971). The early settlement of Scotland: excavations at Morton, Fife. P. P. S. 37, 284 - 366.

Coles, J. M. and Taylor, J. J. (1970). The excavation of a midden in the Culbin Sands. P. S. A. S. 102, 87 - 100.

Coles, J. M. and Scott, J. G. (1963). The late Bronze Age hoard from Peelhill, Strathaven, Lanarkshire. P. S. A. S. 96, 136 - 144.

Conry, J. (1971). Irish plaggen soils - their distribution, origin and properties. J. Soil Science 22, 401 - 416.

Conway, E. M. (1957). Spore production in Bracken, Pteridium aquilinum (L) Kuhn. J. Ecol. 45, 273 - 284.

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

Cormack, W. F. and Coles, J. M. (1964). A Mesolithic site at Low Clone, Wigtonshire. T. D. G. N. H. A. S. 41, 67 - 98.

Cormack, W. F. (1970). A Mesolithic site at Barsalloch, Wigtownshire. T. D. G. N. H. A. S. 47, 63 - 80.

Cowie, T. G. (1980). Callanish (Leobag), Lewis, Western Isles. P. P. S. 46, 371.

Crampton, C. B. (1966). Analysis of pollen in soils in S. Wales. Scot. Geogr. Mag. 82, 46 - 52.

Culleton, E. B. and Mitchell, G. F. (1976). Soil erosion following deforestation in the early Christian period in south Wexford. J. Roy. Soc. Antiq. Ireland. 106, 120 - 130.

Cushing, E. J. (1967). Evidence for differential pollen preservation in late Quaternary sediments in Minnesota. Rev. Paleaob. and Palyn. 4, 87 - 101.

Davidson, D. A., Jones, R. L. and Renfrew, C. (1976). Palaeoenvironmental reconstruction and evaluation: a case study from Orkney. Trans. Inst. Brit. Geog. 1, 346 - 361.

Davis, A. M. (1977). The prairie-deciduous forest-ecotone in the upper middle-west. Annals Ass. Amer. Geogrs. 67, 204 - 213.

Davis, M. B. (1965). A method for determining absolute pollen frequency. In 'Handbook of Paleontological techniques'. Ed. Kummel, B. and Raup, D. M., W. H. Freeman.

Davis, M. B. (1966). Determination of absolute pollen frequency. Ecology 47, N° 2, 310 - 311.

Davis, M. B. (1969). Climatic changes in southern Connecticut recorded by pollen deposition at Rogers Lake. Ecology 50, 409 - 422.

Davis, M. B. (1976). Erosion rates and land use history in southern Michigan. Env. Consv. 3, N° 2, 139 - 148.

Deacon, J. (1974). The location of refugia of Corylus avellana L. during the Weichselian glaciation. New Phytol. 73, 1055 - 1063.

Dickson, J. H. (1973). Bryophytes of the Pleistocene. Cambridge University Press, Cambridge.

Dickson, J. H. (1977). Western Scotland II. INQUA Excursion Guide C 13.

Dickson, J. H. (1978). Bronze Age Mead. Antiquity 52, 108 - 113.

Dickson, J. H. (1979a). Exotic food and drink in Scotland. Glasgow Nat. 19, part 6, 437 - 442.

Dickson, J. H. (1979b). The botany of brochs. Scott. Arch. Forum. 9, 62 - 65.

Dickson, J. H. (1980). Q. R. A. Field Guide, Glasgow Region, March - April 1980. Ed. Jardine, W. G. 64 - 65.

Dickson, J. H. , Dickson, C. A. and Breeze, D. J. (1979). Flour or bread in a Roman military ditch at Bearsden,Scotland. Antiquity 53, 47 - 51.

Dickson, C. A. and Dickson, J. H. (in press). The botanical remains. In 'Excavations at Crosskirk Broch'. Ed. Fairhurst, H. C.

Dimbleby, G. W. (1957). Pollen analysis of terrestial soils. New Phytol. 56, 12-28.

Dimbleby, G. W. (1961a). Soil pollen analysis. J. Soil Science 12, 1 - 11.

Dimbleby, G. W. (1961b). Transported material in the soil profile. J. Soil Science 12, 12 - 22.

Dimbleby, G. W. (1962). The Development of British Heathlands and their Soils. Oxford Forest Memoir, 23.

Dimbleby, G. W. (1965a). Post-glacial changes in soil profiles. Proc. Roy. Soc. Lond. (B) 161, 355 - 362.

Dimbleby, G. W. (1965b). In. 'A Mesolithic Site on Iping Common, Sussex, England.' Keef, P. A. M. , Wymer, J. J. and Dimbleby, G. W. (1965). P. P. S. 31, 85 - 92.

Dimbleby, G. W. (1975). Archaeological evidence of environmental change. Nature 256, 265 - 267.

Dimbleby, G. W. (1976). Climate, soil and man. Phil. Trans. Roy. Soc. Lond. (B) 275, 197 - 208.

Dimbleby, G. W. and Evans, J. G. (1974). Pollen and land-snail analysis of calcareous soils. J. Arch. Sci. 1, 117 - 133.

Donner, J. J. (1957). The geology and vegetation of late-glacial retreat stages in Scotland. Trans. Roy. Soc. Edinb. 63, 221 - 263.

Durno, S. E. (1958). Pollen analysis of peat deposits in eastern Sutherland and Caithness. Scott. Geogr. Mag. 74, 127 - 135.

Durno, S. E. (1959). Pollen analysis of peat deposits in the eastern Grampians. Scott. Geogr. Mag. 75, 102 - 111.

Durno, S. E. (1961). Evidence regarding the rate of peat growth. J. Ecol. 49, 349 - 351.

Durno, S. E. (1965). Pollen analytical evidence for "Landnam" in Scotland. Trans. Bot. Soc. Edinb. 40, 13 - 19.

Durno, S. E. and McVean, D. N. (1959). Forest history of the Beinn Eighe nature reserve. New Phytol. 58, 228 - 236.

Edwards, K. J. (1978). Excavation and environmental archaeology of a small cairn associated with cultivation ridges in Aberdeenshire. P. S. A. S. 109. 22 - 29.

Edwards, K. J. (1979). The environmental impact in the prehistoric period. Scott. Arch. Forum 9, 27 - 42.

Edwards, K. J. (1981). The separation of Corylus and Myrica pollen in modern and fossil samples. Pollen Spores 23, 205 - 218.

Edwards, K. J. and Larmour, R. (1978). Scanning electron micrographs of Myrica and Corylus pollen. Unpublished manuscript.

Edwards, K. J. and Ralston, I. (1978). New dating and environmental evidence from Burghead promontory fort, Moray. P. S. A. S. 109, 202 - 210.

Edwards, K. J. and Gunson, A. R. (1978). A procedure for the determination of exotic pollen concentrations using a Coulter counter. Pollen Spores 20, N° 2, 303 - 309.

Erdtman, G. (1924). Studies in the micropalaeontology of post-glacial deposits in north Scotland. J. Linn. Soc. 46, 449 - 504.

Erdtman, G. , Berglund, B. E. and Praglowski, J. (1961). An introduction to a Scandinavian pollen flora, Vol. 1. Almqvist and Wicksell, Stockholm.

Erdtman, G. Praglowski, J. and Nilsson, S. (1963). An introduction to a Scandinavian pollen flora, Vol 11. Almqvist and Wicksell, Stockholm.

Evans, E. E. (1975). Highland Landscapes:habitat and heritage. In 'The Effect of Man on the Landscape : the Highland Zone.' Ed. Evans, J. G. , Limbrey, S. and Cleere, H. ,C.; B. A. Res. Rep. 11.

Faegri, K. (1936). Quartargeolische Unterschungen im Westlichen Norwegen, I Uber zwei praboreale Klimaschwankungen im sudwestlichen Tiel Bergens Mus. Arbok, (1935), N° 8.

Faegri, K. and Iversen, J. (1974). Textbook of Pollen Analysis. (3rd Ed. by Faegri, K.). Blackwell, Oxford.

Fairhurst, H. C. (1981). Exploring Arran's Past. Central Press, Glasgow.

Fairhurst, H. C. and Taylor, D. B. (1971). A hut circle settlement at Kilphedir, Sutherland. P. S. A. S. 103, 65 - 99.

Frenzel, B. (1966). Climatic change in the Atlantic/Sub-Boreal transition in the northern hemisphere:botanical evidence. In 'Proc. Int. Symp. World Climate 8000 - 0 BC.' R. Meteorol. Soc. London, 99 -123.

Friedel, R. A. and Hoffer, L. J. E. (1970). Spectral characterisation of activated carbon. J. Phys. Chem. 74, (15), 2921 - 2922.

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

Gauld, W. W. (1980). Hill land use in Scotland. Trans. Bot. Soc. Edinb. 43, part 3, 167 - 175.

Geikie, Sir A. (1910). The building up of the Island. In 'The Book of Arran' Vol 1. Ed. Balfour, J., Arran Society of Glasgow.

Gemmel, A. M. D. (1971). The glaciation of the Island of Arran, Scotland. Unpublished PhD thesis, University of Glasgow.

Gemmel, A. M. D. (1973). The deglaciation of the Island of Arran, Scotland. Trans. Inst. Brit. Geogr. 59, 25 - 39.

Gibbs, J. N. (1978). Development of Dutch Elm Disease epidemic in southern England, 1971 - 1976. Ann. Appl. Biol. 88, 219 - 228.

Goddard, A. (1971). Studies of the vegetational changes associated with the initiation of blanket peat accumulation in N.E. Ireland. Unpublished PhD thesis, Queen's University, Belfast.

Godwin, H. (1958). Pollen analysis in mineral soil. An interpretation of a podsol pollen analysis by G. W. Dimbleby. Flora 146, 321 - 327.

Godwin, H. (1967a). Pollen analytical evidence for the cultivation of Cannabis in England. Rev. Palaeob. Palyn. 4, 71 - 80.

Godwin, H. (1967b). The ancient cultivation of hemp. Antiquity 41, 137 - 146

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

Godwin, H. (1978). Fenland : its ancient past and uncertain future. Cambridge University Press, London.

Godwin, H. and Willis, E. H. (1964). *Cambridge University Natural Radiocarbon measurements VI. Radiocarbon 6, 119 - 120.

Godwin, H. , Willis, E. H. and Switsur, V. R. (1965). Cambridge University Natural Radiocarbon Measurements VII. Radiocarbon 7, 207 - 208.

Greig-Smith, P. (1950). Evidence from hepatics on the history of the British Flora . J. Ecol. 38, 320 - 344.

Grigson, C. (1981). Neolithic Fauna. In 'The Environment in British Prehistory'. Ed. Simmons, I. G. and Tooley, M. , Duckworth, London. 191 - 199.

* (See 'Omissions', page 159, for Godwin and Willis, 1962)

Grosse-Brauckman, G. (1972). On plant macrofossils of central European peats. 1. Tissue remains of herbaceous plants and their characteristics. Telma 2, 19 - 55.

Grosse-Brauckman, G. (1974). On plant macrofossils of central European peats. 11. Some more remains and the possibilities for their identification. Telma 4, 51 - 117.

Guido, M. (1974). Milton Loch Crannog redated. Antiquity 48, 54 - 55.

Hafsten, U. and Solem, T. (1976). Age, origin and palaeoecological evidence of blanket bogs in Nord-Trondelag, Norway. Boreas 5, 119 - 141.

Havinga, A. J. (1963). A palynological investigation of soil profiles in cover-sand. Meded. Landboogesch. Wageningen. 63, 1 - 92.

Havinga, A. J. (1968). Some remarks on the interpretation of a pollen diagram of a podsol profile. Acta. Bota. Neerl. 17, 1 - 4.

Havinga, A. J. (1974). Problems of interpreting pollen diagrams from mineral soils. Geol. Mijn. 53, 449 - 453.

Headrick, Rev. J. A. (1807). A View of the Minerology, Agriculture, Manufactures, and Fisheries of the Island of Arran. Edinburgh, 1807.

Hedges, J. (1975). Excavation of two Orcadian burnt mounds at Liddle and Beaquoy. P. S. A. S. 106, 39 - 98.

Hedges, M. (1977). The excavation of the Knows of Quoyscottie, Orkney. P. S. A. S. 108, 130 - 155.

Henshall, A. S. (1964). Dagger grave and cist burials at Ashgrove, Methilhill, Fife. P. S. A. S. 97, 166 - 179.

Heybroek, H. M. (1963). Diseases and lopping for fodder as possible causes of a prehistoric decline in Ulmus. Acta. Bota. Neerl. 12, 1 - 11.

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

Hicks, S. P. (1975). Variations in pollen frequency in a bog at Kangerjoki, N.E. Finland during the Flandrian. Commentations Biologicae 80, 1 - 28.

Hicks, S. P. (1976). Pollen analysis and archaeology in Kuusamo, N.E. Finland, an area of marginal human interference. Trans. Inst. Brit. Geogr. 1, 362 - 384.

Hibbert, F. A. and Switsur, V. R. (1976). Radiocarbon dating of Flandrian pollen zones in Wales and northern England. New Phytol 77, 793 - 807.

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

Iversen, J. (1944). Viscum, Hedera and Ilex as climatic indicators. Geologiska forinengen i Stockholm. Forhandlingar 66, 463 - 483.

Iversen, J. (1954). The late-glacial flora of Denmark, and its relation to climate and soil. Danm. Geol. Unders. (Ser II) 80, 87 - 119.

Iversen, J. (1960). Problems of early post-glacial forest development in Denmark. Danm. Geol. Unders. 4, 1 - 32.

Iversen, J. (1964). Retrogressive vegetational succession in the post-glacial. J. Ecol. 52, 59 - 70.

Iversen, J. (1969). Retrogressive development of a forest ecosystem demonstrated by pollen diagrams from a fossil mor. Oikos. Suppl. 12, 35 - 49.

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

Jacobsen, G. L. (1976). Quantitative determination of charcoal by non-microscopic methods. (unpub.).

James, P. W. (1965). A new check list of British lichens. Lichenologist 3, 95 - 153.

Jardine, W. G. (1977). Location and age of Mesolithic coastal occupation sites on Oronsay, Inner Hebrides. Nature 267, 138 - 140.

Jessen, J. (1955). Key to subfossil Potamogeton. Saertyk af Botanisk Tidsskrift 52, 1 - 7.

Johansen, J. (1978). Cereal cultivation in Mykines, Faroe Islands,AD 600. Danm. Geol. Unders. Arbog (1978), 93 - 103.

Jones, R. L. (1979). Vegetational Studies. In ' Investigations in Orkney'. Ed. Renfrew, C.,The Society of Antiquaries of London.

Jorgensen, S. (1967). A method of absolute pollen counting. New Phytol. 66, 489 - 493.

Jowsey, P. (1966). An improved peat sampler. New Phytol. 65, 245 - 248.

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

Knights, B. A. ,Dickson, C. A. , Dickson, J. H. and Breeze, D. J. (in press). Evidence concerning the Roman military diet at Bearsden, Scotland, in the 2nd century AD.

Lacaille, A. D. (1954). The Stone Age in Scotland. Cambridge University Press, London.

Lamb, H. H. (1964). Trees and climatic history in Scotland. Q. Jl. R. Met. Soc. 90, 382 - 390.

Lamb, H. H. (1977). Climates: Past, Present and Future, Vol. 2. Methuen, London.

Low, A. J. (1972). The effect of cultivation on the structure and other physical characteristics of grassland and arable soils. J. Soil Sci. 23, 363 - 380.

Lowe, J.J. and Walker, M. J. C. (1977). The reconstruction of the late-glacial environment in the southern and eastern Grampian Highlands. In 'Studies in the Scottish Late-Glacial Environment.' Ed. Gray, J. M. and Lowe, J. J., pp 101 - 118. Pergamon Press, Oxford. 101 - 118

Lynch, A. (1981). Man and environment in south-west Ireland, 4000 BC - AD 800. B. A. R. 85.

Maher, L. J. (1972). Absolute pollen diagram of Redrock Lake, Boulder County, Colorado. Quat. Res. 2, 531 - 553.

Mamakowa, K. (1968). Lille Bukken and Leroy - two pollen diagrams from W. Norway. Arbok. Univ. Bergen. 4, 1 - 42.

Maltby, E. and Crabtree, K. (1976). Soil organic matter and peat accumulation on Exmoor : a contemporary and palaeoenvironmental evaluation. Trans. Inst. Brit. Geogr. 1, 259 - 278.

Marshall, D. N. (1978). The History of Bute. (7th Edn.). Buteshire Natural History Society.

Marshall, D. N., Scott, J. G. and Whittington, G. (1976). The excavation at the Hilton cairn. Trans. Bute. Nat. Hist. Soc. 20, 9 - 27.

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

MacArthur, J. (1873). The Antiquities of Arran. (2nd Edn.). Black, Edinburgh. (First pub. 1861).

McCallien, W. J. and Lacaille, A. D. (1941). The Campbeltown raised beach and its contained stone history. P. S. A. S. 75, 55 - 92.

MacDonald, C. M. (no date). The History of Argyll up to the beginning of the sixteenth century. Glasgow.

MacGregor, M. (1965). Excursion Guide to the Geology of Arran. Geological Society of Glasgow.

Mackenzie, W. M. (1910). In ' The Book of Arran Vol 2'. Ed. Balfour, J. Arran Society of Glasgow.

MacKereth, F. J. H. (1965). Some chemical observations on post-glacial lake sediments. Phil. Trans. Roy. Soc. Lond. (B) 250, 165 - 213.

MacKie, E. W. (1964). New excavations at the Monamore chambered cairn, Lamlash, Isle of Arran, in 1961. P. S. A. S. 97, 1 - 34.

McLellan, R. (1976). The Isle of Arran. David and Charles, Newton Abbot.

McLellan, R. (1977). Ancient Monuments of Arran. H. M. S. O., Edinburgh.

McVean, D. N. and Ratcliffe, D. A. (1962). Plant Communities of the Scottish Highlands. Monographs of the Nature Conservancy, No 1, H. M. S. O., London.

*Mannion, A. M. (1978). see 'Omissions' p 159.

Megaw, J. V. S. and Simpson, D. D. A. (1979). Introduction to British Prehistory. Leicester University Press.

Mellars, P. A. and Payne, S. (1971). Excavation of two Mesolithic shell middens on the Island of Oronsay. Nature 231, 397 - 398.

Mellars, P. A. (1976). Fire, ecology, animal populations and man: a study of some ecological relationships in prehistory. P. P. S. 42, 15 -46.

Mellars, P. A. (1979). Excavation and economic analysis of Mesolithic shell middens on the Island of Oronsay. Scott. Arch. Forum. 9, 43 - 61.

Mercer, J. (1968). Stone tools from Lealt Bay. P. S. A. S. 100, 1 - 46.

Mercer, J. (1970). The microlithic succesion in N. Jura, Argyll, west Scotland. Quaternaria 8, 177 - 185.

Mercer, J. (1971). A regression time stone workers camp, Lussa River, Jura. P. S. A. S. 103, 1 - 32.

Mercer, J. (1972). Microlithic and Bronze Age camps 75 - 26 feet OD., N. Carn, Isle of Jura. P. S. A. S. 104, 1 - 22.

Mercer, J. (1974a). The Neolithic level at Lussa Wood, N. Jura, Argyll. Glas. Arch. J. 3, 77.

Mercer, J. (1974b). Glenbatrick Waterhole : microlithic site on the Isle of Jura. P. S. A. S. 105, 9 - 32.

Mercer, J. (1974c). New ^{14}C dates from the Isle of Jura. Antiquity 48, 65 - 66.

Mercer, R. J. (1978). Field survey in the Blackwaterfoot and Machrie areas of the Isle of Arran, Bute. In 'Early Land Allotment in the British Isles'. Ed. Bowen, H. C. and Fowler, P. J., B. A. R. 48, 133 - 136.

Mitchell, G. F. (1965). Littleton Bog, Tipperary: an Irish agricultural record. J. Roy. Soc. Antiq. Ireland. 95, 121 - 132.

Mitchell, G. F. (1972). Soil deterioration associated with prehistoric agriculture in Ireland. 24th Int. Geol. Cong. Symposium 1. Earth Sciences and the Quality of Life. 59 - 68.

Moar, N. T. (1969a). Late Weichselian/Flandrian pollen diagrams from S.W. Scotland. New Phytol. 68, 433 - 467.

Moar, N. T. (1969b). Two pollen diagrams from mainland Orkney. New Phytol. 68, 201 - 208.

Moe, D. (1974). Identification key for the trilete microspores of the Fennoscandinavian Pteridophyta. Grana 14, 132 - 142.

Monro, D. A. (1703). Description of The Western Islands of Scotland. (visit to Arran in 1695). London.

Moore, P. D. (1970). Studies in the vegetational history of mid-Wales. II. The late-glacial period in Cardiganshire. New Phytol. 69, 363 - 375.

Moore, P. D. (1972a). The initiation of peat formation and the development of peat deposits in mid-Wales. Proc. 4th Int. Peat Congr. Helsinki, Vol 1., 89 - 100.

Moore, P. D. (1972b). Studies in the vegetational history of mid-Wales. III. Early Flandrian pollen data from west Cardiganshire. New Phytol. 71, 947 - 959.

Moore, P. D. (1973). The influence of prehistoric cultures upon the initiation of blanket peat in upland Wales. Nature 241, 350 - 353.

Moore, P. D. (1975). Origin of blanket mires. Nature 256, 267 - 269.

Moore, P. D. and Chater, E. H. (1969). Studies in the vegetational history of mid-Wales. I. Post-glacial period in Cardiganshire. New Phytol. 68, 183 - 196.

Moore, P. D. and Bellamy, D. (1974). Peatlands. Elek, London.

Moore, P. D. and Merryfield, D. L. (1974). Prehistoric human activity and blanket peat initiation on Exmoor. Nature 250, 439 - 441.

Moore, P. D. and Wilmott, A. (1976). Prehistoric forest clearance and the development of peatlands in the uplands and lowlands of Britain. Proc. 5th Int. Peat Congr. Poznan Poland, 1 - 15.

Moore, P. D. and Webb, J. A. (1978). An Illustrated Guide to Pollen Analysis. Hodder and Stoughton, Sevenoaks, Kent.

Mornsjo, T. (1968). Stratigraphical and chemical studies on two peatlands in Scania, south Sweden. Botaniska Notiser 121, 343 - 360.

Morris, C. D. (1979). Birsay, Orkney. P. P. S. 45, 330.

Morrison, A. (1978). The Bronze Age in Ayrshire. Ayrshire Archaeological and Natural History Society, Ayrshire Collections 12, N°4, 125 - 153.

Morrison, A. (1980). Early man in Britain and Ireland. Croom Helm, London.

Morrison, M. E. S. (1959). Evidence and interpretation of Landnam in the north-east of Ireland. Botaniska Notiser 112, 185 - 204.

New Statistical Account for Scotland, Vol. V, Edinburgh.

Parish of Kilbride, Rev A. McNaughton (1845), Vol. V, 1 - 39.

Parish of Kilmory, Rev. A. McMillan (1845), Vol V, 40 - 68.

Nichols, H. (1967). Vegetational change, shoreline displacement and the human factor in the late Quaternary history of the S.W. of Scotland. Trans. Roy. Soc. Edin. 67, 145 - 187.

Nordhagen, R. (1954). Ethnobotanical studies on bark bread and the employment of wych elm under natural husbandry. In 'Studies in Vegetational History in honour of Knud Jessen.'. Danm. Geol. Unders. 11R, N^{o} 80, 262 - 308.

Oldfield, F. (1959). The pollen morphology of some European Ericales. Pollen Spores 1, 19 - 48.

Oldfield, F. , Brown, A. and Thompson, R. (1979). The effect of micro-topography and vegetation on the catchment of airborne particles measured by remanent magnetism. Quat. Res. 12, 326 - 332.

O'Sullivan, P. E. (1974). Radiocarbon dating and prehistoric forest clearance on Speyside (east-central Highlands). P. P. S. 40, 206 - 208.

Paton, J. A. (1965). Census catalogue of British Hepatics (4th Ed.). British Bryological Soc., Ipswich.

Pears, N. (1975). The growth of hillpeat in Scotland. Geologiska Foreningers i Stockholm Forhandlingar 97, 265 - 270.

Peck, R. M. (1974). A comparison of four absolute pollen preparation techniques. New Phytol. 73, 567 - 587.

Peglar, S. M. (1979). A radiocarbon dated pollen diagram from the Loch of Winless, Caithness. New Phytol. 78, 245 - 263.

Pennington,W. (1970). Vegetation history in the N.W. of England: a regional synthesis. In 'Studies in the Vegetation history of the British Isles'. Ed. Walker, D. and West, R. G., Cambridge University Press, Cambridge, 41 - 79.

Pennington, W. (1975). The effect of Neolithic man on the environment in N.W. England: the use of absolute pollen diagrams. In 'The Effect of man on the landscape:the Highland Zone,' Ed. Evans, J. G. et al. C. B. A Res. Rep. 11. 74 - 86.

Pennington, W. (1977). Lake sediments and the late-glacial env. in N Scotland. In 'Studies in the Scottish Late-Glacial Environment.' Ed. Gray, J. M. and Lowe, J. J. , Pergamon Press, Oxford. 119 - 142.

Pennington, W. , Haworth, E. Y. , Bonny, A. P. and Lishman, J. P. (1972). Lake sediments in northern Scotland. Proc. Roy. Soc. Lond. (B) 264, 191 - 294.

Perring, F. and Walters, S. M. (1976). Atlas of the British Flora. E. P. Publishing Ltd. for the B. S. B. I.

Piggott, C. M. (1953). Milton Loch Crannog:a native house of the 2nd century AD. in Kirkcudbrightshire. P. S. A. S. 87, 134 - 152.

Piggott, S. (1972). Excavation at the Dalladies long barrow, Fettercairn, Kincardineshire. P. S. A. S. 104, 23 - 47.

Piggott, S. (1973). The Dalladies long barrow:N E Scotland. Antiquity 47, 32 - 36.

Piggott, S. (1973b). A note on climatic deterioration in the Ist millenium BC in Britain. Scott. Arch. Forum. 4, 109 - 113.

Pilcher, J. R. (1968). Some applications of the scanning electron microscope to the study of modern and fossil pollen. Ulst. J. Arch. 31, 87 - 91.

Pilcher, J. R. (1969). Archaeology, palaeoecology and ^{14}C dating of the Beaghmore site. Ulst. J. Arch. 32, 73 - 91.

Pilcher, J. R. (1973). Pollen analysis and radiocarbon dating on a peat on Sleive Gullion, Co. Tyrone, N. Ireland. New Phytol. 72,681-689.

Pilcher, J. R. (1974). The botanical evidence. In 'Dun Mor Vaul'. MacKie, E. W., Glasgow University.

Pilcher, J. R. , Smith, A. G. ,Pearson, G. W. and Crowder, A. (1971). Land clearance in the Irish Neolithic : new evidence and interpretation. Science 172, 560 - 562.

Pilcher, J. R. and Smith, A. G. (1979). Palaeoecological investigations at Ballynagilly, a Neolithic and Bronze Age settlement in Co Tyrone, N. Ireland. Phil. Trans. Roy. Soc Lond. (B) 286, 345 - 369.

Price, R. J. (1980). Geomorphological implications of environment changes during the last 30000 years in Central Scotland. Z. Geomorph. N. F. Suppl. 36, 74 - 83.

Proudfoot, E. V. W. (1978). Camelon native site. P. S. A. S. 109, 112 - 128.

Rackham, O. (1975). Hayley Wood, its history and ecology. Cambridgeshire and Isle of Ely Naturalists Trust Ltd.

Rackham, O. (1980). Ancient Woodland. Edward Arnold, London.

Radley , J. et al. (1974). The excavation of three narrow blade sites in the southern Pennines, England. P. P. S. 40, 1 - 19.

Ratcliffe, D. A. (1977). A Nature Conservancy Review. Cambridge University Press, London, for the N.C.C. and N.E.R.C.

Reitsma, T. (1966). Pollen morphology of some European Rosaceae. Acta. Bot. Neerl. 15, 290 - 307.

Reitsma, T. (1967). Some aspects of the pollen morphology of the genus Sanguisorba L. (Rosaceae). Rev. Palaeob. Palyn. 4, 305 - 310.

Renfrew, C. (1973). Before Civilisation, the radiocarbon revolution and prehistoric Europe. Cape, London.

Renfrew, C. (1979). Investigations in Orkney. The Society of Antiquaries of London.

Ritchie, J. N. G., Ritchie, A., Whittington, G. and Soulsby, J. (1974). A prehistoric field boundary from the Black Crofts, North Connel, Argyll. Glas. Arch. J. 3 - 4, 66 - 70.

Ritchie, J. N. G., Thornber, I., Lynch, F. and Marshall, D. N. (1975). Small cairns in Argyll:some recent work. P. S. A. S. 106, 15 - 38.

Ritchie, J. N. G. (1976). The Stones of Stenness. P. S. A. S. 107, 1 - 60.

Ritchie, J. N. G. and Crawford, J. (1978). Excavations at Sorisdale Killunaig, Coll. P. S. A. S. 109, 75 - 103.

Ritchie, J. N. G. and Ritchie, A. (1981). Scotland : Archaeology and Early History. Thames and Hudson, London.

Robinson, M. and Hubbard, R. L. N. B. (1977). Transport of pollen in the bracts of hulled cereals. J. Arch. Sci. 4, 197 - 199.

Romans, J. C. C. (1962). The origin of the indurated B_3 horizon of podsolic soils in N.E. Scotland. J. Soil. Sci. 13, 141 - 147.

Romans, J. C. C., Durno, S. E. and Robertson, L, (1973). A fossil brown forest soil from Angus. J. Soil Sci. 24, 125 - 128.

Romans, J. C. C. and Robertson, L. (1975). Soils and archaeology in Scotland. In ' The Effects of Man on the Landscape: the Highland Zone' Ed. Evans, J. G. et al. C. B. A. Research Report 11. 124 - 127.

Roy, A. E. et al. (1963). A new survey of the Tormore circles. Trans. Glas. Arch. Soc. n.s. 15, part 2, 59 - 67.

Rymer, L. (1974). The Palaeoecology and Historical Ecology of the Parish of North Knapdale, Argyll. Unpublished PhD thesis, University of Cambridge.

Rymer, L. (1977). A late-glacial and early-post glacial pollen diagram from Drimnagill, North Knapdale, Argyll. New Phytol. 79, 211 - 221.

Scott, J. G. (1966). South West Scotland. Regional Archaeologies, Heineman, London.

Schofield, J. (1976). Excavations south of Edinburgh High Street. P. S. A. S. 107, 155 - 241.

Seddon, B. (1967). Prehistoric climate and agriculture: a review of recent palaeoecological investigations. In 'Weather and Agriculture' Ed. Taylor, J. A. Pergamon, Oxford. 173 - 185.

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

Simmons, I. G. (1969). Evidence for vegetation changes associated with Mesolithic man in Britain. In 'The Domestication and Exploitation of Plants and animals'. Ed. Ucko, P. J. and Dimbleby, G. W. London. 111 - 119.

Simmons, I. G. (1975a). The ecological setting of Mesolithic man in the highland zone. In ' The Effect of Man on the Landscape: the Highland Zone'. Ed. Evans, J. G. et al. C. B. A. Res. Rep. 11. 57 - 63.

Simmons, I. G. (1975b). Towards an ecology of Mesolithic Man in the uplands of Britain. J. Arch Sci. 2, 1 - 15.

Simmons, I. G. and Dimbleby, G. W. (1974). The possible role of ivy (Hedera helix L.) in the Mesolithic economy of W. Europe. J. Arch. Sci. 1, 291 - 296.

Simmons, I. G. and Cundill , P. R. (1974). Late Quaternary vegetational history of the North York Moors. 1. Pollen analyses of blanket peats. J. Biogr. 1, 159 - 169.

Simmons, I. G. , Dimbleby, G. W. and Grigson, C. (1981). The Mesolithic. in 'The Environment in British Prehistory'. Ed. Simmons, I. G. and Tooley, M. Duckworth, London. 82 - 124.

Simpkins, K. (1974). The late-glacial deposits at Glanllynan, Caernarvon. New Phytol. 73, 605 - 618.

Sims, R. E. (1973). The anthropogenic factor in East Anglian vegetational history: and approach using A. P. F. techniques. In 'Quaternary Plant Ecology'. Ed. Birks, H. J. B. and West, R. G. Blackwell, Oxford. 223 - 236.

Sissons, J. B. , Lowe, J. J. , Thompson, K. S. R. and Walker, M. J. C. (1973). The Loch Lomond Readvance in the Grampian Highlands of Scotland. Nat. Phys. Sci. 244, 75 - 77.

Smith, A. G. (1961). Cannons Lough, Kilrea Co Derry: stratigraphy and pollen analysis. Proc. Roy. Soc. Irish. Acad. 61B, 369 - 383.

Smith, A. G. (1970). The influence of Mesolithic and Neolithic man on British vegetation - a discussion. In 'Studies in the Vegetation History of the British Isles'. Ed. Walker, D. and West, R. G. Cambridge University Press, London. 81 - 96.

Smith, A. G. (1975). Neolithic and Bronze Age landscape changes in Northern Ireland. In 'The Effect of Man on the Landscape:the Highland Zone.' Ed. Evans, J. G. et al. C. B. A. Res. Rep. 11. 64 - 74.

Smith, A. G. and Willis, E. H. (1962). Radiocarbon dating of the Fallahogy landnam phase. Ulst. J. Arch. 25, 16 - 24.

Smith, A. G. and Collins, A. E. P. (1971). The stratigraphy, palynology and archaeology of diatomite deposits at Newferry, Co Antrim, Northern Ireland. Ulst. J. Arch. 34, 3 - 25.

Smith, A. G. , Pearson, G. W. and Pilcher, J. R. (1971a). Belfast Radiocarbon Dates. Radiocarbon 13, 124.

Smith, A. , Pearson, G. W. and Pilcher, J. R. (1971b). Belfast Radiocarbon Dates. Radiocarbon 13, 465.

Smith, A. G. and Pilcher, J. R. (1972). Pollen analysis and radiocarbon dating at Sleive Gallion, Co Armagh, Northern Ireland. Ulst. J. Arch. 35, 17 - 21.

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

Smith, A. G. ,Grigson, C. , Hillman, G. and Tooley, M. (1981). The Neolithic. In 'The Environment in British Prehistory'. Ed. Simmons I. G. and Tooley, M. Duckworth, London. 125 - 210.

Smith, D. M. , Griffin, J. J. and Goldberg, E. D. (1973). Elemental carbon in marine sediments:a baseline for burning. Nature 241, 268 - 270.

Smith, D. M. , Griffin, J. J. and Goldberg, E. D. (1975). Spectrometric method for the quantitative determination of elemental carbon. Analytical Chemistry 47, 233 - 238.

Smith, A. J. E. (1978). The Moss Flora of Britain and Ireland. Cambridge University Press, Cambridge.

Sorsa, P. (1964). Studies on the spore morphology of Fennoscandinavian fern species. Ann. Bot. Fenn. 1, 179 - 201.

Soulsby, J. A. (1976). Palaeoenvironmental interpretation of a buried soil at Achnacree, Argyll. Trans. Inst. Br. Geog. 1, 279 -283.

The Statistical Account of Scotland (1793). Ed. Sinclair, Sir J. Glasgow. Parish of Kilbride, Stuart, Rev G., Vol VIII, 578 - 582.
Parish of Kilmory, Hamilton, Rev. J. Vol. IX, 165 - 171.

Stewart, M. E. C. (1964). The excavation of two circular enclosures at Dalnaglar, Perths. P. S. A. S. 95, 134 - 158.

Stewart, W. (1901). Notes on the occurence of Trichomanes radicans Sw. in Scotland. Trans. Nat. Hist. Soc. Glas. 6(ns), 18.-

Stockmarr, J. (1971). Tablets with spores used in absolute pollen analysis. Pollen Spores 13, N^{o}4, 615 - 621.

Stockmarr, J. (1972). Determination of spore concentration with an electronic particle counter. Danm. Geol. Unders. Arbog (1972), Kobenhavn. 1973.

Storrie, M. C. (1967a). Balliekine, Arran:Survivor of two revolutions. Folk Life 5, 92 -98.

Storrie, M. C. (1967b). Landholdings and population in Arran from the late Eighteenth Century. Scottish Studies 2, 49 -74.

Swain, A. M. (1973). A history of fire and vegetation in north-eastern Minnesota as recorded in lake sediments. Quat. Res. 3, 383 - 396.

Swain, A. M. (1978). Environmental changes during the past 2000 years in north-central Wisconsin:analysis of pollen, charcoal and seeds from varved lake sediments. Quat. Res. 10, 55 - 68.

Tallis, J. H. (1964a). Studies on southern Pennine peats. 1. The general pollen record. J. Ecol. 52, 323 - 331.

Tallis, J. H. (1964b). Studies on southern Pennine peats. 2. The pattern of erosion . J. Ecol. 52, 332 - 344.

Tallis, J. H. (1975). Tree remains in southern Pennine peats. Nature 256, 482 - 484.

Tallis, J. H. and Switsur, V. R. (1973). Studies on southern Pennine peats. 6. A radiocarbon dated pollen diagram from Featherbed Moss, Derbyshire. J. Ecol. 61, 743 - 751.

Tauber, H. (1965). Differential pollen dispersal and the interpretation of pollen diagrams, with a contribution to the interpretation of the elm fall. Danm. Geol. Unders. (ser II), 89, 7 - 64.

Taylor, J. A. and Smith, R. T. (1972). Climatic peat - a misnomer? Proc. 4th Int. Peat Congr. Helsinki, Vol 1, 471 - 484.

Taylor, J. A. and Tucker, R. B. (1968). The peat deposits of Wales : an inventory and interpretation. Proc. 3rd Int. Peat Congr. Quebec, 163 - 173.

Ten Hove, H. A. (1968). The Ulmus fall at the transition Atlanticum/ Subboreal in pollen diagrams. Palaeogeogr. Palaeoclimatol. Palaeoecol. 5, 359 - 369.

Tomkieiff, S. I. (1961). Isle of Arran. Geologists' Association Guides, No 32, Colchester.

Troels-Smith, J. (1955). Karakterising af løse jordater. Danm. Geol. Unders. IV, 3, 1 - 73.

Troels-Smith, J. (1960a). Ivy, mistletoe and elm: climatic indicators - fodder plants. Danm. Geol. Unders. IV, 4, 1 - 32.

Turner, J. (1964). The anthropogenic factor in vegetational history. 1. Tregaron and Whixall Mosses. New Phytol. 63, 73 - 90.

Turner, J. (1965). A contribution to the history of forest clearance. Proc. Roy. Soc. Lond. (B) 161, 343 - 354.

Turner, J. (1970). Post-Neolithic disturbance of the British vegetation. In ' Studies in the Vegetation History of the British Isles'. Ed. Walker, D. and West, R. G., Cambridge University Press, Cambridge. 97 - 116.

Turner, J. (1975). The evidence for land use by prehistoric farming communities: the use of three dimensional pollen diagrams. In ' The Effect of Man on the Landscape:the Highland Zone', Ed. Evans, J. G. et al. C. B. A. Research Report 11. 86 - 95.

Tyrrell, G. W. (1928). The Geology of Arran, Geological survey. Edinburgh.

Van Geel, B. (1978). A palaeoecological study of holocene peat bog sections based on the analysis of pollen, spores, and the macro and microscopic remains of fungi, algae, cormophytes and animals. Rev. Palaeob. Palyn. 25, 1 - 120.

Vasari, Y. (1977). Radiocarbon dating of the late-glacial and early Flandrian vegetational succession in the Scottish Highlands and the Isle of Skye. In ' Studies in the Scottish Late-Glacial Environment'. Ed. Gray, J. M. and Lowe, J. J. Pergamon Press, Oxford. 143 - 162.

Waddington, J. C. B. (1969). A stratigraphic record of the pollen influx to a lake in the Big Woods of Minnesota. Geol. Soc. Amer., Special paper 123, 263 - 282.

Walker, D. (1966). The late Quaternary history of the Cumberland lowland. Phil. Trans. Roy. Soc. Lond. (B) 251, 1 - 210.

Warburg, E. F. (1963). Census catalogue of British mosses (3rd Ed.). British Bryological Society, Ipswich.

Watts, W. A. (1961). Post Atlantic forests in Ireland. Proc. Linn. Soc. Lond. 172, 33 - 38.

Whittington, G. (1978). A sub peat dyke on Shurton Hill, Mainland Shetland. P. S. A. S. 109, 30 - 35.

Whittle, A. (1978). Resources and population in the British Neolithic. Antiquity 52, 34 - 32.

Whittle, A. (1979). The Scourd of Brouster, Shetland. D. E. S. ,48.

Whittle, A. (1980). Scourd of Brouster, Shetland. Current Archaeology 65, 167 - 170.

Wilson, D. G. (1975). Plant remains from the Graveney Boat and the early history of Humulus lupulus L. in western Europe. New Phytol. 75, 627 - 648.

Wilson, D. G. (1978). Plant remains including the evidence for hops. In 'The Graveney Boat:a Tenth Century Find in Kent'. Ed. Fenwick, V. B. A. R. 53, 133 - 150.

Omissions

Godwin, H. and Willis, E. H. (1962). Cambridge University Natural Radiocarbon Measurements. Radiocarbon 4, 57 - 70.

Mannion, A. M. (1978). A pollen analytical investigation at Threepwood Moss. Trans. Bot. Soc. Edinb. 43, 105 - 114.

Birks, H. J. B. (1976). Late Wisconsin Vegetation at Wolf Creek, Central Minnesota. Ecological Monographs 46, 395 - 429.

Personal Communications

Personal communications are gratefully acknowledged from the following people :-

Bent Aaby - Danish Geological Survey, Copenhagen.

John Barber - Central Excavation Unit (SDD), Edinburgh.

Dr. H.J.B. Birks - The Botany School, University of Cambridge.

Dr. S.C. Beckett - The Botany School, University of Cambridge.

Professor L. Alcock - Department of Archaeology, Glasgow University.

Dr. A.M. Mannion - Department of Geography, University of Reading.

Professor F. Oldfield - Department of Geography, University of Liverpool.

Dr. G.L. Jacobson - Department of Botany, University of Maine.

Abbreviations of Journal Titles

B. A. R. - British Archaeological Reports.

C. B. A. Res. Rep. - Council for British Archaeology Research Report.

D. E. S. - Discovery and Excavation in Scotland.

P. P. S. - Proceedings of the Prehistoric Society.

P. S. A. S. - Proceedings of the Society of Antiquaries of Scotland.

T. D. G. N. H. A. S. - Transactions of the Dumfries and Galloway Natural History and Antiquaries Society.

APPENDIX A1

PROCEDURE FOR THE PREPARATION OF SEDIMENT SAMPLES FOR POLLEN ANALYSIS

1. Record all relevant information about the site, the location, collection method etc. and about the level being sampled, on a log sheet/record book.
2. Make a smear of the peat on a microscope slide with a drop of water. Primarily this is to check for excessive mineral content but other striking features should be noted especially if they are likely to be lost in the ensuing chemical treatments.
3. Clean the surface of the core/monolith around the level to be sampled, using horizontal strokes of a clean scalpel/spatula.
4. Remove a ½/1 cm slice of peat about 2 - 4 gms in weight and place in a pre-labelled centrifuge tube.
5. Add approx. 10mls 10% sodium hydroxide and place in a boiling water-bath for about 5 minutes stirring, occasionally with a glass rod, record darkness of solution as it gives an indication of the degree of humification of the peat.
6. Remove the tube and stir briskly, sieve through 150μ mesh sieve into a 100ml beaker. Wash the material on the sieve throughly with a fine jet of distilled water.
7. Wash material retained on sieve into a labelled petri dish and keep the sievings for later examination for plant macrofossils etc.
8. Return contents of beaker to centrifuge tube, centrifuge and decant.
9. Wash repeatedly with distilled water, stir, centrifuge and decant until the supernatant is clear.
10. If the sediment smear revealed a high mineral content in the peat carry out steps 10 - 15, otherwise move to step 16.

If the sample is not already in a plastic centrifuge tube transfer it to one using a minimal amount of 7% HCl.

11. In a fume cupboard, wearing protective gloves etc. and with extreme care, add ca. 20mls concentrated hydrofluoric acid (HF). Place caps on the tubes and leave for at least 12 hours, preferably 2 - 3 days.
12. Remove caps and dilute HF with 95% ethanol - this reduces the specific gravity of the solution and aids separation of the sediment by centrifugation.
13. If mineral material remains repeat the procedure. If not, half fill the tube with 10% HCl and place in a boiling water bath for about 15 mins this removes colloidal silicates and silicofluorides.

Carry out steps 14 - 17 in a fume cupboard to avoid unpleasant and dangerous fumes evolved in the acetolysis process.

14. Centrifuge while still hot and decant - repeat the HCl treatment until the yellow colour disappears from the supernatant.

15. Wash with distilled water, stir, centrifuge and decant.

16. Stir the sediment and add ca. 10ml glacial acetic acid stir, centrifuge and decant.

17. Add 9ml acetic anhydride and 1ml concentrated sulphuric acid (care is needed) stir and place in a boiling water bath for 3 - 5 min. Stir occasionally removing the glass rods each time. This prevents steam condensing on the rods and running down into the tubes where it reacts explosively with the anhydrous mixture.

18. Remove the tube from the water bath, add glacial acetic acid to within 2cm of the top of the tube, stir centrifuge and decant.

19. Stir, add 10mls glacial acetic acid, stir, centrifuge and decant. This final addition of glacial acetic acid removes the soluble cellulose acetate products of acetolysis.

20. Stir and using as little distilled water as possible transfer to 10ml conical glass centrifuge tube, stir, centrifuge and decant.

21. Stir, add 9 - 10mls distilled water and adjust the pH to 7 using drops of 10% NaOH, pH7 is the optimum for staining (Faegri, 1936), stir, centrifuge and decant.

22. Add several drops of aqueous safranin stir, leave for a few seconds, then add 10mls distilled water, stir, centrifuge and decant.

23. Stir add ca. 10ml tertiary butyl alcohol (TBA), stir, centrifuge and decant.

24. Washed sediment into a small labelled vial with a minimum of TBA. Stir briskly and gently centrifuge. Remove the clear supernatant using a Pasteur pipette.

25. Add silicone oil (2000c/s viscosity) dropwise to the vial to about 1 - 2 times the volume of the sediment. Stir very thoroughly and leave the vial uncorked in an oven at 50°C for 12 - 24 hours to allow the remaining TBA to evaporate.

26. To prepare a slide for counting a drop of the pollen residue is placed in the centre of a clean slide 0.8mm thick. This is then carefully spread out to the size of the cover slip (a guide square on a piece of paper is useful), any coarse material being removed with a needle and forceps. The slide is then left on a hotplate for a few minutes to allow the residue to level out, minimising the risk of trapped air bubbles. At number zero cover slip is then lowered onto the slide.

NB. If the resulting slide is too thick or has too high a concentration of grains for comfortable counting the initial drop can be diluted with silicon oil before it is smeared out.

27. It is useful to tack the corners of the coverslip using nail polish or a commercial substance such as Glyceel.

APPENDIX A1(b)

PREPARATION OF PEAT SAMPLES FOR 'ABSOLUTE' POLLEN ANALYSIS USING LYCOPODIUM TABLETS

The procedure for preparing samples for absolute analysis is identical to the standard method already described, apart from the fact that the starting weight or volume of the sediment must be known exactly. This is in order to calculate the pollen concentration and, ultimately, influx rates into the sediment.

The method for determining the exact weight of the initial sample is self explanatory. Measuring the exact volume of sediment is slightly more difficult. The procedure described by Bonny (1972) requires the use of an accurate measuring cyclinder with a narrow 0.5cm bore. To this is added an exact volume of distilled water, say 10ml. Sediment is then carefully crumpled into the cylinder until the meniscus reads a volume 2ml greater (i.e. 12ml if a 2ml sample is required). The sediment, being water saturated, sinks and displaces exactly its own volume of water.

The content of the measuring cyclinder are carefully transferred to a centrifuge tube and the required number of *Lycopodium* tablets added before proceeding as in the standard method. Generally enough *Lycopodium* tablets are added to give a ratio of 10:4 fossil to exotic grains/spores (Stockmarr, 1971). In the batch of tablets used each one contained 12,500 ± 500 spores. Counting the slides is by the same method as employed for percentage counts, the exotic grains being scored as they are encountered along with the fossil grains.

APPENDIX A1(c)

A METHOD FOR QUANTITATIVE CHARCOAL ANALYSIS IN PEAT

1. Take 7 - 10gm of peat, place in a weighed cruicible and weigh. Calculate wet weight (W).

2. Place crucible in oven at 70°C for 12 - 24 hours - remove from oven, grind in pestle and mortar to a coarse powder. Reweigh crucible and sample.

3. Replace in oven at 105°C for 4 - 5 hours then weigh every ½ hour. When 3 consecutive weights are the same, take that weight to calculate the dry weight (D).

NB If desired the % dry matter of the peat can be calculated at this stage D/W x 100 = %DM.

4. Transfer the dry powder carefully to a conical (50ml) glass centrifuge tube, brush out crucible with a paint brush and reweigh.

5. Add ca. 10ml sodium hydroxide (NaOH) to the powder and place the tube in a boiling water bath for about 5 min stirring vigorously - centrifuge and decant.

6. Wash the pellet repeatedly with distilled water until the supernatant is clear (stir, centrifuge and decant).

7. Transfer the pellet to centrifuge tube using an absolute minimum of distilled water.

8. In a fume cupboard add ca. 20 - 30 ml conc. nitric acid (HNO_3) and place the tube in a boiling water bath for 1 - 2 hours as necessary. This removes all the non-charred organic material in the sample. Stir and swirl the tube occasionally to prevent the material sticking to it. It may be necessary to top up the contents with dilute nitric acid. Any frothing can be dealt with using n-octanol.

9. Carefully transfer the contents of the flask back into the centrifuge tube whilst still hot - centrifuge and decant.

10. Add ca. 20 mls 10% HNO_3, stir, centrifuge and decant.

11. Wash twice with distilled water, stir centrifuge and decant.

12. Wash the residue back into the original crucible using a minimal amount of 95% ethanol. Allow the ethanol to evaporate in an oven at 50°C.

13. Completely dry the residue at 70°C for 24 hours, reweigh, calculate residue weight (R).

14. Place the residue in a muffle furnace at 400°C for 4 - 5 hours. This removes all remaining organic material, leaving only mineral and ash.

15. Reweigh and calculate the weight of the mineral (M), use this to calculate the charcoal content of the residue (C = R-M).

16. Express the charcoal content as a percentage of the original dry weight C/D x 100 = C%.

NB When transferring the crucible to the balance, use an efficient dessicator. The weights should be as accurate as possible, preferably to 4 decimal places.

APPENDIX A1(d)

LOSS ON IGNITION DETERMINATION FOR PEAT SAMPLES

1. Remove 7 - 10 gms of peat, place in a weighed crucible and weigh - calculate wet weight (W).
2. Place in an oven at 70°C for 12 - 24 hours - remove and grind sample to a coarse powder with a pestle and mortar, reweigh crucible and sample, return to the oven for a further 4 - 5 hours. Then weigh every ½ hour until 3 consecutive weights are the same. Take that weight to calculate the dry weight (D).
3. Return to the oven and increase the temperature to 400°C. Leave for 5 - 6 hours. This burns off all organic material leaving the mineral.
4. Reweigh the crucible and use this to calculate the weight of mineral (M).
5. Calculate the % on ignition (D-M/D x 100) or percentage mineral content (M/D x 100).

NB Crucibles should always be transferred from oven to balance in a dessicator. Weights should be in gms and accurate to 4 decimal places.

APPENDIX A2

VEGETATION SURVEY AND SURFACE POLLEN SPECTRA

During a field work trip to Arran in June 1979 a limited vegetation survey was undertaken, principally around the sampling sites and in woodland types not covered by Adam et al.(1977). A collection of material from moss polsters, surface litter and humus within some of the quadrats was also made. Pollen analysis was later carried out on these samples to investigate surface pollen spectra. The exercise was not really extensive enough to merit full discussion as an insufficient number of quadrats and surface samples were analysed. However I felt that the data were of interest, particularly those from near the sampling sites, hence their inclusion here.

Methods

Vegetation

The vegetation was surveyed using standard techniques involving quadrats and cover abundance recording on the Domin scale. Species in close proximity to, but not in, the quadrats were also recorded. The data are presented in Table A2.1, the site code numbers refer to the sites listed later in this section.

Surface Samples

A 20 x 30 cm plastic sample bag was filled with material from each of the quadrat sites sampled. The contents of the bags were boiled up in distilled water before being sieved through a 150 μ sieve, followed by further boiling and sieving. The coarse plant debris on the sieve was discarded and the sieved liquid was concentrated by centrifugation before being prepared for pollen analysis in the normal fashion (Appendix 1A). The results of the counts are expressed as percentages of total land pollen in Fig. A2.1 The code numbers on the pollen diagram refer to the sites listed below.

Sites

Ar/1/79 Aird nan Ron (NR 905 244) oakwood, canopy at 25' maximum on steep west-facing raised beach cliff. 4 x 4 metre quadrat under closed canopy.

Ar/2/79 Aird nan Ron (NR 905 244) oakwood with Populus tremula understorey on steep west-facing raised beach cliff. 4 x 4 metre quadrat, surface sample collected.

Ar/3/79 Machrie Moor (NR 905 315) site of main section MML80, bog surface vegetation dominated by Molinia caerulea. Evidence of burning of bog surface within last 2 - 3 years. 5 x 5 metre quadrat, surface sample collected.

Ar/4/79 Machrie Moor (NR 901 315) 400 metres west of coring site. Surface vegetation dominated by Calluna vulgaris and Erica tetralix with Molinia caerulea. Area burnt 1 - 2 years ago. 5 x 5 metre quadrat, surface sample collected.

Ar/5/79 Tormore (NR 896 312) cut over bog surface 50 metres to the west of the excavation site and close to the site of TM1. Surface vegetation dominated by Myrica gale and Molinia gale. 5 x 5 metre quadrat, surface sample collected.

Ar/6/79 Tormore (NR 895 313) east-facing 10° slope, 100 metres to north-east of excavation site. Surface vegetation, an even-aged stand of Calluna vulgaris several years old ca. 25 cm high. 5 x 5 metre quadrat, surface sample taken.

Ar/7/79 Tormore (NR 896 311) very acid marshy area with Sphagnum hummocks 100 metres south of the excavation site. 2 x 2 metre quadrat, surface sample taken.

Ar/8/79 Dougarie (NR 877 377) oakwood,full canopy, all the trees are poor and show signs of coppicing on west-facing raised beach slope which is rather terraced. The area is lightly grazed. 4 x 4 metre quadrat, surface sample collected.

Ar/9/79 Dougarie (NR 877 378) oakwood 100 metres to the north of Ar/8/79, rather more open canopy. 4 x 4 metre quadrat.

Ar/10/79 Slidderywater (NR 943 237) alderwood by the Slidderywater, off the Ross road. All the trees were quite old and had multiple trunks. The canopy was fairly open at a height of 8 - 10 metres. 4 x 4 quadrat.

Ar/11/79 Slidderywater (NR 943 237) alderwood by the Slidderywater, off the Ross road as in Ar/10/79. 5° - 10° slope and a small channel running diagonally through the quadrat. 4 x 4 metre quadrat, surface sample taken.

Ar/12/79 Machrie shore (NR 893 338) south-margin of a pool in a dune-slack-type depression. 2 x 2 metre quadrat.

Ar/13/79 Machrie shore (NR 893 338) south east margin of above pool. 1 x 1 metre quadrat.

Ar/14/79 Machrie shore (NR 893 338) east margin of above pool. 2 x 2 metre quadrat.

Ar/15/79 Cleiteadh Buidhe (NR 892 349) hazel wood at landward side of raised beach platform. A full canopy on a west-facing $20^{\circ} - 25^{\circ}$ slope. Quadrat 4 x 4 metres.

APPENDIX A3

A HAZEL NUT BED IN PEAT AT BLACKWATERFOOT, ARRAN

During a field work trip to Arran in February, 1979, a hazel nut bed in a peat layer was brought to my notice. It was found by a local farmer at Blackwaterfoot (NR 898 284) in the course of drainage work. The bed was at the base of about a metre of peat over which was a peaty soil which supported damp pasture. No further details were collected at the time.

A sample was taken from the layer and later analysed for pollen. The pollen count is contained in Table A3.1.

The peat was probably laid down at the margins of a lagoon caused by the periodic flooding of the Blackwater, which until recently (Headrick, 1807) has had its passage to the sea impeded by rock bar acrosss its mouth. The area still floods regularly, hence the need for drainage.

With regard to the age of the layer, the high alder, oak and elm and low grass values plus the absence of heather and plantain pollen suggest that it is post-alder rise and pre-elm decline, possibly around 6000 BP. Certainly comparison with MML80 from Machrie Moor is consistent with this being the case.

Table A3.1

Pollen Analysis Data from the Blackwaterfoot Hazel Bed

	Total	% Total Pollen	% Tree Pollen
Betula	22	3.5	6.0
Quercus	36	6.0	10.5
Alnus	266	42.0	78.0
Ulmus	18	3.0	5.5
Fraxinus	1	0.2	0.3
Hedera	2	0.3	0.6
Salix	1	0.2	0.3
Corylus type	201	32.0	59.0
Myrica type	14	2.0	4.0
Coryloid (sum Corylus T and Myrica T)	215	34.0	63.0
Gramineae	41	6.5	12.0
Cyperaceae	2	0.3	0.6
Filicales undiff.	12	2.0	3.5
Polypodium	2	0.3	0.6
Sphagnum	5	0.8	1.5
Compositae	1	0.2	0.3
Filipendula	3	0.5	0.9
Rumex	2	0.3	0.6
Pteridium	2	0.3	0.6
Myriophyllum alternifolium	2	0.3	0.6
Potamogeton	1	0.2	0.3
Obscured	34		
Broken	85		
Crumpled	10		
Total Tree Pollen	343		
Total Land Pollen	634		
Total unidentified	151		

APPENDIX A4

POLLEN ANALYSIS DIRECTLY ASSOCIATED WITH ARCHAEOLOGICAL EXCAVATIONS IN SCOTLAND

The Mesolithic Period

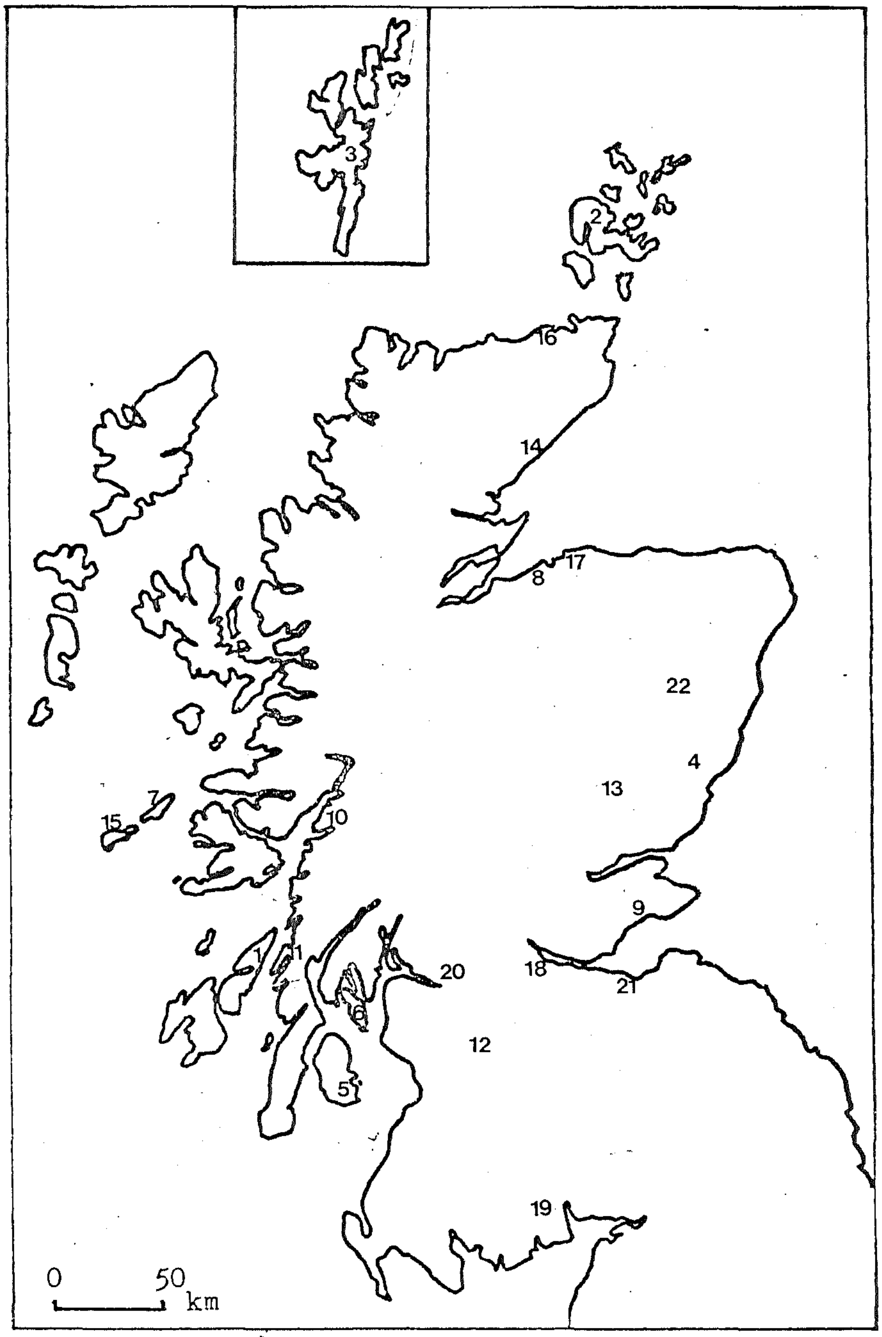
The only excavations of Mesolithic sites to involve pollen analysis in their interpretation are those undertaken by Mercer in northern Jura. The sites, at Lealt Bay (Mercer, 1968, 1970), Lussa river (Mercer, 1970, 1971), North Carn (Mercer, 1970, 1972), Lussa Wood (Mercer, 1974a) and Glenbatrick Waterhole (Mercer, 1974b), are coastal and in the main are associated with the raised beach deposits of the main post-glacial marine transgression. The excavations produced thousands of artifacts, mainly of flint, and a combination of pollen analysis, ^{14}C dating and the study of land/sea-level changes was used to establish a typological sequence for these. The samples were analysed by Durno and consisted of an old land surface predating the raised beach deposits and associated occupation sites (Lealt Bay), peat overlying the raised beach gravels (Lealt Bay, Lussa River) peat directly overlying the occupation site (North Carn), peat overlying fresh-water silt (Glenbatrick Waterhole), fresh-water silt and stoneless hillwash (Glenbatrick Waterhole and North Carn respectively). A six metre core was taken from Bird Loch (Mercer, 1968) to act as a regional reference curve for Jura, aiding the interpretation of the shorter sections and single samples. The diagram produced from Bird Loch is very similar, when expressed in A. P. terms, to ones from the mainland i.e. Kintyre (Nichols, 1967). Before the alder (Alnus) rise, birch (Betula) and hazel (Corylus) are the main woodland components. Alder replaces hazel and there are relatively high proportions of oak (Quercus) and elm (Ulmus). Pine (Pinus) is low throughout apart from a small peak just prior to the alder rise. At the elm decline both elm and oak values fall with a corresponding rise in grass (Gramineae) with some plantain (Plantago sp.). Some pre-elm decline interference is suggested by a slight fall in trees and a double peak of heather (Calluna). Through to about 2000 BP there is a gradual, but erratic, fall in A. P. values. These reach very low levels at this point and there is a great expansion in grass, sedge (Cyperaceae) and heather. Increased human activity in the form of stock grazing and burning are suggested as reasons for this. The shorter sections compare favourably with the main diagram enabling approximate dates to be established for their formation.

The overall interpretation from the sites is that they represent the presence, either seasonally or permanently, of a hunting/gathering population

Figure A4.1

Showing archaeological sites in Scotland with which pollen analysis has been directly associated.

1. Northern Jura (Mercer, (1968-1974b).
2. Orkney (Jones, in Renfrew, 1979, Davidson et al., 1976, Keatinge and Dickson, 1979, Lambert and Godwin, in Childe, 1956, Caseldine and Whittington, in Ritchie, 1976, Jones, in Hedges, 1975, Jones, in Hedges, 1977).
3. Shetland (Whittington, 1978)
4. Fettercairn, Kincardineshire (Durno, in Piggott, 1973, Piggott, 1972, Romans et al., 1973).
5. Monamore, Arran (Durno, in MacKie, 1964).
6. Hilton, Bute (Marshall, et al., 1976).
7. Sorisdale, Island of Coll (Whittington, in Ritchie, 1978).
8. Culbin Sands, Moray (Durno, in Coles and Taylor, 1970).
9. Ashgrove, Fife (Lambert in Henshall, 1964, Dickson, 1978, 1979).
10. Achnacree Moss, Argyll (Ritchie et al., 1974, Soulsby, 1976, Barrett et al., 1976).
11. Claggan, Argyll (Rymer, in Ritchie, 1975, Rymer, 1974).
12. Peelhill, Lanarkshire (Durno,1965, Durno and Taylor, in Coles and Scott, 1964).
13. Dalnaglar, Perthshire (Durno, 1965, in Stewart, 1964).
14. Kilphedir, Caithness (Durno, in Fairhurst and Taylor, 1971).
15. Dun Mor Vaul, Tiree (Pilcher, in MacKie, 1974).
16. Crosskirk Broch, Caithness (Dickson, 1979b, Dickson and Dickson, in press).
17. Burghead, Moray (Edwards and Ralston, 1978).
18. Camelon, Stirlingshire (Dimbleby and Sheldon, in Proudfoot, 1978).
19. Milton Loch, Kirkcudbrightshire (Knox, in Piggott, 1953).
20. Bearsden, Dumbartonshire (Dickson et al., 1979, Knights et al. (in press).
21. High Street, Edinburgh (Hayes, in Schofield, 1976).
22. Howe of Cromar, Aberdeenshire (Edwards, 1978).



3
2
16
14
17
8
22
4
13
7
15
10
9
1
1
20
18
21
6
12
5
19
0
50
km

from before 7500 BP until at least 4500 BP, with subsequent occupations by Neolithic and Bronze Age people. Interference with the woodland on Jura is thought to have begun prior to the elm decline and by the early Iron Age the island is likely to have been as treeless as at present.

The Neolithic Period

Considerably more published material exists concerning Neolithic sites, particularly from Orkney. The majority of this is of direct relevance to the Neolithic and also provides information about later, and occasionally earlier, periods.

Orkney

The earliest work of this nature from Orkney was on three samples from the excavation of Maes Howe (HY 318 128) by Childe in 1954/55 (Childe, 1956). The samples were analysed by Lambert under the auspices of Godwin in Cambridge. One sample came from laid turves sealed under clay below the barrow mound and represents the land surface at the time of construction of this striking chambered tomb. The other two samples come from deposits which had accumulated in the ditch surrounding the monument, presumably representing events subsequent to its construction. The results of the analysis are given in an appendix in Childe's 1956 account.

The partial re-excavation of Maes Howe by Renfrew in 1973/74 (Renfrew, 1979) also yielded material for analysis. Deposits from both north and south sections of the surrounding ditch were analysed, along with two peat layers from the slope of the mound separated by a layer of inorganic amterial. The peat layers are presumed to have formed in situ (Davidson et al., 1976, Jones, in Renfrew, 1979).

The re-excavation at Maes Howe formed part of a larger study aimed at reconstructing the Orcadian environment in prehistory (Davidson et al., 1976, Renfrew, 1979). In the course of this a Neolithic stone circle, the Ring of Brogar (HY 295 134), was also excavated. Profiles from the north and south section of the ditch surrounding this monument were analysed, with the northern one proving to be the most useful.

The material so far mentioned provided data about local events. To put these into a regional context peat sections were collected from the valley bog, Lesliedale Moss (HY 408 103) dating from around 4000 BP and from blanket peat of Wideford Hill (HY 411 121) which began forming at around 3000 bp.

Another project in the early seventies which involved pollen analysis was the excavation by Ritchie of the Stones of Stenness (HY 307 125), not far from both Maes Howe and the Ring of Brogar (Ritchie, 1976). Again ditch deposits were involved from the main ditch around the monument, including an organic layer of uncertain origin (Caseldine and Whittington, in Ritchie, 1976).

The most recent work from Orkney is that of Keatinge and Dickson (1979). This project was directly related to the re-excavation of Skara Brae (HY 231 187) by Clarke in 1972/73 (Clarke, 1976). The original excavation was by Childe in 1928/30 (Childe, 1931). The aim was to evaluate the impact of the Neolithic population inhabiting Skara Brae on the vegetation of Orkney along with an investigation into the later formation of blanket peat in the vicinity. A large number of deposits were sampled in the Bay of Skail area, a six metre core from the Loch of Skail (HY 240 183) provided the main reference curve along with a fen peat section from nearby Pow farm (HY 253 195) and a short section of truncated intertidal peat laid down under fresh-water conditions in the Bay of Skail itself. A six metre core from Glims Moss provided dated horizons for the Loch of Skail core, the marl deposits of the latter being so hard to date. It also tied in with the mineral soil/basal peat samples from the blanket peat of the Burn of Rusht (HY 330 217), the Braes of Aglath (HY 352 182) and Mid Hill (HY 338 239). Analysis was not carried out on samples from the excavation itself. The information from these sections puts the Orkney work as a whole into perspective supplementing the vegetational work of Moar (1969b) and providing as it does a picture of the pre-interference vegetation and the changes which result due to climate and the successive human populations.

Pollen analyses from Orkney collectively represent a considerable mass of data. Dating of the material, either directly by the pollen curves and ^{14}C dates or indirectly from the ^{14}C dating of the monuments, has shown that there is a broad agreement regarding the sequence of events which have taken place. The following is a brief resumé of those events with the sources from which the information was taken. (See Table A4.1 for the explanation of the site abbreviations).

PRE-5000 BP Birch and hazel scrub form the climax woodland on Orkney, with an understorey of tall herbs and ferns such as _Filipendula_, _Geum rivale_, _Athyrium filix-femina_ and _Dryopteris dilatata_. There is no evidence to suggest that pine, oak, ash (_Fraxinus_) or alder are indigenous on the island (LoS, GM, POW, BoS).

ca. 5000 BP A marked decline occurs in the birch/hazel scrub, being replaced for a short time by the tall-herb communities (ca. 200 years), but there is also a marked expansion in grass and plantain. The suggestion is that the fall in the birch/hazel values is due to an increase in on-shore windspeeds in the Bay of Skail at this time plus the effect of Neolithic clearance and grazing (LoS, GM, POW, BoS).

5000 - ca. 4200 BP This covers the period from the decline of the 'woodland' to the building of Maes Howe, the Ring of Brogar and the Stones of Stenness. It also includes the period of occupation of Skara Brae from 4500 - 4000 BP. There is a predominance of herb species and Orkney remains virtually treeless from this time on. The herbs are dominated by grass and plantain, with heather becoming more important later. This indicates widespread grazing with some of the poorer soils being colonised by heath plants. Cereal cultivation may have occured locally (LoS, GM, Pow, GTS).

ca. 4000 - 3500 BP At the time of the construction of Maes Howe, the Stones of Stenness and the Ring of Brogar there was an open landscape with land being intensively used for both pastoral agriculture and cereal cultivation. This situation persisted until about 3500 BP. There may have been clearance of heath for agricultural purposes (LoS, GM, Pow, LM, MHN, SSM).

3500 - 2500 BP Archaeologically on Orkney this period is poorly represented apart from a few mounds and beakers. There appears to be a gap between the Neolithic monuments and the later Bronze Age 'Burnt mounds'. This state of affairs is also reflected in the pollen record. Although agricultural activity persists it appears to be in a much less intensive form. The spectrum is still dominated by herbs but several of the ruderal species decline or disappear. A limited regeneration of trees and shrubs may have occurred as indicated by a rise in pollen of these taxa. However this may be just reflecting events on nearby mainland Scotland. The most significant feature is the initiation of blanket peat in several areas which occurs in the centuries prior to 3000 BP, apparently in response to the increasingly oceanic climate and the grazing pressure of the domesticated animal populations (LoS, GM, WH, LM, BA, BR, MH, SSW, MHN, MHS, MHLL, GDS, LPT, LSS).

2500 - 1500 BP In the middle of the last millenium BC there is an increase in activity corresponding to the building of the houses associated with 'Burnt mounds', debris from cooking sites (see J. Hedges, 1975). The agriculture again is mixed, but pastoralism predominates.

Table A4.1

Orkney Summary, Site Abbreviations

Abbreviation	Location	Reference
LoS	Loch of Skail	Keatinge and Dickson (1979)
GM	Glims Moss	" " (")
POW	Pow Fen	" " (")
BoS	Bay of Skail (inter-tidal deposit)	" " (")
BA	Braes of Aglath (blanket peat)	" " (")
BR	Burn of Rusht (blanket peat)	" " (")
MH	Mid Hill (blanket peat)	" " (")
GDS	Samples from Maes Howe ditch	Lambert and Godwin, in Childe (1956)
GTS	Samples from laid turves below Maes Howe barrow mound	Lambert and Godwin, in Childe (1956)
MHLL	Maes Howe lower peat layer from slope of Maes Howe mound	Davidson et al. (1976) and Jones in Renfrew (1979)
MHUL	Maes Howe upper peat layer from slope of Maes Howe mound	" " (1979)
LM	Lesliedale Moss	" " (")
MHN	Maes Howe north ditch section	" " (")
SSM	Stones of Stenness	Caseldine and Whittington, in Ritchie (1976)
MHS	Maes Howe south ditch section	Jones in Renfrew (1979)
WH	Wideford Hill (blanket peat)	" " (")
RBN	Ring of Brogar north ditch section	" " (")
QY	Soil under Knows of Quoyscottie	Jones, in Hedges (1977) (see under Bronze Age)
LSS	Soil from under burnt mound at Liddle	Jones, in Hedges (1975)
LPT	Peat section from Liddle	" " (")
LGF	Silt from gulley at Liddle	" " (") (see under Bronze Age)

Tree values fall to a very low level and the herbs are dominated by heather and grass, with the presence of many ruderal species. The widespread development of Calluna heath is taken to indicate soil exhaustion and erosion brought about by the deteriorating climate and agricultural mal-practices. From this time onwards the Orkney landscape was very much as it is today (LoS, GM, MHS, RBN, LM, WH, MHUL, QY, LGF).

Shetland

Investigations on Shetland have been less extensive. The most fully published account is of the analysis of material associated with a sub-peat dyke on Shurton Hill (HU 441 403) (Whittington, 1978). The dyke, constructed of vertical and horizontal stone slabs, appears to have marked the boundaries of grazing areas. A ^{14}C date is quoted for the mineral soil under the dyke of 2800 bc, (UB - 2122) no standard deviation is given. Two profiles were analysed, one from 8.5 cm of mineral soil lying under the dyke, the other through the mineral soil and the basal part of the two metres of peat which overlies it. The short mineral soil profile showed a virtually treeless landscape dominated by heather and grass with minor presences of Compositae, Artemisia, Urtica and Caryophyllaceae. This represents the vegetation at the time of the building of the dyke. The longer mineral soil/peat profile showed a similar situation at the soil/peat interface. Interestingly there is charcoal in the basal layers of the peat and the grass curve rises as the heather curve falls sharply, followed by a reversal. This is interpreted as over-enthusiastic Neolithic Muirburn. A few grains of pollen from ruderal species are also present.

The only other report of pollen analysis on Shetland is by Whittle (1979, 1980). Mention is made of a pollen diagram associated with the excavation at the large Neolithic/Bronze Age settlement site at the Scourd of Brouster, with clearances being reported prior to 4000 BP. However no further details, or the source of this information, were given.

The North-East of Scotland

Work in the north-east of Scotland from this period is confined to the analysis of material from the Dalladies Neolithic long barrow, at Fettercairn in Kincardineshire (NO 645 712) (Durno in Piggott, 1973, Piggott, 1972, Romans et al., 1973). The samples came from a buried soil under the barrow and from cut turves used in its construction. The latter were of particular interest as they contained quantities of oak charcoal. The turves were found to represent a brown forest soil but had a pollen spectrum indicating open conditions with some local growth of alder and birch. No oak pollen was encountered. This is taken to represent the open landscape resulting from the clearance of the woodland for agriculture and the subsequent use of part of it as a site for the cairn. Piggott (1973a) remarks that this initial clearance must have been quite extensive in order to allow $7300m^2$, the area of the barrow, to be used for the construction of a burial monument. Analysis of the buried soil under the cairn shows that a degree of leaching had taken place due, it is suggested, to climatic deterioration. No mention is made of the effect that the widespread forest clearance may have had on the water-table. A reference is made to the predominance of birch and alder and the low values of elm, oak and pine at this time in the pollen diagram from Eslie Bog, 4km away, however this comparison is not expanded.

Arran and Bute

Two Neolithic chambered cairns from the south-west of Scotland have provided material for pollen analysis, one on Arran, the other on Bute (see section 2.7). The Arran example is the Monamore cairn (NS 017 289), near Lamlash, re-excavated by MacKie in the early sixties (MacKie, 1964). The cairn was originally excavated by Bryce at the turn of the century. He dug straight into the burial chamber leaving the forecourt untouched and it was this region which received the most attention in the re-excavation. Inwashed soil had accumulated in the forecourt to a depth of 30cm, this deposit was analysed by Durno with a view to discovering the period of time over which it had accumulated. A short peat monolith was removed from the hillside above to act as a reference curve. The diagram for the forecourt shows high levels of tree pollen which increase further after the building of the cairn, before falling dramatically. At this point there are large increases in grass, heather, plantain, Compositae and other herbs. Overall this appears to represent a reduction in activity following the building of the cairn, with an emphatic resumption at a later date, corresponding with events recorded at the base of the hill peat profile. The diagram for this blanket peat deposit, as a whole, is typical of many which began forming during the last millenium BC. The interpretation from the pollen analysis and the ^{14}C dating of charcoal suggests that the cairn was in use for in excess of 1000 years following its construction ca. 5400 BC.

The Hilton cairn on Bute (NS 067 685) (Marshall, et al. 1976) was excavated more recently, in the period 1972 - 76. This Neolithic cairn was on the site of a previously levelled occupation site. It consists of a primary chambered cairn, the contents of which are dated typologically to 2300 BC. Onto this a later secondary Neolithic structure has been added and there is an intrusive Bronze Age cist in this secondary cairn material. Samples were taken for pollen analysis by Whittington of St. Andrews University. There were three from the turf packing surrounding the stones of the primary cairn, one from soil under the cairn, and one from turf and clay packing used to level up the occupation site just outside the primary cairn. The samples from under the cairn and the lower levels of the turf packing show that at the time of construction the area was wooded. The woodland is predominately alder and birch with no elm or oak and very little pine. Indicators of agriculture are not well represented. In contrast the sample from the pre-cairn phase and the one from the later stages of the cairn construction both show an open landscape dominated by grass and heather with several agricultural species, including plantain and cereals. The sample from the top of the cairn has some birch, alder and hazel whereas the pre-cairn sample has virtually no trees. This could be taken to indicate that the original mixed deciduous woodland was extensively cleared, followed by regeneration by alder, hazel and birch prior to the cairn being built. This secondary woodland was then progressively cleared by the builders of the cairn. However the picture may have been complicated by the transport of turf and other material to the site from an outside area.

The Bronze Age

Pollen analysis data has been published from two early Bronze Age 'Beaker' sites in Scotland and in both of these the work is somewhat atypical.

One concerns a burial associated with an adjacent stone-setting which appears to be the foundation of a circular house. The site is in the machair at Sorisdale on the Island of Coll (NM 272 638) (Ritchie, 1978) and the pollen analysis is reported in an appendix by Whittington. Samples were removed from the floor of the grave-pit and from the midden floor associated with the 'house'. Being from the machair, both samples were of a calcareous nature and the pollen and spores were very badly preserved. The grave-pit sample yielded a few corroded spores of Osmunda. The midden floor sample had a large concentration of corroded Osmunda spores and one corroded grain of Corylus. The Osmunda spores obviously originated from a time when the fern was much more common in the Western Isles in the absence of grazing animals. However it is difficult to infer anything else from this much-modified spectrum. Pollen analysis of calcareous deposits often proves to be rather unproductive. This was the case with material from the middle Bronze Age midden site in the Culbin Sands (Durno in Coles and Taylor, 1970). Analysis of a sample largely comprised of windblown sand revealed only a few grains recognisable as pine.

The second site is a burial at Ashgrove, near Methilhill in Fife (NT 352 999). The cist, excavated by Henshall (1964), contained a crouched inhumation with an associated dagger, beaker and spread of highly decomposed plant material. On analysis this plant material was shown to contain various plant macrofossils including amounts of Sphagnum palustre leaves and stems, birch bud scales and a fruit. However it was the pollen spectrum which proved to be most intriguing (Lambert in Henshall, 1964). Tilia cordata, the small leaved lime, provided over 50% of the total pollen, and of the rest 15% was Filipendula, almost 8% Calluna, 7% Plantago lanceolata and 5% Labiatae, plus small amounts of various other trees and herbs and some fern spores. Contamination, either recent or in antiquity, was suggested as one possible source of the pollen. This is unlikely however as Tilia cordata is not thought to be indigenous in Scotland (Birks, 1977, 1980), and no modern planted examples are thought to have been present in close proximity to the site of the excavation. The explanation favoured at the time was that the material represented the remains of flowers placed in the grave with the body and the grave goods, there possibly being also a covering of leaves over the body. Recently another possible source has been investigated by Dickson (1978, 1979). Scrapings were taken from the beaker found in the cist. When analysed for pollen these scrapings were found also to contain pollen of lime, Filipendula and other species in the original sample. The suggestion made is that the beaker contained honey or mead, probably the latter, which spilled out over the floor of the cist when the beaker fell over soon after the burial. Similar examples are known from sites in Denmark (Dickson, 1978).

Orkney also features in the account for the Bronze Age with two sites representing the middle and later parts of the period. Jones (in M. Hedges, 1977) reports the analysis of two profiles from the gleyed clay soils under the Knows of Quoyscottie (HY 302 228), barrows tentatively dated to the mid to late Bronze Age. The pollen content of the two was very similar, showing a largely treeless landscape dominated by heather with Plantago, Compositae, Chenopodiaceae, Cruciferae, Succisa and Urtica. This is interpreted as representing mixed agriculture with a predominance of pastoralism, much as was outlined for the period in the section on the Neolithic.

The other report is also by Jones (in J. Hedges, 1975) and concerns samples from the excavation of burnt mounds at Liddle (ND 464 841) and Beaquoy (HY 301 219). The majority of the data come from Liddle as the Beaquoy samples proved to be poor in pollen. Profiles were taken from the silt which had accumulated in a flag-lined gulley and also from the peat into which the flags had been set. Samples of buried soils from under the mounds were also analysed. Both the peat and the buried soils had a pollen spectrum similar to that described for the middle Bronze Age in the section on the Neolithic, representing an open landscape with low intensity mixed agriculture and perhaps limited regeneration of tree and shrub species. The gulley silt spectrum had more in common with the ones from Quoyscottie outlined above.

Buried soils also play a major part in the interpretation of some Bronze Age sites on the mainland. A sample from one associated with a field bank underlying Achnacree Moss at Black Crofts in Argyll (GR 923 364) (Ritchie et al., 1974, Soulsby, 1976, Barrett et al., 1976) showed that the bank had been constructed at a time when the area was one of Calluna heath. The buried mineral soil gave a ^{14}C date of 1359 ± 50bc and the onset of the overlying peat growth is dated nearby to 980 ± 80bc. An iron podsol developed prior to peat formation and, although no cultural pollen is present in either the soil or the peat, it is thought likely that heath development and subsequent peat formation were promoted by human agricultural activity in an earlier period. A similar landscape of Calluna heath was revealed by the analysis of a buried soil from under and just outside a cairn at Claggan in Argyll (Rymer, in Ritchie, 1975, Rymer, 1974, p.60). However in this case a large amount of Coryloid type pollen was present in addition to high frequencies of grass with Plantago lanceolata and Succisa. Rymer takes this to indicate pastoral agriculture and again raises the question of human involvement in heath formation as the underlying podsol was well developed before the cairn was built.

At Peelhill, Strathaven in Lanarkshire a collection of bronze spear-heads was ploughed up from about 35cm of peaty material. There was some doubt, however, as to which layer within the soil had contained the artifacts. Durno (1965, and Durno and Taylor, in Coles and Scott, 1964) analysed the profile and also material scraped from the bronzes, with a view to matching up the spectra. Within the short profile there were quite marked changes. At the base tree and shrub values were low, the pollen being mainly of birch and alder. Grass, heather and plantain values were high. Up the profile this situation reversed until the trees, again mainly birch and alder, made up 70% of the total pollen. Then birch followed by alder fell again with grass, sedge and hazel replacing them. Plantain and bracken (Pteridium) were also present in the upper layers. Durno interprets these in terms of Iversen's classic landnam phases of slash and burn agriculture followed by regeneration.

The spectrum from the bronzes most closely matched the pollen of the first clearance phase, however as they were probably buried in the first place it is difficult to be sure of the period which they represent.

The Iron Age

In the Iron Age the monuments investigated fall into three categories,

1. Hut circle settlement sites with associated cultivation areas.
2. Brochs and forts i.e. structures which are more obviously fortified.
3. Crannogs or lake dwellings.

The excavations by Stewart at Dalnaglar Perthsire (NO 150 642) (Stewart, 1964) and by Fairhurst and Taylor (1971) at Kilphedir in Sutherland both concerned monuments of the first type and in both cases Durno was responsible for the pollen analysis. At Dalnaglar a section was analysed from a nearby raised bog, material from the site was not examined. The diagram produced from the raised bog showed striking changes about the time at which the site was thought to have been occupied (i.e. from about 2500BP). The tree pollen falls sharply, and heather grass and plantain rise, suggesting fairly widespread clearance. Prior to this the woodland was largely composed of birch, alder, elm, oak and pine in that order of abundance. There is a slight fall in tree pollen before a main one at the elm decline with an associated rise in grass and plantain. In a separate paper (Durno, 1965) this is treated as an example of Iversen's 'landnam' in Scotland, along with the material from Peelhill (Coles and Taylor, 1964). However the clearances involved would appear to be more extensive and of a longer duration than those envisaged by Iversen.

At Kilphedir (Durno, in Fairhurst and Taylor, 1971) several profiles were removed from in and around the site in an attempt to investigate the nature of the land use in the areas of cultivated land. It was also hoped that analysis would add weight to the idea that there had been a double occupation of the site, which the authors had inferred from the layout of the stone-cleared areas. The site was covered by a thin layer of peat which began forming after abandonment. The underlying soil profiles, which were podsolised and showed signs of a thin regional iron pan, became much more strongly podsolised under the monuments. The podsol is thought to have formed under moorland above the level of woodland in the strath below. Analysis of the mineral soil and peaty tops of the soil profiles around the site showed high values of plantain and other open habitat herbs at the base, tree values were low. This situation reversed towards the top of the mineral soil perhaps suggesting the cessation of agriculture in the face of worsening soil and climatic conditions. A further peak in plantain and grass is seen further up some of the profiles, this may be due to secondary usage of the area. A blanket peat monolith was taken from the hillside above the site to give a reference curve. The diagram was typical of a peat which began forming in the mid to late 1st millenium BC (see similar diagram from Monamore, Arran, MacKie, 1964). The tree values fall sharply at the base being replaced initially by grass, plantain, other open habitat herbs and heather. The latter eventually takes over completely with the permanent reduction of tree pollen. From the archaeology Fairhurst and Taylor conclude that, although the site is Iron Age in date, the technology of the occupants was not of a standard with that time. They appeared to have more affinities with the Neolithic and Bronze Age.

In the second category the four Iron Age sites are fortified structures, two brochs, a promontory fort and a fortified house. The first Iron Age broch site to be investigated in detail from the botanical aspect was Dun Mor Vaul on Tiree (NM 042 493) (Pilcher, in MacKie, 1974). The excavation revealed a clear sequence of stratified deposits dating from the late 5th or 6th century BC (a wooden structure) through to the 2nd or 3rd century AD, when the main broch wall was partly demolished with a secondary wall being built inside it to form a round farmhouse. Later use may have been made of it by 'aborigines'. During the excavation about thirty samples were removed for pollen analysis. Unfortunately a complete vertical sequence through the deposits was not available and a composite picture was constructed from three separate locations. The main conclusions drawn from the work were that Tiree was virtually treeless from before the time of construction up to the present day, and that during the Iron Age there was considerable agricultural activity on the island, perhaps more than today, judging by the surface samples which were also analysed. There was evidence for two earlier phases of agriculture on the island prior to the one associated with the occupation of the broch. The four pollen samples from Crosskirk broch, near Thurso, Caithness (Dickson, 1979 b, Dickson and Dickson in Fairhurst, in Press) show a similar treeless agricultural landscape with high values of cereals (1.3 - 8.8%) Plantago lanceolata (0.8 - 11.5%) Compositae (4.4 - 20%) and Gramineae (17.4 - 55%). Two of the samples are from the pre-broch phase, one associated with the rampart of the pre-broch promontory fort, the other from under a slab of the broch floor. The other two samples represent samples from the broch well and from a tank containing ash, cereal chaff, charcoal and marine shells. The latter is thought to represent processing of cereals within the broch.

The promontory fort is at Burghead in Morayshire. A double organic layer separated by sand underlies the structure and is traceable across the face of the cliff. These two layers were analysed by Edwards (Edwards and Ralston, 1978) with a view to discovering something about the pre-fort environment and also if the large amounts of timber used in the construction of the fort were of local origin. Both layers had very low values of tree pollen. The lower layer is thought to represent a podsol forming Calluna heath, formed after forest clearance in an earlier period. This then became covered with windblown sand which enabled the colonisation by a grass dominated flora to take place. In the early Dark Ages this flora contained a high proportion of Compositae (Liguliflorae). There are considerable amounts of oak charcoal from the excavation but no oak pollen was found in the samples, suggesting that the wood for construction was imported from some distance away. The overall picture is of a considerable period of occupation predating the building of the fort which resulted in the impoverished flora represented in the lower layer of deposit. Blown sand, charcoal and other debris allowed the colonisation by a grass dominated community with high Liguliflorae, again before the construction date. The only real comment which can be made about the fort itself is that the timber used in its construction was in all probability imported from another area.

The Camelon native site near Falkirk, Stirlingshire is closely associated with the Roman fort at that site. One of the three phases of occupation of the site may have been in the form of a Roman rectilinear house. Above and below this are the remains of round timber houses of the 'native style'. The site is on a promontory overlooking the river Carron and there is evidence for a complex defensive system. The houses are thought to have been occupied in the 1st and 2nd centuries AD. Two pollen samples were taken from a pit which had either been used for preparing daub or had been filled with rubbish then daub. One sample was abundant in pollen the other had virtually none. The pollen spectrum was dominated by grass with other herbs, including some ruderals. Trees and shrubs were very low with alder being the greatest at 4%. Interpretation of the analysis is difficult due to the uncertain origins of the pit material but the authors (Dimbleby and Sheldon in Proudfoot, 1978) speculate that it might represent the proximity of hay meads and alder trees along the river bank.

The third type of site, the crannog, was also thought to date from the 1st or 2nd centuries AD (Piggott, 1953). However recent ^{14}C dates for an ard and an oak pile recovered from the site (Guido, 1974) place it around 400BC. The crannog is situated in Milton Loch, Kirkcudbrightshire (NX 839 718) and was one of the first sites in Scotland in which pollen analysis was involved. The work was done by Knox (in Piggott, 1953) and there is little detail about the samples taken, the text just refers to peat recovered from the site. The pollen spectrum is one again of an open landscape. The tree pollen, mainly alder with some birch, hazel and a few grains of oak and lime, is low. There are large amounts of grass and cereals, the latter are considered to be 'probably rye' by the author. There are also several other herbs and weeds of cultivation but only Ranunculus occurs in any great quantity.

The Roman Period

Apart from the work at the Camelon native site, discussed in the previous section, which includes a possible Roman phase, two other sites have been analysed in Scotland. One is only a brief account concerning a buried soil under the bank of a Roman marching camp at Kilbuddo in Angus (Romans, 1962). All that is revealed is that pollen analysis contributed to the conclusion that the underlying preserved podsol was well developed prior to being buried.

The second site, the Roman fort at Bearsden, Dumbartonshire, (NS 545 721) (Dickson et al., 1979, Knights et al., in Press) involved considerably more detailed and informed work. The fort formed part of the Antonine Wall defences and is thought to have had a single occupation, probably between 142 and 158 AD. At the end of the occupation the buildings were destroyed, but the surrounding defensive ditches were left open. Pollen analyses along with plant macrofossil, insect, bone and chemical analyses were used in an attempt to ascertain the origins of the various layers in the ditches which accumulated during and after the occupation.

The pollen and plant macrofossil analysis showed that the lowest layer, A, was quite uniform in its content and also quite distinct from the layers above it. The nine pollen samples all contained about 50% tree pollen, mainly birch, alder and hazel, and in total there were thirty herb taxa including grassland and weed species. Of the wide range of macrofossils encountered the most significant find was a large quantity of cereal debris, identified as being wheat pericarp fragments. There were also remains of food plants including seeds of fig (Ficus) and coriander (Coriandrum). Originally the layer was interpreted in terms of it being a dump of flour and other flour based food (Dickson et al., 1979). However a later hypothesis was that the material was sewage from the latrines of the nearby bath house. Certainly the botanical evidence is consistent with this and the presence of parasite eggs (Trichuris and possibly liver fluke), plus remains of grain pests and flies generally associated with rotting organic matter and the chemical analysis of the stearoid material,adds considerable weight to this argument.

The pollen in the upper layers is first characterised by grass, sedge and nettle pollen with grains of open-water plants Lemna and Callitriche. Later willow (Salix), hazel and birch are more common, no food plant remains are present in the upper layers. These clear cut changes probably represent the colonisation of the ditch following abandonment of the fort and the cessation of the sewage input, first by grass, nettles and other weeds and later by shrubby species as the deposits became consolidated.

Later Periods

Pollen analysis is a method which can be of use in excavations of monuments other than those representing prehistoric periods although to date the emphasis has tended to be with the latter. Two examples of this are the investigations in medieval Edinburgh (Hayes in Schofield, 1976) and the examination and excavation of a cairn of a similar period in the Howe of Cromar (NJ 446 004) in Aberdeenshire (Edwards, 1978).

The Edinburgh samples are from the lower levels of a midden thought to date from the early 14^{th} century to the later part of the 15^{th} century, the lowest level may even have accumulated earlier. Pollen is sparse but a picture has been built up from the analysis. The levels of oak,birch and hazel pollen decrease up the midden and by the 15^{th} century grass is very common with a large proportion of Urtica. It is thought that this reflects the 'urbanisation' of the surrounding area of open country with its occasional trees.

In contrast the cairn site is in a rural setting associated with some cultivation ridges. The object of the excavation was to ascertain the function of the cairn and its relationship to these ridges. On excavation the cairn proved to be made of stone of local origin with the intervening spaces filled with peat. Phosphate analysis showed that a burial was unlikely and it seems probable that the cairn was the result of field stone clearance. The only material suitable for the dating of the monument was the overlying peat. This gave a date of 455 ± 95bp, thus setting a minimum antiquity. Samples of the buried soil under the cairn and the basal peat were analysed for pollen, both showed very similar spectra of a vegetation dominated by grass with the possibility of birch, alder and possibly hazel woodland in the area. Both spectra also contain several weeds associated with pastoral agriculture, however the peaty sample also had pollen of *Hordeum* (barley) and significant quantities of Chenopodiaceae and *Artemisia* pollen, indicating arable agriculture. The overall interpretation is that the buried soil represents an earlier phase of pastoral agriculture possibly in a semi-wooded landscape. The peat represents a later episode of mixed arable and pastoral agriculture which resulted in the raising of the cairn.

APPENDIX A5

TROELS -SMITH ANALYSES OF THE PEAT SECTIONS INVESTIGATED IN THIS STUDY

Tables 5.1, 5.2, 5.3, 5.4, and 5.5 contain the Troels-Smith analysis data for sections MML80, TM1, TMD1, TMD4, and TMD5. These original analyses were modified in the ways suggested by Aaby (1979) and it is these simplified analyses which are expressed alongside the pollen diagrams.

Table A5.1

Troels-Smith Sediment Description - MML80

Depth in cm.	Description
452 - 448.5	lim 1, coarse sandy gravel, 10 YR 4/2 As 1, Ag 1, Ga 1, Gs 1, Gg(min.) +, Gg(maj.) +, Th^1 +
448.5 - 420	lim 0, nig 2, strat 1, elas 3, sicc 2, humo 1, homogeneous fibrous peat. $Th^1$4, Dl^1+, Dh^1+, Tb^2+
420 - 410	lim 1, nig 2, strat 1, elas 3, sicc 2, humo 1, homogeneous fibrous peat. $Tb^1$3, Th^1(m.-cari.)1, Dh^1+
410 - 395	lim 2, nig 2, strat 2, elas 3, sicc 2, humo 2, homogeneous fibrous peat. Th^2(m.-cari.)4, Dl^1+, Th^2(Phra.)+,Tb^1(Sphag.)+
395 - 379	lim 1, nig 2, strat 2, elas 3, sicc 2, humo 2, homogeneous fibrous peat. Tb^1(Sphag.)1, Th^1(m.-cari.)3, Th^1(Phrag.)+
379 - 366	lim 1,nig 2, strat 2, elas 3, sicc 2, humo 1, homogeneous fibrous peat. Th^1(m.-cari.)4, Th^1(Phrag.)+, Dl^1(Call.)+
366 - 340	lim 0, nig 2, strat 0, elas 1, sicc 2, humo 2/3 homogeneous fibrous peat. Th^1(Phrag.)1, Th^1(m.-cari.)3, Dl^1+, Dh^1+
340 - 319	lim 0, nig 2, strat 2, elas 2/3, sicc 2, humo 2, homogeneous fibrous peat. Th^1(m.-cari.)3, Th^1(Phrag.)1
319 - 270	lim 0, nig 2, strat 2, elas 2/3, sicc 2, humo 2/3 homogeneous fibrous peat. Th^1(m.cari.)4, Th^1(Phrag)+, Dh^1+

Table A5.1 (cont.)

270 - 210	lim 1, nig 2, strat 2, elas 3, sicc 2, humo 2, homogeneous fibrous peat. Th^1(m.-cari.)3, Th^1(Phrag.)1, Dl^1+
210 - 180	lim 1, nig 2, strat 2, elas 3, sicc 2, humo 1/2, homogeneous fibrous peat. Th^1(m.-cari.)4, Th^1(Phrag.)+, Dl^1+, Tb^1(Sphag.)+
180 - 171	lim 0, nig 2, strat 2, elas 3, sicc 2, humo 1/2, homogeneous fibrous peat. Th^1(m.-cari.)4, Th^1(Phrag.)+, Dl^1+, Tb^1(Sphag.)+
171 - 100	lim 1, nig 2, strat 2/3, elas 3, sicc 2, humo 2, homogeneous fibrous peat. Th^2(m.-cari.)3, Th^1(Phrag.)+, $Dl^1$1, Dh^1+
100 - 79	lim 1, nig 3, strat 2, elas 3, sicc 2, humo 3, homogeneous fibrous peat. Th^1(m.-cari.)2, $Dl^1$1, Dh^1+, Th^1(Phrag.)+, $Sh^4$1
79 - 66	lim 1, nig 3, strat 2/3, elas 3, sicc 2, humo 1/2, Homogeneous fibrous peat. Th^1(m.-cari.)4, Dl^1+, Dh^1+, Th^1(Phrag.)+, Tb^1(Sphag.)+
66 - 58	lim 1, nig 2, strat 2, elas 3, sicc 2, humo 1, homogeneous very fibrous peat. Th^1(Moli.)2, Th^1(m.-cari.)2, Th^1(Phrag.)+, Dh^1+, Dl^1+
58 - 41	lim 1, nig 2, strat 2, elas 3, sicc 2, humo 1/2, homogeneous fibrous peat. Th^1(Moli.)2, Dh^1(Moli.)+, Th^1(m.-cari.)2, Dl^1+, Dh^1+
41 - 32	lim 1, nig 2, strat 2, elas 3, sicc 2, humo 1, homogeneous very fibrous peat. Th^1(Moli.)2, Th^1(m.-cari.)2, Th^1(Phrag.)+

Table A5.1 (cont.)

32 - 28	lim 1, nig 2, strat 2, elas 3, sicc 2, humo 1/2, homogeneous fibrous peat. Th^1(Moli.)4, Th^1(m.-cari.)+, Dl^1+, Dh^1+
28 - 25	lim 1, nig 2, strat 2, elas 3, sicc 2, humo 1/2, homogeneous fibrous peat. Th^1(Moli.)4, Th^1(m.-cari.)+, Dh^1+
25 - 17	lim 1, nig 2, strat 2, elas 3, sicc 2, humo 1, homogeneous very fibrous peat. Th^1(Moli.)2, Th^1(m.-cari.)2, Dh^1+
17 - 12	lim 1, nig 2, strat 2, elas 3, sicc 2, humo 1/2, homogeneous fibrous peat. Th^1(Moli.)4, Th^1(m.-cari.)+, Dh^1+
12 - 0	nig 2, strat 2, elas 3, sicc 2, humo 1/2, homogeneous fibrous peat. Th^1(Moli.)4, Th^1(m.-cari.)+, Dl^1+, Dh^1+

Table A5.2.

Troels-Smith Sediment Description - TM 1

Depth in cm.	Description
185 - 181	lim 0, nig 4, strat 0, elas 0, sicc 2, humo 4, plastic peat with mineral granules, 10 YR 2.5/1 (black) $Sh^4 3$, $Th^2 +$, $Dh^1 +$, Gg 1, Ga +, Gs +
181 - 176	lim 0, nig 4, strat 0, elas 0, sicc 2, humo 4, plastic peat with fine mineral, 10 YR 2.5/1 (black) $Sh^4 3$, $Th^2 1$, Ga +, $Dh^1 +$
176 - 159	lim 0, nig 4, strat 0, elas 0, sicc 2, humo 4, plastic peat, 10 YR 2.5/1 (black) $Sh^4 3$, $Th^2 1$, $Dh^1 +$
159 - 86	lim 0, nig 4, strat 1, elas 0, sicc 2, humo 3/4, slightly fibrous peat, 10 YR 2.5/1 (black) $Sh^4 2$, Th^2(vagi.)2, $Dh^1 +$, $Dl^1 +$
Includes two sub-layers :-	
127.5 - 129.5 and 89 - 91	lim 1, nig 4, strat 2, elas 1, sicc 2, humo 2, very fibrous peat, 10 YR 2.5/1 (black) $Sh^4 1$, $Th^2 1$, Th^1(vagi.)2
86 - 74	lim 0, nig 4, strat 1, elas 0, sicc 2, humo 3, slightly fibrous peat, 10 YR 2.5/1, (black) $Sh^4 1$, Th^1(vagi.)2, Tb^1(Sphag.)1
74 - 40	lim 0, nig 4, strat 1, elas 0, sicc 2, humo 3, slightly fibrous peat, 10 YR 2.5/1, (black) $Sh^4 1$, Th^3(vagi.)2, $Th^1 1$, $Dl^1 +$, $Dh^1 +$
40 - 25	lim 0, nig 4, strat 0, elas 1, sicc 2, humo 4, plastic very slightly fibrous peat, 10 YR 2.5/1 (black) $Sh^4 3$, $Th^2 1$, Th^1(vagi.)+, $Tb^2 +$

Table A5.2 (cont.)

25 - 2	lim 0, nig 3, strat 1, elas 2, sicc 2, humo 2/3, very fibrous peat, 10 YR 3/2, (dusky red) Dh^1(vagi.)3, $Th^2$1, Dh^1+
2 - 0	lim 0, nig 2, strat 1, elas 2, sicc 2/3, humo 2, very fibrous rooty peat, 10 YR 3/3, (dusky red) Dh^1(vagi.)1, $Th^2$1, $Tl^1$2, Tb^2+

Table A5.3

Troels-Smith Sediment Description - TMD 1 (Ditch section Tormore)

Depth in cm.	Description
50 - 38.5	lim 0, nig 2, strat 1/2, elas 0, sicc 2, humo 4, crumbly peat with mineral, 10 YR 3/2, (dark greyish brown) $Sh^4 2$, Ga 1, Gs 1, Gg +, $Th^2 +$
38.5 - 34	lim 0, nig 3, strat 1, elas 1, sicc 2, humo 4, granular slightly greasy peat, 10 YR 3/1 $Sh^4 2$, $Th^2 1$, Gg 1, Ga +, Gs +
34 - 22	lim 0, nig 4, strat 0, elas 1, sicc 2, humo 3/4, dense plastic peat, 7.5 YR 2.5/0, (black) $Sh^4 2$, $Th^3 2$, Ga +, Gs +
22 - 12	lim 0, nig 3, strat 2, elas 1, sicc 2, humo 3, crumbly slightly fibrous peat, 10 R 3/1(dark reddish grey) $Sh^4 3$, $Th^3 1$, $Tl^1 +$
12 - 0	nig 2/3, strat 0, elas 2/3, sicc 2/3, humo 3, fibrous peat, 5 YR 3/3, (dark reddish brown). $Sh^4 2$, $Th^1 1$, $Tl^2 1$, $Dl^1 +$

Table A5.4.

Troels-Smith Sediment Description - TMD.4 (Ditch section Tormore)

Depth in cm.	Description
74 - 63	lim 1, nig 4, strat 0, elas 1, sicc 2, humo 3, plastic slightly fibrous peat, 10 YR 2.5/1, (reddish black) $Sh^4 3$, $Th^3 1$, Gg +, Ga +, Gs +
63 - 56	lim 1, nig 4, strat 0, elas 1, sicc 2, humo 3, plastic slightly fibrous peat, 10 YR 2.5/1, (reddish black) Gg 1, $Sh^4 2$, $Th^3 1$, Ga +, Gs +
56 - 52	lim 1, nig 4, strat 0, elas 1, sicc 2, humo 3/4, plastic greasy peat, 10 YR 2.5/0, (black) $Sh^4 3$, $Th^3 1$, Ga +, Gs +
52 - 47	lim 1, nig 4, strat 0, elas 0, sicc 2, humo 4, granular peat, 5 YR 6/2, (pinkish grey-mineral, 10 YR 2.5 /0 , (black-peat) $Sh^4 1$, Gg 1, Ga 1, Gs 1
47 - 42	lim 0, nig 4, elas 1, sicc 2, humo 3/4, strat 0, greasy fibrous peat, 10 YR 2.5/0, (black) $Sh^4 3$, $Th^3 1$, Ga +, Gs +
42 - 29	lim o, nig 3, strat 0, elas 2, sicc 2, humo 3, fibrous peat, 10 R 3/2, (dusky red) $Sh^4 2$, $Th^2 2$, Ga +
29 - 20	lim 0, nig 4, strat 0, elas 1, sicc 2, humo 3, fibrous peat, 10 r 2.5/2, (very dusky red) $Sh^4 3$, $Th^3 1$, Ga +
20 - 13.5	lim 1, nig 3, strat 0, elas 2, sicc 2, humo 3/4, plastic slightly fibrous peat, 5YR /32, (reddish brown) $Sh^4 3$, $Th^3 1$, Ga +, Gs +

Table A5.4 (cont.)

13.5 - 7.5	lim 1, nig 3, strat 0, elas 2, sicc 2, humo 3/4, plastic slightly fibrous peat, 5 YR 2.5/2, (reddish brown) $Sh^4 3$, $Th^3 1$, Ga +, Gs +
7.5 - 0	nig 3, strat 0, elas 2, sicc 2, humo 3, very fibrous peat, 7.5 YR 3/2, (dark brown) $Th^3 1$, $Tb^2 2$, $Sh^4 1$, Tl^2+

Table A5.5.

Troels-Smith Sediment Description - TMD 5 (Ditch section Tormore)

Depth in cm.	Description
34 - 28	lim 1, nig 4, strat 0, elas 1, sicc 2, humo 3/4, slightly fibrous peat, 10 R 2.5/1, (reddish black) $Sh^{4}3$, $Th^{3}1$, Ga +, Gs +, Gg +
28 - 24.5	lim 1, nig 1/2, strat 0, elas 0, sicc 2, humo 4, granular peat, 10 YR 7/3, (very pale brown) Ga 1, Gs 2, Gg 1, $Sh^{4}+$
24.5 - 14	lim 0, nig 4, strat 0, elas 1, sicc 2, humo 3/4, fibrous peat, 10 R 2.5/1, (reddish black) $Sh^{4}2$, $Th^{3}1$, $Tl^{3}1$, Ga +, Gs +,
14 - 0	lim 0, nig 3, strat 0, elas 2/3, sicc 2, humo 2/3, fibrous peat, 10 YR 2.5/2, (very dusky red) $Sh^{4}2$, $Th^{3}1$, $Tl^{3}1$, Ga +, Gs +

APPENDIX A6

SYMBOLS USED TO EXPRESS THE TROELS-SMITH ANALYSES

Figures A6.1, A6.2, and A6.3 show the symbols used to express the deposit elements present in the peat as revealed in the Troels-Smith analyses. The numbers on the figures correspond to the proportion of the deposit elements in the peat, (see section 4.6). The Troels-Smith analyses as expressed alongside the pollen diagrams also show the humicity of the deposit by means of the thickness of line used.

1 (Humo 0 and part 1) ———— (0.3 mm.)

2 (part Humo 1 and 2) ———— (0.5 mm.)

3 (Humo 3 and 4) ———— (0.7 mm.)

(After Aaby, 1979).

Figure A6.1

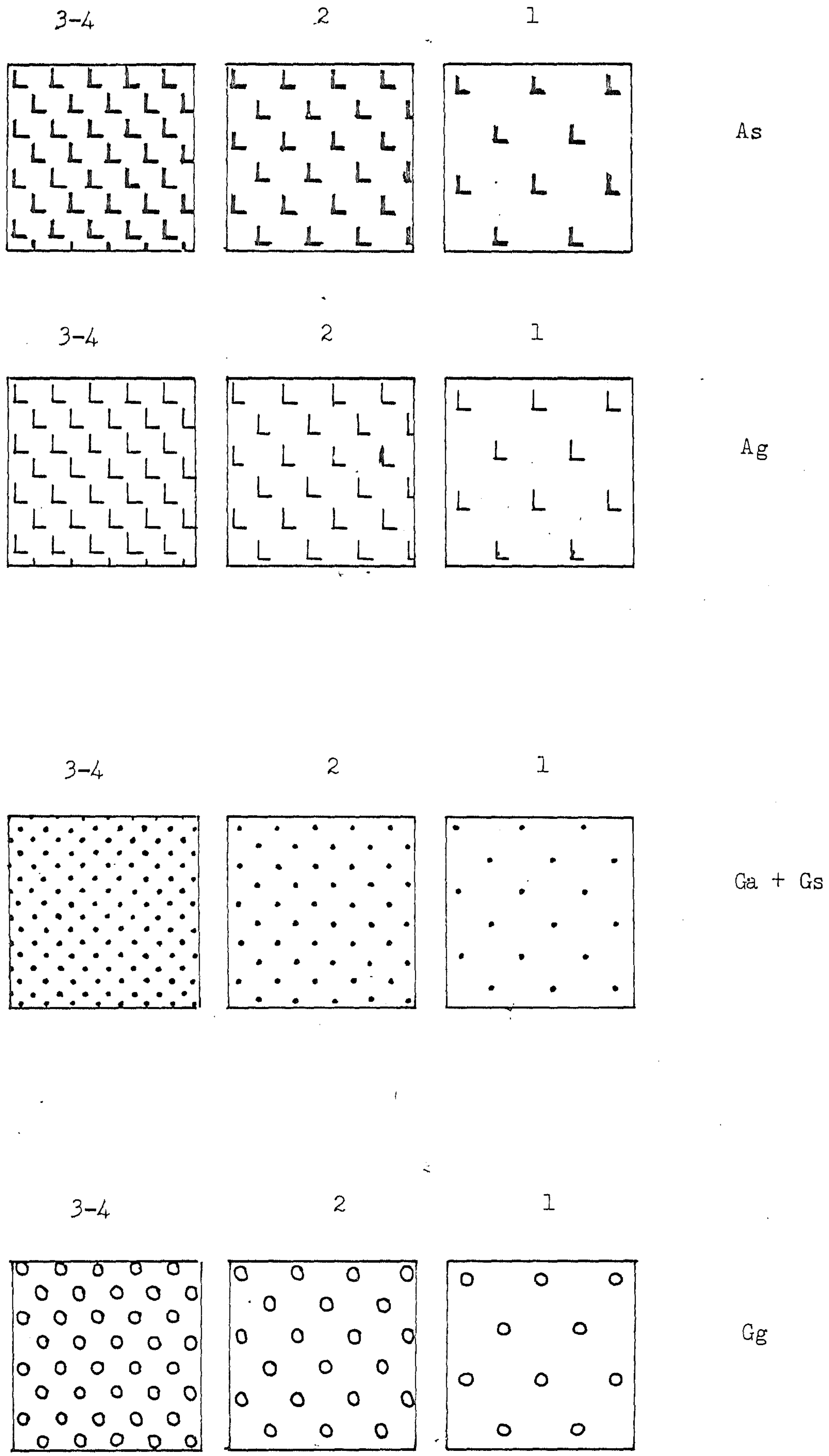


Figure A6.2

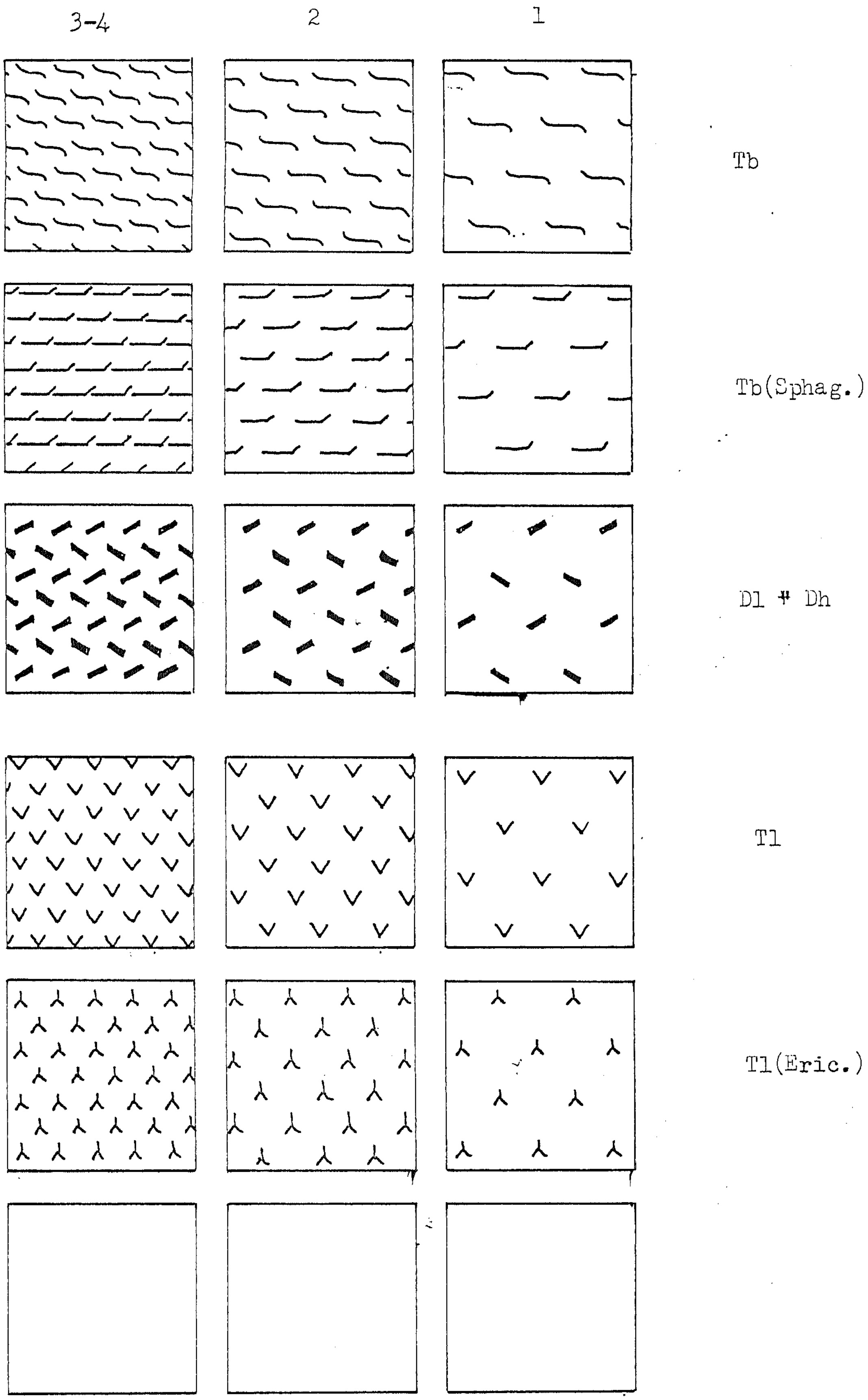
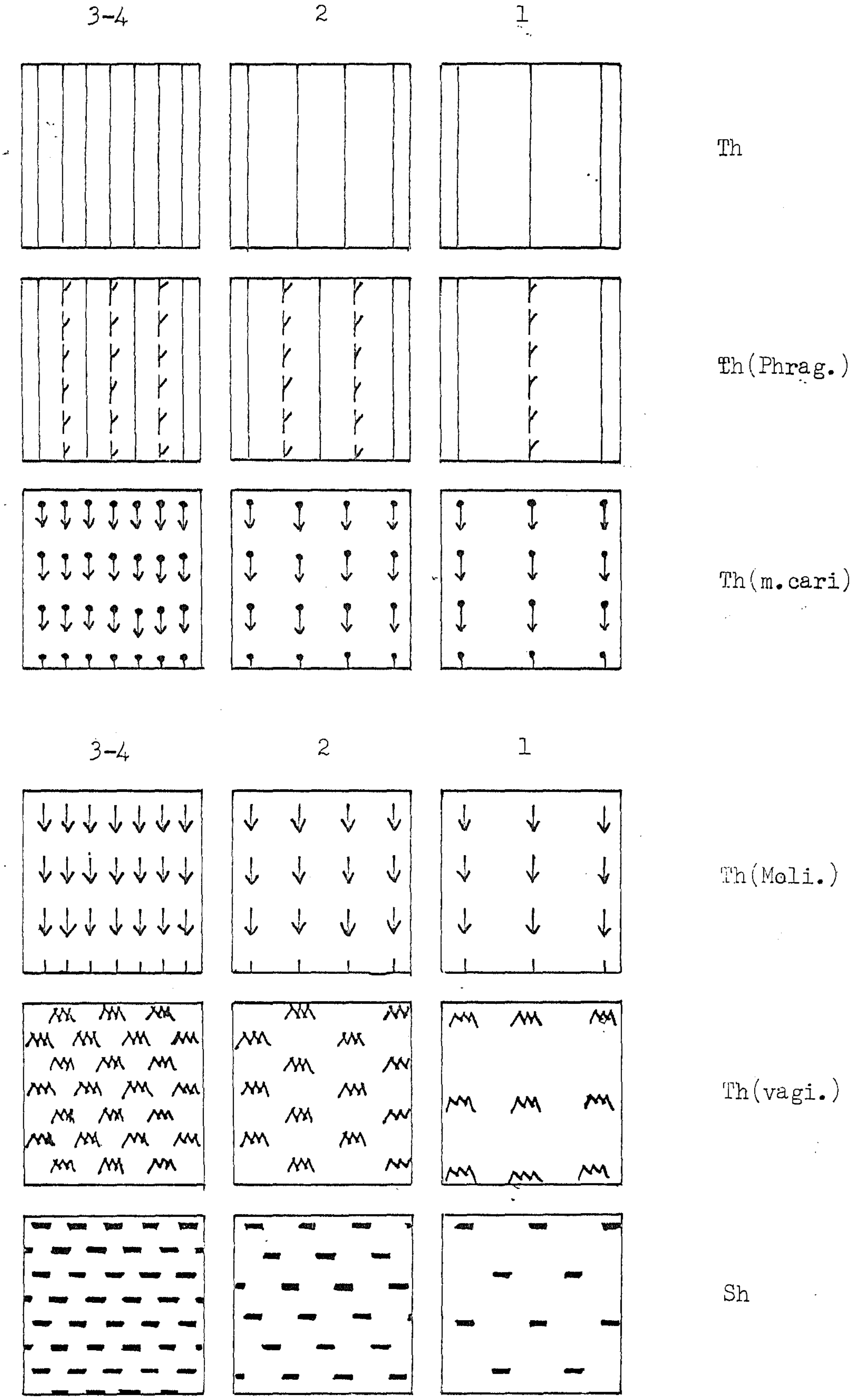


Figure A6.3



APPENDIX A7

CONSTITUENT TAXA IN THE POLLEN TYPES USED IN THIS THESIS

Prunus Type - includes *Prunus* and *Rosa*.

Sorbus Type - includes *Sorbus aria*, *S. aucuparia*, some grains of *Crataegus*, and *Rubus saxatilis*.

Potentilla Type - includes *Potentilla* and *Fragaria*.

Genista Type - includes *Genista*, *Ulex*, *Cytisus*, and *Sarothamnus*.

Ononis Type - includes *Ononis* and *Melilotus*.

Plantago major/media Type - includes *P. major* and *P. media*.

Lobelia Type - includes *Lobelia dortmanna* and *Digitalis purpurea*.

Viola palustris Type - includes *Viola palustris* and *V. riviniana*.

Rhinanthus Type - includes *Rhinanthus*, *Bartsia*, *Euphrasia*, and *Veronica*.

Mentha Type - includes *Mentha*, *Lycopus*, *Thymus*, *Origanum*, and *Salvia*.

Stachys Type - includes *Galeopsis*, *Stachys*, *Lamium*, *Ajuga*, and *Scutellaria*.

Scilla Type - includes *Scilla*,*Endymion*.

Armeria Type - includes *Armeria* and *Limonium*.

Cannabis/Humulus Type - includes *Cannabis sativa* and *Humulus lupulus*.

Allium Type - includes *Allium*, *Ruscus* and *Polygonatum*.

Majanthemum Type - includes *Convallaria*, *Paris*, and some grains of *Polygonatum*.

Hernaria Type - includes *Hernaria* and *Illecebrum*.

Polygonum bistorta Type - includes *P. bistorta* and *P. viviparum*.

Polystichum Type - includes *P. setiferum*, *P. lonchitis*, *Asplenium marinum*, and *Phyllitis scolopendrium*.

APPENDIX A8

A BRIEF SUMMARY OF INDICATOR SPECIES

Betula/Alnus - A peak in *Betula* and/or *Alnus* following a period of forest clearance may indicate a phase of woodland regeneration.

Fraxinus - Ash is often seral following the clearance of woodland and in addition tends to be found on soils around human settlements, which are often enriched by refuse etc..

Prunus Type - This pollen type includes *Prunus* and *Rosa*. These may be present in secondary woodland or scrub and may also be used in hedgerows. They can also be found in natural clearances in woodland and in habitats such as cliff ledges.

Sorbus Type - The common *Sorbus* species (i.e. *S. aucuparia*) can be found in similar habitats to *Prunus* type above.

Hedera - Ivy occurs commonly in the canopy of deciduous woodland and its behaviour can be an indication of the presence or absence of clearance. However it is very temperature sensitive and it is difficult to be sure of the conditions it indicates.

Ilex - Holly is present in the understorey of deciduous woodland and may become a substantial component of secondary woodland.

Calluna and other Ericaceae - A rise in *Calluna* and to a lesser extent, other Ericaceae indicates the spread of *Calluna* heath. This tends to ba associated with increasingly acid soils which are in turn a consequence in many cases of agricultural activity and deteriorating climate. Heath vegetation increases further the acidity of the soil. *Calluna* may also be present in small woodland clearances and its value as an indicator is possibly of greatest use in tracing pre-and early Neolithic events (Dimbleby, 1965, Pilcher and Smith, 1979).

Gramineae - An expansion in grass pollen is often taken as an indication of an increase in open habitats due to clearance for agriculture purposes at the expense of woodland. However in all the peat sections in this study this assumption is not possible due to the presence of local peat-forming members of the Gramineae. *Phragmites* rhizome fragments are present throughout the majority of MML80, apart from the upper 60 cm where they are replaced by an equal abundance of *Molinia* shoot bases. The other sections are composed almost totally of blanket peat with the regular presence of *Molinia* remains. In view of the fact that the behaviour of the regional grass curve is therefore obscured, Gramineae values have largely been ignored as an indicator of clearance and agriculture.

Compositae - Liguliflorae - Rosette forms of ligulate composites are commonly found in pasture. There is the possibility however that the pollen originated from species in natural habitats, *Lapsana* for example.

Compositae - Tubuliflorae - Similarily several of these are weed species with *Cirsium* possibly being the best known from grazed and disturbed ground. Again however the pollen may have originated from a natural habitat.

Rumex - The genus *Rumex* as a whole tends to have weedy tendencies often being present on waste and disturbed ground. *Rumex acetosa/acetosella*, the species most commonly encountered here, tend to be particularly associated with pasture and other grazed areas, although *R. acetosa* is also found in wetlands.

Caryophyllaceae - The presence of Caryophyllaceae pollen can be taken to indicate arable farming, although species such as *Silene* and *Lychnis* tend to be present in woodland and marshy areas respectively. Weedy species include species of *Stellaria* and *Cerastium*.

Artemisia - Mugwort is also associated with disturbed ground and is therefore often common in arable fields.

Urtica - Nettle is a plant with a requirement for phosphate which flourishes in the enriched soils around human settlements. It appears to be a good indicator of human activity particularly where large amounts of animal dung and other waste material are involved. In pollen diagrams it may not be such a precise measure of activity as stands of nettles can persist long after settlements are abandoned.

Rubiaceae - Pollen encountered from this family was most likely that of the genus *Galium*. *Galium aparine* tends to be associated with weedy areas around human settlements and with hedgerows. Species such as *Galium saxatile* and *G. verum* may be associated with grazed heaths along with *Potentilla erecta*.

Cruciferae - Weed species of this family are common, flourishing in regularly disturbed areas. Some species (eg *Cardamine*) are also present in grazed areas and in water-meadows.

Potentilla Type - Many species of *Potentilla* are included under this broad category although the vast majority of the pollen encountered is likely to be that of *P. erecta*, which is common in blanket bogs but may also be in many other habitats including grazed heaths (Boulet, 1939). There may also be a connection between the frequency of *Potentilla* pollen and the incidence of fire (Iversen, 1964, Mamakowa, 1968).

Filipendula - Meadowsweet tends to be present in tall-herb communities found along damp stream sides and similar habitats. Although not a direct indicator of human activity, the frequency of pollen from tall-herb communities may rise as forests are cleared, allowing them to expand. Conversely they are also sensitive to grazing and may decrease along with the forest.

Trifolium - Several species of Trifolium, especially T. repens, tend to be concentrated with farming particularly pastoralism on improved grassland.

Lotus corniculatus - L. corniculatus may be present on the margins of pasture, especially on banks and drier areas, it may also be present on grazed heath.

Lotus pedunculatus - L. pedunculatus tends to be present in wetter marshy areas and is not necessarily associated with agriculture.

Papilionaceae - This very general category includes Papilionaceae undiff., Vicia/Lathyrus type, Genista type, Ononis type. Although these are not strictly linked with agriculture they do tend to be favoured by forest clearance and disturbed or waste ground.

Umbelliferae - There are several weedy species of Umbelliferae which commonly occur in disturbed habitats and in association with arable agriculture. Many other species however are found in woodland and similar natural habitats.

Plantago lanceolata - Plantain is a very good indicator of pastoral agriculture and of human interference generally.

Plantago media/major - These two species are often associated with disturbed arable ground but can also be found in grazed areas which have been trampled by cattle (e.g. drinking areas).

Chenopodiaceae - Members of the Chenopodiaceae tend to occupy the same habitats as P. major/media and are also present in littoral habitats.

Succisa - Succisa is commonly found on grazed land especially if it is of poorer quality. However it is equally common in marshy areas and on dry banks in the absence of grazing.

Rhinanthus - This plant can be very common in hay meadows and undergrazed pasture, it is also found on dry banks and slopes.

Labiatae - Species such as Galeopsis and Lamium are often found in disturbed habitats and other species such as Stachys occur in natural woodland. Teucrium is found in a variety of habitats both open and wooded.

Melampyrum - This plant may be an indicator of forest clearance and fire (Dickson, 1980), but may also be present under a more or less open canopy.

Campanula and Jasione - Both of these species tend to be present on grazed heaths and also occupy dry banks, cliffs and ledges.

Ranunculaceae - The majority of the species in this genus tend to occur in weedy or man-made habitats of some form (with the exception of the aquatic ones). Many are associated with pasture and damp marshy areas.
Pteridium - Bracken tends to increase with the opening of the forest canopy. It also sporulates more prolifically under these conditions. It is often a component of the vegetation of the forest floor where it plays a subordinate role, reproducing vegetatively by means of its tough rhizome. The rhizome is resistant to fire and produces new shoots when fragmented. For these reasons, bracken is very hard to erradicate.
Gelasinospora - Spores originating from this fungus are common in peat and they are taken by van Geel (1978) to indicate local dry conditions and possibly burning. The curve of their frequency appears to follow that of Pteridium and to a certain extent the amount of charcoal in the peat.
Filicales - Ferns tend in the main to be common in woodland and a fall in the values of fern spores is often an indication of forest clearance.
Assulina and Amphitrema - These are genera of rhizopods which van Geel (1978) takes to indicate local wetness on the bog surface.
Hyalospenia subflava - This is a rhizopod which indicates disturbance of the peat (van Geel, 1978).
Corylus - Hazel pollen increasing as tree pollenfalls is a common sequence in a clearance phase. It is one of the first shrubs to recolonise cleared ground. It is markedly resistant to fire.
Polygala - This plant is present in blanket bog vegetation and may also be common in grazed heaths.

APPENDIX A9

TRANSLATION OF AN ANONYMOUS 13th CENTURY GAELIC PROSE POEM.

Arran

"Arran of the many stags - the sea impinges on her very shoulders! An island in which whole companies were fed - and with ridges among which blue spears are reddened! Soft blackberries on her waving heather; cool water there is in her rivers, and mast upon her russet oaks! Greyhounds there were in her, and beagles; blaeberries and sloes of the dark blackthorn; dwellings with their backs set close against her woods. And the deer fed scattered by her oaken thickets! A crimson crop grew on her rocks, in allher glades a faultless grass. Over her crags affording friendly refuge leaping went on and fawns were skipping! Smooth were her level spots - her wild swine,they were fat; cheerful her fields, her nuts hung on her forest hazels' boughs, and there was sailings of long galleys past her! Right pleasant their condition all when the fair weather sets in! Under her river banks trouts lie; the sea gulls wheeling round her grand cliff answer one the other - at every fitting time delectable is Arran'."

APPENDIX A10

ABBREVIATIONS USED IN THIS THESIS.

SDD (AM)	Scottish Development Department, Inspectorate of Ancient Monuments.
CEU	Central Excavation Unit.
AP	Arboreal (tree) Pollen.
TP	Total Pollen (excluding spores and Aquatics).
BP	Years before present (1950).
BC	Years before Christ.
AD	Years after Christ.
bp	Radiocarbon years before present (1950).
bc	Radiocarbon years before Christ.
ad	Radiocarbon years after Christ.
^{14}C	Radiocarbon (Carbon 14)
μ	microns (10^{-6} metre).
OS	Ordnance Survey.
OD	Ordnance Datum.
ca.	Circa (approximately).

Figure 5.1 MML80 Relative Diagram

Figure 5.1 MML80 MACHRIE MOOR. ARRAN 1980/81 ANALYST D.ROBINSON

Figure 5.2 MML80 Relative Diagram 100 - 270 cm.

Figure 5.2 MML80 MACHRIE MOOR. ARRAN 1980/81 ANALYST D.ROBINSON (100 - 270 cm.)


(100 - 270 cm.)
Gramineae
Cyperaceae
Calluna vulgaris
Plantago maritima
Pteridium aquilinum
Unknown
Broken
Corroded
Crumpled
Exotic
Calculation sum
Number of Taxa in calculating sum
Sum Trees
Sum Shrubs
Sum Ericaceae
Sum Gramineae
Sum Other Herbs
CM
P.A.Z.
MM-6c
MM-6b
MM-6a
MM-5b
MM-5a
MM-4b

Figure 5.3 MML80 Influx Diagram

Figure 5.3

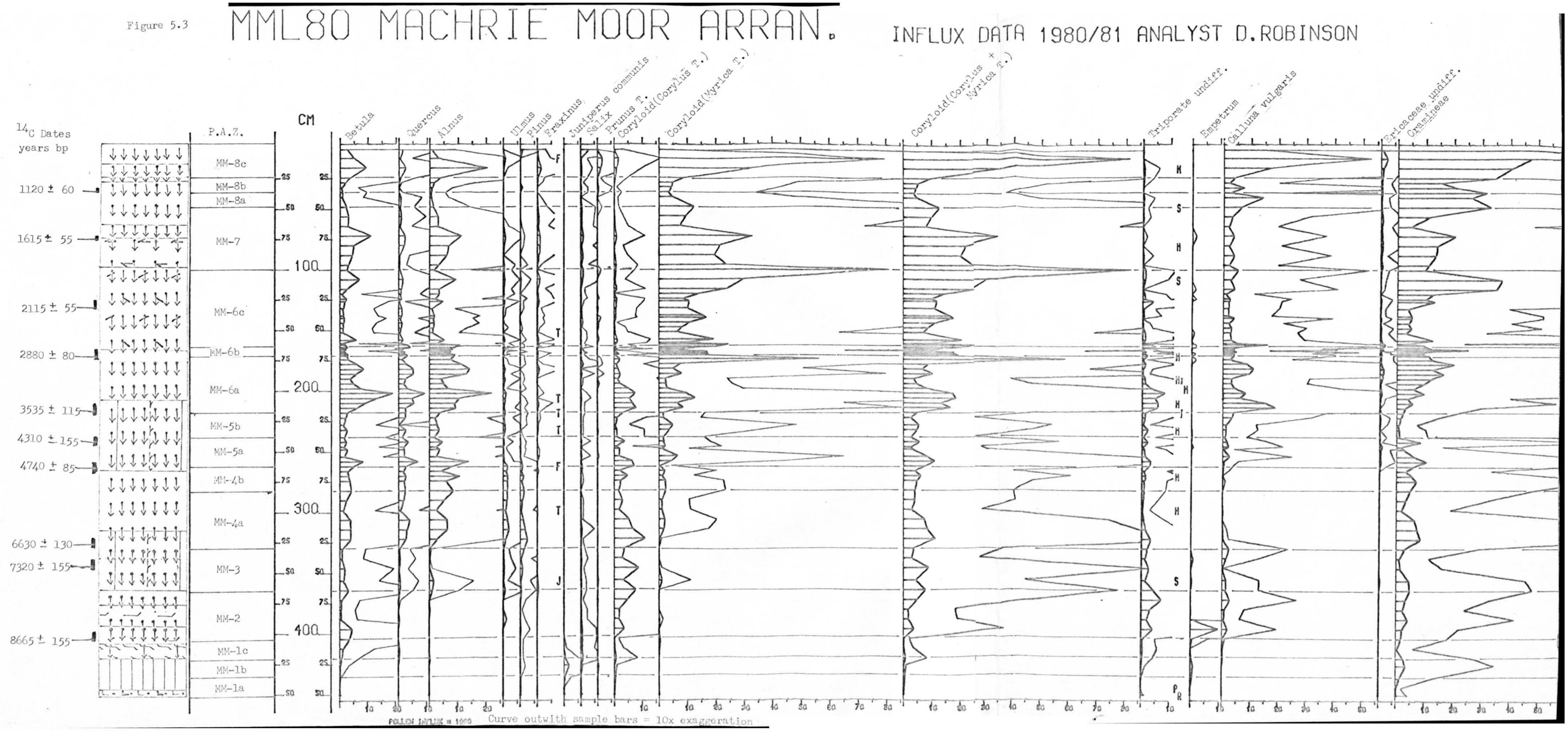

MML80 MACHRIE MOOR ARRAN.
INFLUX DATA 1980/81 ANALYST D.ROBINSON
14C Dates years bp
P.A.Z.
CM
Betula
Quercus
Alnus
Ulmus
Pinus
Fraxinus
Juniperus communis
Salix
Prunus T.
Coryloid(Corylus T.)
Coryloid(Myrica T.)
Coryloid(Corylus + Myrica T.)
Triporate undiff.
Empetrum
Calluna vulgaris
Ericaceae undiff.
Gramineae
1120 ± 60
1615 ± 55
2115 ± 55
2880 ± 80
3535 ± 115
4310 ± 155
4740 ± 85
6630 ± 130
7320 ± 155
8665 ± 155
MM-8c
MM-8b
MM-8a
MM-7
MM-6c
MM-6b
MM-6a
MM-5b
MM-5a
MM-4b
MM-4a
MM-3
MM-2
MM-1c
MM-1b
MM-1a
100
200
300
400
POLLEN INFLUX = 1980
Curve outwith sample bars = 10x exaggeration

Figure 6.1 TM1 Relative Diagram

Figure 6.1 TM1 TORMORE ARRAN. ANALYST.D.ROBINSON 1979.

Figure 6.2 TM1 Relative Diagram (basal 20 cm)

Figure 6.2 TM1 TORMORE ARRAN. ANALYST.D.ROBINSON 1979.(Basal 20 cm.)

Figure 6.3 TM1AB Relative Diagram

Figure 6.3

TMIAB TORMORE ARRAN.

ANALYSED. D.ROBINSON 1980

Curve with sample bars = 10x exaggeration

Figure 6.4 TM1AB Influx Diagram

Figure 6.4 TM1AB TORMORE ARRAN. INFLUX DATA ANALYSED. D.ROBINSON 1980

Figure 6.5 TMD1 Tormore

Figure 6.5 TMD1 DITCH SECTION TORMORE. ANALYSED D.ROBINSON 1979.

Figure 6.6 TMD4 Tormore

Figure 6.6 TMD4 DITCH SECTION TORMORE. ANALYSED D.ROBINSON 1979

Figure TMD5 Tormore

Figure 6.7 TMD5 DITCH SECTION TORMORE. ANALYSED D.ROBINSON 1979

Figure 6.9 Soil Samples

SOIL SAMPLES TORMORE. ANALYSED D.ROBINSON 1980

Figure 6.9

Figure A2.1 Surface Samples

Figure A2.1 SURFACE SAMPLE DATA ARRAN JUNE 1979. ANALYSED.D.ROBINSON

Table A2.1 Arran Quadrat Data

Table A2.1

Quadrat Data from Arran (see Appendix A2).

	Ar/01/79	Ar/02/79	Ar/03/79	Ar/04/79	Ar/05/79	Ar/06/79	Ar/07/79	Ar/08/79	Ar/09/79	Ar/10/79	Ar/11/79	Ar/12/79	Ar/13/79	Ar/14/79	Ar/15/79
Athyrium filix-femina	1							2		2					4
Dryopteris borreri	7														
Dryopteris dilitata	2								2	-	2				
Dryopteris filix-mas															4
Blechnum spicant	-						-	3	2						
Polypodium vulgare	-	1													
Pteridium aquilinum	1	4		-				5	5	-	-			-	
Aira precox									2						
Anthoxanthum odoratum	-	4						4	4	2					
Alopecuris geniculatus													-		
Arrhenatherum elatius															1
Brachypodium sylvaticum	2	2													
Carex binervis										-					
C. demissa							1								
C. echinata							2								
C. nigra							5						-	4	
C. panicea					-										
C. pulicaris															
C. remota							2				2				
C. rostrata			-												
Carex sp.									2						
Dactylus glomerata								1	3						1
Deschampsia caespitosa									2		7				
Eleocharis palustris												3		5	
Eriophorum angustifolium			-	2			2								
E. vaginatum				5	2		-								
Festuca rubra	-						1								
Glyceria fluitans															
Holcus lanatus	1	1										5	4		
Holcus mollis									2						
Juncus acutifloris							-	3					-		
J. articulatus															
J. bulbosus							1						2		
J. effusus											3			-	
Luzula pilosa (sterile)	1														
L. pilosa	-	2													
L. sylvatica		-						2	2						
Molinia coerulea			9	6	6	4	2								
Molinia litter			5		5									-	
Poa sp.	1														
Scirpus fluitans								4	2		3	5	2		
Allium ursinum															
Alisma plantago-aquatica														5	
Ajuga reptans												-		-	
Callitriche sp.									-		2				
Calluna vulgaris		-	2	6	4	10	4						7		
Cardamine flexuosa															1
C. pratense									-		-				
Cerastium holostioides								-							
Chrysosplenium sp.								-			1				3
Cirsium palustre								2			2				-
Conopodium majus	-	1						4	2	2					4
Corydalis claviculata	1														
Corylus avellana		-						-							
Digitalis purpurea								2	2						-
Drosera rotundifolia							3								
Endymoin non-scriptus	3							4	2	-					1
Epilobium montanum															2
E. palustre											2				
Eupatorium cannabinum															-
Erica cinerea		-				2									
E. tetralix			2	6	4	2	1								
Filipendula ulmaria										-	3				
Galium aparine	2														3
G. palustre												-			
G. saxatile									2	1	2				
Geranium robertianum															1
Geum urbanum															1
Hedera helix								-	-						
Heracleum sphondylium	-														3
Hydrocotyle vulgaris							4					5	-	4	
Iris pseudacorus												-		-	
Lathyrus montanus		2													
Lonicera peryclymenum	2	3						2	4						
Lotus corniculatus		-													
Lysimachia nemorum										2	-				2
Lythrum salicaria												-	-	-	
Mentha aquatica										-	2				
Menyanthes trifoliata							-								
Myosotis discolor															-
Myrica gale			-		7									-	
Narthecium ossifragum					2										
Oxalis acetosella	1	2						3	3	4	4				
Peplis portula												2	7		
Petasites hybrida															-
Polygala serpyllifolia					-										
Populus tremula	-	4													
Potamogeton polygonifolius							5					5		-	
Potentilla erecta		1	2	-	2	-	2	1						-	
P. palustris			-				-						-	5	
Primula vulgaris	3	3						2	-						3
Prunella vulgaris									1						
Ranunculus acris								-							
R. bulbosus															3
R. ficaria	-	1								3	3				2
R. flammula							-					3	4	-	
R. repens										3	3				
Rubus fruticosus agg.	6	1												-	
Rumex acetosa									1						4
R. crispus															3
R. obtusifolius	-														
Sanicula europaea															1
Salix sp.			-											-	
Salix aurita	-						-				-				
Scrophularia nodosum															2
Silene dioica															5
Solidago virgaurea		2							3						
Sorbus aucuparia								-	-						
Stachys sylvatica															3
Stellaria holostea	-							3							
S. holostiana		3							3						
S. media								-							2
Teucrium scorodonia	3	2						2	2						
Ulex europaeus					-									-	
Urtica dioica	3							-							2
Valeriana officinalis											3				3
Veronica chamaedrys															
Vicia sepium								-	-						
Viola sp.	1							3	3						2
Algae/algal mud							5						4	4	
Bare ground/rock								6	5	1	3				4
Leaf litter	5					4					3				
Open water							6					6		4	
Total Bryophyte Cover	5	5	4	4	3	1	7	5	5	4	4	5		6	5

N. B. Abundance recorded on the Domin scale, the symbol - denotes a species absent from the quadrat but present close by.