ASPECTS OF VEGETATION AND SETTLEMENT HISTORY IN THE OUTER HEBRIDES, SCOTLAND

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Submitted for the degree of Doctor of Philosophy,

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March 1999

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ABSTRACT

Although the Outer Hebrides today are virtually treeless, many parts of the islands appear to have sustained woodland during the early Holocene. The reasons for the decline in trees and shrubs, which took place between the Mesolithic and Iron Age periods, may include natural factors (e.g. climate or soil change) and/or human impact.

In order to gain an insight into the relationship between people and vegetation change, profiles from five sites were analysed for pollen, spores and microscopic charcoal content: Loch a' Chabhain and Loch Airigh na h-Achlais (South Uist), Fobost (a valley mire in South Uist); Loch Olabhat (North Uist), and the Neolithic archaeological site of Eilean Domhnuill (located in Loch Olabhat).

Other than at the archaeological site, arboreal pollen values were high (>75%) at the beginning of the Holocene. There is no evidence for a clear Mesolithic presence at any of the sites. Inferred woodland decline started *c.* 7900 BP (8690 cal BP) at Frobost, probably due to an expansion of the mire, and *c.* 5300 BP (6080 cal BP) at Loch a' Chabhain, probably also due to natural factors. Both areas may have been used for grazing from the Neolithic onwards. At Loch Airigh na h-Achlais woodland reduction started in the Neolithic, accelerating during the Bronze Age, perhaps due to climatic deterioration and/or grazing pressures. The profile from Loch Olabhat has strong evidence of human impact during the early Neolithic: a decline in arboreal taxa, an increase in cultural indicators, and signs of erosion in the catchment area. Woodland removal and cultivation here may ultimately have led to rising loch levels and the inundation of Eilean Domhnuill. At Loch Airigh na h-Achlais and Loch Olabhat there may be evidence for heathland management by fire during prehistoric and historical times.

Archaeological evidence points to a shift in settlement areas between the Iron Age and the Neolithic, from peat-covered inland areas to the machair along the west coast. A general expansion in heath and mire communities suggests that inland localities may have become increasingly infertile.

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Acknowledgements

This thesis could not have been completed without the help and support of a number of people and organizations. I am, first and foremost, grateful to my supervisor, Prof. Kevin Edwards, who provided invaluable assistance at every stage of the project. I thank the University of Sheffield and the Department of Archaeology for providing me with a studentship, and Patrick Ashmore and Historic Scotland for funding the radiocarbon dates. I am also grateful to the Departments of Archaeology at the University of Wales, Lampeter and Göteborgs Universitetet in Sweden, who kindly provided me with facilities and support during the last two years.

I would like to thank Rob Craigie for assistance in all matters technical, Ian Armit and Pam Grinter for providing information on Eilean Domhnuill, and the people who, at various times of the year and in all kinds of weather, helped in the collection of the cores: Kevin Edwards, Alex Woolf, Ross Dean, Tessa Roper, Mike Glide, John Algie, Jeff Millar, and John Raven. Gretel Boswijk and Tony Bewlay provided me a with a place to stay in Sheffield; I will be forever grateful for their hospitality. I would also like to thank Gretel for proofreading part of the text. Finally, I want to say a big thank you to my partner, Cornelius Holtorf, who managed to stay his usual calm, supportive self while I was under stress, and I would like to apologise to him for the fact that, despite his best efforts, I never managed to slip 'postmodernism' into my thesis.

Chapter 1

INTRODUCTION

1.1 Introduction

The Outer Hebrides is a group of wind-swept, barren, virtually treeless islands beyond the west coast of Scotland. The vegetation on the islands today is dominated by blanket peat, acid heath, and machair grassland, and only a few stands of trees are present, usually in inaccessible gorges or on small loch islands. It would appear that the islands are simply too wet and windy to support any significant tree growth. The perception of these islands as marginal and infertile has coloured archaeological and palaeoecological research. It was assumed that the islands were also barren and treeless in the past, and therefore rather uninteresting. Yet, in recent years this perception has started to change.

Numerous reports of subfossil wood remains during the last two centuries (MacGillivray, 1830; Niven, 1902; Erdtman, 1924; Jehu and Craig, 1925, 1926; Beveridge, 1926; Elton, 1938; Blackburn, 1946; and Heslop-Harrison and Blackburn, 1946) suggest that trees and shrubs did grow on the islands in the past. Initial pollen research, however, seemed to contradict this: a core from Little Loch Roag in Lewis produced very little arboreal pollen, and it was argued that the Outer Hebrides as a whole had never had much woodland cover, with the exception of a little birch and hazel scrub (Birks and Madsen, 1979). This evidence was disputed, however, by Wilkins (1984) who, without a great deal of effort, found 40 new sites with subfossil wood (including birch, pine and willow) in Lewis, close to the Little Loch Roag coring site. Since then numerous pollen profiles from both loch and peat deposits have provided evidence of extensive, albeit open, woodlands throughout the islands. These woodlands contained not only birch and hazel, but at many sites also pine, willow, oak, elm, and alder (Bennett *et al.*, 1990; Brayshay and Edwards, 1996; Fossitt, 1996; Lomax 1997).

Whereas the presence of trees and shrubs on the islands is now fairly well established, the reason for their decline is still a matter of debate. At some sites woodland decline started well within the Mesolithic period, and while some argue for climatic causes (for example at Loch Buailaval Beag in Lewis; Fossitt, 1996), others have suggested that Mesolithic hunter-gatherers may have directly or indirectly initiated woodland clearance at a number of sites (Bohncke, 1988; Edwards, 1996). The latter suggestion is particularly interesting in light of the fact that no Mesolithic archaeological sites have been found on the islands to date.

In some parts of the islands woodland persisted into the Neolithic, Bronze Age, Iron Age or even later. The presence of people on the islands during these periods is well recognized, and their apparent influence can often be seen in the vegetation record: trees and shrubs decline, heath and blanket bog expand, and potential pastoral and arable indicator taxa such as *Plantago lanceolata* and Cerealia-type appear or become more prominent. There may even be evidence for the practice of heathland burning (Edwards *et al.*, 1995). Yet even during the second half of the Holocene, not every incident of woodland decline can be explained by clearance and agriculture. At some sites woodland appears to decline gradually, and there is no evidence of deliberate clearance by people. Thus climatic factors probably still played a significant role in the changes in the vegetation. During the last 1500 years the islands have been almost entirely treeless and covered in heath and blanket bog.

1.2 The project

The aim of this thesis is to gain further insight into the relationship between people and vegetation change in the southern Outer Hebrides, and the study focuses on the following questions:

1) What was the vegetation at the sites selected for analysis, and in particular, what evidence is there for the presence of woodland? Many pollen diagrams from the islands in recent years have pointed to quite high tree and shrub frequencies (over 60%; Bohncke, 1988; Bennett *et al.*, 1990; Edwards, 1990; Brayshay and Edwards, 1996; Fossitt, 1996; Lomax, 1997), which has led researchers to suggest that the islands may have had considerable woodland cover in the past. How does the

evidence from this study compare? What taxa are likely to have been growing in the islands? Can patterns in woodland extent and composition be discerned?

2) When and why did woodland go into decline? At a number of sites investigated woodland decline started over 8000 years ago, while at others trees and shrubs persisted into the Iron Age (Edwards *et al.*, 1995; Brayshay and Edwards, 1996; Fossitt, 1996). How can these differences be explained? Are there any geographical patterns to the decline in woodland on the islands?

3) Which changes can potentially be attributed to human impact, such as deliberate clearance for agricultural activity, and which are more likely to reflect climatic or other natural changes, such as progressive soil decline? Is there any evidence for the management of heathland, as has been suggested for other sites in the islands (Edwards *et al.*, 1995)?

4) Can changes in the vegetation be tied to the settlement history of the islands? The islands have a rich archaeological history from the Neolithic period onwards, and patterns of human settlement may well be reflected in the pollen diagrams.

5) Is there any evidence at these sites that Mesolithic hunter-gatherers exploited the resources of the Outer Hebrides? Despite lack of archaeological evidence for the presence of Mesolithic hunter-gatherers, researchers have argued for possible Mesolithic impact at several sites in the islands, based on the evidence of declines in trees and shrubs and increases in microscopic charcoal (Bohncke, 1988; Edwards *et al.*, 1995; Edwards, 1996; Brayshay and Edwards, 1996; Lomax, 1997). Can this be supported by the sites in this study? How does the evidence compare with palaeoecological sites in the Inner Hebrides (Hirons and Edwards, 1990; Edwards and Mithen, 1995; Edwards and Berridge, 1994), where the early presence of Mesolithic people is well established (Wickham-Jones, 1994; Mithen and Lake, 1996)?

In order to examine these questions, five sites from four different geographical areas were selected for a comparative study (Fig. 6.1, 7.1, 8.1, and 9.1). One peat core and one loch core were taken from the western side of South Uist, another loch core comes from the east coast of the island, and a loch core and soil monolith have been collected in northwestern North Uist. The sites were selected from areas which, based on the archaeological evidence, appear to have had different settlement histories: the peat core at Frobost was collected in the vicinity of two known Neolithic chambered tombs; the core from Loch a' Chabhain comes from an area with a number of Iron Age sites; and the area around Loch Olabhat in North Uist has a great density of sites dating from the Neolithic onwards, including a Neolithic settlement site in the loch itself, from which the soil monolith was taken. On the other hand, there are no known prehistoric sites in the immediate vicinity of Loch Airigh na h-Achlais near the east coast of South Uist.

In each case the cores were analysed for pollen and spores, pollen preservation, microscopic charcoal and organic content of the sediment. Radiocarbon dates were obtained for all profiles except the soil monolith. The vegetational history at each of these sites was then reconstructed and compared to that of other sites on the islands in order to build up a picture of the vegetational history of the islands in general. Archaeological evidence for settlement patterns was used to assess the impact of people on the landscape in different parts of the islands.

1.3 The thesis

The thesis has been divided into 12 chapters (including this introduction). Chapters 2 to 4 provide the background to the current project, providing information which helps put the data obtained into context. Chapter 2 deals with the geographical background of the Outer Hebrides, focusing on the geology, climate and vegetation of the islands today. Chapter 3 reviews the existing palaeoecological studies on the islands, while Chapter 4 looks at the archaeological evidence. Chapter 5 describes the methods employed during this study, including site selection, data collection, laboratory methods, and data analysis. Chapters 6 to 10 describe and analyse the results of pollen and charcoal analysis at the five sites investigated in this study. Chapter 11 presents a synthesis of the results obtained from these sites, as well as other sites in the Outer Hebrides, and attempts to tie them in with the archaeological evidence for settlement history. Conclusions are presented in Chapter 12.

1.4 Conventions and definitions

1.4.1. Dates

As a general rule the dates in this study are expressed as uncalibrated radiocarbon years before present (BP), followed in parentheses by calibrated dates BP. In the review of archaeological evidence (Chapter 4), which is based on previously published data, dates are usually expressed as calendar years BC or AD, following the convention in archaeological texts. The term 'Lateglacial' (*c.* 14000-10000 BP [16790-11410 cal BP]) refers to the transition period between the last glacial and the current warmer period. The present interglacial (*c.* 10000-0 BP [11410-0 cal BP]) is referred to as the 'Holocene' or 'Postglacial'.

1.4.2 Nomenclature

Vascular plant nomenclature follows Stace (1991), while pollen and pteridophyte spore nomenclature follows Bennett (1994a) and Bennett *et al.* (1994). The term 'arboreal' includes both trees and shrubs. 'Heath' taxa refer to dwarf shrubs of the Ericaceae and Empetraceae families.

Chapter 2

THE GEOGRAPHICAL SETTING OF THE OUTER HEBRIDES

2.1 Introduction

The Outer Hebrides form a chain of islands off the west coast of Scotland, separated from the mainland and the islands of the Inner Hebrides by the Minch and the Sea of the Hebrides (Fig. 2.1). The archipelago is about 213 km in length with a coastline approximately 1800 km long (Boyd, 1979), and covers an area of about 2900 km^2 (Fettes *et al.*, 1992). There are some 119 islands in the group, of which 16 are currently inhabited (Boyd, 1979). Four outlying island groups are normally included with the Outer Hebrides: the Flannan Isles and St. Kilda, 30 km and 65 km west of Lewis respectively, Sula Sgeir and North Rona 70 km to the north of Lewis, and the Shiant Isles which lie 8 km southeast of Lewis (Fettes *et al.*, 1992). The economy of the islands is based primarily on fishing, crofting agriculture, tourism and weaving. The population is small, numbering only 29,600 in the 1991 census (General Register Office Scotland, 1993), half of whom live on Lewis and Harris (Ritchie, 1991). Apart from Stornoway, which is the largest town and commercial centre of the area, the population is distributed in crofting settlements throughout the islands (Boyd, 1979).

The Outer Hebrides present a considerable variety of geological and geographical features, from sandy coastlines to flat peat-covered areas, rocky knolls and lochs, and high hills. This chapter presents a summary of the general geographical setting of the islands; their geology, climate, land-use and vegetation.

2.2 Geology

With the exception of a small area to the north of Stornoway, the islands are almost entirely composed of metamorphic gneisses and igneous rocks of Precambrian age, collectively known as Lewisian gneiss. This coarse-grained, banded or streaky metamorphic rock is amongst the oldest rock form in the British Isles and was formed *c.* 2800 - 1600 million years ago. On weathering the gneiss

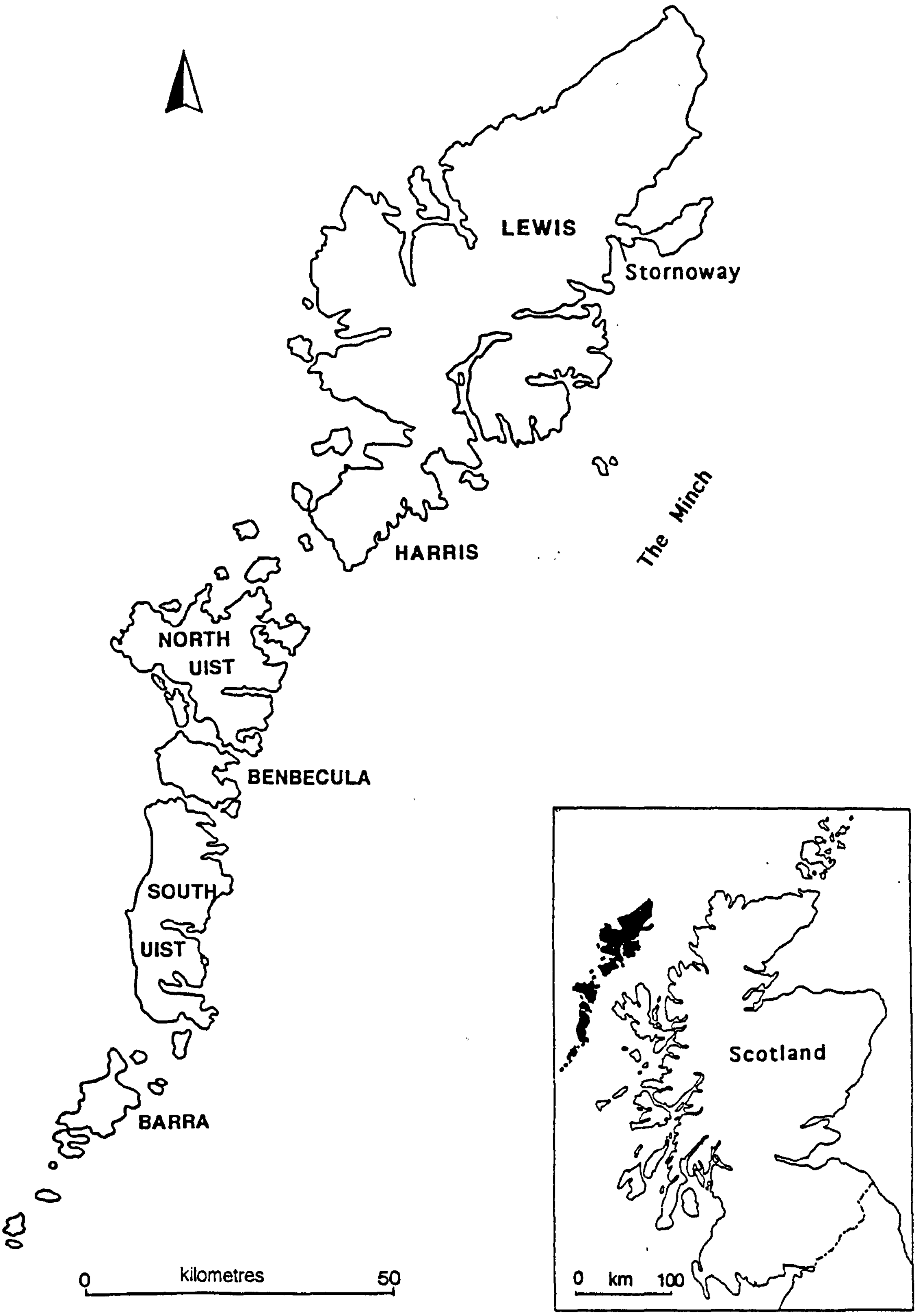


Fig. 2.1 Location of the Outer Hebrides

tends to produce a subdued undulating landscape, typified by central Lewis today (Smith and Fettes, 1979; Gribble, 1991). The area north of Stornoway has younger rocks, of either upper Palaeozoic or lower Mesozoic age, which form a thick sequence of sandstones and conglomerates (Fettes *et al.*, 1992), and erode with relative ease, resulting in the presence of good agricultural land around Broad Bay.

The eastern seaboard, and in particular the mountainous areas of North and South Uist, have been affected by a great thrust, the Outer Hebrides Thrust or Fault, which formed *c.* 2200 million years ago and runs north-south. In addition, there are numerous other faults trending northwest-southeast and east-west, which have affected the landscape, with many of the sea inlets and valleys having this orientation. The east coast plunges quickly to deep water in the Minch, whereas the west coast is characterised by a submerged shelving platform and a shallow sea (Gribble, 1991).

Glaciation has also left its mark on the landscape. The Outer Hebrides probably had its own local ice-cap during the last glacial maximum, although the northeast of Lewis may have been covered by the mainland ice sheet. The islands were wholly glaciated at this time with the possible exception of the extreme north-west of Lewis (Peacock, 1984; Sutherland and Walker, 1984). Deglaciation led to severe erosion, stripping off any residual cover the rocks may have had, and formed the characteristic 'knock-and-lochan' landscape of rocky knolls and small peat or water-filled hollows, typical of central North Uist (Gribble, 1991; Hudson, 1991)

There is evidence for early interglacial raised beaches on the coasts of north Lewis and northwest Barra (Baden-Powell and Elton, 1937; Peacock, 1984), but to date no postglacial raised beaches have been found on the islands, unlike the Inner Hebrides and the west coast of mainland Scotland (Donner, 1970; Dawson, 1984). The Outer Hebrides were not in an area of heavy ice-loading, and the eustatic rise in sea-level after deglaciation was greater than the isostatic uplift of the islands themselves, so that any raised beaches will have been obliterated by a subsequent postglacial rise in the sea-level (Peacock, 1984, 1991).

It is likely that the area of the Outer Hebrides was much greater in the early Holocene than it is today, perhaps forming one large island. Ritchie (1968,1985) has estimated that sea-level has risen at least 4 to 5 m since 8800 BP (9840 cal BP), with a further relatively rapid rise in the order of 5 m after 5100 BP (5840 cal BP). The rise in sea-level would have drowned the low-lying landscapes between the Uists and Benbecula, as well as the shallow areas of sand on Harris and Barra, creating a series of smaller islands (Boyd, 1979). Evidence of coastal submergence can be found in the numerous accounts of inter-tidal organic deposits, reported from the eighteenth century onwards (Sinclair, 1794; MacRae,1845; Beveridge, 1926; Jehu and Craig, 1923, 1925, 1926; Elton, 1938; Ritchie,1966, 1985).

2.3 Climate

The Outer Hebrides have been classified as 'hyperoceanic', with high precipitation, humidity and wind speeds, and a low annual temperature range (Angus, 1991). Rain falls in measurable amounts three days out of every four when measured over a year, and is particularly frequent and heavy in late summer and autumn (Manley, 1979). Average rainfall levels vary from 1100 mm at Stornoway, to 2610 mm at Loch Ashavat (Glentworth, 1979; Angus, 1991). Precipitation exceeds evaporation during every month of the year except June (Glentworth, 1979), and this long history of water surpluses has led to severe leaching of the soil and the formation of peaty podzols, gleys and peaty gleys, and blanket peat (Angus, 1991; Hudson, 1991).

The winter is mild for the latitude and relatively free of frost and snow. Snow has been recorded as falling on 47 days a year at Stornoway, but seldom remains on the ground for long. The warmest months are July and August (12.9°C mean daily temperature), whereas the sunniest months are May and June. The coldest months are January and February (4.1°C). This annual temperature range of 8.8°C is among the lowest in Britain (Angus, 1991). The warmest parts of the islands are in southern South Uist and Barra. Birse (1971) has described most of the Outer Hebrides as 'fairly warm', and only the higher summits are 'very cold', with no areas classified as 'extremely cold.'

The dominant factor in the climate appears to be the strong and persistent wind; most of the island area is classified as 'very exposed' (wind speeds of 6.2 - 8.0

m/s) (Birse and Robertson, 1970). The weather recording station at the Butt of Lewis is considered one of the most gale-swept places in the British Isles, and between 1931 and 1960 it recorded an average of 50 days a year with gale force winds (Manley, 1979). The wind may come from any direction, but most frequently blows from the south or southwest (Angus, 1991). In the southern islands, therefore, the most exposed areas are on the western side, with the hills on the eastern side providing more shelter (Birse and Robertson, 1970).

The oceanic climate appears to have a significant impact on the vegetation. One of the effects of high precipitation and high wind speeds is that montane plants tend to grow at much lower altitudes than in more continental areas, and that the growth of bryophytes such as *Sphagnum* spp. is favoured (Angus, 1991). The wind speeds tend to stunt the upward growth of plants, including trees, and encourage the lateral growth of dwarf forms, e.g. of *Calluna vulgaris* and *Juniperus communis*. In addition the winds are often salt-laden, particularly when they blow from the south or southwest, and maritime species such as *Plantago maritima* and the lichen *Ramalina siliquosa* may grow far inland (Angus, 1991; Currie, 1979).

2.4 Soils

The soils of the Outer Hebrides have formed since the last glaciation (Hudson, 1991), with hard granites and gneisses leading to the formation of a soil system based primarily on acid rock, covered by acid glacial deposits and blanket mire (Smith and Fettes, 1979; Boyd, 1979).

Peat is the dominant soil on the islands today (Glentworth, 1979). Blanket peat is defined as a soil having a surface horizon greater than 50 cm thick with an organic content of more than 60% (Hudson *et al.*, 1992). The depths of blanket peat on the islands average 1.5 m, but can reach as much as 5 m in pockets on Lewis (Goode and Lindsay, 1979). For centuries the peat bogs have been utilised as a source of fuel for domestic use on the islands (Boyd, 1979). Peatland is considered generally unsuitable for arable agriculture but it is used for grazing, and can be improved by mechanical means (Glentworth, 1979).

The soils around the crofting townships generally consist of podzols and peaty brown soils, while calcareous soils (machair; see below) can be found along the west coast of the southern islands (Glentworth, 1979) (Fig. 2.2). Further inland the land rises and becomes undulating and hummocky, with hollows filled with peat and lochs interspersed with bare rock. Along the east coast of the southern isles there is also an upland area with steeper slopes, where peat and bare rock alternate, and heather moor and grassland can be found on the better drained slopes. The rocky summits of these hills rise to 608 m in South Uist and 347 m in North Uist, while the highest mountains (up to 800 m OD) can be found in Harris (Caird, 1979).

Machair

One of the outstanding geographical features of the islands is the coastal plains of wind-blown calcareous shell sand known as 'machair'. In the Uists and Barra the machair covers about 10% of the total land area, and stretches almost continuously along the west and north coasts, varying in width from a few metres to some 2 km (Fig. 2.2). Two small patches can also be found on the east coast, at Rosinish on Benbecula and Kallin on Grimsay, and there are also small areas of machair in Harris and Lewis (Caird, 1979; Whittington and Ritchie, 1988; Ritchie, 1991).

Machair sand consists of a highly variable mixture of siliceous and calcareous fractions; the calcareous fraction can be as much as 60%, and appears to decrease with age, distance from the sea and amount of water saturation. Because of its alkaline nature, the machair areas can support a rich and varied flora not found on any other part of the islands, as well as providing relatively productive pastoral and arable farmland (Ritchie, 1967). The machair is also a breeding habitat for birds, including rare species such as the corncrake, and has the highest density of breeding waders in the British Isles (Angus and Elliott, 1992).

The history of the machair has been extensively studied by Ritchie (1967, 1979, 1985), Whittington and Ritchie (1988), Ritchie and Whittington (1994), Gilbertson *et al.* (1996) and Whittington and Edwards (1997). On present evidence it appears that the sands of the machair were originally derived from two sources: glacial sand deposited off the coast by the retreating Devensian icesheet, and

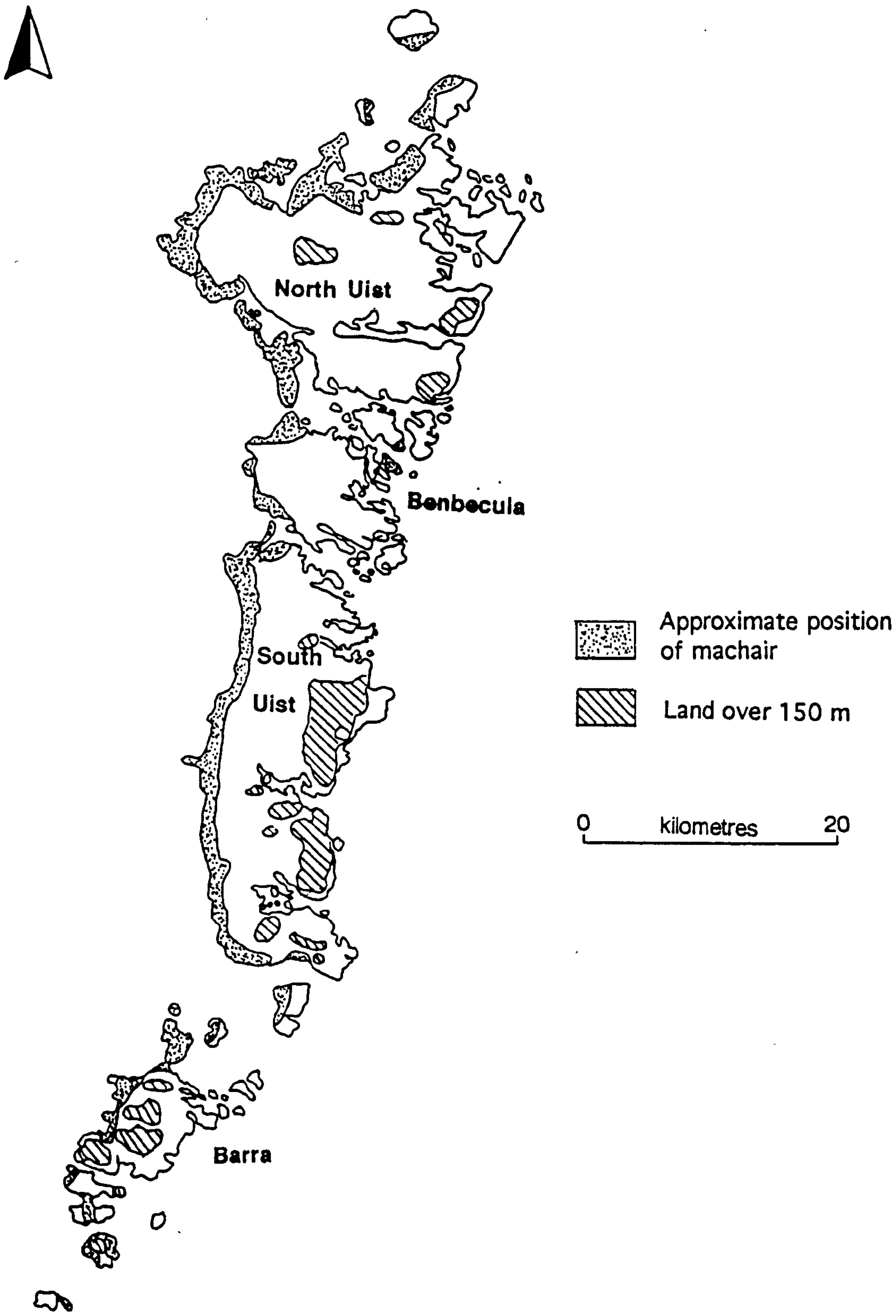


Fig. 2.2 Location of machair and high land in the southern Outer Hebrides (Branigan and Foster, 1995)

postglacial shell sand. As the sea-level rose, these deposits were moved towards the land mass of the Hebrides, either as a continuous process or in a series of discrete events (Ritchie and Whittington, 1994). Eventually this led to the formation of thick, high dune-ridges along what was then the coastline, possibly at around 7000-8000 BP (7800-8890 cal BP) (Whittington and Ritchie, 1988; Gilbertson *et al.*, 1996). These dunes were then re-worked by the strong wind, and through a sequence of erosion and deposition processes, sand was deposited progressively land inwards, producing an area of 'high machair', similar to that found close to the present day shore-line, and an area of lower relief further inland. Lochs and marshlands were impounded and eventually filled in by the redeposition of sand (Ritchie, 1979; Gilbertson *et al.*, 1996). As sea-level continued to rise, the dunes and machair continued to move further inland, and at the same time coastal erosion took place, so that the organic-rich loch sediments which had been buried by sand emerged on the coast lines, where some of them can still be seen today in the form of 'inter-tidal peats' (Ritchie and Whittington, 1994).

Over the centuries the areas of the 'high machair' eroded periodically, possibly accelerated by agricultural activity (Mate, 1992) and the sand was redeposited further inland as 'low machair', a process which continues today. During periods of greater landform stability, fossil soils could be formed, often containing evidence of human occupation, dating anywhere from Neolithic to recent historic times (Gilbertson *et al.*, 1996). As most Iron Age sites are located in and on top of present-day machair, it may be possible to argue that the main deflation phase, which reduced the earlier high machair or low dunes to low, flat plains took place before the Iron Age (*c.* 500 BC - AD 500) (Ritchie, 1979).

2.5 Land-use

The southern islands show a transition of habitat from west to east, from 'light' land (machair) in the west to 'black' land (peat) around the crofts, to the high hills on the east coast. Over the centuries the soils of both the 'light' ground and 'black' ground have been modified by agricultural activity. The 'mull' soils of the light ground have been grazed, tilled and drained, while the 'mor' soils of the black land have been affected by lazy-bed cultivation, burning (to improve the quality of grazing), and reclamation schemes (Boyd, 1979)

The nature of the soils and climate of the Outer Hebrides makes arable agriculture relatively difficult. In terms of land classification, only a very limited area has been classified as class 4 – 'land capable of producing a narrow range of crops' (Hudson *et al.*, 1992). The machair plains have been described as the best agricultural lands on the islands, despite the fact that they are very alkaline and deficient in organic material (Caird, 1979; Glentworth, 1979). In the 19th century the machair was used to grow barley, oats, rye, and potatoes, as well as natural grass and wild clover (Caird, 1979). Today the land is used either as unfenced common grazing land, or worked in a 'run-rig' system where cultivation of black oat, rye and potatoes is alternated with common grazing (Boyd, 1979; Hudson *et al.*, 1992).

Despite the fact that they form the best soils on the islands, cultivation on the machair plains is not without its problems. Sand deposition, caused by wind erosion of neighbouring dunes, can damage crops and grazing land. The machair itself is easily eroded, and despite the wet climate, periods of drought in spring and summer can lead to serious soil-drifting (Roberts *et al.*, 1959; Ritchie, 1967; Angus and Elliot, 1992). An additional problem is that the organic content and general fertility of the machair soils is very low, so that only a few crops can be harvested in succession (Kerr, 1954; Roberts *et al.*, 1959). The soils can, however, be improved by the addition of seaweed and peat, which help retain moisture and reduce the risk of drought damage and sand-blow (Kerr, 1954; Hudson *et al.*, 1992).

Between the machair and the peat-covered hills lie the croft houses and enclosed croftland. This land is cultivated or grazed intensively and is often referred to as the 'inbye' (Ritchie, 1991). The removal of peat for fuel and subsequent drainage of the soils, along with the application of seaweed, shell-sand and midden refuse has created a *Juncus*-rich grassland suitable for grazing around many of the crofting townships (Glentworth, 1979). In the past, these areas have also been used for spade cultivation, particularly in the eighteenth and nineteenth centuries when the population of the islands was much higher than it is today. In order to make the land more productive, 'feannagan', or lazy-beds, were constructed wherever site conditions permitted. These ridges, consisting of peat and/or mineral soils, were designed to provide adequate rooting depth and free drainage in areas where these did not occur naturally. Crops produced in lazy-beds included potatoes, oats, turnips, and black oats, with seaweed often applied as a fertiliser (Glentworth, 1979).

The more hilly ground on the eastern side of the islands is used as common grazing for sheep and cattle (Boyd, 1979).

2.6 Vegetation

The present day vegetation of the islands is relatively impoverished when compared with the Scottish mainland: 805 plant species have been recorded on the mainland, whereas 470 were counted on South Uist and only 407 on Barra (Perring and Walters, 1962). This lack of species diversity is probably partly due to the limited range of soil types (Johnson and Simberloff, 1974), and the exposure to frequent westerly gales and salt-laden precipitation, which may make the islands inhospitable to certain plant species (Brayshay, 1992). In the following account, plant nomenclature follows Stace (1991).

Peat bog and moorland communities

Lowland acid heath is the most widespread habitat of the Outer Hebrides, and wet heath communities are particularly common. These often include *Calluna, Erica*, and *Eriophorum vaginatum,* as well as *Potentilla erecta* and the grasses *Trichophorum cespitosum* and *Molinia caerulea* (Currie, 1979; Kent *et al.*, 1994).

Blanket peat bog is extensive on the islands, particularly in North Uist and Lewis, and typically consists of *Agrostis* bog, with large cushions of *Sphagnum* moss (usually *S. cuspidatum*, *S. papillosum* or *S. rubellum*). The drier areas of the mires are often dominated by *Calluna vulgaris*, *Empetrum nigrum*, and *Eriophorum angustifolium. Menyanthes trifoliata* thrives in deep mire pools, along with sedges, while the shallower pools tend to support *Potamogeton polygonifolius*, *Drosera* spp. and *Narthecium ossifragum* (Boyd and Boyd, 1990; Hudson *et al.*, 1992).

Unlike blanket bogs, valley mires receive much of their water as run-off, which carries soil-enriching minerals. Valley mires are usually located in small rock basins, and are much wetter than blanket bogs because the water flows to the centre of the valley, where it eventually drains away via a water track. *Carex* fen, with *Ranunculus flammula*, *Nymphaea alba*, *Potentilla palustris*, *Equisetum* and the mosses *Sphagnum recurvum* and *Polytrichum commune* can often be found, while *Sphagnum* hummocks support species such as *Calluna vulgaris*, *Erica cinerea*, *Potentilla erecta*, *Narthecium ossifragum*, *Drosera* spp., *Trichophorum cespitosum*, *Pinguicula vulgaris*, *P. lusitanica*, *Selaginella selaginoides*, *Carex rostrata* and *C. pauciflora* (Boyd and Boyd, 1990).

Coastal Communities

Typical species of machair grassland include *Festuca rubra*, *Trifolium repens*, *Galium verum*, *Achillea millefolium*, *Plantago lanceolata*, *Lotus corniculatus*, *Ranunculus acris*, *R. bulbosus*, *Bellis perennis*, *Taraxacum officinale* (*T.* sect. *Ruderalia*), *Euphrasia officinalis*, *Prunella vulgaris* and *Poa subcaerulea* (Dickinson and Randall, 1979; Kent *et al.*, 1994; Gilbertson *et al.*, 1995). Many of these plants are wild flowers which give the machair plains their beautiful aspect in spring and summer before they are grazed by cattle and sheep. If the machair is left ungrazed for a period of years, the red fescue (*Festuca rubra*) flourishes and eliminates virtually all other species (Boyd and Boyd, 1990).

Where cliffs and shorelines are exposed to regular inundation by sea-spray, maritime plants such as vernal squill (*Scilla verna*) and red fescue, much favoured by sheep, tend to flourish (Hudson *et al.*, 1992).

Machair lake margin communities

The machair edge has some of the most diverse and ecologically interesting vegetation on the islands. The vegetation of the muddy or peaty shores on the landward side of the machair lochs tends to be dominated by *Phragmites australis* fen, *Festuca rubra* and the sedges *Carex panicea* and *C. flacca*, as well as flowering plants such as *Ranunculus ficaria*, *R. flammula*, *Lychnis flos-cuculi*, *Cardamine pratensis*, *Hydrocotyle vulgaris*, *Potentilla palustris*, *Polygonum amphibium*, *Galium palustre*, *Dactylorhiza purpurella*, *D. fuchsii*, and *Leontodon autumnalis* (Boyd and

Boyd, 1990).

Neutral/acidic grassland communities

With the exception of dune pastures, semi-natural grassland communities (dominated by *Agrostis* and *Festuca*) are uncommon on the islands, and are confined to hill slopes with deeper soils, and to areas adjoining crofting land where grazing pressure has suppressed the moorland vegetation (Boyd and Boyd, 1990).

Montane communities

The mountain tops of the Outer Hebrides have a small range of plant species compared with the Scottish mainland. Only 29 of the 118 species of British montane vascular plants have been recorded on the islands, perhaps because the islands are too wind-blown, rugged and limited in surface area to develop extensive montane communities (Boyd and Boyd, 1990). The steep upper slopes of the hills and mountains on the Outer Hebrides are often colonised by *Agrostis* grassland, while the exposed rocky tops tend to have a sparse cover of fescue (*Festuca*), woolly fringemoss (*Rhacomitritum lanuginosum*), and lichens (Hudson *et al.*, 1992).

Woodland

At present the islands are almost entirely treeless. Individuals of several tree species appear in scattered locations, but stands of trees are rare (Bennett and Fossitt, 1989). What little natural or semi-natural woodland remains is confined to sheltered locations, in steep gorges and on islands in freshwater lochs; areas which are inaccessible to sheep and deer (Boyd and Boyd, 1990).

There are several small islands with woodland cover in the lochs of the National Nature Reserve of Loch Druidibeg in South Uist (Fig. 2.3). A number of these have been investigated by Spence (1960), who recorded the presence of *Salix atrocinerea*, *S. aurita* and *Sorbus aucuparia*, along with undergrowth taxa such as *Lonicera periclymenum*, *Rosa dumalis* and *Rubus fruticosus*. The islands are protected from grazing animals, but not from the wind, and the shrubs on the southwestern side of the islands tend to exhibit wind-pruning (Spence, 1960).

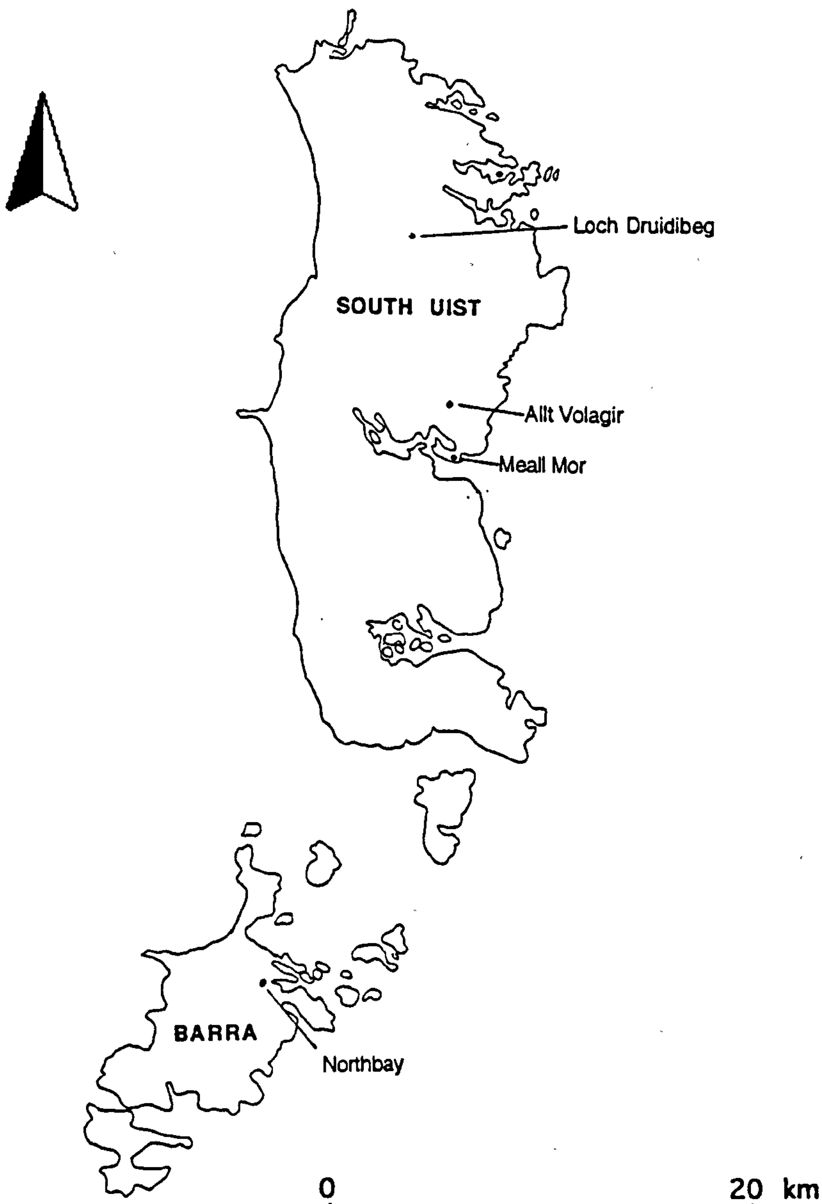


Fig. 2.3 Location of woodland sites mentioned in Chapter 3

One of the best examples of natural woodland on the Outer Hebrides can be found at Allt Volagir, an isolated gorge on the eastern side of South Uist. *Populus tremula* and *Corylus avellana* are the dominant tree species at this site, but *Betula pubescens*, *Salix aurita*, *S. atrocinerea* and *Sorbus aucuparia* were also found growing along the steep high cliffs (Spence, 1960; Currie, 1979). In addition, Bennett and Fossitt (1989) have described a stand of birch (*Betula pubescens*), along with rowan (*Sorbus aucuparia*) and willow shrubs (*Salix aurita*), at Meall Mór in South Uist. The presence of woodland in this area probably only occurs because the site is relatively far from human habitation and the grazing pressure is lower than it could be. It is also relatively well-sheltered from the wind by the standards of the Outer Hebrides (Bennett and Fossitt, 1989; Birse and Robertson, 1970).

Aside from natural woodland, there are a number of plantations on the islands. One of the most important is located in the grounds of Stornoway Castle in Lewis. The trees at this site were planted around 1850, using soil imported from the mainland. Species present include spruce, fir, cypress, pine, copper and common beech, wych and common elm, sycamore, ash, oak, laburnum, whitebeam, plum and maple. The castle grounds are a natural haven for birds and have an interesting ground flora and insect population which would not otherwise be found on the islands (Cunningham, 1962). 'Policy' woodlands also have been planted around most of the large houses on the islands (Currie, 1979; Boyd and Boyd, 1990), and experimental plots of conifers such as lodgepole pine (*Pinus contorta*) and Sitka spruce (*Picea sitchensis*) are grown for commercial purposes at several sites in Lewis (Boyd and Boyd, 1990).

Although it is possible for trees to grow on the islands, they do not necessarily thrive. A study of a small plantation at Northbay in Barra has shown that the trees at the west end of the plantation were suffering from severe foliage loss, and some were dead or dying, presumably due to the strong salt-laden winds (Gearey and Gilbertson, 1997).

2.7 Summary

The geology of the islands is dominated by Lewisian gneiss, which on weathering forms acid soils. The climate of the islands is very oceanic, with high levels of rainfall and strong winds. The combination of wet climate and acid soils have helped lead to the formation of blanket bog and heathland, which dominate the islands today.

The southern islands have three characteristic geographical areas: machair, 'blackland', and hills. The machair has been used for many centuries as the main arable land, the blackland has been occupied by settlements and improved for cultivation, while the peat covered inlands have been used primarily for grazing.

Heath and blanket bog communities dominate the vegetation on the islands, but calcareous grasslands can also be found in the machair, and typical montane communities on the highest hills. Woodland is scarce, and restricted to small islands in lochs and gorges which are inaccessible to grazing animals, as well as several small plantations.

Chapter 3

REVIEW OF EXISTING PALAEOECOLOGICAL STUDIES

3.1 Introduction

This chapter presents an overview of the research that has been conducted to date on the vegetation history of the Outer Hebrides, focusing in particular on pollen analysis. The history of palynological research on the islands stretches back to the 1920s, but as the discipline developed the islands were largely ignored. In the last 10 years much has been done to change this, and our knowledge of the vegetation history of the islands has improved considerably. However, not all areas have been equally well researched. Much of the pollen-analytical work to date has been conducted on the islands of Lewis and South Uist and to a lesser extent Barra, while the vegetation history of North Uist, Benbecula and the smaller islands remains relatively unstudied.

This chapter has been divided into sections on the basis of the main research issues on the islands: Lateglacial sites, trees and shrubs in the Holocene, woodland decline, heathland development and possible management, pollen analysis at archaeological sites, pollen analysis and machair, and taphonomic studies.

3.2 Lateglacial sites

The term Lateglacial as it is used in this study refers to the transition from the last cold phase (the Late Devensian) to the present Interglacial phase (the Holocene), spanning a period from *c.* 14000 BP to 10000 BP (16790-11410 cal BP). Edwards and Whittington (1994) list 7 sites on the Outer Hebrides with Lateglacial deposits: Loch Bharabhat 1, Loch Suirstavat, Loch na Muilne and Loch na Beinne Bige in Lewis, and Loch Lang, Reineval, and Loch Airigh na h-Aon Oidhche in South Uist (Fig. 3.1a and 3.1b). Since then, three more sites with extensive Lateglacial deposits have been added to the list: Loch Buailaval Beag, Loch a'Phuinnd (Fossitt, 1996) and Loch Hellisdale (Kent *et al.*, 1994; Brayshay and Edwards, 1996).

The pioneer vegetation on the Outer Hebrides generally consisted of herb-

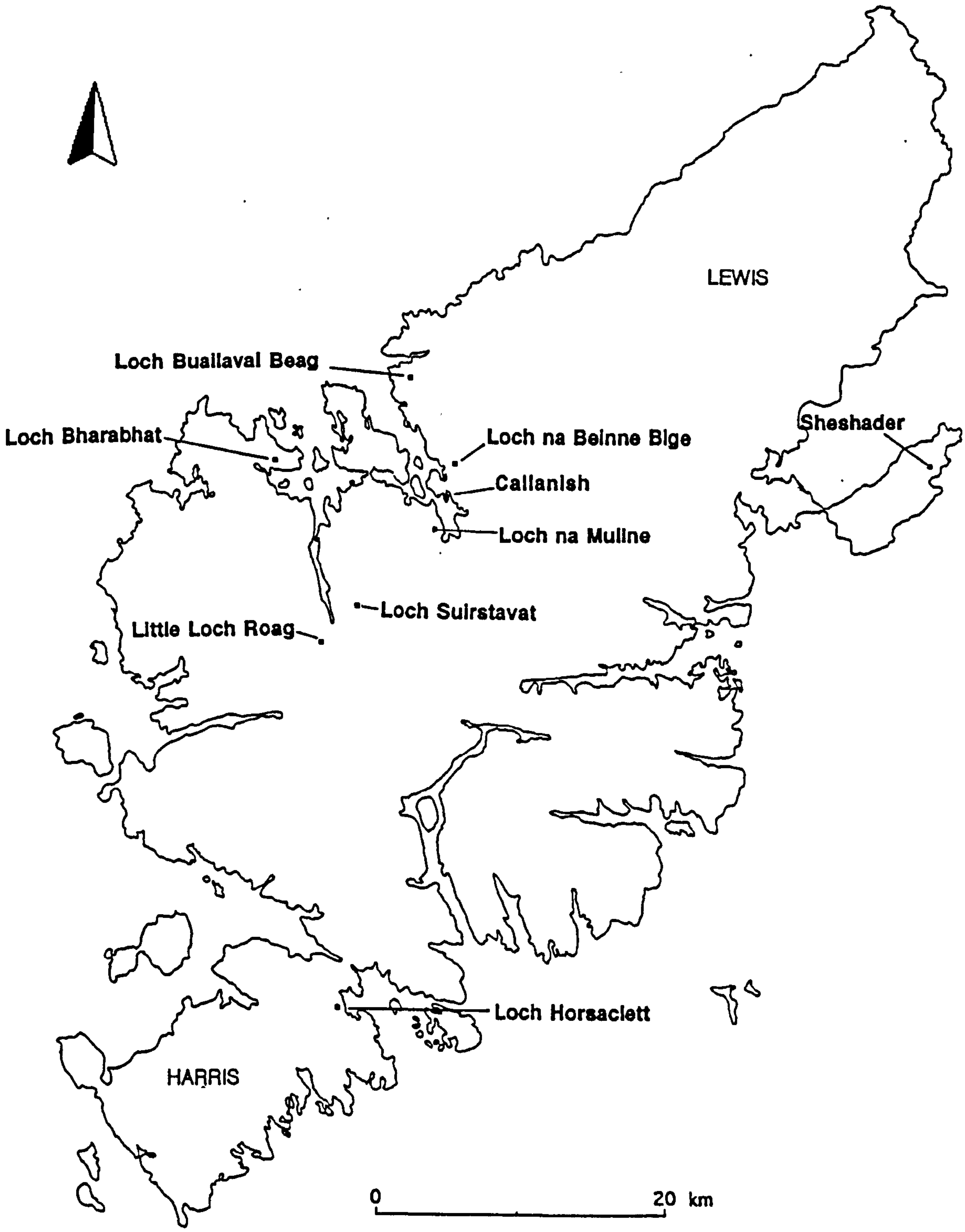


Fig. 3.1a Location of main palaeoecological sites in Lewis and Harris

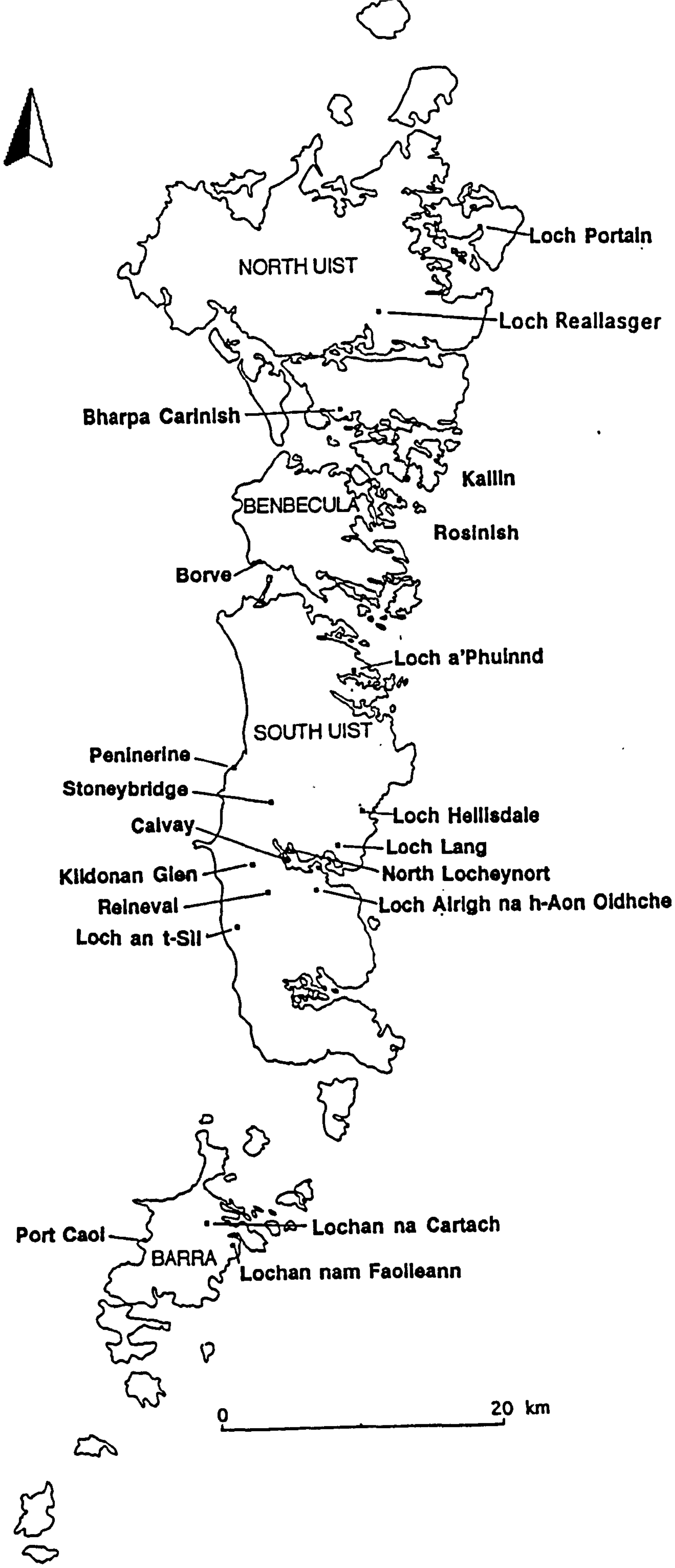


Fig. 3.1b Location of main palaeoecological sites in the southern Outer Hebrides

rich grassland with *Polypodium*, *Rumex*, and *Huperzia selago* as well as *Salix* scrub. As ground-cover increased *Empetrum nigrum* expanded and eventually dominated the vegetation at most sites (Fossitt, 1996). The exception is Loch an t-Sìl, where Poaceae remained the most important taxon. *Betula* and *Juniperus* may have formed patches of scrub, but there appears to have been no tree growth on the islands at this time. The Lateglacial vegetation on the Outer Hebrides was not entirely homogeneous. Aside from varying frequencies of *Empetrum* and Poaceae pollen, there are other local differences. For example, *Artemisia* and *Juniperus* featured prominently in the vegetation at Loch Hellisdale, but were not important at most other sites (Brayshay and Edwards, 1996). At some sites there is evidence for a colder period (the Loch Lomond Stadial; *c.* 11000-10000 BP [13020-11140 cal BP]), characterised in the pollen record by a decline in *Juniperus communis* and *Betula*, and an increase in *Empetrum* (Fossitt, 1996; Edwards and Whittington, 1994). Edwards and Whittington (1994) argue that the prominence of *Empetrum* may be deceptive, as it appears that at least some of the pollen may be of secondary origin, resulting from the erosion of interstadial deposits. If that is the case, then grassland, with sedges and *Huperzia*, were more important than they currently appear (Edwards and Whittington, 1994). The end of this phase is marked by climatic warming at around 10000 BP (11410 cal BP), leading to the appearance or expansion of trees and shrubs such as *Betula* and *Corylus*.

3.3 Trees and shrubs

3.3.1 Early research

The presence or absence of wood on the islands has been an issue since the very beginning of research into the vegetation history of the islands in the early part of this century. Early researchers looked at the peat bogs themselves, working on the theory that peat-stratigraphic units could be correlated with different climatic periods. Layers of undecomposed peat with *Sphagnum* were associated with wet periods, while more humified layers, often containing wood macrofossils, were considered indicative of a warmer and drier climate (Blackford, 1993). Lewis (1906,

1907) found one such layer with preserved wood in the Outer Hebrides, and the presence of these macrofossils led him to suggest that the islands were covered with "thick woods of birch and hazel, with some alder..." at some time in the Holocene (Lewis, 1906: 353). Samuelsson (1910) found two separate layers of wood remains containing birch twigs and hazelnuts in Lewis, and he, too, concluded that the island had been covered in woodland, first by birch forest and later by mixed birch and hazel forest. Erdtman (1924) was the first to publish the results of pollen analysis from the Outer Hebrides, taking samples from 11 peat bog sites in Lewis. In general, the lower layers showed high percentages of birch pollen, usually accompanied by high hazel and pine values, with a rise in alder at a later date, suggesting to Erdtman that these taxa grew on the island. Unfortunately Erdtman's study concentrated solely on tree pollen, and it is impossible to reconstruct the frequencies of arboreal versus non-arboreal pollen from his data (Erdtman, 1924). Elton (1938) looked at peat from an inter-tidal site on the island of Pabbay, taking samples for pollen analysis from a deposit which contained fragments of birch bark. He mentioned the presence of abundant *Betula* pollen, and argued that hazel and birch scrub was present in the Outer Hebrides, including the island of Pabbay, and that some of this woodland may have survived into historic times (Elton, 1938).

The general view among researchers around 1940 was, therefore, that the Outer Hebrides, despite the lack of tree-growth in the 20th century, had not been entirely treeless in the past. However, the publication of the first 'real' pollen diagrams, from Calvay and Stoneybridge in South Uist (Heslop Harrison and Blackburn, 1946) and Lochan nam Faoileann in Barra (Blackburn, 1946), may have helped to change this perception. It is difficult to compare the diagrams from these sites to modern pollen studies because of their lack of stratigraphic detail and the narrow range of recognisable land pollen taxa. Comparison is also made difficult by the fact that the taxa in the older diagrams are expressed in terms of total tree pollen, rather than total land pollen (TLP), the sum more commonly used today. Nevertheless, several interesting points can be made about the sites: at all three sites non-arboreal pollen percentages were generally deemed high throughout the profiles, and the authors concluded that at no time in the Holocene was there extensive tree cover on the islands. Yet, values for tree and shrub pollen were high enough in one zone at Lochan nam Faoileann for Blackburn to suggest that "...quite considerable numbers of forest trees grew on the better drained parts of the island during that period" (1946: 48). All three sites also had *in situ* fragments of birch towards the bottom of the profile, proving that there were at least birch trees growing on the islands. Moreover, if the pollen diagrams are redrawn using 'total land pollen' as the pollen sum, tree and shrub values are considerably higher than suggested by the older versions. Arboreal pollen values reach maxima of 48% at Lochan nam Faoileann, 63% at Calvay, and 77% at Stoneybridge (Brayshay and Edwards, 1996). Such values are in line with more recent studies, and high enough to suggest that there were some trees growing in these areas at some stage in the past.

3.3.2 Modern studies

The first 'modern' pollen diagram on the Outer Hebrides came from a mire beside Little Loch Roag, an exposed site on the west coast of Lewis (Birks and Madsen, 1979). Arboreal pollen frequencies were very low, and the pollen spectra suggested that in the early Holocene the vegetation was dominated by species-rich grassland with tall-herb and willow communities. Around 7700 BP (8440 cal BP) *Betula* and *Corylus avellana*-type attain their highest values (12% and 10% TLP respectively), suggesting to the authors that there were small patches of scrub in sheltered locations in the area at this time, but no other trees or shrubs (Birks and Madsen, 1979).

On the basis of the diagram from Little Loch Roag, Birks and Madsen (1979) argued that the Outer Hebrides as a whole had never had any extensive forest cover, confirming the conclusions drawn by Heslop Harrison and Blackburn (1946) and Blackburn (1946). There may have been some birch and hazel scrub growing in sheltered areas in the early Holocene at Little Loch Roag, but the presence of pollen from other trees, the authors argue, reflects long-distance dispersal. Because this was the only detailed, complete pollen study of the area at the time, it was very influential and its results were used in subsequent iso-pollen and vegetation maps of the British Isles (Huntley and Birks, 1983; Birks, 1989). Since then, however, new pollen diagrams, as well as studies using other palaeoecological methods, have been published which contradict Birks and Madsen's interpretation of the islands as a virtually treeless landscape. Indeed, it appears that the sequence from Little Loch Roag is atypical, not just of the island of Lewis, but of the Outer Hebrides as a whole.

Macroscopic remains of trees have been noted in the peat bogs of the Outer Hebrides for at least 150 years (MacGillivray, 1830; Smith, 1875; Niven, 1902; Lewis 1906, 1907; Samuelsson, 1910; E. Beveridge, 1911; Erdtman, 1924; Jehu and Craig, 1925, 1926; G. Beveridge, 1926; Geddes, 1936; Elton, 1938; Blackburn, 1946; Heslop Harrison and Blackburn, 1946), and in 1984 Wilkins published an article that specifically challenged Birks and Madsen's interpretation, using the evidence of *in situ* tree remains. Wilkins (1984) noted 40 sites on the island of Lewis alone, which had been discovered simply by walking the length of exposed peat profiles near roads. *Pinus*, *Betula* and *Salix* macrofossils were encountered. One site contained so many *Pinus* remains that Wilkins described it as a "virtual forest of stumps" (1984: 254), rejecting the idea that any trees present on the islands would have been represented by isolated individuals. Moreover, the woodland sites were not limited to sheltered, inland sites. A single pine stump was even found within 3 km of the Little Loch Roag coring site. Pine pollen frequencies from a sample directly below the stump were low (about 5%), and Wilkins (1984) suggests this may be due to strong westerly winds dispersing the pollen to a greater extent than one would expect at less exposed sites. Another possibility is that the peat sampled for pollen analysis was not exactly contemporaneous with the wood. Eleven samples from the woodland sites were radiocarbon dated, and the dates for the three species fell into three distinct time ranges: 9140-8550 BP (10300-9530 cal BP) for *Salix*, 7980-5030 BP (8880-5790 cal BP) for *Betula*, and 4870-3910 BP (5600-4360 cal BP) for *Pinus*. These dates correlate well with relatively high values for these taxa in the Little Loch Roag pollen diagram (Wilkins, 1984).

Recently Fossitt (1996) has published data from another 40 new sites with wood remains in the Outer Hebrides as a whole. *Salix* and *Betula* had the widest distribution, but *Alnus glutinosa* macrofossils were also encountered in Lewis. Pine stumps were again found in Lewis, but there are still no confirmed reports of *Pinus* macrofossils in the southern Outer Hebrides. Thirteen sites were radiocarbon dated, with dates falling into two discreet groups: 9200-7800 BP (10330-8570 cal BP) and 5200-3800 BP (5950-4190 cal BP), which the author suggests correlate well with palynological evidence of woodland decline, rather than periods of high arboreal pollen values, on the islands (Fossitt, 1996).

The studies conducted by Wilkins (1984) and Fossitt (1996) provide further irrefutable evidence that trees did grow on the Outer Hebrides, but the total extent of woodland is difficult to reconstruct from macrofossil studies alone. The preservation of trees growing *in situ* requires a suitable medium for preservation in an area where trees were growing, and can provide only a very local picture of woodland cover over a restricted period of time. Since the publication of Wilkins' (1984) study, however, new pollen diagrams seem to confirm the evidence of the macrofossils.

One of the first new palynological studies was conducted by Bohncke (1988), who published a series of pollen diagrams from a site 11 km to the northeast of the Little Loch Roag coring site. The diagrams were based on three overlapping peat-cores extracted near a sub-peat field wall on a small peninsula near the archaeological site of Callanish in western Lewis. The diagrams show high frequencies of *Betula* pollen in the first part of the Holocene, reaching over 70% by 8400 BP (9400 cal BP) and 87% at around 4300 BP (4850 cal BP), far higher than at Little Loch Roag. Bohncke (1988) suggests that birch may have been occupying sheltered valleys, with *Salix*, *Sorbus* and *Corylus* also occurring in suitable sites. The canopy was probably never closed, however, and tall-herb and fern communities grew among the trees (Bohncke, 1988).

Evidence for extensive woodlands has also been found on South Uist, particularly on the hilly eastern side of the island. Bennett *et al.* (1990) were the first to publish results from this area, taking a lake core from Loch Lang, where tree and shrub pollen frequencies reach a maximum of 60% TLP at *c.* 7700 BP (8440 cal BP) and again at *c.* 4500 BP (5170 cal BP). *Betula* and *Corylus* were the dominant species, but *Quercus*, *Ulmus*, *Fraxinus excelsior* and *Alnus glutinosa*, and possibly *Pinus* may also have been present, and the authors suggest that open woodland covered about half the island (Bennett *et al.*, 1990).

Since the publication of the pollen profiles from Callanish and Loch Lang, high arboreal pollen frequencies have been recorded for the early Holocene at virtually every site investigated. In Lewis evidence for quite extensive woodland has been found at Loch Buailaval Beag (maximum arboreal pollen 60.4% TLP; Fossitt, 1996), Loch na Muilne (82.1%), Loch Bharabhat (68.2%) and Loch na Beinne Bige (93.2%) (Lomax, 1997). As at other sites on the islands, *Corylus* and *Betula* were the dominant taxa, but *Quercus*, *Ulmus*, *Alnus*, *Pinus*, *Sorbus*-type (cf. rowan), *Fraxinus* and *Populus* have also been recorded (Fossitt, 1996; Lomax, 1997). At Sheshader on the east coast of Lewis (Newell, 1988) tree and shrub pollen reach over 90% some time before 4150 BP (4720 cal BP), with *Corylus avellana*-type pollen dominating the assemblage. *Salix*, *Pinus*, *Ulmus*, *Quercus* and *Alnus* pollen values are low throughout the profile, and it is unlikely that these taxa were ever present locally (Newell, 1988).

Woodland cover was also quite extensive at Loch Horsaclett in Harris at the beginning of the Holocene: arboreal pollen frequencies of up to 60% were recorded (Fossitt, 1990). Again, *Corylus* and *Betula* were the dominant taxa but *Quercus*, *Ulmus*, *Fraxinus*, *Alnus*, *Pinus*, *Sorbus*, *Populus* and *Salix* were probably also present locally. At Loch Reallasger in North Uist woodland cover reached its greatest extent (up to 70%) between 9900 and 8300 BP (11240-9280 cal BP) and taxa present included *Betula*, *Corylus*, *Salix*, and possibly *Sorbus* (Fossitt, 1990).

Meanwhile, other east coast sites in South Uist have confirmed the findings at Loch Lang. At Loch a' Phuinnd tree and shrub pollen frequencies reach a maximum of 57.7% (Fossitt, 1990, 1996). *Ulmus* and *Quercus* values increase *c.* 7600 BP (8390 cal BP) and these trees may have been growing in the area at this time, along with birch and hazel. Other woodland taxa that were probably present include *Salix*, *Sorbus aucuparia*, *Populus* and *Hedera helix*, and after 6000 BP (6810 cal BP) *Alnus glutinosa* and possibly *Pinus sylvestris*. At North Locheynort tree and shrub pollen frequencies likewise reach almost 60% (Edwards, 1990; Brayshay and Edwards, 1996), while at Loch Hellisdale woodland cover was at its densest between 8000 BP and 6000 BP (8890-6810 cal BP) with arboreal pollen frequencies reaching a maximum of 80.7% TLP (Kent *et al.*, 1994; Brayshay and Edwards, 1996). At Loch Airigh na h-Aon Oidhche tree and shrub representations reach 63.9% by 8500 BP (9510 cal BP) (Edwards *et al.*, 1995; Brayshay and Edwards, 1996). *Alnus glutinosa* frequencies at this site are amongst the highest on the islands (15.4%), and alder may well have been growing locally, along with small stands of *Quercus*, *Ulmus*, *Fraxinus excelsior* and *Sorbus.*

In the western part of South Uist, evidence for extensive woodland is more variable. At Loch an t-Sìl tree and shrub values reach a maximum of *c.* 75% around 7600 BP (8390 cal BP), at Kildonan Glen they reach 79%, but maximum arboreal pollen frequencies are only 42.2% at Reineval, and 38% at the inter-tidal site of Peninerine (Brayshay, 1992; Brayshay and Edwards, 1996). Woodland also appears to have been less diverse at these sites, with generally lower values for trees such as *Quercus*, *Ulmus* and *Alnus* than at the sites in eastern South Uist.

In Barra the presence of local birch woodland is clear at Port Caol, an inter-tidal peat site located on Borve point. Not only were birch macrofossils found in the profile, but during the early Holocene tree and shrub pollen frequencies reached a maximum of 95.3%, of which *Betula* was by far the greatest contributor (88% TLP). Still before 9200 BP (10330 cal BP) however, arboreal pollen frequencies fall to less than 20% (Brayshay and Edwards, 1996).

At Lochan na Cartach, on the eastern side of Barra, maximum tree and shrub pollen percentages, made up largely of birch and hazel, reached 87% (Brayshay and Edwards, 1996). Values for *Ulmus* are quite high (up to 7.9%) and it is possible that elm was also growing in the area, as well as *Populus tremula* and *Sorbus*-type.

McVean (1961) was the first to investigate the vegetation history of the island group of St. Kilda. He analysed three peat sites on Hirta, and found that the percentage of total arboreal pollen at two of the sites was broadly between 6% and 35%, which McVean argued was high enough to suggest that St. Kilda once had a cover of birch and hazel scrub, possibly with some *Pinus*, *Alnus*, *Ulmus* and *Quercus*. Since then Walker (1984) has published a diagram from Gleann Mor, also on Hirta, that contradicts McVean's findings. Pollen of *Betula*, *Corylus*, *Salix* and *Alnus* was present in the profile but never reached more than 6 or 7%, and has therefore been attributed to long-distance sources, although the possibility cannot be entirely ruled out that small numbers of birch and alder trees, along with willow and hazel scrub, may have grown in sheltered localities on the island.

3.4 Woodland decline during the Mesolithic

At several sites in the Outer Hebrides woodland decline started at an early date, still within what elsewhere would be accepted as the Mesolithic period (*c.* 10000-5000 BP [11410-5730 cal BP]). Some researchers have attributed this to the impact of hunter-gatherers, although so far no archaeological sites dating to the Mesolithic have been found in the islands. Others have concluded that a deterioration in climate and/or natural soils contributed to the decline of trees and shrubs.

One site where changes have been interpreted as possible evidence for human impact is Callanish in western Lewis (Bohncke, 1988). Birch pollen frequencies decreased sharply at this site around 7900 BP (8690 cal BP) coinciding with an increase in *Calluna vulgaris*, Poaceae, *Potentilla*-type pollen and charcoal. Bohncke has argued that these changes may reflect Mesolithic people burning the forest to encourage the expansion of heather moor and grassland in order to attract deer and other mammals, which could then be hunted.

A number of sites in South Uist may also have evidence for the presence of hunter-gatherers. Bennett *et al.* (1990) have suggested that decreases in arboreal taxa and a rise in the charcoal curve at a very early date (*c.* 9000 BP [10200 cal BP]) at Loch Lang could potentially reflect human activity. At North Locheynort there is a sustained charcoal peak from *c.* 7280 BP (8090 cal BP) to as late as *c.* 4460 BP (5130 cal BP) while at the same time there are reductions in *Betula, Ulmus, Quercus* and *Pinus* (Edwards, 1990; Brayshay and Edwards, 1996). Charcoal values are also high in Mesolithic age levels at Reineval, especially *c.* 6000 BP (6810 cal BP) where again they are associated with a decline in trees and shrubs (Edwards, 1996). There appear to be two episodes of woodland removal at Loch an t-Sìl, at *c.* 8040 (9000 cal BP) and *c.* 7870 BP (8620 cal BP), associated with expansions in Poaceae, *Calluna* and charcoal, and a decrease in undifferentiated ferns and *Osmunda* (Edwards *et al.*, 1995). A similar reduction in ferns at two sites in Shetland has been interpreted as possible evidence of grazing by red deer (Bennett *et al.*, 1990; Edwards and Moss, 1993). Other evidence comes from coastal sites: Whittington and Edwards (1997) hypothesise that Mesolithic activity may have accelerated change at the machair site of Borve in Benbecula. Fire frequencies appear to have increased around 6045 BP (6850 cal BP), and burning of the vegetation may have facilitated erosion at the site.

It has been suggested that Mesolithic people could be at least partly responsible for all the changes described here. The woodland could have been cleared deliberately to increase browse in the area, while increases in charcoal could either be due to deliberate burning of the woodland, or the presence of domestic fires (Edwards *et al.*, 1995; Edwards, 1996).

Not every woodland decline during the Mesolithic has been interpreted as evidence of human impact. At Loch Buailaval Beag, for example, woodland taxa underwent a major decline after 7900 BP (8690 cal BP) and were replaced by blanket bog communities. There is no evidence for an increase in fire frequencies at this time, and Fossitt has interpreted this event as a result of natural climatic changes, rather than the presence of Mesolithic people in the area (Fossitt, 1996). Nor is there evidence for a decline in woodland at all sites during the Mesolithic; tree and shrub taxa persisted into the Neolithic in some areas, and as late as the Iron Age in parts of eastern South Uist (Edwards *et al.*, 1995).

3.5 Changes in the vegetation from the Neolithic to the Iron Age

Woodland generally continued to decline during the Neolithic, and blanket bog, heath and grassland communities became more prominent. At the same time probable evidence for the presence of people on the island increases in many pollen diagrams. At Callanish, trees and shrubs, which had regenerated to a certain extent after a decline around 7900 BP (8690 cal BP), suffered a decline *c.* 5035 BP (5800 cal BP). The presence of Cerealia-type and *Plantago lanceolata* pollen and a significant rise in the charcoal curve at this time, suggest that these changes could reflect Neolithic activity in the area. Between *c.* 4580 and 3900 BP (5310-4350 cal BP) there was another phase of strong birch regeneration, with birch pollen frequencies reaching a maximum of 87% TLP. A second Neolithic clearance took place *c.* 4250 BP (4830 cal BP) after which the area appears to have been used alternately for pastoral and arable agriculture (Bohncke, 1988).

At Loch Horsaclett in Harris the first significant decline in woodland occurred around 5000 BP (5730 cal BP), and the area was predominantly treeless by 2000 BP (1960 cal BP) (Fossitt, 1990). At Lochan na Cartach in Barra there was a major reduction in arboreal pollen values from 4140 BP (4700 cal BP) onwards, and trees and shrubs were replaced by *Calluna* and Cyperaceae, while at Loch Hellisdale there was progressive woodland starting at *c.* 5000 BP (5730 cal BP), and accelerating after 3000 BP (Brayshay and Edwards, 1996; Kent *et al.*, 1994). The trees and shrubs at this site were replaced by grassland, to be followed at *c.* 1400 BP (1300 cal BP) by a marked expansion in *Calluna vulgaris* blanket peat communities.

Not all sites have evidence of apparent deliberate clearance of woodland. At Loch Lang in South Uist a spread of blanket peat in the area appears to have begun around 5500 BP (6290 cal BP), and from about 4300 BP (4850 cal BP) onwards woodland taxa started to decline and were replaced by grasses, sedges, *Calluna* heath and blanket bog. These changes were gradual and were not accompanied by major erosional events or a rise in the charcoal curve, and cereal-type pollen does not appear until after 1480 BP (1360 cal BP) The authors therefore argue that the decline in woodland was brought about by slight but persistent grazing pressure rather than major clearance episodes (Bennett *et al.*, 1990).

Elsewhere, particularly on the eastern side of South Uist, woodland decline did not begin until the Bronze Age. The first major decline in woodland taxa at Loch a'Phuinnd, for example, began shortly before 4000 BP (4460 cal BP), but accelerated *c.* 3400 BP (3660 cal BP), coinciding with the start of an erosional phase in the sediment record (3400-2900 BP [3660-3060 cal BP]) (Fossitt, 1996). The *Plantago lanceolata* curve becomes continuous around 3800 BP, suggesting human activity in the area, but cereal-type pollen is not recorded at the site until 1400 BP (1300 cal BP).

At Callanish, a regional decline in trees and shrubs is recorded from about 3500 BP (3770 cal BP) onwards. This reduction in woodland is associated with increases in Poaceae, *Plantago lanceolata* and other characteristic pastoral indicators, as well as indicators of cultivation such as *Spergula arvensis* and *Convolvulus arvensis*, suggesting that the area was used for both grazing and arable at this time (Bohncke, 1988). Similar evidence comes from Loch Bharabhat on the Bhaltos peninsula in Lewis (Lomax, 1997). A decline in trees, an increase in the *Plantago lanceolata*, and *Hordeum*-type pollen recorded for the first time at *c.* 3600 BP, suggest that arable agriculture was brought to the area during the early Bronze Age.

There are no clear indications of human impact at Loch Airigh na h-Aon Oidhche before *c.* 3680 BP (4030 cal BP), when there is a marked reduction in arboreal pollen accompanied by a slight rise in charcoal (Edwards *et al.*, 1995). The authors suggest that the spread of heathland taxa for most of the Postglacial in this area is likely to be a reflection of progressive soil deterioration and blanket peat formation, rather than forming evidence of human clearance phases. At Loch Reallasger evidence for woodland decline takes place even later, around 2130 BP (2110 cal BP) (Fossitt, 1990). Even at the top of the diagram, however, arboreal levels remain relatively high (30%); the pollen frequencies in these spectra do not seem to reflect the present treeless, peat-covered nature of the area, and the top of the profile may well be missing.

3.6 Heathland development and possible management

Heathland and blanket bog communities have probably been present on the islands since the beginning of the Holocene. At Loch Lang heathland already existed within the open woodland from around 9740 BP (11170 cal BP), although a final expansion did not take place until *c.* 1500 BP (1380 cal BP) (Bennett *et al.*, 1990), while at Loch Buailaval Beag in Lewis, peat growth has probably taken place from 7900 BP (8690 cal BP) onwards (Fossitt, 1996). The lack of anthropogenic indicator taxa at this time could indicate that peat bog and heathland initiation had natural rather than anthropogenic origins at these sites.

In some parts of the islands heathland and mire expansion appears to have taken place in particular between 5000 and 4000 BP (5730-4460 cal BP), and although environmental factors may have played a part, the presence of people on the islands may also have had an effect. Edwards *et al.* (1995) have looked at the evidence for a possible fire–wet heath relationship at several sites in South Uist. They suggest that a correlation between high values of charcoal and *Calluna vulgaris* could be an indication of the practice of heathland management by burning, in order to increase the productivity of the heath as grazing land. At a number of sites there appears to be such a correlation, although it is impossible to prove that the relationship is causal.

At Loch an t-Sìl *Calluna* frequencies and charcoal values rose in particular *c.* 5000 BP (5730 cal BP), while at Reineval, an increase in *Calluna* values from 4500 BP (5170 cal BP) also appears to be associated with high charcoal values. The profile at Airigh na h-Aon Oidhche shows a sharp increase in the charcoal curve around 1500 BP (1380 cal BP), associated with a rise in *Calluna*, suggesting possible heathland management at this site in the early Historic period. However, not all sites with high *Calluna* values have evidence of management. At the coastal site of Peninerine, *Calluna vulgaris* dominated the vegetation starting at *c.* 8100 BP (9020 cal BP), but there is no sign that fire played any part in its expansion (Edwards *et al.*, 1995; Brayshay and Edwards, 1996).

3.7 Pollen analysis at archaeological sites

Several pollen analytical studies have been conducted specifically near archaeological sites, in order to look at the relationship between the vegetation and the archaeology of the area. Bohncke's (1988) sites located close to Callanish have already been discussed (section 3.3.2). The other site in Lewis with pollen evidence from an archaeological context is Sheshader on the east coast. In a profile taken alongside a buried peat wall, the pollen spectra suggest that hazel and birch woodland grew in the area some time before 4150 BP (4720 cal BP). Arboreal pollen values then fall sharply, while *Plantago lanceolata* and Asteraceae pollen feature more prominently and there are indications of fire, possibly reflecting deliberate clearance for grazing land. After 3700 BP (4040 cal BP) moorland vegetation expanded, and arable agriculture may have taken place in the vicinity. It is during this time, *c.* 2900 BP (3060 cal BP), that the wall itself was probably built, perhaps to enclose land for grazing. Carbonised plant remains found in the deposits indicate that the vegetation may have been managed by burning (Newell, 1988).

Another stone structure, possibly a linear clearance cairn, was found in an old peat-cutting near Loch Portain in North Uist (Mills *et al.*, 1994). Radiocarbon dates put the construction of the wall into the earlier half of the first millennium BC (Late Bronze Age or Early Iron Age), and it was hoped that pollen analysis would help determine the purpose of the wall. Mixed peat and mineral matter, found to the west of the bank and dating to some time before 4490±50 BP (*c.* 5180 cal BP), two millennia before the construction of the stone wall, had been interpreted in the field as possible evidence of arable activity, but the pollen spectra showed no evidence for arable, and agricultural activity in the area is likely to have been restricted to rough grazing. Arboreal pollen frequencies were low, and it appears that woodland had not been important in the area since at least 4490 BP (5180 cal BP) (Mills *et al.*, 1994).

The site of Bharpa Carinish is located in the southwest of North Uist, close to the Neolithic long cairn known as Caravat Barp (Crone, 1993). Features discovered at the site included three hearth complexes dated to the late 4th/early 3rd millennium BC which may have been part of a settlement, a stone enclosure with a *terminus post quem* date of 2750±50 BP (930-830 cal BC [2880-2780 cal BP]), a fieldbank dating to the last two centuries BC, and a cairn constructed in the early centuries AD. The long cairn itself is undated. Peat started to form at the site *c.* 3100 BP (3310 cal BP) and the vegetation at this time consisted primarily of herb-rich grassland, with some patches of heath, which became more prominent by the time the enclosure bank was built. There are no indicators of arable agriculture in the diagram, and if the enclosure bank was associated with agriculture at all, it is likely to have been grazing activity. The same can be said for the Iron Age field bank at the site; there is no evidence of any arable activity, and heathland taxa dominate. Arboreal pollen frequencies are very low right from the start of the profile, and it appears that the area around Bharpa Carinish was largely treeless by 3100 BP (3310 cal BP). The presence of *Betula* and *Corylus* charcoal in the Neolithic hearth complexes, however, suggests that these taxa may have been growing in the area in earlier times.

3.8 Pollen analysis and machair

Machair is most commonly found on the west coast of the southern islands, but there are a few patches on the eastern side. In order to investigate the formation of machair on the east coast, Whittington and Ritchie (1988) looked at deposits from two such sites where the peatland meets windblown sand, at Rosinish on Benbecula and Kallin on the island of Grimsay. At Rosinish six peat sites and one sand deposit were sampled, while at Kallin three sand deposits were investigated.

The seven profiles from Rosinish tend to be short and largely undated. The sequences are dominated by *Calluna* and to a lesser extent Poaceae, while arboreal pollen frequencies are generally low. This is to be expected as most of the sequences cover only the last few thousand years. The exception is Rosinish V, where *Corylus* and *Alnus* frequencies are quite high at the bottom of the profile before decreasing rapidly (Whittington and Ritchie, 1988).

The pollen spectra from Kallin are generally dominated by Poaceae and *Calluna*. *Betula* and *Corylus* may have been growing in the area at the beginning of the Holocene, but there is no clear evidence for the presence of other trees. At Kallin III there is a phase, starting at 4800 BP (5540 cal BP) which is charaterised by high Poaceae and charcoal concentrations, and which may reflect human influence on the landscape. As machair encroached, and the fine sand fraction increased in the Kallin sites, the pollen spectra became increasingly dominated by *Calluna*, Poaceae and Cyperaceae. At Kallin I machair expansion is dated to sometime before 4550±60 BP (*c*. 5200 cal BP) and at Kallin III to sometime before 3900±100 BP (*c*. 3310 cal BP) (Whittington and Ritchie, 1988).

Whittington and Edwards (1997) have recently investigated a series of inter-tidal peats at Borve, Benbecula. The study was conducted to gain greater insight into the evolution and timing of the spread of machair on the islands, and in particular to test models of machair formation proposed by Ritchie (1979) (discussed in Chapter 2 of this study), and refined by subsequent study at the site of Cladach Mór, North Uist (Ritchie and Whittington, 1994). Radiocarbon dates from samples taken at Borve suggest that the rate of machair formation was slow and variable, and that there were periods of stability sufficiently long to allow vegetation to grow and decay on top of the sand deposits (Whittington and Edwards, 1997). At Borve 3 peat began to form *c.* 8855 BP (10020 cal BP), and this phase is dominated by the pollen of *Corylus avellana*-type and Cyperaceae, but also included *Betula*, *Calluna vulgaris*, *Empetrum nigrum*-type, Poaceae and *Sphagnum*, suggesting to the authors the presence of a marshland with hazel and birch growing in drier locations before 7500 BP (8280 cal BP). *Pteridium* became prominent in the vegetation from 6735 BP (7590 cal BP) until it was replaced by grasses and tall herbs, probably as a result of the increased proportion of sand in the soil. From *c.* 6045 BP (6850 cal BP) until the top of the sequence, Poaceae is totally dominant, probably reflecting the presence of calcareous grassland. The input of sand appears to have slowed down between *c.* 6045 and 6020 BP (6850 and 6820 cal BP) and at this point charcoal appears in the sequence in large quantities, which could potentially be due to anthropogenic fires. The occurrence of fire may have led to changes in the vegetation and possibly facilitated marine and wind erosion at the site (Whittington and Edwards, 1997).

At Borve 2 peat formation started *c.* 6040 BP (6850 cal BP). The basal pollen zone is dominated by *Calluna vulgaris*, suggesting the presence of dry heath at the site, which was eventually replaced by *Pinus*, Poaceae, *Pteridium* and *Ophioglossum*. It is likely that at this time the site was a 'wet slack', similar to those found in the machair landscape today, subjected to alternating periods of flooding and drying-out. Perhaps because of this the preservation in this zone is poor, which may at least partly account for the prominence of *Pinus* pollen, which tends to remain identifiable even when badly deteriorated (Whittington and Edwards, 1997).

The organic material at Borve 1, deposited between two levels of machair sand, started to accumulate at 3400$\pm$70 BP (*c.* 3660 cal BP). Heath, and to an increasing extent grassland, were common in the area. An increase in Cyperaceae, *Selaginella selaginoides*, and *Sphagnum* along with a decrease in *Plantago lanceolata* pollen suggest that the vegetation may have been deteriorating into acid grassland. A subsequent decrease in Cyperaceae, *Selaginella*, and *Sphagnum* could suggest that the drainage in the area may have been improving due to fresh inputs of sand (Whittington and Edwards, 1997).

3.9 Taphonomic studies

Besides research on the vegetation history of the Outer Hebrides, there have been a number of studies that have attempted to improve the interpretation of ancient pollen spectra by looking at the modern day vegetation.

Randall *et al.* (1986) looked at modern pollen–vegetation relationships of 11 plant communities on the Monach Isles, and concluded that none of the communities produced pollen spectra that were complete and accurate reflections of their parent communities; at every site there were important local plants which where either absent or seriously under-represented in the pollen spectrum. However, each community did produce its own distinct pollen assemblage. Stable dune plant communities were reasonably well represented by *Plantago lanceolata*, *Bellis perennis* and *Festuca rubra*, while dune slacks were represented by the characteristic species *Hydrocotyle vulgaris*. Machair plant representation was also quite good, although the prominent grass *Festuca rubra* was seriously under-represented. Maritime grassland communities were poorly represented, apart from the presence of *Plantago* spp. Salt marshes were represented by three prominent taxa: *Spergularia marina*, *Plantago maritima* and *Triglochin*. The mixed fen community was represented by high frequencies of *Potentilla palustris* and *Eleocharis* pollen, but many other local species were under-represented, as was the case in the *Eleocharis* fen community. *Carex nigra* communities produced high frequencies of Cyperaceae pollen, but the floristic richness of the plant community was not reflected in the pollen spectra. Lastly, *Calluna* heath was represented by *Calluna vulgaris*, *Plantago lanceolata* and *P. maritima*.

Kent *et al.* (1994) studied the vegetation along an east-west transect across South Uist, and tried to relate the modern data to the past vegetation by comparing the plant communities to pollen spectra from pollen diagrams, including Loch Hellisdale and Loch Lang. They found little evidence for machair plant communities in the diagrams, and concluded that this was partly due to the fact that many machair species are low pollen producers or poor dispersers. The woodland site of Allt Volagir, on the other hand, contained trees and understorey species that were well represented in the diagrams, which strengthens the view that Allt Volagir forms a remnant of ancient woodland. An arctic-alpine community, similar to that found in the pollen diagrams in the early Postglacial period, can still be seen today on the slopes of Beinn Mhor. *Pteridium*-infested grassland found along the transect also seems well-represented in the diagrams, as are blanket bog communities (characterised by *Eriophorum* and *Potamogeton*) and heath communities (characterised by *Calluna vulgaris*) (Kent *et al*, 1994).

Fossitt (1994a) has studied the modern pollen rain in Shetland, Ireland and the Outer Hebrides, using samples from small lakes. The pollen samples from the Outer Hebrides were dominated by *Calluna vulgaris*, Poaceae and Cyperaceae, reflecting quite accurately the bog-covered, treeless nature of the islands. The mean value for trees and shrub pollen, which must come almost exclusively from long-distance sources, was 13.8% TLP. Tree and shrub frequencies, however, did not accurately reflect the presence of local woodland. A sampling site located close to the woodlands of Allt Volagir and Meall Mór was found to have an arboreal pollen representation of only 9.6%, the lowest frequency of any of the sites Fossitt studied in the Outer Hebrides. Fossitt also found that sampling sites surrounded by farmland could not be distinguished from those surrounded by blanket peat by looking at the pollen assemblages they produced, although in general there was in increase in Poaceae representations on the farmland sites (Fossitt, 1994a).

The poor representation of tree and shrub pollen on the Outer Hebrides is confirmed by Gearey and Gilbertson (1997), who examined a small plantation on Barra and discovered that arboreal percentages decreased rapidly as they moved away from the woodland edge. *Pinus*, a prominent tree in the plantation and well known for its ability to be carried long distances, was particularly badly represented in the pollen samples. The authors argued that the wind was an important factor in carrying the pollen away from the site, and, like Fossitt (1994), concluded that even if a sampling site was located close to an area of woodland, this would not necessarily be reflected in the pollen spectra (Gearey and Gilbertson, 1997).

3.10 Summary

The general view of the vegetation history of the islands has changed over the years from one of a more wooded environment in the past (based on macrofossils), to a vision of a treeless landscape, and back to a recognition that the islands did have woodland, and that this woodland cover was quite extensive and diverse. At virtually all sites examined there is evidence of the presence of trees and shrubs, at least at the beginning of the Holocene, although the extent to which the woodland remained open rather than forming a continuous cover remains uncertain (cf. Tipping, 1994a; Edwards and Whittington, 1997). In parts of western Lewis woodland species may have been restricted to birch and hazel, but at many other sites researchers have also argued for the local presence of rowan, oak, elm, alder, ash and pine. Detecting the presence of woodland on the islands is complicated by the possibility that the oceanic weather conditions on the Outer Hebrides may have had an effect on deposition of tree and shrub pollen, and thus taphonomic studies conducted on the mainland may not necessarily be applicable to the islands.

The timing of the decline in trees and shrubs is variable. At a number of sites the initial decline in woodland took place in Mesolithic times (particularly between 8000 and 7000 BP [8890 and 7800 cal BP]), and in some cases this has been attributed to early human impact. There is no clear proof of the presence of people on the islands during this period since, to date, no archaeological evidence for Mesolithic settlement has been found, but then such evidence may have been washed away by the sea, covered in machair sands, or lie buried beneath metres of peat (Edwards, 1996). During the Neolithic, evidence for human impact appears to increase at many sites; there are signs of pastoral and arable agriculture, as well as possibly heathland management (Edwards *et al.*, 1995). At a number of sites in eastern South Uist woodland persisted to some degree until the Bronze Age or Iron Age. In the last 2000 years the islands have been effectively treeless. To what extent the changes on the islands, from a wooded environment at the start of the Holocene to a treeless landscape covered in blanket bog today, are a result of human impact, and to what extent they are due to climatic conditions, is still a matter of some debate.

Chapter 4

ARCHAEOLOGY AND SETTLEMENT HISTORY

4.1 Introduction

In order to gain a greater appreciation of the relationship between people and landscape it is important to look at the settlement history of the islands. The geography of the Outer Hebrides, and above all the fact that much of the area is covered in peat bog and machair, and that little arable agriculture has disturbed the soils of the islands, has helped preserve many archaeological sites which might otherwise have been destroyed. What is revealed is a rich and diverse archaeological landscape.

Figures 4.1a and 4.1b show the location of archaeological sites mentioned in this chapter. Distribution maps were also created for sites from the Neolithic (Fig. 4.2a and 4.2b), Bronze Age (Fig. 4.3a and 4.3b), Iron Age (4.4a and 4.4b), and Pre-Norse period (Fig. 4.5a and 4.5b), in order to be able to make a comparison between the settlement history and vegetation history of the islands (Chapter 11).

4.1.1 History of Archaeology in the Outer Hebrides

The islands largely escaped the attentions of antiquarians in the 19th century, unlike Orkney and many other parts of Scotland, but this changed in the early part of this century when Erskine Beveridge, an antiquarian living on the island of Vallay, investigated the machair areas of the northwest corner of North Uist, uncovering a large number of sites, most of them dating to the Iron Age (Beveridge, 1911). Subsequently, a steady stream of excavations and surveys has taken place, focusing in particular on Neolithic monuments (Scott, 1935, 1947b; Henshall, 1972) and Iron Age settlements (MacKie, 1965, 1966, 1969, 1983, 1989; Young, 1952, 1956, 1962; Armit, 1992a). In recent years extensive survey and excavation projects by the University of Edinburgh in Lewis (Harding and Armit, 1990; Armit, 1994; Harding, 1996), and the University of Sheffield in South Uist and Barra (Branigan and Foster, 1995; Parker-Pearson, forthcoming), both with a greater emphasis on the

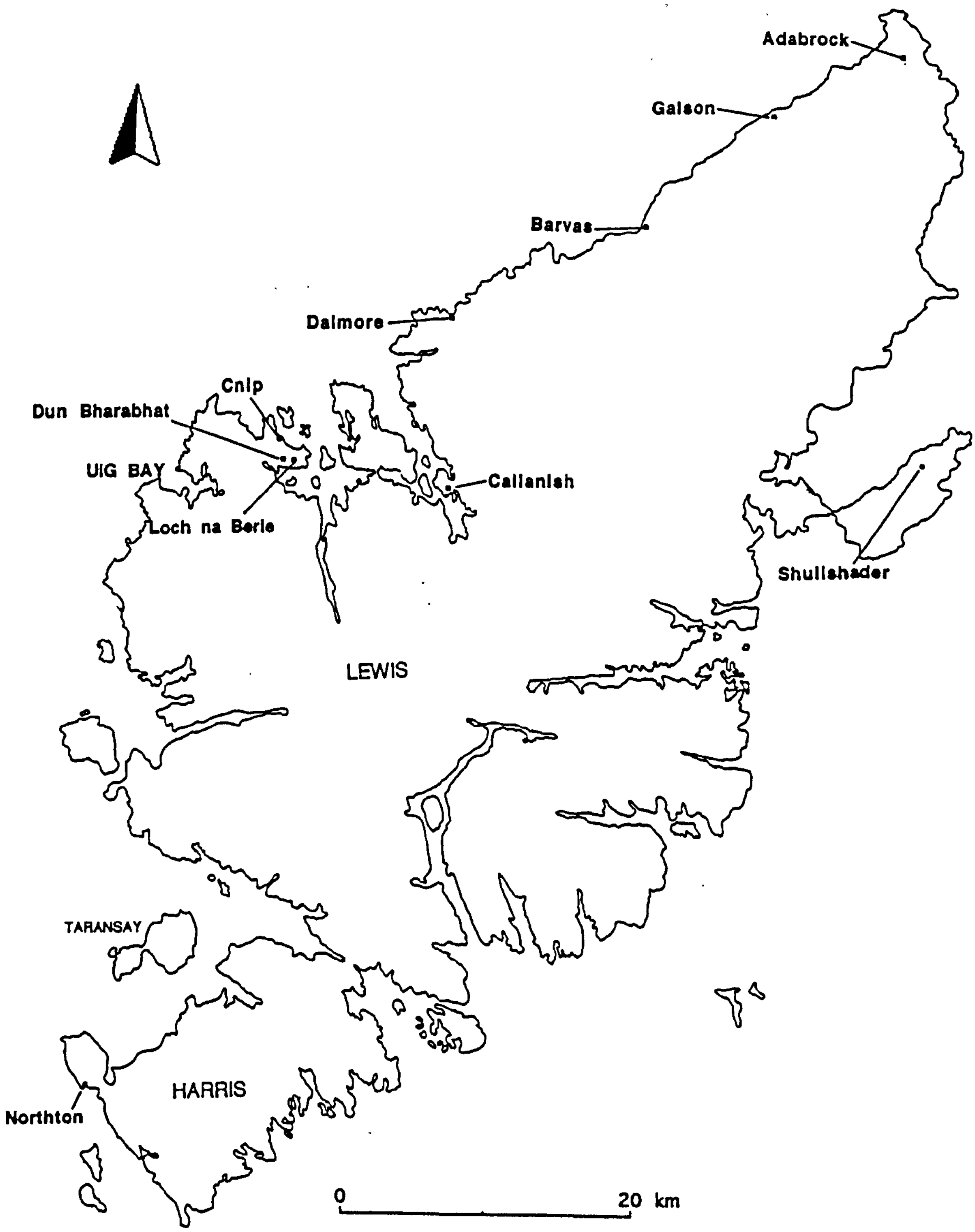


Fig. 4.1a Location of main archaeological sites in Lewis and Harris discussed in Chapter 4

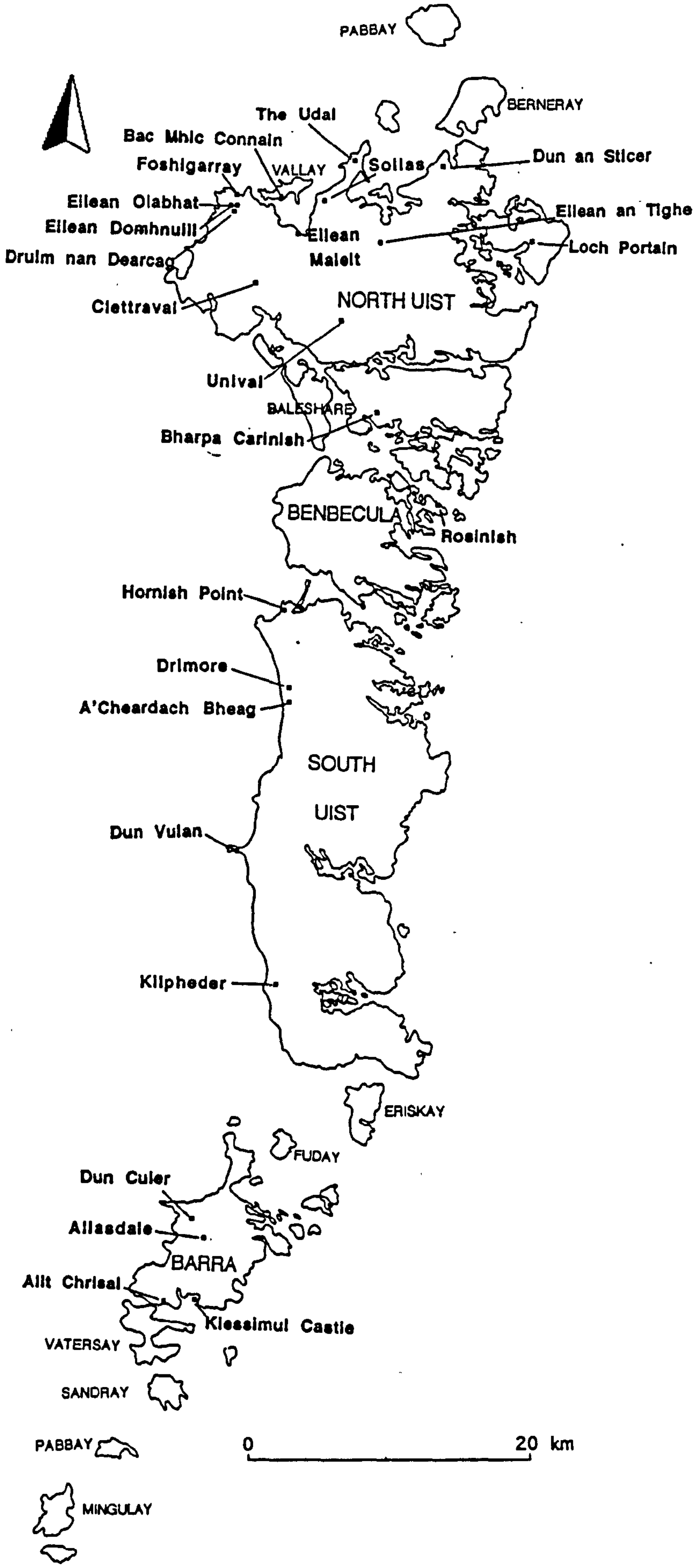


Fig. 4.1b Location of main archaeological sites in the southern Outer Hebrides discussed in Chapter 4

development of landscapes rather than individual sites, have led to the discovery and investigation of a many new sites covering several periods. Yet gaps in the settlement history are still evident, particularly for the Late Bronze Age. Moreover, the geographical extent of archaeological evidence has remained limited. Much of the recent investigation has focused on the coastal areas, and in particular the machair plains of the islands, where many sites have been revealed by erosion. The potential wealth of sites lying in the peat-covered inland areas is still to be uncovered.

4.1.2 Distribution maps

The distribution maps presented here are based on a variety of sources (RCAHMS, 1928; Megaw and Simpson, 1961; Henshall, 1972; Armit, 1992a, 1992b, 1996; Discovery and Excavation in Scotland 1960-1997). The maps form a snapshot of settlement and burial patterns on the Outer Hebrides between the Neolithic and Pre-Norse periods, but they contain a great deal of uncertainty and rough guesswork, and should therefore be treated with caution. For example, some types of sites, such as cupmarked stones and standing stones, are difficult to date, and have been placed within certain periods on the basis of the latest opinion. Moreover, what must be recognized when looking at distribution maps is that they are to large extent an artefact of the history of research in an area, rather than a complete and accurate reflection of the actual distribution of sites. The Outer Hebrides is no exception. The preponderance of settlement sites on the coasts of the islands during the Neolithic and Bronze Age may partly result from the fact that most of the archaeological surveys to date have concentrated on these areas. In addition, coastal areas are subject to erosion, making the finding of sites in these areas easier.

The emphasis on Lewis has generally been on the area around Callanish, and in recent years on the machair areas of the Bhaltos peninsula. The north-eastern part of Lewis, an area with few roads and a thick covering of peat, has seen little research and few sites are known. It is perhaps no accident that most of the sites in the inland areas of Lewis are located along the main road from Callanish to Stornoway. In North Uist, the distribution of sites of all ages is heavily affected by the work of local antiquarian Erskine Beveridge, who at the beginning of the century put a lot of effort into finding sites near his home on the island of Vallay, off the northwest coast of North Uist. A certain amount of bias is thus unavoidably built into these maps.

4.2 The Mesolithic Period

4.2.1 The Mesolithic in the Outer Hebrides

To date no archaeological sites dating to the Mesolithic period have been found on the Outer Hebrides (Edwards, 1996). This is rather surprising, as there is plenty of evidence for the presence of Mesolithic hunter-gatherers on the west coast of mainland Scotland and in the Inner Hebrides (Wickham-Jones, 1994). In fact, Kinloch, on the island of Rhum in the Inner Hebrides, has produced one of the earliest radiocarbon dates for an occupation site in Scotland so far (8590±95 BP [7700-7500 cal BC]) (Wickham-Jones, 1990). Only Daer Reservoir in Clydesdale has so far produced an earlier date: 9075±80 BP (8095-8026 BC) (Anonymous, 1998).

Mesolithic people appear to have travelled quite freely between the islands of the Inner Hebrides, and this, along with faunal evidence for deep-sea fishing, suggests that they certainly had sea-worthy boats (Finlayson and Edwards, 1997). There is no reason to suppose that these vessels could not have reached the Outer Hebrides. Nor is there any reason to suppose that the islands were unattractive to hunter-gatherers, as recent palaeoenvironmental studies suggest that they were not the barren and treeless areas of the present day (see Chapter 3). In fact, the environment and available resources on the Outer Hebrides were probably very similar to those of the Inner Hebrides.

Why, then, has there been no evidence of people occupying the islands during the Mesolithic? It is possible that hunter-gatherers did occupy or visit the islands but that the archaeological evidence has simply not been found, due to a series of environmental and other factors. Settlement sites are likely to have been small-scale and hard to detect archaeologically (Wickham-Jones, 1990), and any bone assemblages that may have been present are likely have disappeared in the acid soils of the islands (Edwards, 1996). Perhaps more importantly there has been a significant rise in sea-level since Mesolithic times, possibly as much as 5 metres since 5100 BP (5840 cal BP) (Ritchie, 1985), which will have inundated large areas of land, particularly on the west coast. Any possible Mesolithic coastal sites could now be several kilometres out to sea. Meanwhile, any inland sites are likely to be hidden beneath several metres of peat or machair.

The situation in the Outer Hebrides may be similar to that of the Northern Isles. Until recently it was thought that no Mesolithic occupation ever took place on the Orkney islands, but now artefact scatters likely to be of Mesolithic age have come to light, and other artefacts have been reinterpreted (Wickham-Jones, 1992; Saville, 1996), providing some hope that Mesolithic sites will also be found in the Outer Hebrides. In the meantime attempts have been made to use other sources of evidence: in recent years the pollen sequences from a number of sites on the islands have been used to argue for possible Mesolithic impact on the vegetation (for example Bohncke, 1988; Bennett *et al.*, 1990; Edwards *et al.*, 1985; see also Chapters 3 and 11).

4.2.2 The Mesolithic in the Inner Hebrides

The evidence from the Inner Hebrides may give us some idea of the sort of Mesolithic sites which could potentially come to light in the Outer Hebrides. Evidence of a Mesolithic presence in Scotland includes lithic scatters, middens and occupation sites (Finlayson and Edwards, 1997). In the Inner Hebrides lithic assemblages are often made up of predominantly narrow-blade microlithic tools, such as those found on Jura (Mercer, 1970, 1971, 1972), Islay (McCullagh, 1989; Mithen, 1990) and Colonsay (Mithen 1989; Mithen and Finlayson, 1991). Midden sites have also been discovered, both in open contexts and in caves or rockshelters. Examples include several sites on Oronsay (Mellars, 1987), one of which yielded a date of 6190 $\pm$ 80 BP (5230-5000 cal. BC), a site at An Corran on Skye, the nearest known Mesolithic site to the Outer Hebrides (Saville and Miket, 1994), as well as a cave on the small island of Ulva (Russell *et al.*, 1995). Within these middens were preserved shells and the bones of fish, birds and mammals, as well as artefacts such as barbed points, antler mattocks and chipped-stone tools. The general picture is one of a very mixed economy based on hunting, gathering, fishing and collecting shellfish, perhaps with different islands, as well as the mainland, used for different resources (Finlayson and Edwards, 1997). Investigations into seasonality at the middens on Oronsay suggest that the island was either inhabited all year round, or that repeated visits were made during the year (Mellars and Wilkinson, 1980; Andrews *et al.*, 1985; Mellars, 1987).

Structural evidence from the Mesolithic period has come from Kinloch on Rhum, where excavations revealed a series of pits and hollows, together with a number of stakeholes and two slots. The excavator suggests that the stakeholes are the remains of a small-scale structure, either a windbreak or an enclosed tent, with hearths located outside. The pits may have had various functions, but in their last phase appear to have been used to contain domestic refuse (Wickham-Jones, 1990).

4.3 The Neolithic period

The first archaeological evidence for settlement on the Outer Hebrides is dated to the Neolithic period, a phase which in Scotland appears to start around the beginning of the fourth millennium cal BC, although in a general Scottish context there is probably considerable overlap with Mesolithic cultures (Armit and Finlayson, 1992, 1996). Two types of Neolithic sites have been found on the islands: ritual sites such as chambered tombs, stone circles and standing stones; and settlement sites (Fig. 4.2). The remains of ritual sites are plentiful and prominent; many of them can still be seen in the landscape today, and our perception of the Neolithic in the islands is coloured by this evidence. In contrast, the settlement sites are much harder to find.

The earliest radiocarbon dates from an archaeological context are from Bharpa Carinish in North Uist (Crone, 1993). Charcoal from a hearth spread at the site produced a radiocarbon date a 5520±90 BP (4540-4160 cal BC) but the excavator argues that this date is surprisingly old for a sophisticated hearth and is therefore likely to be an aberration. Dates from other hearths at the site range between 4490± 50 BP (3370-2980 cal BC) and 4430±100 BP (3380-2880 cal BC).

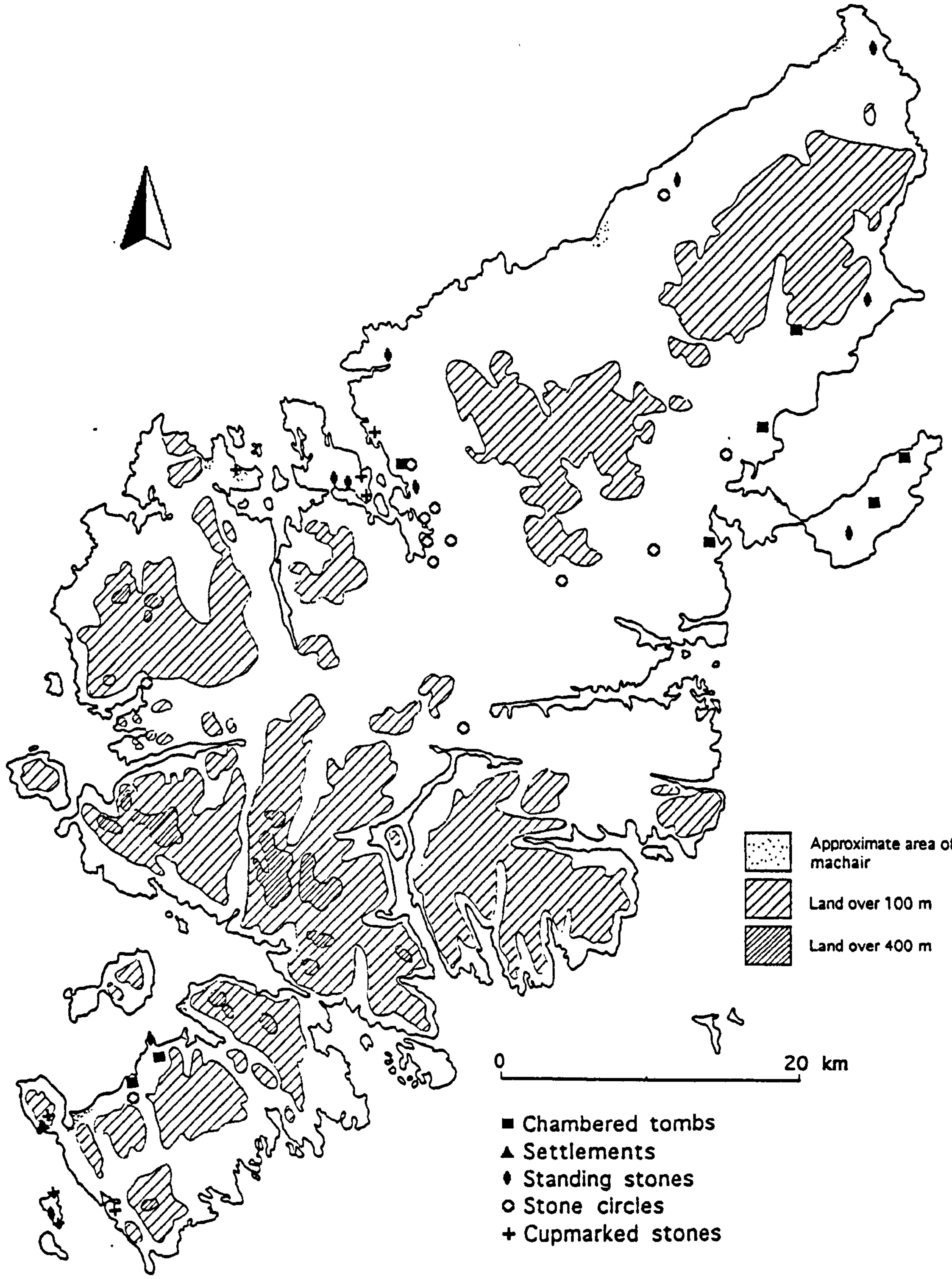


Fig. 4.2a Distribution of Neolithic sites in Lewis and Harris

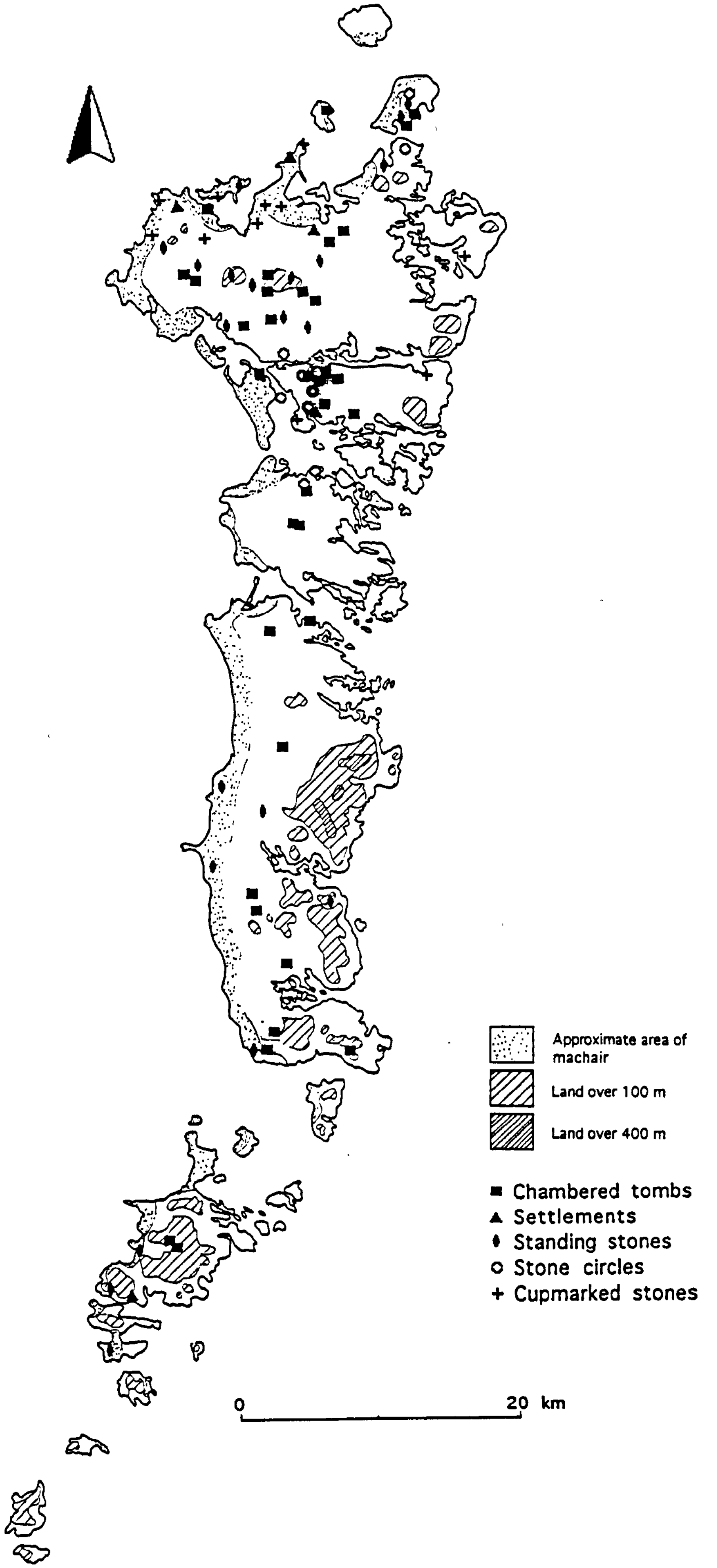


Fig. 4.2b Distribution of Neolithic sites in the southern Outer Hebrides

Other early dates from the Outer Hebrides include a radiocarbon date of 4470±95 BP (3358-2994 cal BC) from the shaft of an axe found at Shulisader in Lewis (Sheridan, 1992) and 4411±70 BP (3218-2933 cal BC) from animal bones at Northton on Harris (Burleigh *et al.*, 1973), suggesting that by at least 3000 cal BC, the islands were well and truly settled.

4.3.1. Neolithic settlements

There are currently six sites recorded on the Outer Hebrides which appear to form the remains of Neolithic settlements. Eilean an Tighe and Eilean Domhnuill (see Chapter 9) on North Uist are both located on small islands in lochs (Scott, 1951; Armit, 1992b). Bharpa Carinish is an inland site discovered beneath the peat near the long cairn of Caravat Barp (Crone, 1993). Northton and the Udal are sites located in the machair on Harris and North Uist respectively (Simpson, 1976; Crawford, n.d., 1996). Allt Chrisal is located on the rocky coastline of Barra (Foster, 1995).

Although their locations are diverse, these sites have certain elements in common. The remains of slight, small-scale structures accompanied by large quantities of ceramics are the only indicators of extensive occupation. There is no evidence of monumental domestic architecture, such as that found on Orkney and Shetland (Ritchie and Ritchie, 1991). From the remains at Eilean Domhnuill and Allt Chrisal it appears that Neolithic buildings on the Hebrides tended to be insubstantial structures of elongated oval or rectilinear shape (in these cases measuring about 6.5 m x 4 m externally). The stone settings found on these sites may be the remains of the foundations of turf walls, with roofs constructed of timber (Armit, 1992b; Foster, 1995). Similar turf huts were built in Scotland until the late 18th century AD. The dry-stone foundation of these houses would have been as little as 30 cm high (Noble, 1984), and the houses could easily be dismantled and the most important elements, the crucks and the collar beams, could be retained for use in the next house, while turf was readily available everywhere (Crone, 1993). At Eilean Domhnuill at least 11 building phases were discovered, and in each case it appears that building materials from one house were used to build its successor (Armit, 1992b). The archaeological remains of these types of buildings would not be very visible, especially if the site was not occupied for a very long period of time. At Eilean an Tighe the structural remains were so insubstantial, and the remains of pottery found so numerous, that the excavator originally argued that the site was a pottery workshop (Scott, 1951). At Bharpa Carinish the building evidence was even more limited: the entire assemblage of structural features consisted of three stone-built hearths, five shallow pits and half a dozen small post-holes, and there is some doubt as to whether the site was permanently occupied or used only in association with the nearby tomb (Crone, 1993). The exception appears to be the Udal, where the excavator has described the remains of what appears to have been a fairly substantial building with double walls '...of the Skara Brae type' (Crawford, 1996: 94). Unfortunately the site reports from the Udal remain unpublished and this assertion cannot be independently verified.

The general picture of Neolithic settlement that is emerging is one of isolated small-scale farming settlements, with one principal building, occupied perhaps by an extended family. Some sites, such as Eilean Domhnuill and Allt Chrisal, may have been occupied over centuries, if not millennia, although not necessarily continuously (Armit, 1992b; Foster, 1995). The fact that some of these sites were located on small islands with, in the case of Eilean Domhnuill, a causeway and an elaborate entrance facade, may indicate that not all were of equal status and complexity. The more elaborate settlements were perhaps occupied on a permanent basis, while the more insubstantial sites may have been used for particular purposes only.

It is obvious that there must be many more settlement sites on the islands than the six that have so far been discovered. There are several possible reasons why more have not been found: unlike the chambered tombs the settlement sites are ephemeral and could easily be dismantled leaving few traces behind; many sites today may lie buried beneath peat, machair or sea; the sites may lay hidden beneath later occupation layers; or they may have been misidentified. For example, because of its shape and location on an island in a loch, Eilean Domhnuill was thought to be an Iron Age dun until recent investigations proved otherwise (Armit, 1992b).

4.3.2 Neolithic ritual and burial sites

Ritual sites on the islands include standing stones, cup-marked stones, stone circles, stone settings, and chambered tombs. The latter appear to be the earliest of these monuments, and are perhaps the most prominent archaeological feature of the islands, as their monumentality makes them highly visible. To date some 45 chambered tombs have been recorded, with the greatest density on the island of North Uist, while Lewis, Harris and Barra have relatively few.

Henshall (1972) has listed and classified the tombs, most of which fall within the 'Hebridean Group', but there are also two Clyde-type cairns, and many cairns that have remained unclassified. The Hebridean passage grave normally consists of a round cairn with a peristalith made up of split stones set on their ends and located around, or sometimes beneath, the cairn. The cairn itself contains a large oval or round chamber made of orthostats, and sometimes has a funnel-shaped forecourt. There are also six long-cairns known on the islands (Henshall, 1972). From the present data it is impossible to attempt to develop a chronology of cairn erection and use, as very few have been excavated and none have been radiocarbon dated. It is thus impossible to tell whether they were all in use at the same time. Nor can any realistic attempts be made to associate individual tombs with individual settlement sites. However, the ceramic assemblages at both the funerary and domestic sites are very similar, suggesting that the tombs and settlements are at least broadly contemporaneous (Armit, 1992b).

The chambered tombs are generally situated on the slopes of the peat covered hills (Crone, 1993), usually in prominent locations providing a good view of the surrounding countryside. These areas are considered 'marginal' today, and lie outside the main areas of habitation, but they may have been far more densely occupied in the Neolithic, before the onset of extensive blanket peat spread. Aside from human bones, the tombs often contain the remains of offerings of pottery and food, and may have been used for many centuries before they were sealed off. The cairns were certainly used for burials, but they may also have fulfilled additional functions, such as locations for community ritual practices, or as territorial markers (Henshall, 1972; Armit, 1992b). Perhaps they helped to legitimise claims to land by appealing through the ancestors in the tomb, as Renfrew (1976) has suggested for the cairns on Arran and Rousay.

4.3.3. Ritual Sites of the Later Neolithic

Some time during the Later Neolithic period, the chambered tombs were sealed and generally went out of use, while standing stones, and in particular stone circles, began to take over as the most important type of ritual monument. The largest concentration of stone circles can be found in the Callanish area on Lewis, but there is also a concentration of megalithic circles and ovals along the south coast of North Uist, where they tend to be located close to chambered tombs (Burl, 1976).

Callanish is the most famous archaeological site on the islands. The main stone setting is well known, but three other circles can also be found in the neighbourhood, along with several alignments, arcs, and single standing stones. The site has been interpreted variously as an astronomical observatory, a calendrical computer, or a location for communal ritual and burial functions (Burl, 1976). Some time after the placing of the stones in the main setting at Callanish, a small chambered tomb was placed within the circle, which was used at least until 2000-1700 cal BC. The monument itself did not go out of use until the Bronze Age, sometime between 1500–1000 BC, when it may have been deliberately despoiled (Ashmore, 1984).

Other ritual sites which may date to this period are cup-marked stones. Their exact purpose is unknown, but one theory is that they mark out sacred places in the landscape (Bradley, 1992). In Scotland cup-marks can be found in a variety of locations: on natural surfaces, standing stones, stones in stone circles, chambered tombs (particularly on Clava tombs in north-east Scotland), and inside Bronze Age burial monuments dating to the late third millennium BC (Burgess, 1990; Bradley, 1992). Numerous sites with cup-marks have been found in the Outer Hebrides and many more are likely to be discovered in the future. One example comes from Portain, North Uist, where a cup-mark was found on the cover slab of a Bronze Age short cist (Megaw and Simpson, 1961). Dating these forms of rock art is problematic, but they are usually considered to be of Late Neolithic or Bronze Age date. Some researchers argue that the designs were generally created in the Middle and Later Neolithic, and that some of the stones were then later reused in funerary and ritual monuments in the Bronze Age (Burgess, 1990; Bradley, 1992).

4.3.4 Neolithic subsistence economy

The range of plant remains found at the Neolithic sites suggests that a mixed economy using a variety of food sources, both cultivated and wild, was the norm for the islands. At Allt Chrisal only one cultivated species was found: naked barley (probably of the six row variety) (Boardman, 1995), which is the most common type of cereal found on prehistoric sites in Scotland (Boyd, 1988). Barley was also found at Bharpa Carinish (along with emmer and bread wheat) and Eilean Domhnuill (along with bread wheat) (Crone, 1993; P. Grinter, pers. comm.). Archaeological evidence for the processing of grains on site is provided by querns, of which several have been found at Allt Chrisal and Eilean Domhnuill (Foster, 1995; Armit, 1990a).

Wild species found in the archaeobotanical remains at Allt Chrisal include seeds of bramble (*Rubus fruticosus*), strawberry (*Fragaria vesca*), bilberry (*Vaccinium myrtillus*), possibly cowberry (*V.* cf. *vitis-idaea*), and Brassica (*Brassica* sp.) as well as a few hazelnut shells (*Corylus avellana*). In addition, the leaves of the common sorrel (*Rumex acetosa*) and common orache (*Atriplex patula*) may have been eaten raw or as a vegetable (Boardman, 1995).

The presence of wild plant species at Allt Chrisal would suggest that despite the adoption of agriculture, gathering was still an important part of the subsistence economy. Fishing and fowling are also likely to have been significant. Because the soils of the Outer Hebrides are generally very acidic, very few bones from Neolithic sites have been preserved, and our knowledge of the domestic and wild fauna is therefore restricted. The site of Northton, where the presence of machair sand has aided preservation, has perhaps produced the best evidence for animal bones. Sheep and cattle bones were recovered in about equal proportions at this site (Simpson, 1976). Sheep, cattle and dog bones were also found in the bone assemblage from Eilean Domhnuill, along with a single pig bone, and the bones of sea duck and redshank. Only one red deer bone was recovered, suggesting it was not available

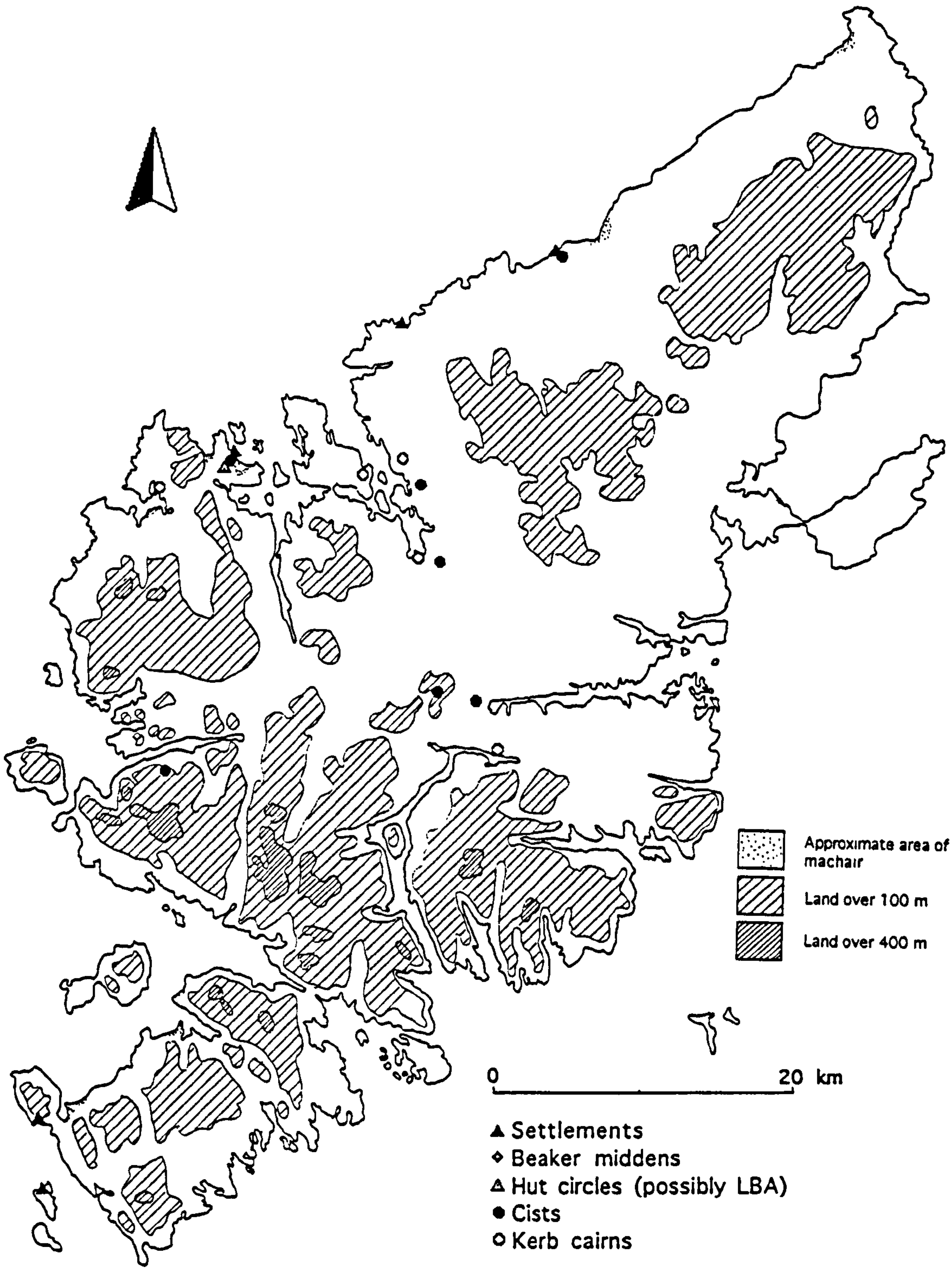


Fig. 4.3a Distribution of Bronze Age sites in Lewis and Harris

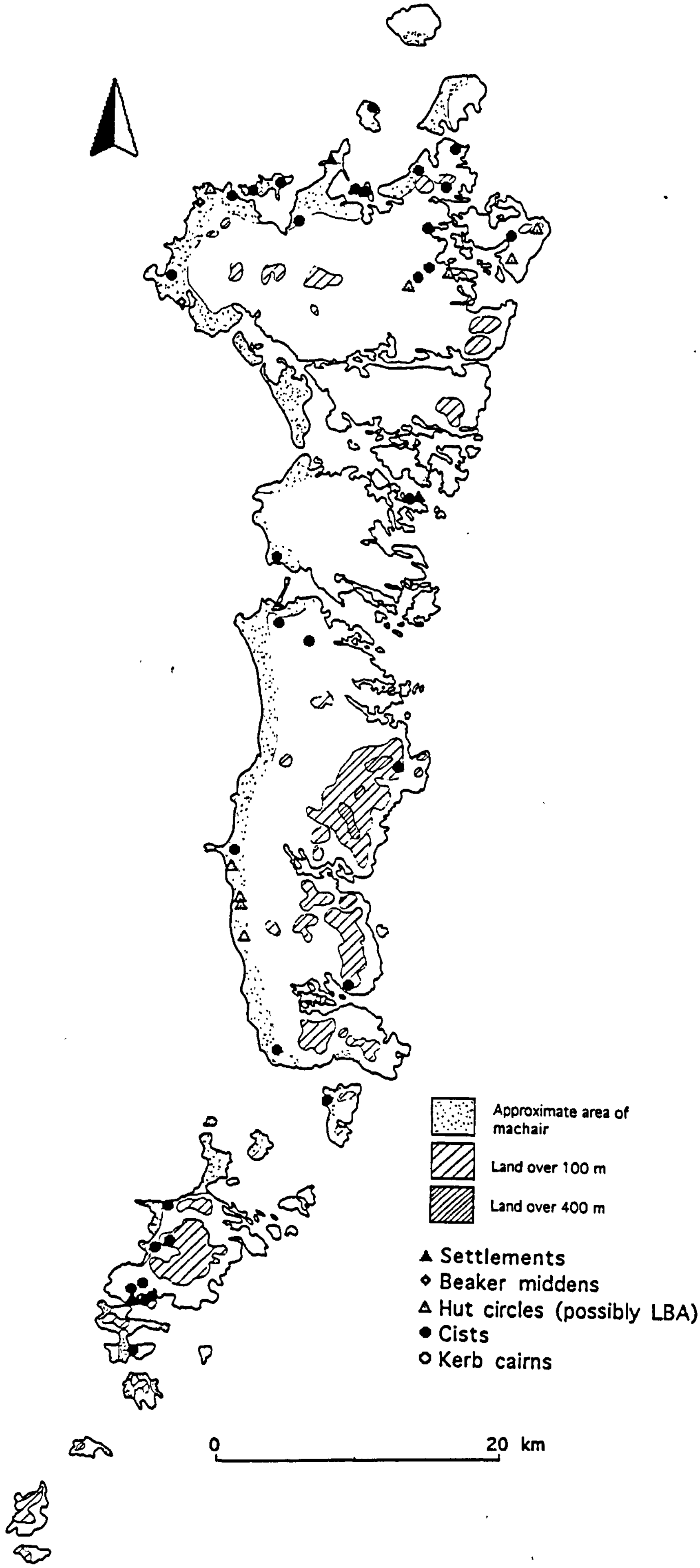


Fig. 4.3b Distribution of Bronze Age sites in the southern Outer Hebrides

locally in North Uist at this time (Hallén, 1992 in Armit, 1996). At Northton, besides sea birds, there was also evidence for the exploitation of shellfish, lobster, crab, seal, and whale (Simpson, 1976). Fish bones are rarely recovered from Neolithic sites, but this may be due to preservational problems.

4.4 The Bronze Age

Around 2000 cal BC large communal monuments appear to have become less significant, and individual burials, under small cairns or barrows or in stone cists became common. This period also saw the first appearance of Beaker pottery on settlement sites and in graves in the Outer Hebrides (Armit, 1996).

4.4.1 Beaker period settlement sites

The appearance of Beaker pots has traditionally been seen as a sign of migration of people. It now appears more likely that Beakers, and associated artefacts, were adopted into the local traditions, rather than introduced by a wave of 'incomers' (Burgess, 1976). Several settlement sites with Beaker pottery have been found in the Outer Hebrides, many of them overlying Neolithic sites. At Allt Chrisal the Beaker period remains directly overlie the Neolithic levels, and Beaker ceramics appear to have been adopted at this site without any break in the cultural tradition (Foster, 1995). To date there are no inland or island settlement sites from this period, and virtually all of the known sites have been found in the machair (Fig. 4.3), where they have generally been revealed by erosion. Like the Neolithic sites, it is probable that many more Beaker and Bronze Age sites remain hidden beneath the peat in the inland areas of the islands.

Sites with Beaker pottery have been found on all the major islands. In Lewis middens and structures were found eroding out of the machair at Dalmore (Ponting and Ponting, 1984) and at Barvas (Cowie *et al.*, 1986; Cowie, 1987). At Northton on Harris two separate Beaker levels were identified, radiocarbon dated to around 1974 cal BC and 1804 cal BC respectively. Two stone structures were found in the lower Beaker midden. These structures had been dug into the sand dunes and revetted with drystone walling to a height of about 2 m, the traditional method of building in machair in later periods, too. Simpson (1976: 138) argued that the stone walls may have been built to form a pit as a shelter for a light hut or tent, while others have argued that a timber-framed roof covered the structure, resting on the sand dunes (Armit, 1996). At the Udal in North Uist no evidence of Beaker period domestic buildings was discovered, but 70 'ritual pits' (Crawford, n.d.: 7) were found, along with three large postholes, as well as middens and plough-marks, in a phase dated to around 1900 cal BC (Crawford, 1996).

Rosinish is one of only two sites with Beaker pottery known on the eastern side of the islands. Like the Udal, the site has evidence for arable agriculture: underneath a midden, plough and ard marks were discovered, made by a stone-tipped wooden plough or ard. Spade marks were also present. A U-shaped stone structure, dated to the second half of the second millennium BC formed the main evidence for buildings at this site (Shepherd and Tuckwell, 1977).

4.4.2 Beaker and Bronze Age burial sites

Beaker pottery sherds have been found in chambered tombs on the Outer Hebrides, including Unival and Clettraval (Scott, 1935, 1947b), where they are probably associated with the sealing of the tomb, rather than forming a part of any communal funerary rituals (Henshall, 1972). Most of the evidence for Bronze Age burials thereafter comes from cists and cairns (Fig. 4.3).

There appears to have been a considerable amount of heterogeneity of burial practices in the Bronze Age. Several types of cists and cairns were used, and inhumation and cremation burials, both single and multiple, have been recorded. Some of the cists on the islands contained pottery of the local collared urn tradition, but, with one possible exception, no Beaker pottery sherds have been found. So far virtually all the Bronze Age burial sites come from coastal sites, mostly in machair or sand-dunes. Many were discovered in the early part of this century and have not been examined in detail or dated (Megaw and Simpson, 1961).

A record of the diversity of Bronze Age burial monuments has been preserved at Cnip in Lewis, where a cairn eroding out of a sand dune proved to be made up of three types of burial monuments built into and on top of each other, preserving beneath them the evidence of a ploughed soil. A short cist with a cairn formed the earliest phase, followed by a corbelled cist and, finally, a kerb cairn. A ^{14}C sample from burnt organic material in the corbelled cist produced a date of 3410±55 BP (1780–1670 cal BC) (Close-Brooks, 1995). Another short cist in the area, which contained an inhumation, yielded a radiocarbon date of 3360±50 BP (1730–1580 cal BC), placing it in roughly the same period as the inurned cremation in the corbelled cist, and suggesting that several types of burial practices were in use at the same time (Dunwell *et al.*, 1995a). There was no conclusive evidence for a settlement of Bronze Age date at this site, although a series of hut circles located nearby may date to earlier prehistory, and could have been associated with the cairns.

4.4.3 The Later Bronze Age

Towards the end of the Bronze Age there is a gap in the settlement evidence of the Outer Hebrides. No settlement sites dating to the period between 1700 cal BC and the mid first millennium BC have been found to date. There is also remarkably little evidence for funerary and ritual sites, although kerb cairns may have continued in use during this period. Aside from midden and cultivation evidence found on Baleshare (Barber forthcoming in Armit, 1996), and presumably associated with a domestic site, the only other archaeological evidence consists of finds of metal hoards, such as the one recovered at Adabrock on the northern tip of Lewis (Coles, 1960), and single finds of metalwork generally found in peat bogs (Megaw and Simpson, 1961). At this time the characteristic settlement site in the southern Inner Hebrides was the hut circle, and it is possibly that these structures in the Outer Hebrides are also of Late Bronze Age date. Another possibility is that the settlement sites of the Later Bronze Age have been obscured by later building phases. Many of the island sites that were in use during the Iron Age may have deposits dating to the Later Bronze Age. For example, underwater excavations at Dun Bharabhat in Cnip in Lewis suggest that this Iron Age site was occupied for some time in the first millennium BC before the dun was built (Harding and Armit, 1990).

4.4.4 Bronze Age subsistence economy

The Neolithic mixed economy based on agriculture, hunting, gathering, fishing and fowling appears to have continued into the next period. The food remains in Beaker levels at Northton were similar to those found in the Neolithic levels, and included cattle and sheep, shellfish (predominantly limpets), crab, lobster, sea urchin, seal, walrus and sea birds (Simpson, 1976). Unlike the Neolithic levels, however, the Beaker levels also contained abundant quantities of red deer. No milling equipment or grain impressions were found, and Simpson (1976) suggests that the economy at this site was based entirely on hunting, gathering and pastoralism.

That arable agriculture was taking place at other sites is clear. Ard marks have been found at Rosinish (Shepherd and Tuckwell, 1977), the Udal (Crawford, 1996), and Cnip (Close-Brooks, 1995). Archaeobotanical remains from Rosinish, in the form of carbonised grains, suggest that naked barley was the most important crop, with hulled barley and emmer wheat forming an insignificant component (Shepherd and Tuckwell, 1977). A small quantity of fish bone has also been recovered at this site (Shepherd, 1976).

4.5 The Iron Age

The Iron Age period in Scotland is usually considered to start around the eighth century BC and to end with the first Roman invasion of Scotland in the late first century AD. In practice the Roman invaders appear to have had little influence on the material culture of the Outer Hebrides (Armit and Ralston, 1997), and the Roman period is thus included in this section.

4.5.1 Settlement sites in the Iron Age

Whereas settlement sites in the Neolithic and Bronze Age were rather flimsy and are hard to detect archaeologically, in the Iron Age there was a shift to monumental domestic architecture. Brochs, duns, and wheelhouses, all built of stone and generally conspicuous in the landscape, became the three standard types of domestic sites on the islands (Fig. 4.4).

In the past, much emphasis has been placed on the special status of broch

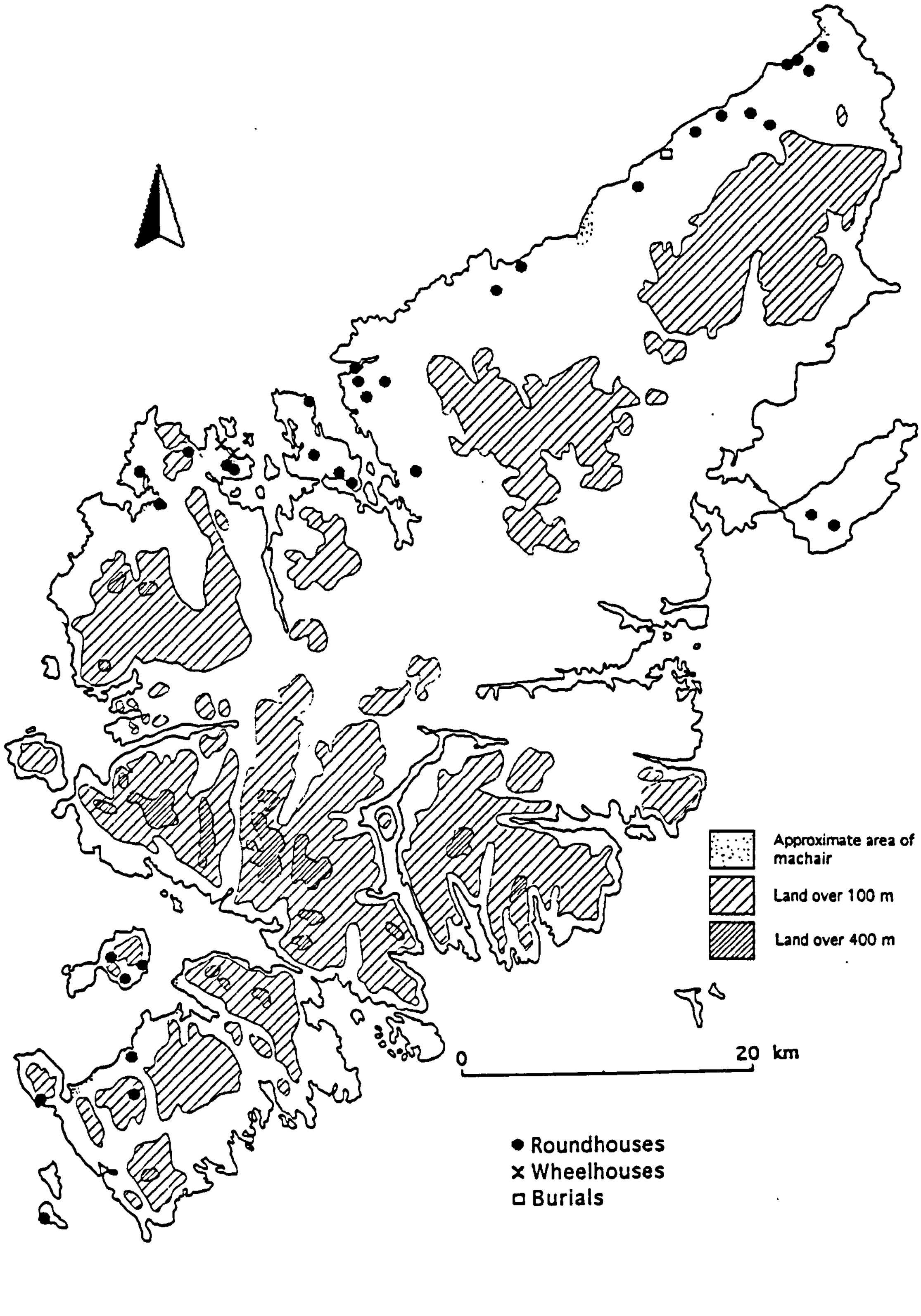


Fig. 4.4a Distribution of Iron Age sites in Lewis and Harris

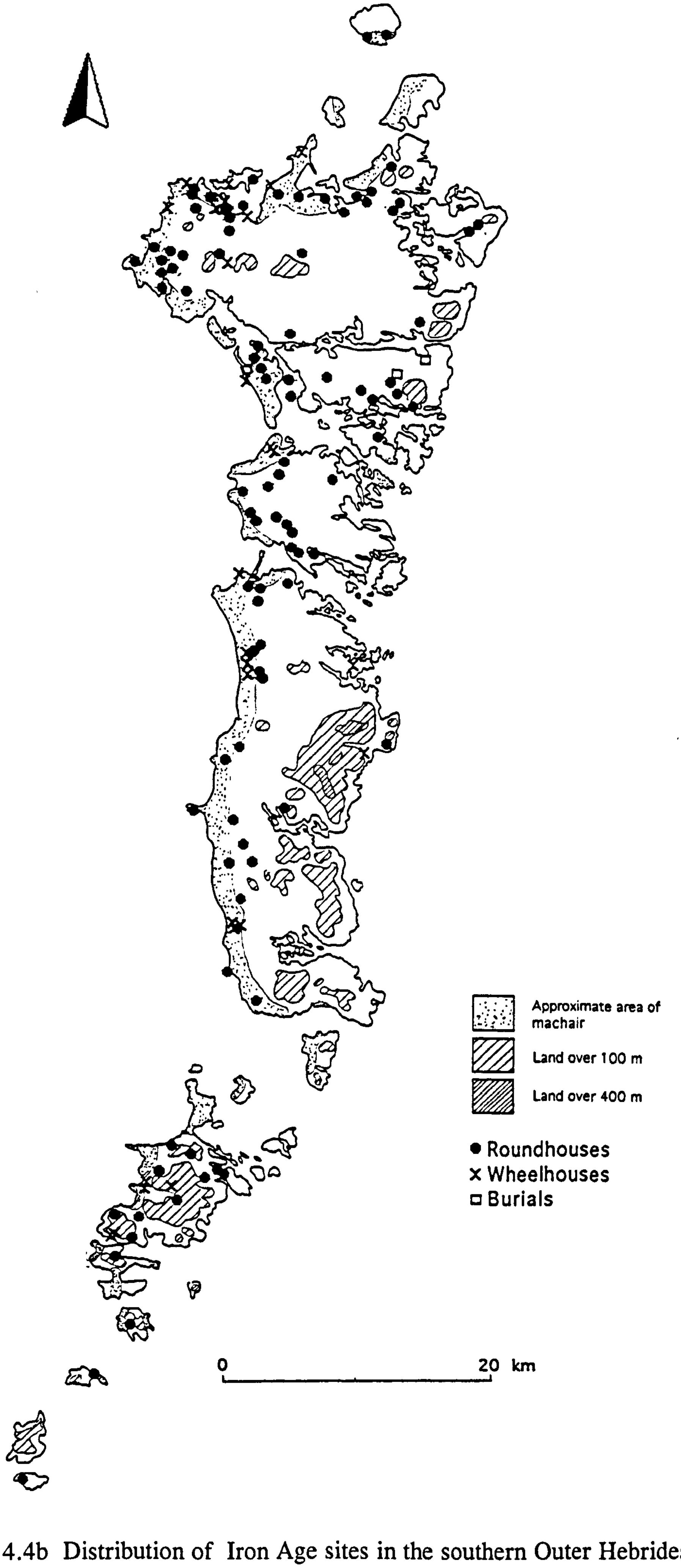


Fig. 4.4b Distribution of Iron Age sites in the southern Outer Hebrides

towers. Brochs have been defined as circular structures built in stone, characterised by complex architectural features such as hollow walls with cells and stairs (MacKie, 1965; Ritchie and Ritchie, 1991), which allowed them to be built to great heights (up to 14 metres, judging from the better-preserved examples such as Mousa on Shetland; Armit, 1990d). The brochs were assumed to have been inhabited by some type of elite, most likely 'incomers' to the islands (Scott, 1947a; Young, 1962; MacKie, 1969, 1971), and it has even been suggested that they were built by professional engineers (Ritchie and Ritchie, 1991). Duns, on the other hand, were seen as more simple buildings with a single solid wall, and were taken to be the houses of more lowly farmers (Scott, 1947a; MacKie, 1965). It now appears, however, that the classification of sites is strongly dependent on preservation. At many Iron Age sites, poor preservation and stone-robbing have destroyed or obscured many of the characteristic 'broch features', so that most of the Iron Age roundhouse sites on the Outer Hebrides have been put into the 'dun' category, which has helped to give credence to the idea that the broch towers were somehow special. But all the roundhouse sites on the islands that have been excavated to date, including the ones that were thought to be duns, were discovered to have broch-like features such as intra-mural cells or galleries, and it is possible that there have never been any simple duns on the islands at all (Armit, 1996: 116).

In recent years it has been suggested by Armit (1988b) that we should do away with the terms 'broch' and 'dun' and use the term 'Atlantic roundhouse' instead, creating a category that would include brochs, galleried duns (a miscellaneous group of duns with some but not all of the classic broch features), semibrochs, and island duns. This category could then be subdivided into simple roundhouses and more complex structures. The latter would include a sub-group of structures with evidence of a tower-like building, in other words, brochs (Armit, 1988b). Armit (1990a) also argues that there was a gradual development from simple roundhouses to more complex forms during the second half of the first millennium BC, with the broch probably appearing in the last centuries of the millennium.

The real question is why duns and broch towers were built in the first place.

Traditionally these sites were thought to have been defensive structures (Lethbridge, 1952; MacKie, 1965, 1969; Young, 1962; Hedges and Bell, 1980), but their location, often on promontories or islets, appears to have been the most important asset in defence. The buildings themselves are almost incidental, and perhaps served as a symbolic expression of control over the local environment, rather than functioning as serious defensive structures (Armit, 1996). Scott (1947a) already noted that the brochs and duns tended to be located in areas of good agricultural land, and suggested that they were built to control this asset.

The brochs may have been imposing, but they were not very practical. Their height meant that, unlike earlier and later domestic buildings on the islands, they were not sheltered from the wind. In addition, large wooden timbers were needed to construct the roof, and in the Outer Hebrides wood was probably a scarce commodity by this time (see Chapter 3, and results of this study), although it may have been imported from the mainland (Harding, 1984).

Some time at the end of the first millennium BC the people of the Outer Hebrides started building wheelhouses. The name 'wheelhouse' reflects the visual appearance of the building in plan: a circular structure, with a hearth in the centre and a periphery divided by radial piers, creating individual cells (Ritchie and Ritchie, 1991). There were no multiple floor levels, and the sites tended to extend outwards with secondary buildings. Wheelhouses were often revetted into a sand-dune for extra stability, or built into earlier brochs or duns. Only a few, such as Allasdale in Barra (Young, 1952), are free-standing. The entrance to the wheelhouse was often below ground, covered with stone slabs and sand. The advantage of wheelhouses over brochs was that they were semi-subterranean and thus provided shelter from the wind. The internal cells were individually corbelled by stone slabs, and it is likely that only the centre of the building was roofed using timber, requiring far less wood than a broch tower. It has been argued that environmental pressures, such as lack of suitable timber, led to the building of wheelhouses and the gradual abandonment of brochs. Yet it was still a monumental structure that required considerable skill, and numbers of people, to build (Armit, 1992a).

In essence wheelhouses served the same function as brochs and duns. Both types were isolated settlements, probably built as farms for extended families. Wheelhouses were about as common in the Outer Hebrides as the Atlantic roundhouses, and appear to have commanded about the same size of land. Unlike the roundhouses, however, most of the wheelhouses were built in the machair, and only one, Eilean Maleit on North Uist, is known to occupy an islet site (Armit, 1992a). This change may be due to environmental pressures, with agriculture now shifting entirely to the machair plains (Barber and Brooks, n.d.; see also Chapter 11).

Dating wheelhouses is problematic, complicated by the fact that many are multi-phased buildings with later re-use and extensive modifications. Traditionally they have been dated to the mid-1st century AD, but a wide range of dates for their construction have been quoted ranging from the 6th century BC at the Udal and Hornish Point (Crawford, n.d.; Barber *et al.*, 1989) to the late first to early third centuries AD at Sollas (Campbell, 1991). This range of dates overlaps considerably with the period when duns and brochs were also being built. The decline of wheelhouses is somewhat better dated: during the first and second centuries AD the wheelhouses at Sollas, Cnip and the Udal in their original form went into decline, although they were generally not abandoned but were modified or rebuilt (Campbell, 1991; Crawford n.d.).

4.5.2 Iron Age ritual and burial sites

Few Iron Age burial sites have been identified on the Outer Hebrides. One possible reason is that the non-monumental nature of the graves makes them difficult to find, while lack of grave goods may make them difficult to identify. At the Udal there may be evidence for a number of cremation platforms as well as two inhumation burials dated to the first century AD, possibly associated with the Iron Age wheelhouse at the site (Crawford, n.d., 1996). At Northton, two inhumations were found dug into a Beaker period cist (Simpson, 1976), and at Galson in Lewis an inhumation burial was found which may have been associated with the wheelhouse at the site (Ponting, 1989).

Ritual sites on the islands include pits with apparent ritual and votive offerings, which seem to be closely associated with domestic settlements. In the wheelhouses at Sollas 150 such pits were found, containing both animal bones and artefacts, and dating primarily to an early phase in the use of the wheelhouse (Campbell, 1991). At Hornish Point, South Uist, the severed and dismembered body of a child was found divided between four pits, accompanied by animal bones (Barber *et al.*, 1989). Other possible ritual deposits include a kerb of red deer jaw bones at A' Cheardach Bheag, South Uist (Fairhurst, 1971), and the head of great auk, along with cattle bone and a pot, found placed behind a wall in the wheelhouse at Cnip in Lewis (Armit, 1996).

4.5.3 The Romans

During the first century AD, the Roman army started to make incursions into southern Scotland. The Roman presence in Scotland lasted only a few decades, was primarily military in nature (Hanson, 1997), and appears to have had little effect on the archaeological record of the Outer Hebrides. Artefacts of Roman manufacture or influence are limited to a few sherds of Samian pottery (Robertson, 1970: 270; RCAHMS, 1928: 29), a Romano-British brooch (Lethbridge, 1952), and possibly some Severan silver coins (Robertson, 1983: 417).

4.5.4 The Iron Age subsistence economy

During the early Iron Age, when the Atlantic roundhouses were being built, there appears to have been a contraction of settlements into coastal areas (Armit, 1992a). This may be due to the fact that the inland parts of the islands had started to suffer from peat bog spread by this time, thus becoming less productive and no longer useful for anything but rough grazing and peat-cutting (Barber and Brooks, n.d.; see also Chapter 11).

There is little palaeoeconomic evidence available from the Atlantic roundhouses because the bones from these sites, which were generally not located on the machair, tend to be poorly preserved. The mixed economy of the Neolithic and Bronze Age, though, appears to have persisted. At Dun Cuier in Barra, species represented included cattle, sheep and pig, as well as wild animals such as red deer, otter, grey seal, sea-birds and fish including wrasse, black bream and cod (Young, 1956). At Dun Vulan sheep bones dominated but cattle were also well represented, and there was an unexpectedly high number of pig bones. Carbonised grains and saddle and rotary querns provide evidence of arable agriculture (Parker-Pearson and Sharples, 1992). Hulled barley was probably the most important crop, with wheat, oats and possibly rye also cultivated. The introduction of iron tools, the rotary quern and the horse may have made agriculture on the islands more efficient at this time (Armit, 1990c).

Unlike duns and brochs, wheelhouse sites are generally found in the alkaline sands of the machair, and the bones from these sites tend to be far better preserved. In the wheelhouse at Cnip, and in the re-occupied roundhouse at Loch na Berie, the most unusual feature was the high proportion of red deer bones, which at Cnip equalled cattle and sheep representations (McCormick, 1991 in Armit, 1996). This preponderance of deer was not found at any of the sites investigated in the Uists, and it may be that red deer herds survived for longer on Lewis, and perhaps were even managed and culled selectively.

Cattle and sheep were present at Cnip in about equal proportions. Although the sheep were of about average size for the Iron Age, the cattle found at the site were very small. This may have been because of the lack of good grazing in the area, particularly if the machair was used primarily as arable land and the cattle were left to graze on low quality peatland. McCormick (1991 in Armit, 1996) suggests on the basis of age-at-death statistics that the cattle were primarily used to satisfy short-term requirements for meat, and that dairying did not play a significant part. Arable agriculture is confirmed by the finds of saddle and rotary querns. Arable fields were probably located on the machair, where traces of agriculture are not well preserved (Armit, 1996).

As in other periods, sea-birds, including great auk, shag, black guillemot, puffin, gannet, diver, razorbill and migratory geese, were also exploited (Campbell, 1991). At Cnip the fish bones included those of hake, saithe, cod and ballan wrasse (Armit, 1996). Whale bones found at Foshigarry and Bac Mhic Connain are likely to be the remains of occasional stranded, rather than deliberately hunted, animals (Hallén, 1994).

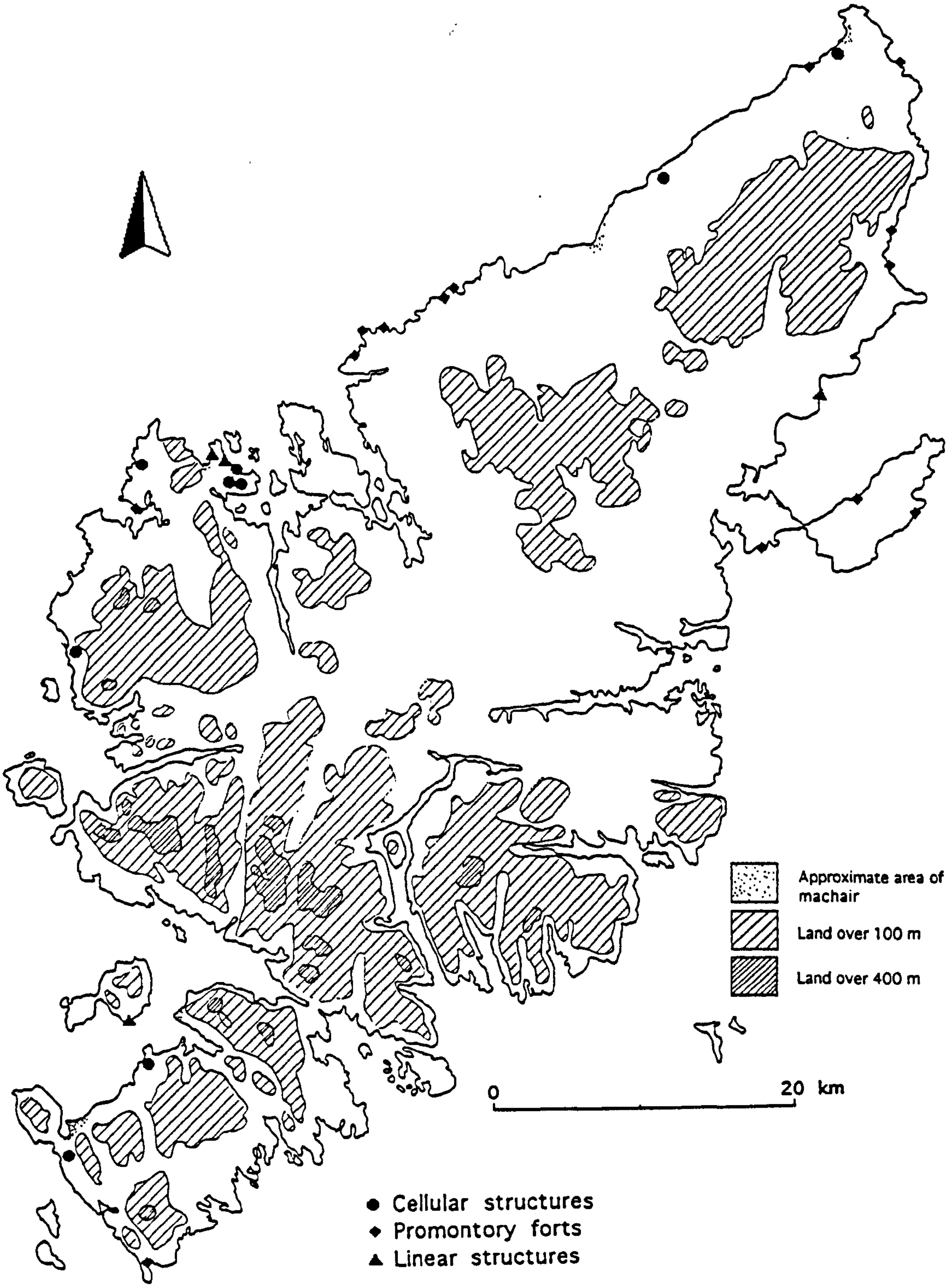


Fig. 4.5a Distribution of Pre-Norse sites in Lewis and Harris

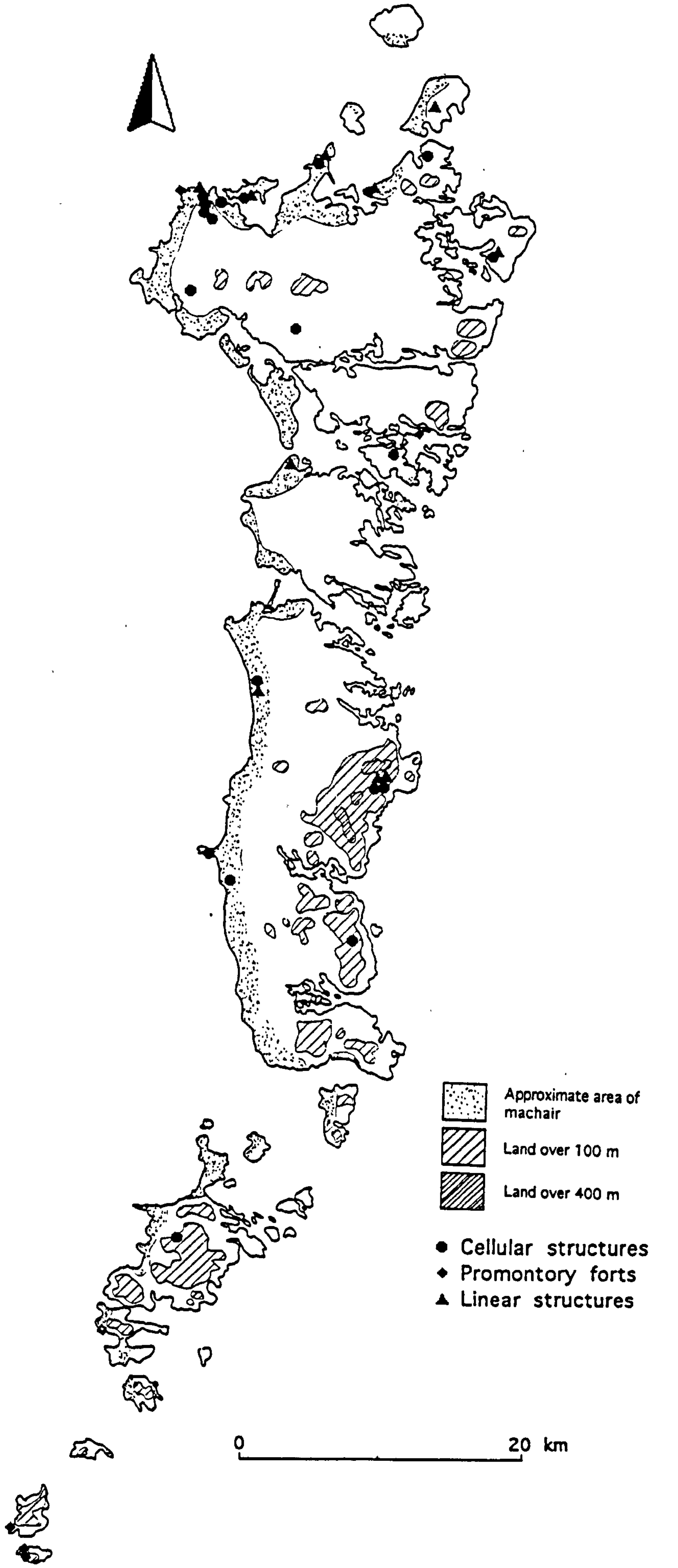


Fig. 4.5b Distribution of Pre-Norse sites in the southern Outer Hebrides

4.6 The Pre-Norse period

By the middle of the first millennium AD separate kingdoms had started to emerge in Scotland (Ralston and Armit, 1997), of which the Scottish and Pictish were closest to the Outer Hebrides. The islands may well have been affiliated with the northern sector of the Pictish kingdom at this time (Bannerman, 1974), but how strong this influence was is unclear. There is no literary documentation that provides any clues to political affiliation, and the archaeological evidence for such an affiliation is limited to a few Pictish symbol stones (Beveridge and Callander, 1931).

4.6.1 Pre-Norse settlements

Settlements in the Outer Hebrides during this period were still concentrated in machair areas, but the buildings themselves were adapted and changed. Around this time many wheelhouses in the Outer Hebrides were converted into cellular structures (Armit, 1990c). These were eminently suited to the environment of the islands; they were sunk into the ground for insulation and had roofs that required a minimum of timber. The cellular structures at Eilean Olabhat have been dated to the early first millennium AD, and those at Loch na Berie, Dun Cuier and the Udal to the mid to late 1st millennium AD (Armit, 1996; Harding and Armit, 1990; Young, 1956; Crawford, n.d.) and thus appear to fill the gap between wheelhouses and the building of Norse settlements on the islands. All the cellular structures discovered in the islands to date had been built into ruined duns, brochs or wheelhouses or revetted into sandhills, and there is evidence of settlement continuity at many of these sites (Harding and Armit, 1990; Armit, 1992a).

While the architecture changed and became non-monumental, greatly elaborated personal ornaments, particularly metalwork, started to appear, taking over as symbols of wealth (Armit, 1990b). Examples include a Romano-British brooch found at Kilpheder (probably dating to the second century AD) (Lethbridge, 1952), and a number of penannular brooches found in fifth or sixth century layers at Loch na Berie (Harding and Armit, 1990).

4.6.2 Pre-Norse burial and ritual sites

There are few burials that can be securely dated to this period, but one example is the long cist cemetery eroding out of the sand at Galson on Lewis, which dates to around the fourth century AD (Ponting, 1989).

During the second half of the first millennium AD Christianity probably played an increasingly important role on the islands, as elsewhere in Scotland. Evidence for Christian beliefs, though, is generally limited to place name evidence (such as the name Pabbay for an island occupied by a 'paper' or priest) and archaeological evidence for a chapel and cemetery enclosure on the island of North Rona, where an Early Christian monastic community may have been located from the seventh to ninth centuries AD (RCAHMS, 1928, no. 9).

4.7 The Viking period until today

The Outer Hebrides were first visited by Vikings some time around AD 800, and remained part of the Norse world until AD 1266. There are very few written records about the Hebrides from this time, nor are there many archaeological sites, and most of the evidence for Viking occupation is based on place-names which include typical Norse elements (Fraser, 1974; Cox, 1989). Lewis appears to have been most greatly influenced by Viking settlers; 108 of the 126 village names on the island are of Norse origin or have Norse elements. What is unclear from this evidence, however, is to what extent Norse incomers and natives actually became integrated.

4.7.1 Norse settlements

The archaeological evidence for settlement is scarce, and is based on a single house at Drimore in South Uist (Maclaren, 1974), unpublished evidence from a settlement at the Udal, and the forthcoming publication of excavations at Barvas on Lewis. One reason that so few sites have been discovered is that the shape of Viking houses may be very similar to later structures, and much of the evidence may be obscured by later building phases. Some sites may even be occupied until this day.

The house at Drimore (dating to the late ninth or early tenth centuries AD) proved to be a large rectilinear structure measuring 14 m by 5 m, with the upper part of the building possibly made of turf. Cattle and sheep were kept at the site, but pig, horse, dog, and red deer bones were also present (Maclaren, 1974). At Barvas barley and oats were staple crops, and flax was also grown. As at Drimore, cattle and sheep were the dominant domesticated animals, and the patterns of culling suggest that dairying was important. Fish remains were common and included large cod, ling, and saithe, which suggest offshore fishing, as well as species from shallower waters, such as flounder, turbot and plaice (Cowie *et al.*, forthcoming).

Hoards of Viking Age silver and gold objects, deposited in the ground either for safe-keeping or perhaps as offerings, have also been found on the islands (Graham-Campbell, 1976). Examples include a hoard of six and half gold ringers apparently from Oronsay (off North Uist) and a number of silver penannular arm-rings at South Dell in Lewis. From the later Norse period comes one of the most famous finds on the islands: the Lewis Chessmen - elaborately carved chess pieces made of walrus ivory, probably dating to the mid-twelfth century, found in the sand dunes at Uig Bay in 1831(Taylor, 1978).

4.7.2 Viking Age burials

Viking Age burial sites known to date include two cemeteries and a few isolated graves. The largest of these sites is located on the Cnip headland in Lewis, where 7 burials have so far been recovered (Dunwell *et al.*, 1995b). The Vikings at this time were pagans, and grave goods of personal ornaments and utilitarian objects were contained within the graves, which allows them to be easily distinguished from Christian burials. The cemetery, which was in use during the latter part of the ninth century AD, was probably the burial ground of a farming community living nearby.

4.7.3 The Lords of the Isles

With Norse control waning, the islands fell under the rule of a succession of local rulers know as the Lords of Isles, starting with Somerled MacGillibride in the mid-twelfth century, although the first Lord to be officially invested was John of Islay in AD 1354. This lasted more or less until the 16th century when the Scottish crown started to wield more control over the islands (McLean, 1980).

Little is known about the general population of Hebrides at this time. Written sources tend to deal with secular and religious leaders, and the best known monuments from this period are castles and churches. The settlements of the common people remained largely unrecorded until the eighteenth century, but, from what little is known, it appears that they were still small and made up of slight buildings, using perishable materials such as turf. The buildings could be pulled down when no longer inhabited and used to manure the fields, making them rather hard to detect archaeologically. These types of houses probably remained the norm into the eighteenth century (Dodghson, 1993). Examples of medieval houses have been excavated at Eilean Olabhat and Druim nan Dearcag in North Uist, where several small-scale sub-rectangular buildings (measuring about 6m x 4m at Druim nan Dearcag) have been found, along with a series of storage structures and enclosures (Armit, 1990b, 1996).

Atlantic roundhouses (duns and brochs) were also reoccupied during this period, often as secondary buildings within the original shells. One example is Dun an Sticer in North Uist, where a sixteenth century building can still be seen within the ruins of the broch (RCAHMS, 1928, no. 171). Elaborate buildings include castles, of which there are few in the Outer Hebrides. Kiessimul Castle in Barra (RCAHMS, 1928, no. 439) was constructed in the fifteenth century and, like the old brochs, was built on an island.

There appears to have been a considerable increase in the population during the seventeenth and eighteenth century on islands (Dodghson, 1993). In the eighteenth century *bailtean*, nucleated settlements of tenant farmers associated with runrig and open field systems, appear to have formed the principle settlement pattern on the islands. The later nineteenth and early twentieth centuries saw the use of 'blackhouses' – rectilinear buildings with low roofs and thick walls, which were constructed either using turf, or more recently, drystone walls with an earthen core, and which housed both people and livestock.

Other archaeological evidence from the last few centuries comes from the traces of cultivation that are still visible in the landscape today, in particular 'lazy-beds', a form of intensive land-use of rig and furrow used for the cultivation of crops such as potatoes (Glentworth, 1979). Until relatively recently transhumance was a normal practice in the isles, and the remains of shielings, built to house the people who tended the cattle and sheep in summer pastures, still dot the landscape. These buildings vary from rectilinear structures with stone walls or turf walls, to multi-celled structures.

4.8 Summary

No Mesolithic sites are known on the islands to date, although these may remain hidden beneath sea, machair and peat. Neolithic settlement evidence consists of small-scale sites, while ritual sites were generally monumental, taking the form of chambered tombs and stone circles. During the Bronze Age, small-scale settlement continued, and the burial evidence consists primarily of cists and kerb cairns. In the Iron Age, settlements became primarily coastal, and monumental stone buildings such as brochs and wheelhouses were constructed, while burials became less visible. During the pre-Norse and later periods a reversion to small-scale, easily dismantled buildings took place, which persisted until the 18th century.

Chapter 5

METHODOLOGY

5.1 Site selection

One of the main aims of this study was to investigate human impact in different parts of the Outer Hebrides. In order to do this sites had to be selected that would not only provide good information on the relationship between people and vegetation, but that could also be compared to each other. Ideally the pollen in these profiles should derive from regional as well as local vegetation, and cover most of the Holocene. In this study, deposits from three lochs, a valley mire, and an archaeological site were chosen for analysis.

5.1.1 Pollen catchment area

In order to be able to interpret the pollen record of any given site it is important to consider where the pollen is likely to come from. All pollen records will include pollen from both local and more distant sources, but the relative proportions of these components may vary considerably. Factors that are likely to have an influence on the pollen record, and the pollen source area of any given site, include the type and size of the basin, the type of vegetation surrounding the site, as well as the production and dispersal characteristics of individual pollen and spore taxa (Jacobsen and Bradshaw, 1981; Prentice, 1985, 1988).

Some plants produce more pollen than others, and some pollen is dispersed a greater distance than others (Tauber, 1965; Andersen, 1970, 1973: Bradshaw, 1981). As a general rule small, light pollen grains will travel greater distances before settling than large, heavy grains. This means that *Quercus* pollen found in a lake profile is likely to have originated from an area far larger than, for example, *Fagus*. The vegetation around the site will also have an effect on the dispersal of pollen, and this is likely to have changed over time. During wooded phases, trees surrounding the coring site may have acted as a buffer against the wind, so that a higher percentage of the pollen in the loch derives from local sources. Conversely, during phases when the landscape was more open, the wind may have blown in more pollen from long distance sources (Jacobsen and Bradshaw, 1981).

One of the factors that affects the size of the pollen catchment area is the type and size of the basin under investigation. A closed lake will receive pollen from the air (deposited primarily by raindrops) and from aquatic plants growing in the lake. If the lake has a stream flowing into it, it will also recruit pollen from the surfaces and soils of the stream catchment area and, potentially, older pollen that has eroded out of soils and peat (Jacobsen and Bradshaw, 1981). In areas of high rainfall this stream-borne component can be very important. In a study of a lake in Cumbria with a surface area of 10.2 ha and a catchment area of about 4 km^2, Bonny (1978) used pollen traps to investigate recruitment processes, concluding that up to 85% of the pollen eventually deposited mid-lake may have been stream-borne. The importance of the stream-borne component is likely to vary with the vegetation of the catchment. For example, deforestation may lead to an increase in stream-borne pollen deposited in the lake because of increased surface run-off (Pennington, 1979).

The pollen catchment area of a mire will depend at least partly on the type of mire in question. Blanket mires are fed entirely by rainfall, and will receive virtually all of their pollen from the rainout component (airborne pollen) as well as local plants growing on the mire itself. Mires (including valley mires) that receive water from both land-drainage and precipitation will also have an element of extra-local pollen supplied by ground water (Jacobsen and Bradshaw, 1981). The importance of this pollen input will vary with the volume of the water supply, the rate of flow, and the size of the water catchment area (Moore *et al.*, 1991). The pollen input of local plants can be very high when the vegetation of the mire is dominated by high pollen-producers, such as Poaceae and Cyperaceae. In lakes the local vegetation of aquatic plants can usually be identified and excluded from the pollen sum, but many of the taxa growing on a mire can also be found in the surrounding countryside, which can lead to problems in distinguishing between regional and local vegetation changes.

The size of the basin (both in lakes and in mires) also appears to have an influence on the pollen catchment area. Modern studies in temperate woodland have suggested that in small lake basins (1-5 ha in area) most of the pollen originates from within 10-100 km^2 of the site, in other words a radius of around 1.5-5.5 km (Jacobson and Bradshaw, 1981). In larger lakes, most of the pollen tends to come from further away, from an estimated area of 1000-10,000 km^2 around the site (a radius of 14-44 km). It must be pointed out, however, that these figures are derived from wooded sites in temperate zones, and may not apply to open, windy areas such as the Outer Hebrides.

Fossitt (1994a) has conducted a study of modern pollen in the Outer Hebrides, and used the following terms to describe the different spatial components of pollen recruitment: local pollen (from vegetation within 200 metres of the edge of the loch); regional pollen (from vegetation outside the catchment area of the lake but within 10 km of the site); and long-distance pollen (from a distance of more than 10 km, including off-island sources). Fossitt sampled 30 small lochs (0.5-4 ha in surface area) in the islands, and found that local patterns in the vegetation were often hard to detect. For example, there were no obvious differences in the pollen assemblages of sites located close to farmland and those in blanket peat. Similarly, at a site located close to a small woodland, arboreal pollen frequencies were no higher than at treeless sites on the islands. This suggests that small lochs on the islands provide a pollen signal that is predominantly regional rather than local. In the same study, arboreal pollen accounted for an average of 13.8% of total land pollen, and as the islands are virtually treeless today, this provides a minimum for the amount of pollen deriving from long-distance sources (such as the Scottish mainland). A maximum figure for long-distance input cannot be established, since some of the non-arboreal pollen may come from local, regional and long-distance sources. However, as most non-arboreal pollen taxa are not generally dispersed over great distances, long-distance input of these taxa in the Outer Hebrides may be quite minor.

5.1.2 Sites selected for this study

Pollen profiles from small to medium-sized lochs were thought to be the most appropriate to this study, as they are likely to provide a regional signal without being overwhelmed by either local or long-distance pollen. Loch a' Chabhain (Chapter 6) is the smallest loch in this study (*c.* 1.2 ha), followed by Loch Airigh na h-Achlais (*c.* 2.3 ha; Chapter 8), while Loch Olabhat (Chapter 9) is considerably larger (13 ha) and is therefore likely to have a larger pollen catchment area than the other two sites. Both Loch Airigh na h-Achlais and Loch Olabhat have stream inflows, which will affect the pollen catchment areas of these sites, potentially bringing in higher proportions of extra-local pollen (see sections 8.1 and 9.1).

In addition to the three loch cores, one peat core was also collected, in order to study the local picture of vegetation and settlement history close to two chambered tombs. The core comes from a valley mire near Frobost (Chapter 7), not far from the site of a previous loch profile (Reineval; Edwards *et al.*, 1995). The mire has a stream flowing through it, potentially depositing pollen from vegetation growing on nearby slopes (section 7.1).

Finally, a profile was taken from the Neolithic settlement site of Eilean Domhnuill (Chapter 10), located on a small island in Loch Olabhat. The site was chosen in order to look at the environment and impact of people at a known archaeological site, and to complement the record from the loch. Pollen from archaeological deposits can derive from the air, plants growing on the site itself, and from plants brought in deliberately or inadvertently by people, and can thus potentially be good sources of information on local conditions at the site as well as agriculture and other human practices (Dimbleby, 1985). The taphonomic processes in archaeological deposits can be very different from those in lake and peat deposits, and comparsion between profiles from different types of sites can be difficult (see Chapter 10 for a longer discussion).

5.2 Data Collection - Coring

The loch sites of Loch a' Chabhain, Loch Airigh na h-Achlais and Loch Olabhat were cored from an anchored inflatable dinghy, using a Russian corer with a chamber 50 cm long and 8 cm wide (Jowsey, 1966). Where possible the core was taken from the deepest part of the loch, as far as this could be ascertained. Sediments in areas of deeper water in the middle of the loch tend to be more uniform in terms of both percentage pollen composition and pollen concentrations. In shallow areas, disturbance of sediments by wave action is likely to be more pronounced, which may lead to resuspension and redeposition of pollen elsewhere (Davis, 1968; Davis *et al.*, 1969; Bonny, 1978). Shallow areas close to shorelines are also to be avoided because the regional pollen signal can be obscured by high frequencies of very local pollen from vegetation growing on the edge of the lake (Bonny, 1978). Core segments were extracted alternately from two core locations about 50 cm apart, with an overlap of 5 cm between each segment. The 50 cm segments of lake material were extruded onto plastic guttering and wrapped securely in black plastic for transport back to the Sheffield.

The peat core from Frobost was also extracted using the Russian corer. The basal segment, however, had to be recovered using a coring head with a narrower chamber (5 cm wide) because the clay in the lowest segment proved difficult to penetrate. Again, alternating holes about 50 cm apart were used to collect the core, and segments overlapped in depth by 5 cm.

The soil monolith from Eilean Domhnuill was collected using two Kubiena tins, 25 cm long and 10 cm wide. The samples remained in the tins, which were wrapped in cling-film and plastic bags before being transported back to Sheffield.

Once in Sheffield, all samples were stored in a cold store at 4°C.

5.3 Subsampling for pollen and charcoal analysis

The profiles from Loch a' Chabhain, Loch Airigh na h-Achlais and Frobost were subsampled at 4 cm intervals. The profile from Loch Olabhat was initially also subsampled at 4 cm intervals, but at a later stage additional samples were taken from the top half of the profile, as this appeared to be the area of most interest. Consequently the sediment at Loch Olabhat was subsampled at 2 cm intervals from 132 cms to 192 cms, and from 222 cm to 316 cm. No further subsamples were taken from the profile between 192 and 222 cm, where initial analysis had revealed that very little pollen had been preserved. The soil profile from Eilean Domhnuill was likewise subsampled at 2 cm intervals. In all cases 1 cm^3 of sediment , measured by displacement, was extracted for pollen analysis.

5.4 Loss-on-ignition

Samples of approximately 1 cm^3 were taken for loss-on-ignition tests to determine the organic content. The samples were dried overnight at 105°C and weighed, then ignited in an oven for two hours at 550°C and re-weighed (Dean, 1974). The weight of material lost, expressed in percentage terms, provides a measurement of the amount of organic material in the sample. This can provide valuable information on sedimentary processes which can help in identifying changes which may be of significance in interpreting the pollen diagrams (e.g. erosion).

5.5 Laboratory procedures

Pollen preparation followed standard procedures (Berglund and Ralska-Jasiewiczowa, 1986; Fægri and Iversen, 1989; Moore *et al.*, 1991). During the laboratory procedures, filtered water was used at all times to minimise contamination by modern pollen in the water.

Samples were taken from the cores using a small spatula, and in each case 1 cm^3 of sediment was measured by displacement in 10% HCl in 10 ml measuring cylinders. The samples were then transferred to 15 ml polycarbonate centrifuge tubes. Tablets with a known quantity of *Lycopodium clavatum* spores were added to each sample to act as exotic marker grains and enable the calculation of pollen, spore, and charcoal concentrations and accumulation rates (Benninghoff, 1962; Stockmarr, 1971). The samples were stirred, centrifuged for 5 minutes at 3000 r.p.m. and decanted.

The resulting pellets were subjected to potassium hydroxide digestion by adding 15 ml 10% KOH and placing the tubes in a hot water bath for 15 minutes. The samples were then washed through a 180μm sieve, centrifuged and decanted.

After KOH digestion, the loch samples were subjected to hydrofluoric acid treatment to remove silica: 5 ml of 40% HF was added to the samples, which were then stirred and placed in a hot water bath for 20 minutes. The samples were centrifuged and decanted. 5 ml 10% HCl was added to each sample to neutralise the HF, and the tubes were placed in a warm water bath for 5 minutes, centrifuged and decanted.

All samples were subjected to acetolysis: the samples were dehydrated by the addition of glacial acetic acid, placed in the centrifuge for 3 minutes and decanted. They were then suspended in 5 ml of an acetolysis mixture consisting of 9 parts acetic anhydride and 1 part sulphuric acid, and placed in the water bath for 3 minutes, after which they were centrifuged and decanted. The pellets were once again subjected to dehydration by adding 5 ml glacial acetic acid, centrifuged and decanted. The samples were then stained with one drop of aqueous safranine mixture (2 drops of the stain mixed with 2 ml water), and suspended in filtered water with a few drops of 10% KOH to neutralise acids, centrifuged and decanted. The samples were then suspended in 5 ml ethanol, centrifuged and decanted, followed by suspension in 1 ml tetr-Butyl alcohol, and once again centrifuged, and decanted into small glass tubes. About 2 ml of silicone oil was added to each tube.

The tubes were left in a warm cabinet overnight to allow the tetr-Butyl alcohol to evaporate, after which the resultant mixture could be mounted on microscope slides. Silicone oil was chosen as a mounting medium because it does not lead to swelling of the grains (Andersen, 1978), and because slight pressure on the cover slip allows the pollen grains to be rotated on the microscope slide, making identification easier.

5.6 Counting and identifying of pollen and spores

A Zeiss Axiolab microscope was used to count and identify pollen, charcoal and spores. A x40 objective and a x10 eyepiece was usually sufficient for identification, but occasionally use was made of a x100 oil immersion objective. The slides were traversed at regular intervals, and in order to overcome any problems with non-random distribution of pollen grains, at least half a slide was examined for each level.

Ideally, a large number of pollen grains (1000-2000 grains per sample) should be counted in order to achieve a high degree of statistical accuracy and to ensure that rare taxa, which may be indicative of human impact, are not missed (Berglund and Ralska-Jasiewiczowa, 1986). However, in practical terms this has to be weighed against time constraints. Mosimann (1965) suggests that a count of 500 grains would strike a balance between statistical reliability and practicality, and thus a minimum of 500 pollen grains of terrestrial vascular plants was counted for each level in this study, wherever possible. Occasionally pollen concentrations were too low to achieve this number, particularly in Lateglacial levels, and in these cases at least 200 pollen grains were counted. In addition all aquatic taxa and spores found in the samples were recorded, but were not included in the total pollen sum. *Lycopodium* spores, which had been added as 'exotic' marker grains, were recorded using a mechanical counter during ordinary pollen counting in order to enable the creation of concentration and accumulation rate diagrams (see section 5.9).

Pollen and spores were identified using the keys in Faegri and Iversen (1989) and Moore *et al.* (1991), as well as the pollen reference collection in the Department of Archaeology and Prehistory at the University of Sheffield. An attempt was made to identify Cerealia-type pollen to taxa, but poor exine condition and/or crumpling of most of these grains did not allow for more accurate identification, although in two cases (at 172 cm at Loch Olabhat and 198 cm at Loch Airigh na h-Achlais) the pollen grains were of *Hordeum*-type.

As noted in Chapter 1, pollen (and plant) nomenclature follows Stace (1991), using the -type procedures detailed in Bennett (1994a) and Bennett *et al.* (1994).

5.7 Preservation

Throughout the time that it lies exposed to the atmosphere or buried, pollen can be subject to deterioration processes, including fungal and bacterial activity, oxidation, and post-depositional compaction (Sangster and Dale, 1961; 1964; Cushing, 1967; Havinga, 1964, 1967, 1984; Hall, 1981; Lowe, 1982). A record of the preservational state of pollen and spores can be an effective tool in assessing depositional conditions and disturbance in a lake or mire (Berglund and Ralska-Jasiewizowa, 1986). Preservation of pollen in the samples in this study varied from very well preserved to severely corroded. Deteriorated but determinable pollen grains were recorded during regular pollen counting and divided into three categories (in increasing order of severity): 'crumpled' (physically crumpled grains), 'broken' (physically broken grains), or 'corroded' (exine of grain etched, pitted, or thinned) (Cushing, 1967; Delcourt and Delcourt, 1980). Whenever a pollen grain showed signs of more than one type of deterioration it was recorded in the more severe category (e.g. 'corroded', if the grain was both broken and corroded) (Cushing, 1967).

5.8 Microscopic charcoal analysis

Estimates of the abundance of microscopic charcoal in the samples can help shed light on fire intensity and frequency within the source areas of the sites (Patterson *et al.*, 1987). However, the processes that lead to the formation of the charcoal record are still poorly understood. There are as yet little empiricial data on the possible differences in the charcoal production of different types of vegetation (Patterson *et al.*, 1987), the sources of microscopic charcoal found in a profile (Clark, 1988), and the effects of site and sediment characteristics on charcoal representation (Tolonen, 1986). Moreover, the cause of the fires that produced the charcoal, whether natural or anthropogenic in nature, can only be inferred (Tipping, 1996).

A knowledge of the source area of charcoal is essential in determining whether local, extra-local, regional, or long-distance fires are represented. Patterson *et al.* (1987) suggest that the dispersal and deposition of charcoal is similar to that of pollen; i.e. a small basin is likely to have evidence of local fires, while a large site such as a blanket bog may derive most of its charcoal from an area up to several kilometres away. On the other hand, there is some evidence from North America to suggest that local fires within the catchment of a lake are poorly represented in the fossil charcoal record (Clark, 1988; MacDonald *et al.*, 1991). The charcoal fragments encountered on pollen slides are usually small (5-80μ in diameter), of a size that are easily swept up into the atmosphere during a fire, where they can be kept suspended in the air for long periods of time before being deposited at a considerable distance. Thus local fires may actually be under-represented in the charcoal record of a small lake, and larger particles (which are usually removed by sieving during laboratory preparations for pollen analysis), may provide a better indication of local fire activity (Clark, 1988; MacDonald *et al.*, 1991). MacDonald and Edwards (1991), however, suggest that these processes may not apply universally, pointing out that there appears to be a correspondence between the abundance of small charcoal fragments, large charcoal fragments, and vegetation change in Scotland. They suggest that the transport and deposition of charcoal particles may depend on factors such as vegetation type and fire regime.

There is at the moment no single accepted method for recording microscopic charcoal values, a fact which can make comparison between sites analysed by different researchers difficult (Swain, 1973; R. Clark, 1982; Tolonen, 1986; Patterson *et al*, 1987; J.S. Clark, 1988; Rhodes, 1998). Methods that have been used in recent years include counting particles (Tolonen, 1986), classification of particles according to size (Waddington, 1969), and estimating charcoal area by means of point counts (Clark, 1982). The chosen method of measuring charcoal should be both statistically valid and practically viable, and will thus depend on the amount of charcoal present in the samples. Early analyses showed that there was not enough charcoal in the samples in this study to use the point count method developed by Clark (1982), which was originally intended for use in sediments in Australia containing a greater concentration of charcoal than most European lake sites contain. When charcoal concentrations are low this method can yield zero values, and can become very time-consuming (Patterson *et al.*, 1987). Instead, in this study, charcoal fragments were counted individually along with the pollen grains. As charcoal may be broken up by the laboratory procedures used to extract pollen, an estimate of the area of charcoal in each level was also calculated. The area of each particle was measured using a graticule in the microscope eye-piece, and the sum of these values was produced for each level in the profile. Two sets of calculations were made for each level: charcoal concentrations (total charcoal area per cm^3) as well as charcoal:pollen ratios (charcoal concentrations:pollen concentrations) (see section 5.10) to compensate for the problem of changing charcoal concentrations due to variable sedimentation rates (cf. Swain, 1973).

5.9 Radiocarbon dates

Samples from the profiles of Loch a' Chabhain, Loch Airigh na h-Achlais and Frobost were submitted for conventional radiocarbon dating at the Glasgow

University Laboratory located at the Scottish Universities Research and Reactor Centre at East Kilbride. Five samples each were taken for dating from the profiles from Loch a' Chabhain and Loch Airigh na h-Achlais, and three from Frobost. In addition, seven samples were taken from the Loch Olabhat profile for AMS (Accelerator Mass Spectometry) dating at the University of Arizona. The profile from Eilean Domhnuill is undated.

For conventional radiocarbon dates, slices of sediment 5-10 cm in thickness were extracted. Sample thickness for AMS dating of the Loch Olabhat profile was 1 cm.

On the basis of the uncalibrated radiocarbon dates, time-depth curves were constructed, so that a date could be assigned to each level in the profile (Fig. 6.2, 7.2, 8.2, 9.3). By necessity these dates will be estimates, not least because radiocarbon dates have only a probablistic relationship to the true age of the sample, and the real pattern of sediment accumulation can never be known. There are a number of ways that a time-depth curve can be calculated, including linear interpolation (Webb and Webb, 1988), cubic spline interpolation, and the fitting of a polynomial curve (Bennett, 1994b). The simplest and most straight-forward method is linear interpolation, where a series of straight lines is drawn connecting points that represent the mean age and mean depth of each sample. Interpolated ages can then be read off for intermediate levels, and a date for the base of the sequence can be calculated by extrapolation. This method provides reasonable estimates of dates and gradients, but does not take into account the errors in radiocarbon dates. It also creates gradients that change at every radiocarbon dated level, a situation which is unlikely to have occurred in nature. In cubic spline interpolation a curve is fitted that passes through the data points (radiocarbon ages), but also incorporates information from other points than the two in question. The result is a smoother curve with no abrupt changes in gradient at each data point. However, like linear interpolation, it does not take into account the errors on the radiocarbon ages, and in addition the method can produce sections with negative deposition time. A poynomial curve involves creating a curve that best fits the data. The curve does not necessarily pass through all the data points (since radiocarbon dates are only statistical estimates of age, and may not provide the best fit), and can thus be used even when radiocarbon dates are inverted. The method is the only one of the three to incorporate the errors on the radiocarbon ages (Bennett, 1994b). None of these methods are perfect, and each will give different results. In this study linear interpolation was used, as it is the simplest method and imposes the least assumptions on the data. It is considered by some to be the most accurate method when only a few radiocarbon dates are available and none are inverted (Berglund and Ralska-Jasiewiczowa, 1986). All ages for individual levels are rounded off to the nearest 10 years.

The radiocarbon dates, and interpolated ages, were calibrated using the datasets of Stuiver *et al.* (1998), calculated with the computer program Calib revision 4.0 (1998) (cf. Stuiver and Reimer, 1993), and ages are rounded to the nearest ten years. The dates in this study are generally expressed as uncalibrated radiocarbon years before present (BP), in line with most publications on palynological data, followed by calender years (cal BP), which allow easier comparison with archaeological data. In archaeological contexts, dates are generally expressed as calibrated dates BC or AD, as the information is derived from previously published material.

5.10 Diagram construction

Pollen diagrams were created for Loch a' Chabhain, Loch Airigh na h-Achlais, Loch Olabhat and Eilean Domhnuill based on percentages (Fig. 6.3, 7.3, 8.3, 9.4, and 10.3), concentrations (Fig. 6.4, 7.4, 8.4, 9.5 and 10.4), accumulation rates (Fig. 6.5, 7.5, 8.5 and 9.6), and deterioration frequencies (Fig. 6.6, 7.6, 8.6, 9.7 and 10.6). An additional percentage pollen diagram was created for Loch Olabhat, focusing on a period with probable human impact (Fig. 9.8). The profile from Eilean Domhnuill is undated and thus accumulation rates could not be calculated for this site. The envelope at the back of the thesis contains fold-out versions of the percentage diagrams.

Pollen frequencies were calculated by dividing the number of recorded grains of a taxon by the total land pollen sum (TLP) in each sample. Spores, and any obligate aquatic pollen taxa, are excluded from this figure, since their abundance may vary considerably over time, potentially distorting the patterns of change of land taxa which are more likely to reveal information on human impact, a subject which was of particular interest in this study. Instead the representation of spores and aquatic taxa was determined by dividing the number of grains recorded for the taxon by the total pollen sum plus the sum of the category (e.g. TLP + aquatic taxa) (cf. Berglund and Ralska-Jasiewiczowa, 1986). Summary diagrams, showing major changes in the vegetation at a glance, were also created, using the total values for tree, shrub, heath and herb taxa.

Pollen values in percentage diagrams are numerically interdependent, as their sum must always be 100. This means that an increase in any one taxon will automatically lead to a decrease in the frequencies of the others, even if their actual pollen input remains the same. To overcome this problem, concentration diagrams based on the concentration of pollen grains in a known volume of sediment, were also created. Concentrations were calculated using the following formula:

$$Tx = \frac{Cx*Tm}{Cm*V}$$

Where Tx = the concentration of each taxon

Cx = the number of recorded pollen grains for each taxon

Tm = the number of *Lycopodium* marker spores added to each sample

Cm = the number of marker spores counted in each sample

V = volume of each sample (1 cm^3)

All concentrations are expressed as units of pollen grains per cm^3.

Charcoal concentrations, expressed as charcoal area per cm^3, were calculated in the same way (in this case Cx = total charcoal area). Charcoal:pollen ratios were caculated by dividing charcoal concentrations by pollen concentrations in each level.

Accumulation rates are a measure of annual pollen accumulation per unit area, expressed as grains per cm^2 per year. The term 'pollen influx' is often used to express this measure, but has been avoided in this thesis, as it is somewhat misleading, in that it suggests that these values reflect the actual yearly influx of pollen at the site. In reality a number of processes, including deterioration, erosion and redeposition are likely to have altered the pollen assemblage considerably over the years. Accumulation rates for pollen, spores and charcoal were obtained by dividing the concentration values in each level by the sedimentation rate of the matrix (the uncalibrated time represented by a unit thickness of sediment, calculated on the basis of the time-depth curve). These figures are only estimates; sedimentation rates can vary considerably from year to year, and the precise time of deposition for the sediment in a sample can never be known (Bennett, 1994b).

The deterioration diagrams show the percentages of well preserved, crumpled, broken and corroded pollen grains in each sample. These graphs were calculated by dividing the number of grains in each category by the total pollen sum. Deterioration rates of individual taxa were calculated by dividing the number of grains of that taxon in each deterioration category by the total number of grains of the taxon recorded in the level.

Percentage, concentration, accumulation rate and deterioration data were calculated using TILIA 1.10 and the graphs were drawn using TILIA Graph 2.0 (Grimm, 1991). The stratigraphy is presented in the diagrams by symbols derived from the Troels-Smith (1955) system, as modified by Aaby and Berglund (1986).

The pollen diagrams were divided into Local Pollen Assemblage Zones with the aid of the stratigraphically constrained cluster analysis programme CONISS (Grimm, 1987, 1991), based on the percentage data of all pollen taxa reaching 2% in at least one level of the profile. Zonation divides the pollen diagram into a series of discrete units, based on changes in the pollen content alone. It effectively summarizes the data and can aid in the the description and interpretation of the diagram (Birks, 1986).

5.11 Multivariate data analysis

In order to study the relationship between different taxa, the pollen and spore data in this study were also subjected to multivariate data analysis. The chosen method was detrended correspondence analysis (DCA), as it avoids to some extent the problems exhibited by other commonly used ordination techniques, such as the 'arch effect' and compression of data towards the ends of the axes in, for example, principle components analysis (Hill and Gauch, 1980; Kent and Coker, 1992).

The computer programme DECORANA (Hill, 1979) was used to analyse the pollen data. At Loch a' Chabhain, Frobost, Loch Airigh na h-Achlais, and Loch Olabhat three separate data sets were analysed:

1) All levels in the profiles (Fig. 6.7, 7.7, 8.7 and 9.8).

2) All levels from the portions of the diagrams which showed an abundance of trees and shrubs (Fig. 6.8, 7.8, 8.8 and 9.9).

3) All levels from the portions of the diagrams after the decline in arboreal taxa (Fig. 6.9, 7.9, 8.9 and 9.10).

At Eilean Domhnuill, the entire profile formed one data set (Fig. 10.6), and no other divisions were made.

As the focus in this study was on terrestrial taxa, any demonstrably aquatic taxa were excluded from the analysis. In order to minimize any possible spurious correlations arising from taxa that were present in only very small quantities, the remaining taxa were only included if they exceeded 1% TLP in at least one level of the relevant portion of the diagram. The exception is Cerealia-type pollen, which because of its importance as an indicator of anthropogenic activity, was included in the data set whenever it appeared in that part of the profile, despite its low values.

Detrended correspondence analysis was also used to compare the data from Eilean Domhnuill to those from Loch Olabhat (Fig. 10.5). In this case sample scores rather than taxa scores were plotted, using those taxa common to both profiles which exceeded 2% TLP in at least one of the profiles (*Alnus*, *Corylus avellana*-type, *Calluna vulgaris*, Poaceae, *Cichorium intybus*-type, *Filipendula*, *Polypodium*, Pteropsida (monolete) indet. and Cerealia-type).

Chapter 6

LOCH A' CHABHAIN

6.1 Location

Loch a' Chabhain (NGR NF 753293) lies 4 km from the west coast of South Uist near the township of Bornish (Fig. 6.1). It occupies a small rock basin at the junction between the 'blackland' and 'upland' areas of the island. The loch is in a low-lying area, at approximately 10 m OD, but the land rises immediately to the south. The top of Ben Corary, located just 1 km to the south, reaches 97 m in height and Sheaval, 3 km south-west of the site, attains 223 m OD. The closest reach of Loch Eynort, a sea loch connected to the Minch, is 2 km to the east of the site.

The present-day vegetation surrounding the lake is dominated by *Calluna vulgaris*, *Eriophorum angustifolium* and *Myrica gale*. *Sphagnum* spp., *Dactylorhiza* sp., *Prunella vulgaris*, *Drosera rotundifolia*, *Polygala serpyllifolia*, *Pinguicula vulgaris*, *Lotus corniculatus* and *Potentilla palustris* are also present. *Equisetum* cf. *fluviatile*, *Phragmites australis* and *Nymphaea alba* can be found growing in the loch itself, with *Potamogeton* spp. growing in the shallower areas and along the stream course to the west.

Loch a' Chabhain has a surface area of about 1.2 ha. A stream flows out towards the west, connecting it with the larger loch of Upper Loch Bornish. There is no stream flowing into the loch, and considering the size of the loch, the pollen catchment area of the loch is likely to be small, with much of the pollen derived from local and extra-local vegetation within a few km of the site (see Chapter 5).

There are few archaeological sites in the immediate vicinity of the coring area. The closest prehistoric site is the Iron Age dun known as a Loch an Duin, located in Upper Loch Borinish, about 1 km west of Loch a' Chabhain (Fig. 6.1).

6.2 The profile

A core was extracted from the middle of the loch, where the water level was approximately 75 cm in depth. The core is 391 cm long (95-486 cm below water level), and approximately 20 cm of unconsolidated lake muds at the top remain

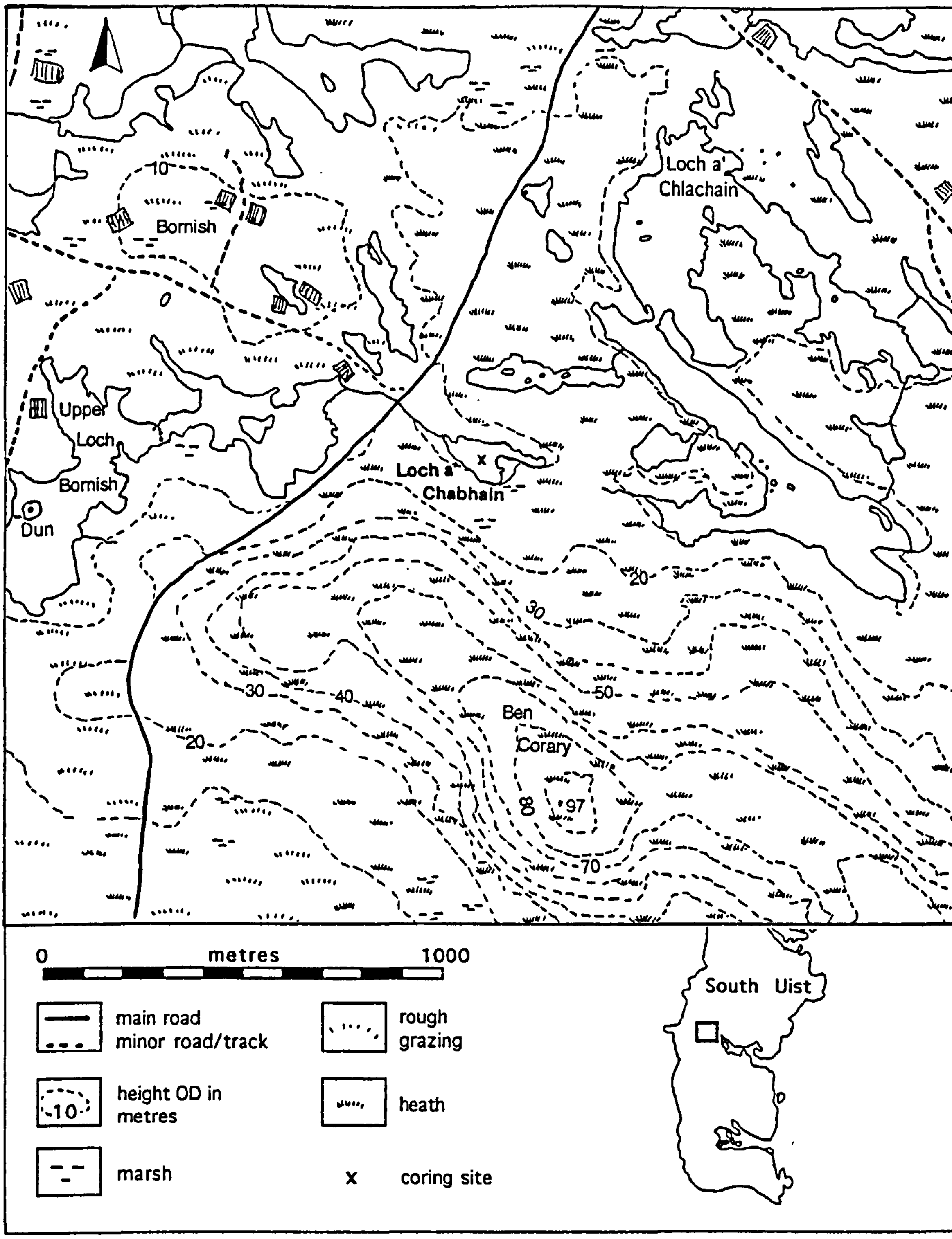


Fig. 6.1 Loch a' Chabhain and surrounding area

unsampled. The tip of the corer struck rocks at 486 cm, and no obviously Lateglacial deposits were recovered.

The core was described in the laboratory as follows:

95–107 cm	Orange-brown gyttja
107–486 cm	Dark brown gyttja

6.3 Radiocarbon dates

Five radiocarbon dates were obtained from the profile. These are listed below, and presented in a time-depth curve (Fig. 6.2).

Lab. no.	Depth (cm)	^{14}C dates (BP)	Calibrated dates (1 σ)
GU-4821	145-155	5360±70	6280-6000 cal BP; 4330-4050 cal BC
GU-4820	173-183	6240±60	7250-7030 cal BP; 5300-5080 cal BC
GU-4818	397-407	8700±80	9890-9550 cal BP; 7940-7600 cal BC
GU-4819	291-301	8250±70	9400-9090 cal BP; 7450-7140 cal BC
GU-4817	459-469	9520±100	11090-10504 cal BP; 9140-8650 cal BC

On the basis of these radiocarbon dates, if the uppermost level of the core is taken to be 0 BP, the top 50 cm of the profile would appear to represent deposition covering the last 5300 radiocarbon years. This would mean a deposition rate far lower than in any other part of the profile (Fig. 6.2). At the same time, the inferred vegetation of the uppermost levels does not reflect the virtually tree-less nature of the modern day landscape (see below). There is thus a strong possibility that, for some unknown reason, the top of the core is missing, a phenomenon observed elsewhere (Edwards and Whittington, in press), though presumably the unconsolidated surface muds that were not sampled contained a record of the present-day and recent vegetation. In order to come up with a more realistic date for the top of the core, the line between the two uppermost radiocarbon dates (GU-4820 and GU-4821) has been extended to achieve an extrapolated date of 3630 BP (Fig. 6.2; dotted line).

6.4 Pollen preservation

Pollen preservation was generally good throughout the profile. On average 16.2% of the pollen grains in each sample showed signs of deterioration. The most

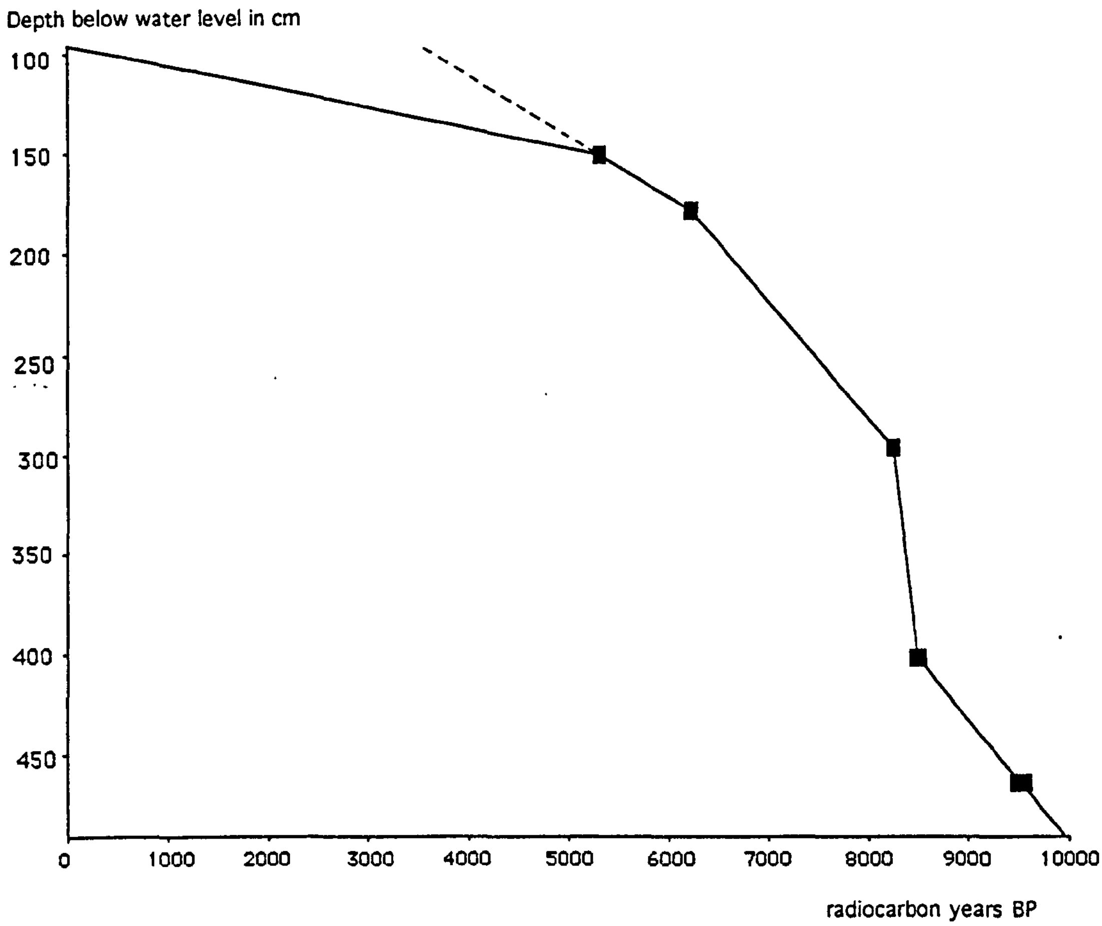


Fig. 6.2 Loch a' Chabhain: time-depth curve

common type of deterioration was corrosion, but broken grains (in particular *Pinus*) were also recorded, especially towards the top of the profile. *Betula* and *Corylus* tended to exhibit signs of corrosion, especially towards the top of the profile, where corroded *Corylus* grains reached a maximum of 57.7% at 108 cm and corroded *Betula* grains 40% at 136 cm. Corroded *Calluna* grains were more commonly recorded towards the bottom of the profile. Crumpled Poaceae grains were present throughout the sequence.

6.5 Local pollen assemblage zones

The percentage diagram (Fig. 6.3) was divided into 4 local pollen assemblage zones, with the aid of the constrained cluster analysis programme CONISS (Grimm, 1987). In addition, zone LAC-4 was divided into two subzones. These zones are described below:

LAC-1

482-466 cm 9780-9550 BP

Percentage diagram (Fig. 6.3)

The basal zone is characterised by high frequencies of Poaceae (up to 49% TLP) and *Betula* pollen (maximum 32%). *Salix*, *Juniperus communis*, and *Corylus avellana*-type pollen are also present in low frequencies, while *Pinus* values are relatively high at 5%. *Ulmus* and *Quercus* appear for the first time at 468 cm. *Empetrum nigrum*-type rises from 5% to 20% at the top of the zone, and *Calluna vulgaris* pollen is present in low quantities throughout the zone. Poaceae levels decrease to 29% by the top of the zone. Among the herb taxa, *Ranunculus acris*-type, *Cichorium intybus*-type and *Plantago maritima* are commonly recorded. *Huperzia selago* values attain their highest level (4%), and Pteropsida (monolete) indet. and *Polypodium* spores are also present. Frequencies for aquatic taxa, made up entirely of *Myriophyllum alterniflorum*, are low (maximum 6%), but higher than in any other zone.

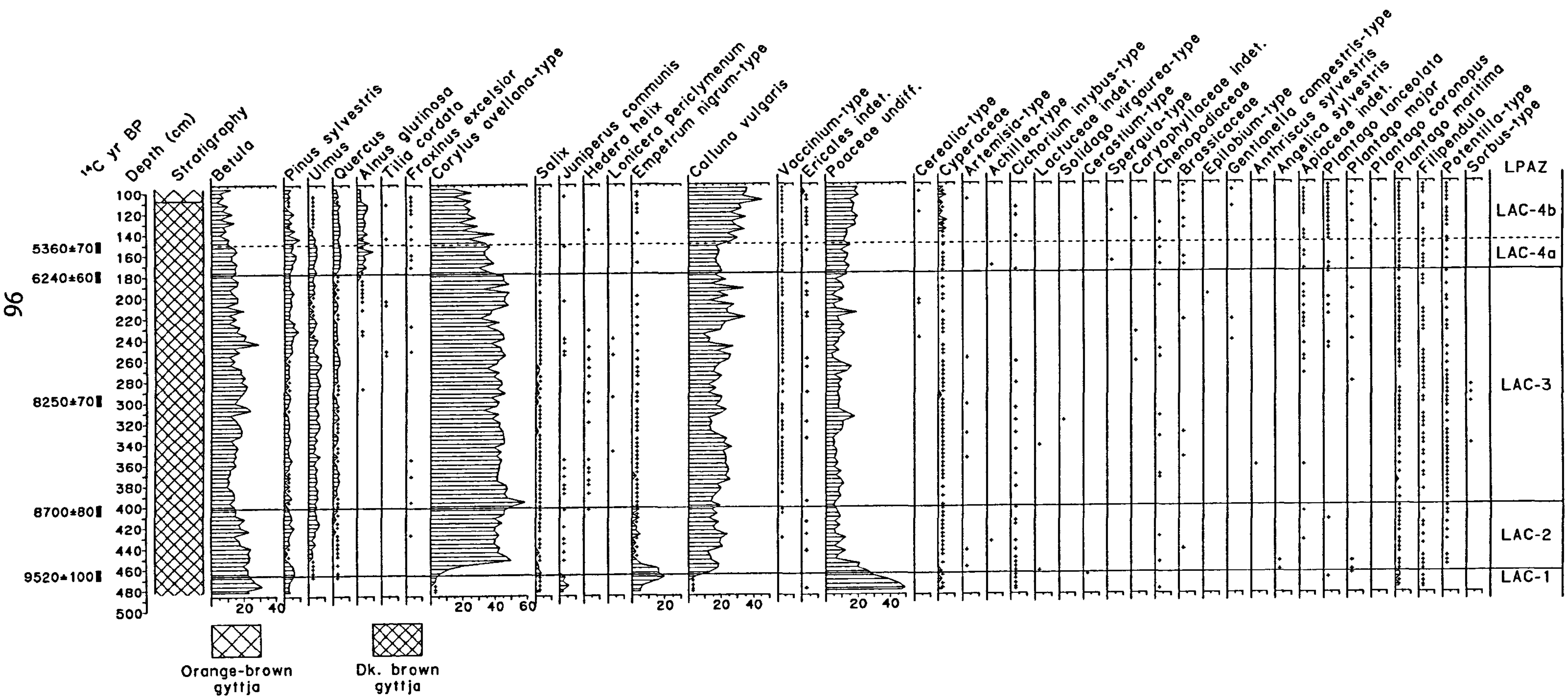


Fig. 6.3 Pollen and spore percentage diagram from Loch a' Chabhain (+ = <2%). Shaded curves are exaggerated x10.

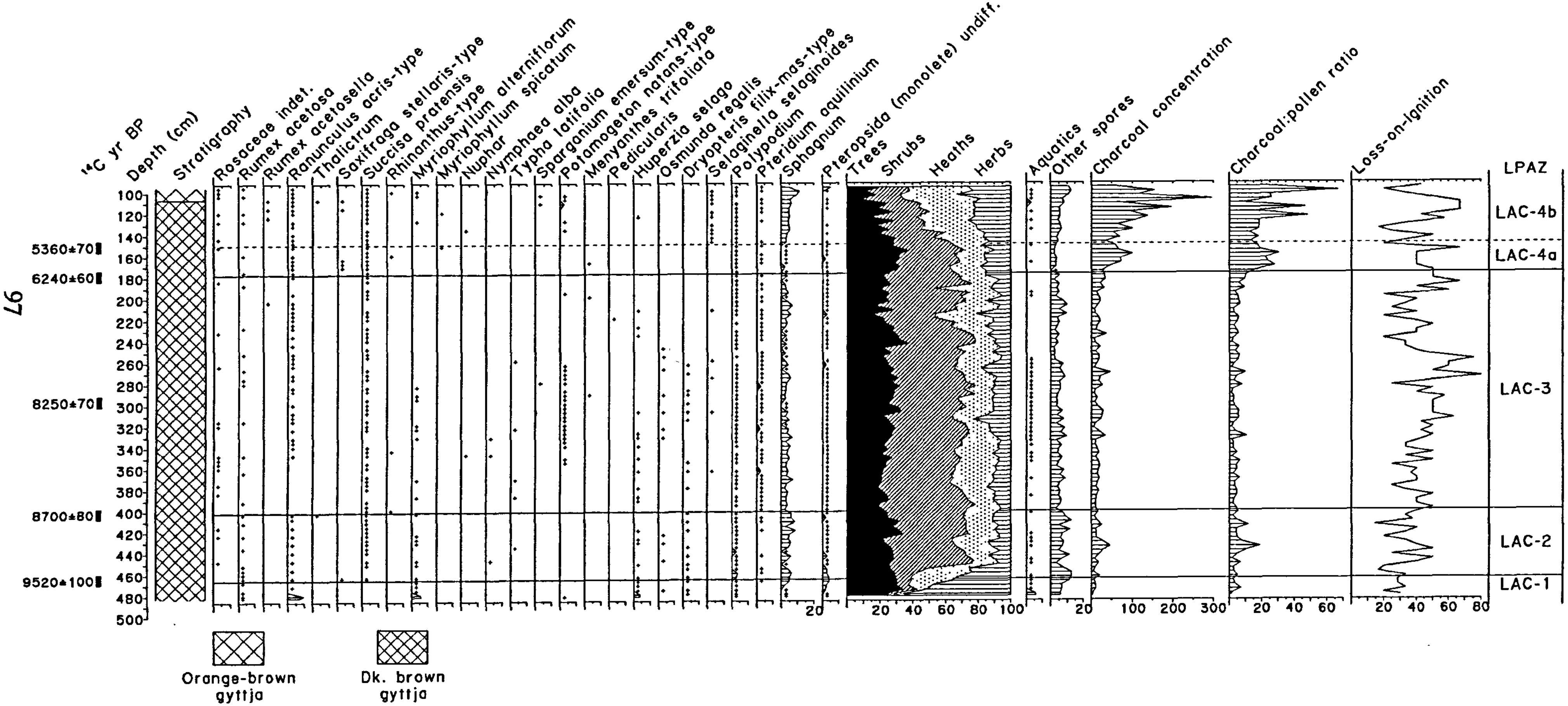


Fig. 6.3 (continued)

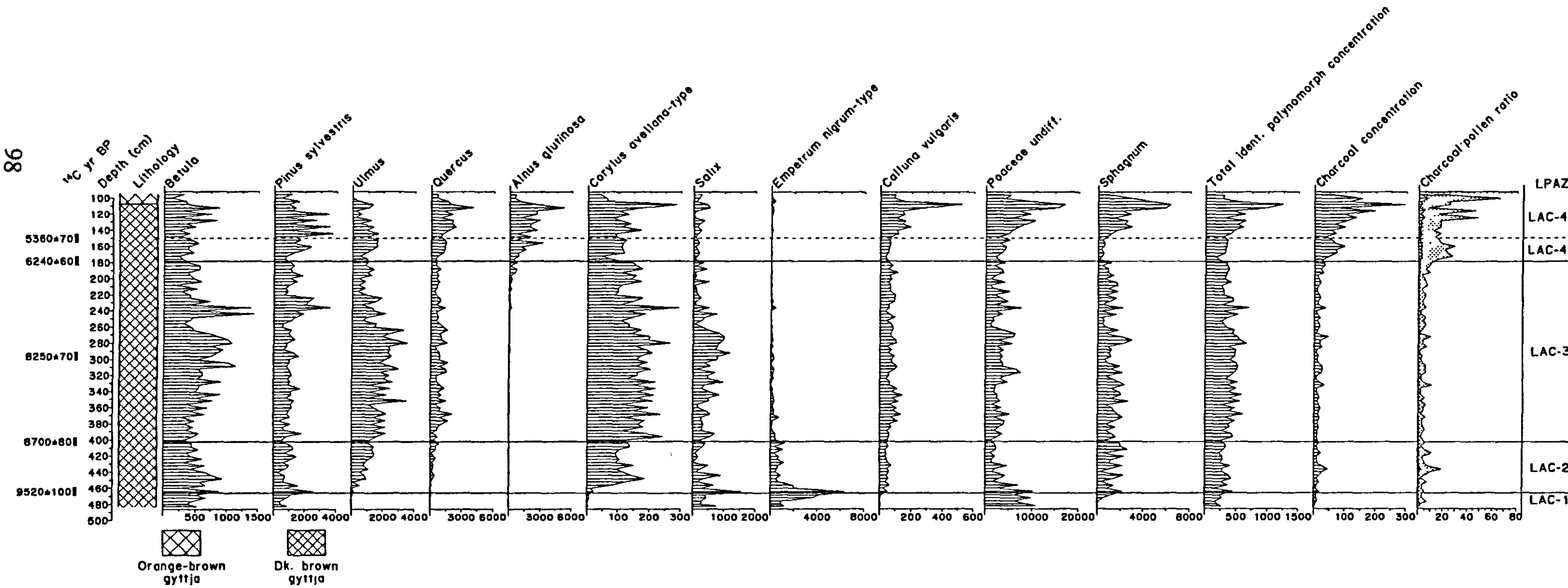


Fig. 6.4 Pollen and spore concentrations (grains cm^{-3}) and charcoal concentrations (cm^2 cm-3) at Loch a' Chabhain. Selected taxa. Shaded curves are exaggerated x10. Note the variable horizontal scale.

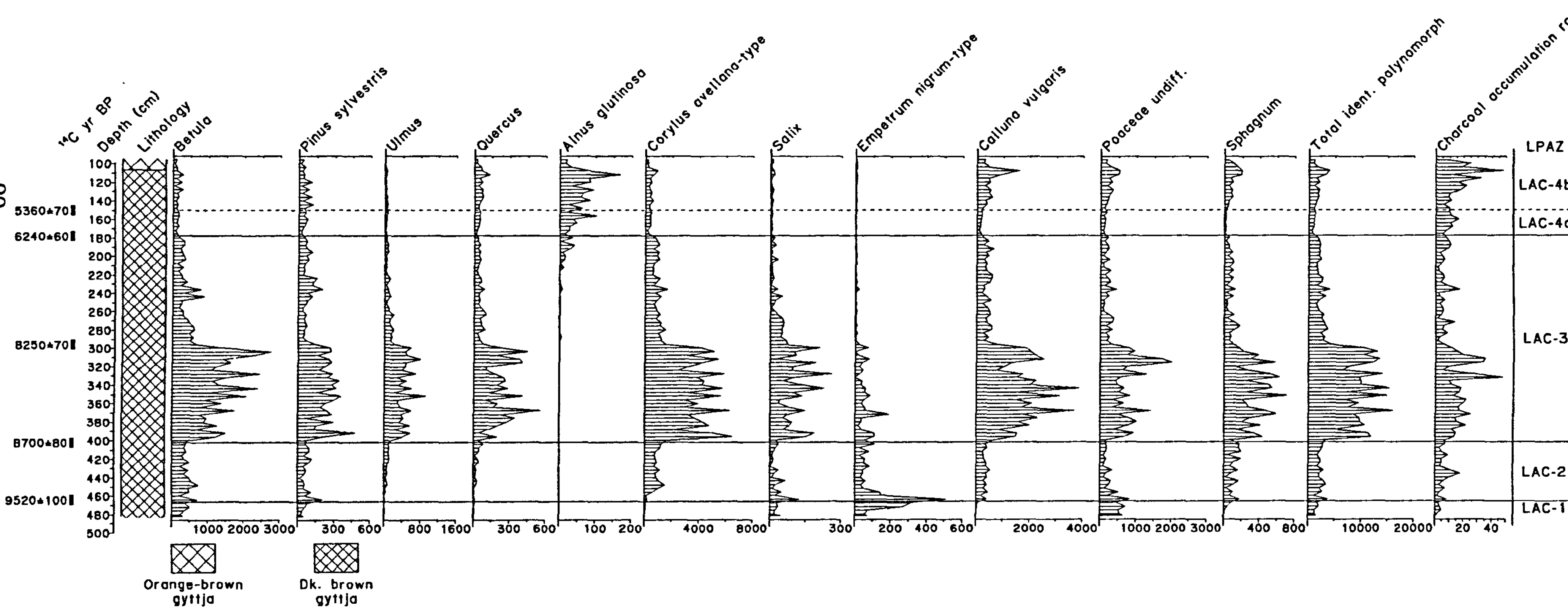


Fig. 6.5 Pollen and spore accumulation rates (grains cm^{-2} yr^{-1}) and charcoal accumulation rates (cm^2 cm^{-3} yr^{-1}) at Loch a' Chabhain. Selected taxa. Shaded curves are exaggerated x10. Note the variable horizontal scale.

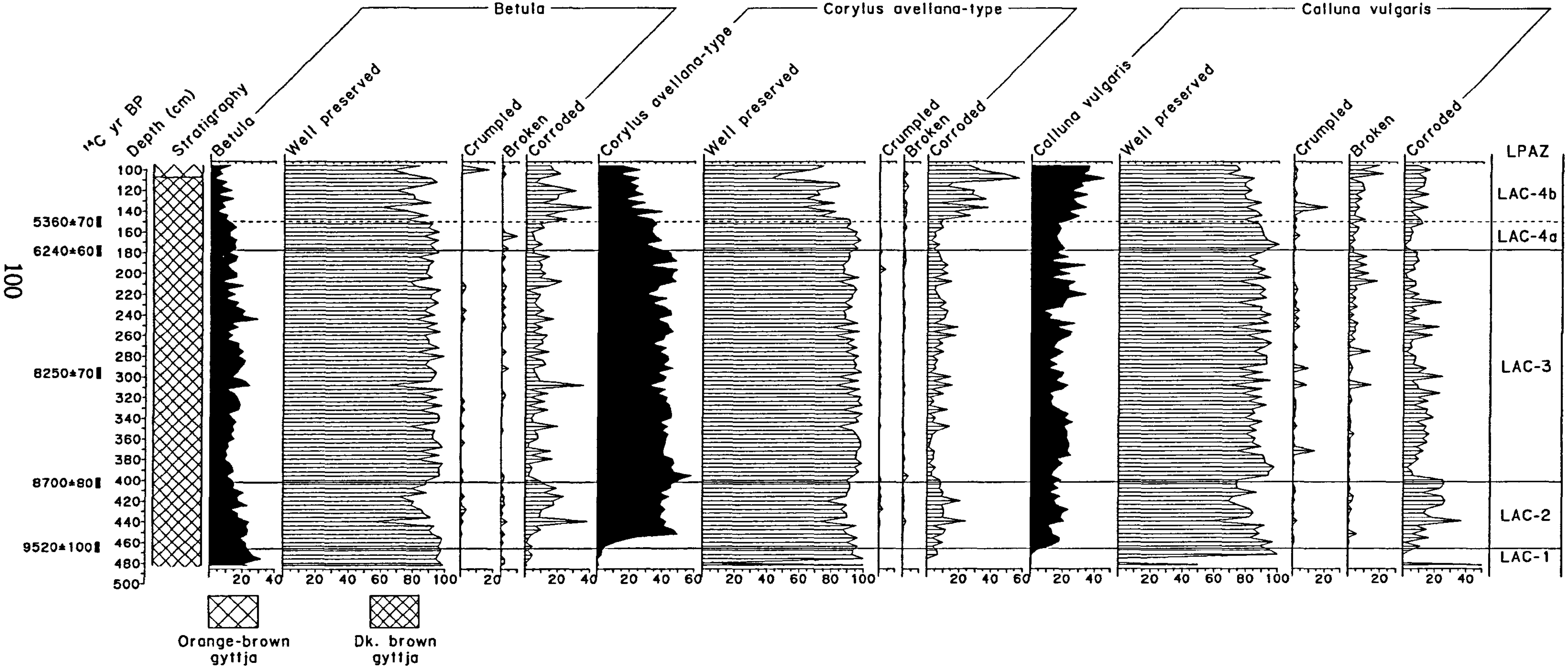


Fig. 6.6 Preservation diagram for major pollen types and TLP at Loch a' Chabhain. The black silhouettes are expressed as %TLP, the other graphs are a percentage of the individual taxa.

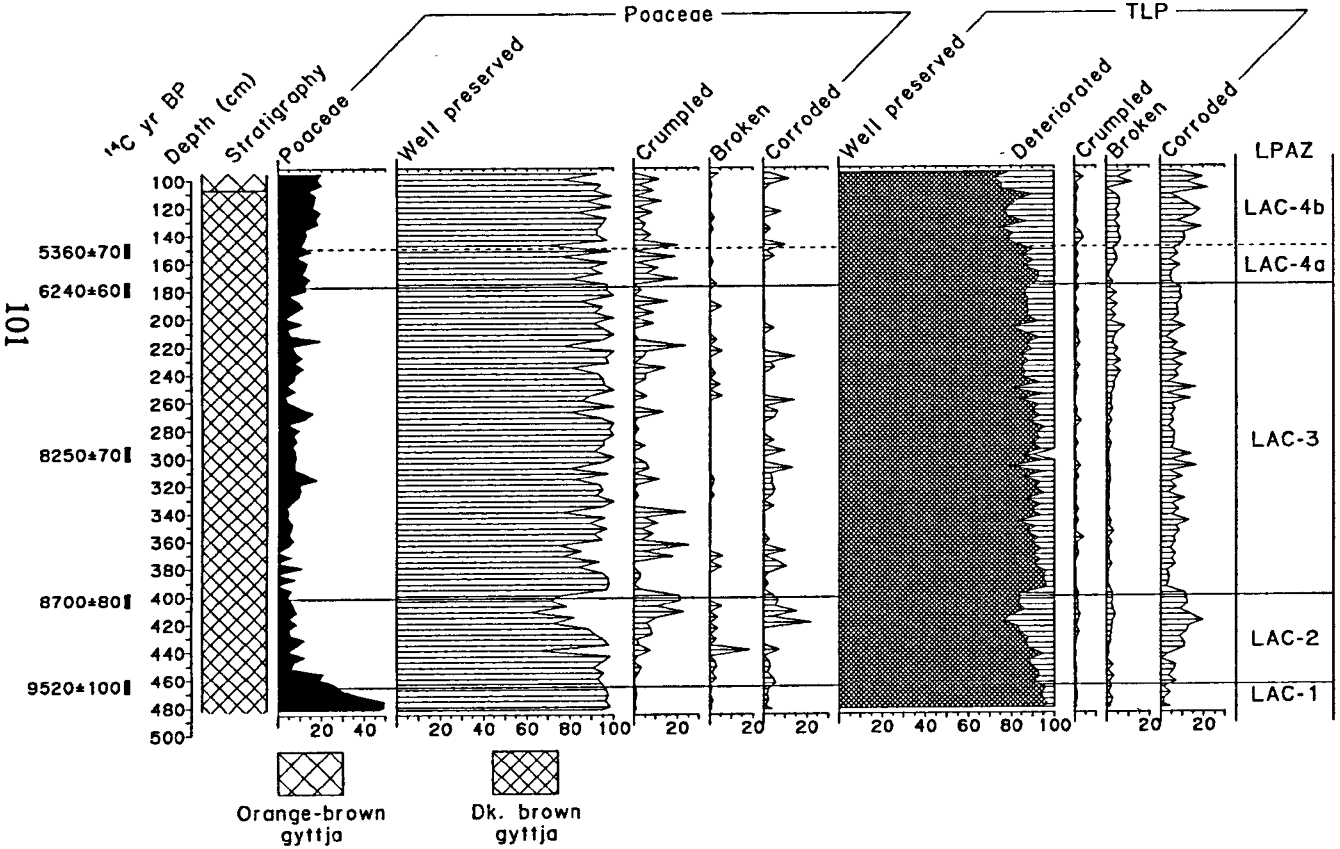


Fig. 6.6 (continued)

Concentration and accumulation rate diagrams (Fig. 6.4 and 6.5)

Pollen and spore concentrations are the lowest for the profile (mean 1.9 $\times 10^4$ grains cm^{-3}). Accumulation rates are similarly low, ranging from 1058 grains cm^{-2} $year^{-1}$ to 1840 grains cm^{-2} $year^{-1}$.

Charcoal (Fig. 6.4 and 6.5)

Charcoal concentrations are low, with a mean value of 6.2 x 10^{-4} cm^2 cm^{-3}, while accumulation rates range from 1.1 to 4.2 x 10^{-4} cm^2 cm^{-2} $year^{-1}$.

Loss-on-ignition (Fig. 6.3)

Loss-on-ignition values (20-33%) are the lowest for the entire profile.

Deterioration diagram (Fig. 6.6)

Pollen preservation was very good. The percentage of deteriorated grains ranges between 3% and 5.9%, most of which consist of corroded *Betula* and *Corylus avellana*-type grains, as well as a few broken *Pinus* grains.

LAC-2

466-402 cm 9550-8710 BP

Percentage diagram

Zone LAC-2 is characterised by a rise in the *Calluna vulgaris* curve to 24%, and high frequencies of arboreal pollen, which rise from 39% to a maximum of 76%. *Corylus* increases from 6% at the bottom of the zone to almost 50% TLP, while *Betula* declines slightly. *Empetrum nigrum*-type pollen values decline from 16.2% to 1%, and Poaceae values fall to 6%. *Plantago maritima*, *Potentilla*-type, *Ranunculus acris*-type and *Succisa pratensis* appear intermittently. *Sphagnum* frequencies are relatively high, reaching almost 9%, with Pteropsida (monolete) indet. and *Polypodium* also making contributions to the spore component. Aquatic taxa are negligible.

Concentration and accumulation rate diagrams

Pollen and spore concentration values are slightly higher than in the previous zone (mean 2.6 x10^4 grains cm^{-3}), as are accumulation rates which reach a peak of 2738 grains cm^{-2} $year^{-1}$ at 432 cm (mean 2180 grains cm^{-2} $year^{-1}$).

Charcoal

Charcoal concentrations increase to a mean value of 16.3 x 10^{-4} cm^2 cm^{-3}, while charcoal accumulation rates reach 17.9 x 10^{-4} cm^2 cm^{-2} $year^{-1}$ at 436 cm.

Loss-on-ignition

On average, loss-on-ignition values increase, fluctating between *c.* 14% and 50%.

Deterioration diagram

Pollen preservation in this zone is not as good as previously, and the mean of deteriorated pollen grains is 14.6%. At 440 cm 36% of all pollen grains are deteriorated, a category consisting primarily of corroded *Betula*, *Corylus* and *Calluna vulgaris* grains.

LAC-3
402-178 cm 8710-6240 BP

Percentage diagram

Arboreal pollen frequencies remain high, never falling below 53%, and peaking at 78% (396 cm). *Betula* values are slightly lower on average than in the previous zone, but *Corylus* remains high, with a peak of 58% toward the bottom of the zone. *Alnus* appears for the first time at 288 cm, but its curve does not become continuous until 204 cm. *Calluna* fluctuates between 9 and 34%, and Poaceae between 4% and 19%. *Plantago lanceolata* pollen appears for the first time at 252 cm, and Cerealia-type pollen at 240 cm. *Plantago maritima*, *Ranunculus acris*-type and *Succisa pratensis* are still present. The *Sphagnum* curve is similar to the previous zone, *Osmunda regalis*, *Dryopteris filix-mas*-type and *Selaginella selaginoides* are recorded occasionally, and *Pteridium aquilin um* becomes more common.

Concentration and accumulation rate diagrams

Total pollen and spore concentrations rise from 2.3 x10^4 grains cm^{-3} at the start of the zone to 6.5 x10^4 grains cm^{-3} at the top. Accumulation rates, too, are much higher than in previous zones, particularly between 408 and 300 cms, where a mean value of 10010 grains cm^{-2} $year^{-1}$ is recorded.

Charcoal

Charcoal concentration values are similar to those in the previous zone (mean 16.2 x 10^{-4} cm^2 cm^{-3}), while charcoal accumulation rates range from 1.5 to 47.5 x 10^{-4} cm^2 cm^{-2} $year^{-1}$.

Loss-on-ignition

Loss-on-ignition rates are very variable, fluctuating between 20 and 80%.

Deterioration

Deterioration frequencies are lower than in the previous zone. The highest percentage of deteriorated grains occurs at 308 cm (20.7%), primarily due to the presence of corroded *Corylus*, *Betula* and *Calluna vulgaris* grains.

LAC-4a

178-150 cm 6240-5360 BP

Percentage diagram

Overall, arboreal pollen frequencies remain high (63-71%), but the proportions among the tree and shrub taxa have changed. The subzone sees a reduction in *Corylus avellana*-type pollen to 30%, while *Betula* frequencies remain steady, and *Pinus*, *Quercus*, *Ulmus*, and *Alnus* all increase slightly. *Calluna* frequencies are similar to those in zone 3 (16-20%), and Poaceae values increase slightly to 15%. *Sphagnum* representation declines slightly. *Polypodium* and *Pteridium* spores are also present in low frequencies, while aquatics are virtually absent.

Concentration and accumulation diagrams

Total concentration rates are considerably lower than in zone LAC-3, ranging between 1.6 $\times 10^4$ grains cm^{-3} and 3.4 $\times 10^4$ grains cm^{-3} (mean value 2.5 $\times 10^4$ grains cm^{-3}). Accumulation rates are the lowest for the entire profile (mean 916 grains cm^{-2} $year^{-1}$).

Charcoal

Charcoal values increase at the beginning of the zone and remain high thereafter. Charcoal concentrations have a mean value of 67.5 x 10^{-4} cm^2 cm^{-3}, while charcoal accumulation rates range from 5.1 to 16.3 x 10^{-4} cm^2 cm^{-2} $year^{-1}$.

Loss-on-ignition

Loss-on-ignition values are variable, fluctuating between 20 and 66.7%.

Deterioration diagram

Frequencies of deteriorated grains range between 7.1 and 14.4%. Again, these consist primarily of corroded *Betula*, *Corylus* and *Calluna vulgaris* grains.

LAC-4b

150-96 cm 5360-3660 BP

Percentage diagram

Arboreal pollen representation starts to decline to a minimum of 32%, and all tree and shrub taxa decrease in frequency. *Corylus* percentages decline to 15% toward the top of the zone, and *Ulmus* disappears by 100 cm. *Calluna vulgaris* increases to a peak of 46%. Poaceae values increase slightly to 18%, while

Cyperaceae frequencies rise to 5% for the first time. *Plantago lanceolata*, *P. maritima*, *Potentilla*-type, *Ranunculus acris*-type and *Succisa pratensis* are present among the other herb taxa. The *Sphagnum* curve rises, reaching a maximum of 11% towards the top of the profile. *Selaginella selaginoides*, *Polypodium* and to a lesser extent *Huperzia selago* and *Pteridium* are also recorded. Aquatic taxa values are also slightly higher than in the previous subzone, up to 3%, of which *Potamogeton natans*-type is the most important contributor.

Concentration and accumulation rate diagrams

Pollen and spore concentrations in this subzone are at their highest. The mean value for pollen and spore concentrations is 6.9 x10^4 grains cm^{-3}. Accumulation rates are also higher than in the previous subzone (mean 2141 grains cm^{-2} $year^{-1}$).

Charcoal

Charcoal concentrations are high, from 35.1 x 10^{-4} cm^2 cm^{-3} at the bottom of the subzone to 295.3 x 10^{-4} cm^2 cm^{-3} at 108 cm, as are charcoal accumulation rates which range from 5.8 to 48.1 x 10^{-4} cm^2 cm^{-2} $year^{-1}$.

Loss-on-ignition

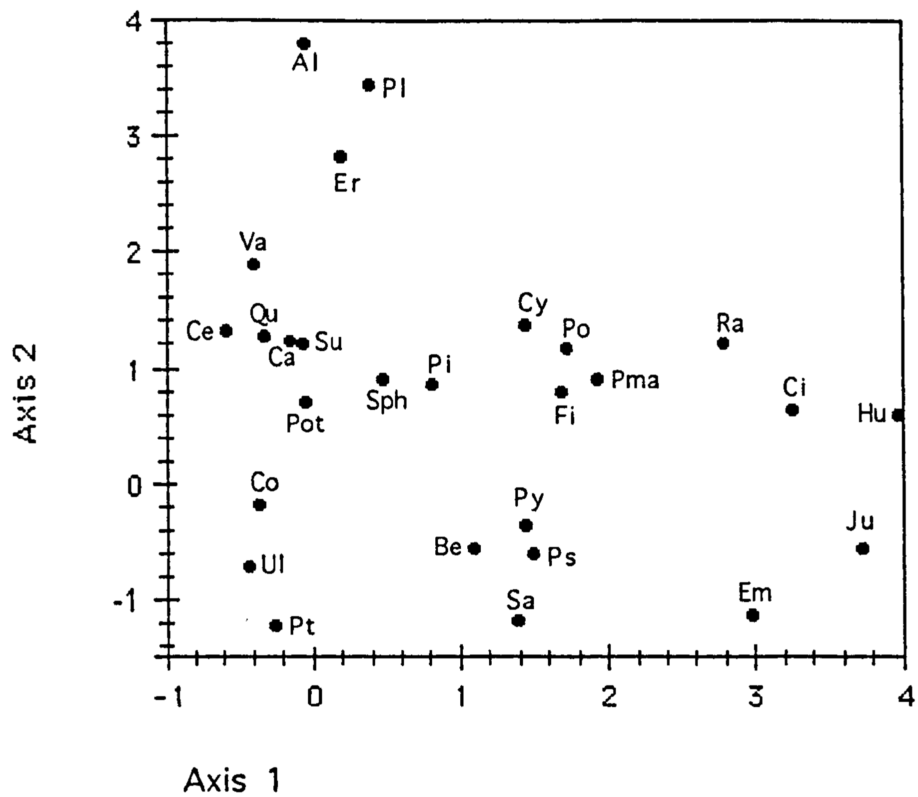
Loss-on-ignition values fluctuate between 17% and 67%.

Deterioration diagram

Deterioration values of 9-28% were found in this subzone, with corroded *Betula*, *Corylus* and *Calluna vulgaris* grains making up the largest part.

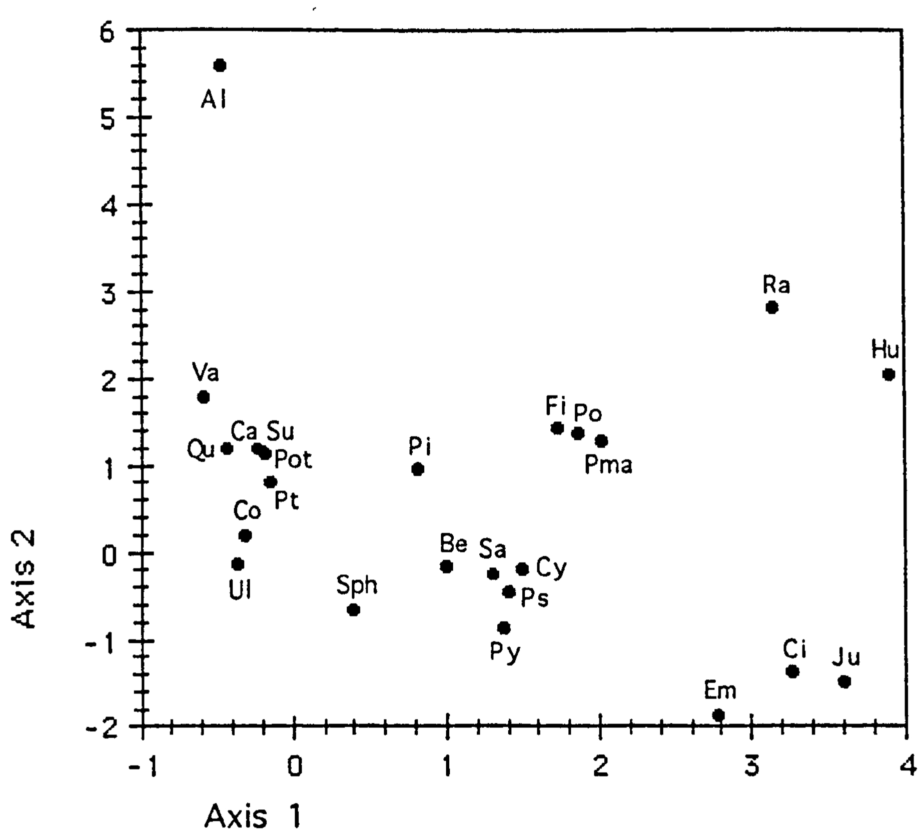
6.6 Detrended Correspondence Analysis (DCA)

The percentage data were subjected to DCA in order to examine the general trends in changing vegetation patterns in the profile. Figure 6.7 presents the data from the entire core. To the right are taxa associated with possible remnants of an open Lateglacial environment (e.g. *Cichorium intybus*-type, *Huperzia selago*, *Juniperus* and *Empetrum nigrum*-type). Towards the bottom middle of the plot is a



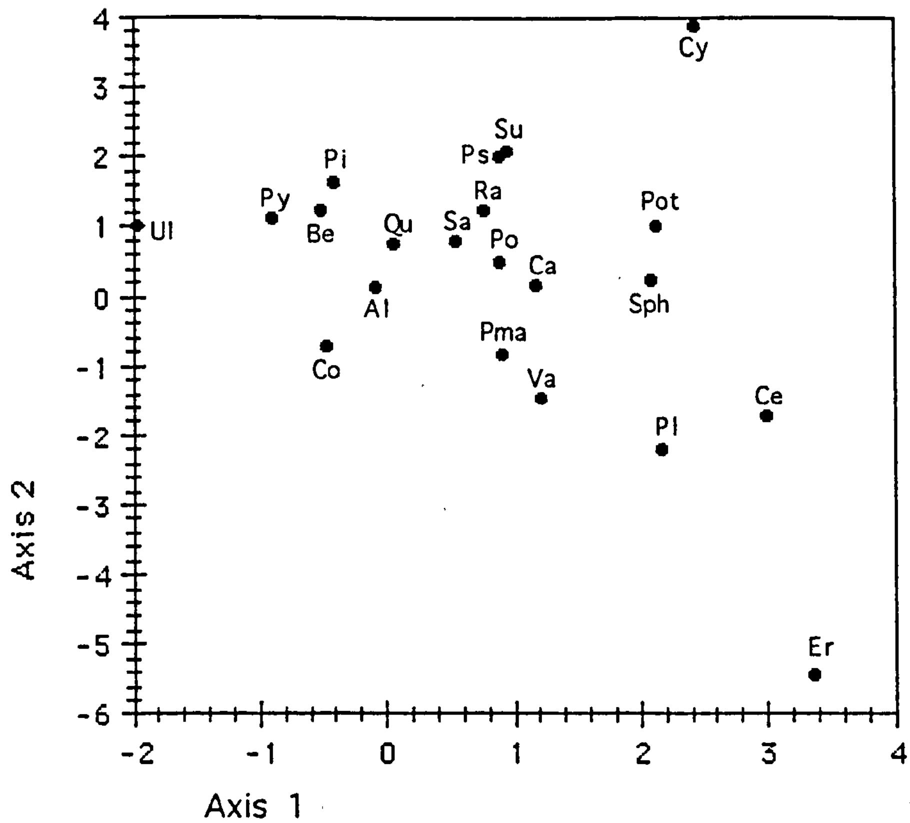
Key:
(Al) *Alnus*; (Be)*Betula*; (Ca) *Calluna vulgaris*; (Ce) Cerealia-type; (Ci) *Cichorium intybus*-type; (Co) *Corylus avellana*-type; (Cy) Cyperaceae; (Em) *Empetrum nigrum*-type; (Er) Ericales indet.; (Fi) *Filipendula*; (Hu) *Huperzia selago*; (Ju) *Juniperus communis*; (Pi) *Pinus sylvestris*; (Pl) *Plantago lanceolata*; (Pma) *Plantago maritima*; (Po) Poaceae; (Pot) *Potentilla*-type; (Pt) *Pteridium aquilinium*; (Ps) Pteropsida (monolete) indet.; (Py) *Polypodium*; (Qu) *Quercus*; (Ra) *Ranunculus acris*-type; (Ro) Rosaceae indet.; (Ru) *Rumex acetosa*; (Sa) *Salix*; (Se) *Selaginella selaginoides*; (Sph) *Sphagnum*; (Su) *Succisa pratensis*; (Ul) *Ulmus*; (Va) *Vaccinium*-type.

Fig. 6.7 Loch a' Chabhain: DCA, entire profile



Key:
(Al) *Alnus*; (Be)*Betula*; (Ca) *Calluna vulgaris*; (Ce) Cerealia-type; (Ci) *Cichorium intybus*-type; (Co) *Corylus avellana*-type; (Cy) Cyperaceae; (Em) *Empetrum nigrum*-type; (Er) Ericales indet.; (Fi) *Filipendula*; (Hu) *Huperzia selago*; (Ju) *Juniperus communis*; (Pi) *Pinus sylvestris*; (Pl) *Plantago lanceolata*; (Pma) *Plantago maritima*; (Po) Poaceae; (Pot) *Potentilla*-type; (Pt) *Pteridium aquilinium*; (Ps) Pteropsida (monolete) indet.; (Py) *Polypodium*; (Qu) *Quercus*; (Ra) *Ranunculus acris*-type; (Ro) Rosaceae indet.; (Ru) *Rumex acetosa*; (Sa) *Salix*; (Se) *Selaginella selaginoides*; (Sph) *Sphagnum*; (Su) *Succisa pratensis*; (Ul) *Ulmus*; (Va) *Vaccinium*-type.

Fig. 6.8 Loch a' Chabhain: DCA, bottom of profile (466-178 cm)



Key:
(Al) *Alnus*; (Be)*Betula*; (Ca) *Calluna vulgaris*; (Ce) Cerealia-type; (Ci) *Cichorium intybus*-type; (Co) *Corylus avellana*-type; (Cy) Cyperaceae; (Em) *Empetrum nigrum*-type; (Er) Ericales indet.; (Fi) *Filipendula*; (Hu) *Huperzia selago*; (Ju) *Juniperus communis*; (Pi) *Pinus sylvestris*; (Pl) *Plantago lanceolata*; (Pma) *Plantago maritima*; (Po) Poaceae; (Pot) *Potentilla*-type; (Pt) *Pteridium aquilinium*; (Ps) Pteropsida (monolete) indet.; (Py) *Polypodium*; (Qu) *Quercus*; (Ra) *Ranunculus acris*-type; (Ro) Rosaceae indet.; (Ru) *Rumex acetosa*; (Sa) *Salix*; (Se) *Selaginella selaginoides*; (Sph) *Sphagnum*; (Su) *Succisa pratensis*; (Ul) *Ulmus*; (Va) *Vaccinium*-type.

Fig. 6.9 Loch a' Chabhain: DCA, top of profile (178 cm - top) cluster of taxa typical of the very early Holocene, such as *Betula* and *Salix*, associated with *Polypodium* and Pteropsida. Above that is a cluster of wet grassland taxa (e.g. Cyperaceae, Poaceae, *Plantago maritima* and *Filipendula*) that were generally present throughout the profile, but were most prominent during the early Holocene. To the left of the diagram is a loose cluster of trees (*Pinus*, *Quercus* and *Corylus avellana*-type) and other taxa, such as *Vaccinium*-type, *Calluna vulgaris*, *Potentilla*-type, and *Sphagnum*, that were prominent throughout the middle section of the diagram, in particular zone LAC-3. At the very top are found *Alnus* and *Plantago lanceolata*, which only became prominent in zone LAC-4.

Figure 6.8 covers zones LAC-2 and LAC-3, the woodland phase of the diagram. The results are similar to those in Figure 6.6: possible Lateglacial remnants are to the right of the graph, the trees and shrubs and grassland taxa of the very early Holocene are in the middle, while the later tree taxa (*Corylus*, *Ulmus* and *Quercus*) pull out to the left, along with heathland taxa (*Calluna vulgaris* and *Vaccinium*-type).

Figure 6.9 is based on zone LAC-4, from the time when trees and shrubs were starting to decline. The clusters in this diagram are not as obvious as those in Figures 6.7 and 6.8. To the left are a loose group of woodland remnants, associated with *Polypodium*, as well as Poaceae and *Calluna vulgaris*, which were becoming more prominent as the trees and shrubs declined. Towards the middle top there are taxa of wet environments, including wet grassland (left) and peatland (*Sphagnum* and *Potentilla*-type on the right), which appear to have expanded particularly in subzone LAC-4b. On the far right, two potential anthropogenic indicators, *Plantago lanceolata* and Cerealia-type, appear closely together. Both only become prominent in subzone LAC-4b.

6.7 Inferred vegetation history

9780-9550 BP (*c.* 11190-10900 cal BP)

No obviously Lateglacial deposits were recovered from Loch a' Chabhain, and the basal levels of the profile are radiocarbon dated to the early Holocene period (9780 BP [11190 cal BP]). The vegetation of the earliest part of the profile is dominated by grassland, but high frequencies of *Betula* (up to 31% at 9680 BP [11150 cal BP]) were also recorded, suggesting the local presence of birch. Other typical Lateglacial/early Holocene pollen taxa such as *Salix*, *Rumex acetosa* and *Juniperus communis* were also present. The inferred vegetation for this period is one of a mosaic of open grassland, interspersed with patches of willow, birch and juniper scrub. *Empetrum* heathland became more important in the landscape around 9630 BP (11010 cal BP) as the grassland contracted. *Pinus* pollen was also recorded, but the frequencies are low (<5%), and it seems unlikely that pine was growing locally. *Ulmus* and *Quercus* pollen is recorded as early as 9570 BP (10900 cal BP) but in very low frequencies, and is likely to derive from long-distance sources.

Sphagnum spores are recorded from the base of the profile, albeit in low frequencies, and it appears that mire communities were already present in the area from before 9700 BP (11160 cal BP). Aquatics are low throughout the profile, but during this period *Myriophyllum alterniflorum* had a minor presence in the loch.

9550-6240 BP

As temperatures increased, *Calluna vulgaris* replaced *Empetrum nigrum* as the dominant heathland taxon around 9570 BP (10900 cal BP), a change which is reflected in both the percentage and absolute data. Frequencies of corroded pollen are relatively high (9-19%) between 9200 and 8700 BP (10330-9640 cal BP), with corroded *Calluna vulgaris* grains particularly prominent. This may be an indication that some of the pollen is derived from older deposits, although there are no clear indications of erosion (either of minerogenic or organic material) in the sedimentary record or the loss-on-ignition curve.

Arboreal pollen frequencies in general are high during this period (53-71%), and *Betula* scrub or woodland was prominent. The *Corylus avellana*-type curve starts to rise rapidly from 9470 BP (10690 cal BP) and hazel may have arrived in the area around this time. The date of the spread of *Corylus* at Loch a' Chabhain corresponds quite closely to the timing of the *Corylus* rise at Loch Lang (*c*. 9400 BP; Bennett *et al.*, 1990), but the rise of hazel in South Uist is by no means a synchronous event. At Loch a'Phuinnd *Corylus* does not invade the local birch woodland until *c*. 8500 BP (9510 cal BP) (Fossitt, 1996), and at Reineval it apparently does not appear until 7990 BP (8890 cal BP). On the other hand, at the east coast site of Loch Airigh na h-Aon Oidhche, the rational limit of *Corylus* has been dated far earlier at 9900 BP (11240 cal BP) (Brayshay and Edwards, 1996). Although the general spread of *Corylus* was due primarily to rising temperatures, local hydrological and pedological conditions probably affected local expansion.

By 9360 BP (10620 cal BP) *Corylus avellana*-type frequencies have reached a peak of almost 50% and hazel was the dominant woodland taxon. The rational limit for *Ulmus* is reached surprisingly early at 9310 BP (10500 cal BP). In general, dates for the rational limit of elm in the Outer Hebrides centre around 8000 BP (8890 cal BP), although elm may have occurred as early as 8980 BP (10180 cal BP) at Loch Airigh na h-Aon Oidhche (Brayshay and Edwards, 1996). *Ulmus* pollen frequencies are at their highest at Loch a' Chabhain from 8940 to 7570 BP (10050–8380 cal BP), with a maximum of 8% at 7700 BP (8440 cal BP), and it is possible that elm was growing in the area during that period, perhaps in small stands or as scattered individuals. Elm may also have grown locally at other sites in South Uist, including Loch Lang, Loch a'Phuinnd and Lochan na Cartach (Bennett *et al.*, 1990; Fossitt, 1996; Brayshay and Edwards, 1996). *Quercus* pollen does not appear until 8640 BP (9570 cal BP) and frequencies remain below 5%. The presence of *Quercus* pollen could be attributed to long-distance input, perhaps from the east coast of South Uist, where it has been argued that oak occurred locally at Loch Lang and Loch a'Phuinnd (Bennett *et al.*, 1990; Fossitt, 1996) and/or from mainland Scotland and the islands of the Inner Hebrides.

Alnus pollen appears for the first time at 8110 BP (9020 cal BP), but the *Alnus* curve does not become continuous until 6680 BP (7540 cal BP) when alder may have invaded damper areas. Occasional grains of *Hedera helix* and *Lonicera periclymenum* were also recorded, and it is likely that these were growing in association with the trees and shrubs. *Salix* frequencies are very low, but as *Salix* is generally considered to be under-represented in the pollen record (Bradshaw, 1981), some willow scrub may still have been present in the area before *c*. 9000 BP (10200 cal BP).

Fraxinus excelsior pollen grains were also recorded sporadically during this phase, and as this taxon is usually regarded as being seriously under-represented in the pollen record (Andersen, 1970,1973; Bradshaw, 1981) the possibility cannot be excluded that a few ash trees were growing in the local woodland. However, if ash was growing at Loch a' Chabhain, its presence (from *c.* 9040 BP [10210 cal BP]) is very early indeed, and its identification here could be erroneous. *Fraxinus* apparently did not become established in south-west Scotland until *c.* 4000 BP (4460 cal BP) and may have reached Colonsay around 3600 BP (3910 cal BP) (Birks *et al.*, 1987). As far as the Outer Hebrides are concerned, Bennett *et al.* (1990) suggest that *Fraxinus* may have occurred at Loch Lang, but only after 4400 BP (4950 cal BP) The earliest potential evidence for a local presence of ash comes from Loch Reallasger in North Uist, where the taxon may have been present after 6880 BP (7690 cal BP) (Fossitt, 1990).

Pinus frequencies increase to 4.6% at 7500 BP (8280 cal BP), after which they remain relatively high (>4%) until *c.* 4920 BP (5630 cal BP). It is possible that pine trees were growing in the area during this period, perhaps as scattered individuals. The question of the presence of pine on South Uist is a debated issue. No pine macrofossils have yet to be recorded on the island, and researchers have generally shied away from stating that pine was present, although pine pollen frequencies are similar to those at some sites on Lewis, where pine macrofossils are abundant (Wilkins, 1984; Fossitt, 1996). In a sample taken from just below a pine stump on Lewis, the frequency of *Pinus* pollen was only 5% TLP (Wilkins, 1984), and *Pinus* pollen frequencies were also less than 5% at Little Loch Roag (Birks and Madsen, 1979). The low values at Loch a' Chabhain therefore do not necessarily exclude local presence (see Chapter 11 for a longer discussion).

The occasional presence of grains of *Tilia cordata* in the profile is likely to reflect long-distance pollen transport. *Tilia* appears to have reached its northernmost geographical limit in the central Lake District and northeast England by 5500 BP (6290 cal BP) (Birks, 1989), a limit which corresponds closely to that of present day and apparently native populations of *Tilia cordata* (Piggott and Huntley, 1978).

It appears that elements of mixed woodland were quite extensive in the area around Loch a' Chabhain during this period (9550-6240 BP [10900-7160 cal BP]). These woods would have consisted primarily of *Betula* and *Corylus*, but *Ulmus*, *Pinus*, and later *Alnus*, may also have been present. The woodlands were not continuous, and are likely to have included grasses, tall-herb communities (such as *Filipendula*, *Anthriscus sylvestris* and Apiaceae indet.), and ferns. Patches of heathland were also present in the landscape. Cerealia-type pollen appears for the first time at 7300 BP (8100 cal BP), but this is likely to derive from large grass pollen such as *Glyceria* spp. rather than cultivated cereals (Andersen, 1979; Dickson, 1988; Edwards and Whittington, 1997).

Sphagnum frequencies remain low throughout this period and its curve is relatively smooth. Peat bog communities are likely to have been present, but perhaps at some distance from the site, and there does not appear to have been any expansion of mire into the immediate area. In the lake itself *Myriophyllum alterniflorum* was now less prominent. Aquatic taxa are recorded only sporadically, and include *Potamogeton* and *Nymphaea alba*.

Sedimentation rates between 8700 and 8250 BP (9640 and 9270 cal BP) were much higher than in other parts of the profile. One explanation may be that the younger of these two radiocarbon dates is inaccurate. Between 8330 BP and 7500 BP (9350-8280 cal BP) loss-on-ignition values are particularly high (up to 80%), which suggests a significant input of organic material (presumably peat) into the lake. The presence of older charcoal in this material may have affected the radiocarbon date of 8250±70 BP, making it rather too old. On the other hand, increased erosion is not suggested by the deterioration data - frequencies of deteriorated grains are not particularly high, and thus there is no indication of increased input of reworked pollen.

6240-5360 BP

Woodland and scrub communities remained dominant, but there may have been a change in the relative importance of the taxa. Around 6180 BP (7090 cal BP) *Corylus* frequencies started to suffer a decline, falling from 45% to 30% by 6050 BP (6850 cal BP), a change which is also seen in the concentration and accumulation rate diagrams. However, the decline is not reflected in the total arboreal pollen frequencies, which remain high (63-71%). *Betula* remains an important component while *Quercus* and *Alnus* values increase slightly, both in percentage and absolute terms.

Quercus pollen is consistently recorded at frequencies over 4% between 6240 and 5360 BP (7160 and 6150 cal BP). Whether this reflects the local presence of oak or an increase in oak trees elsewhere on the island is unclear. Like pine, the presence of oak on the island remains disputed. Bennett *et al.* (1990) argue for the local presence of oak at Loch Lang, where *Quercus* pollen frequencies reach 15%, and the taxon may also have been present at Loch a'Phuinnd (Fossitt, 1996). The *Alnus* curve at Loch a' Chabhain, although more erratic, also rises, reaching a maximum of 9.3% at 5550 BP (6350 cal BP), and alder, too, may have been present. As in the previous phase, the woodland remained open and interspersed with patches of *Calluna vulgaris* heath and grassland.

Charcoal values increase significantly around 6240 BP (7160 cal BP), suggesting an increase in the incidence of fire, whether natural or of anthropogenic origin. The woodland around the site does not appear to have been affected, and it is therefore unlikely that the charcoal represents local fires set by Mesolithic people to clear the woodland or to increase browse. There is also no increase in *Calluna vulgaris* at this time, and burning of heathland to increase productivity for grazing animals appears unlikely. But it is perhaps possible that the rise in the charcoal curves could be attributed to an increase in fires on other parts of the island of South Uist. Another explanation for the increase in charcoal could be climatic: Tipping (1996) suggests that in phases when the climate was drier, natural fires were more frequent, leading to higher charcoal values in the pollen record. At Loch a' Chabhain, however, the main increase in charcoal values occurs around 6240 BP, well outside Tipping's drier phases, which he argues occurred between 8000-7000 BP and after 6000 BP (Tipping, 1996) (see also section 11.1.4 for a longer discussion).

5360-3660 BP (*c.* 6150-3990 cal BP)

Trees and shrubs declined in importance during this period, and *Calluna vulgaris* heathland started to expand, a change which is reflected in both the percentage and absolute data. The reduction in arboreal pollen is gradual and does not affect all taxa simultaneously: *Corylus*, *Pinus* and *Betula* declined from 5300 BP (6080 cal BP) onwards, and *Ulmus* from 5050 BP (5820 cal BP) while *Quercus* and *Alnus* frequencies were not reduced until 4040 BP (4490 cal BP). The decline in *Ulmus* (from 4.1 to 2.1%) takes place around the same time as a general decline in elm trees on the British mainland (Godwin, 1975; Huntley and Birks, 1983; Birks, 1989), and could simply reflect the decrease in long-distance pollen input. Alternatively, whatever was affecting elm in other parts of Europe, be it disease or human activity, was also affecting the elm trees in the Outer Hebrides at this time. The traditional elm decline is not detectable at many other sites in the Outer Hebrides, as *Ulmus* representations have never been very high in the islands.

The reason for the decline in trees is not obvious. Fire could be one element - charcoal values are high during this period - but the main increase in charcoal occurred at 6240 BP (7160 cal BP) and this does not correlate with a significant decline in arboreal pollen. There is also little evidence for arable agriculture in the area at this time. Two Cerealia-type pollen grains were recorded from this period, at 4420 and 3790 BP (5000 and 4190 cal BP), which may reflect arable agriculture in the area, but they could also derive from natural grasses (Andersen, 1979; Dickson, 1988; Edwards, 1989; Edwards and Whittington, 1997). Other anthropogenic indicator species are scarce, and extensive arable activity thus appears unlikely. The gradual nature of the woodland decline would suggest that, if any anthropogenic activity was involved at all, the reduction in trees and shrubs was more likely due to grazing pressures rather than deliberate clearance. The other possibility is that there was a gradual expansion of peat bog between 5360 and 3660 BP (6150-3990 cal BP) which led to a decline in woodland. This change could have been due to natural soil deterioration, perhaps exacerbated by a deterioration in climate which may have occurred between 4300 and 4000 BP (4850-4460 cal BP) (Birks and Williams, 1983). A rise in the *Sphagnum* percentage and concentration curves and the slight increase in Cyperaceae could suggest that the area was indeed becoming wetter at this time.

There may be evidence for peat erosion into the loch between 5360 and 3360 BP (6150 and 3600 cal BP). Loss-on-ignition values are relatively high, as are frequencies of deteriorated pollen (9-28%; primairly corroded *Betula*, *Corylus* and *Calluna*), which could be an indication of the presence of reworked pollen in the profile. The erosion of peat is not necessarily associated with human activity, and may simply reflect rising loch levels, perhaps due to climatic deterioration.

By the top of the profile tree and shrub pollen frequencies have declined to 32%. This figure is considerably higher than the pollen values recorded by Fossitt (1994a) in surface samples in the islands today (mean 13.8%). It is also higher than arboreal pollen frequencies in the upper levels of the profiles from the other sites in this study (13% at the top of Loch Airigh na h-Achlais, 9.9% at Loch Olabhat, and less than 10% at Frobost, except at the very top, where *Pinus* frequencies reach 13.1%). The uppermost level at Loch a' Chabhain does not accurately reflect the modern-day vegetation in the area, which is dominated by *Calluna* and Poaceae, and as indicated above, the top part of the profile is assumed to be missing.

6.8 Summary

The pollen record at Loch a' Chabhain starts during the early Holocene. Between 9780 and 9360 BP (11190 and 10620 cal BP) the landscape around Loch a' Chabhain was fairly open, dominated by a patchwork of *Betula* scrub and grassland, and, briefly, *Empetrum* heath. *Corylus avellana* invaded the local landscape *c.* 9470 BP (10690 cal BP) and quickly rose to dominance. Woodland cover was quite extensive between 9360 and 5300 BP (10620-6020 cal BP) and consisted primarily of *Corylus* and *Betula*, although *Ulmus*, *Pinus sylvestris*, and, after 6680 BP (7540 cal BP), *Alnus* may also have been present, either in small stands or as scattered individuals. The status of *Quercus* is more dubious, but local presence cannot be ruled out. The woodlands were never continuous, and were probably interspersed with patches of *Calluna vulgaris* heath and Poaceae. The charcoal curves increase around 6240 BP (7160 cal BP) but fire does not appear to have affected the local vegetation at this time, and the rise in charcoal may therefore be a reflection of an increase in fires elsewhere on the island. Around 5300 BP (6080 cal BP) the woodland started to decline, and *Calluna vulgaris* and Poaceae expanded to take its place. This change was gradual and may have been due to local grazing pressures, or perhaps the gradual encroachment of blanket mires in the area. There is a marked deficiency of cultural pollen indicators, and active clearance of woodland by people is unlikely. By the top of the profile the woodlands were significantly reduced in extent, but had not entirely disappeared. It seems that the top of the profile is missing, and the uppermost level has been dated by extrapolation to 3660 BP (3990 cal BP).

Chapter 7

FROBOST

7.1 Location

The coring site of Frobost (NGR NF 753254) lies at an altitude of less than 10 m OD, in a valley mire at the edge of the uplands in the centre of South Uist. A small stream runs through the bog, and flows northward into Loch Cnoc a' Buidhe (Fig. 7.1).

The present-day surface vegetation of the mire is dominated by *Calluna vulgaris*, Cyperaceae spp. including *Eriophorum vaginatum*, and Poaceae spp. *Potentilla* spp., *Prunella vulgaris*, *Drosera intermedia*, *D. rotundifolia*, *Pinguicula vulgaris*, *Ranunculus acris*, *Polygala serpyllifolia* and *Sphagnum* spp. were also present, while *Potamogeton* sp.was recorded in the wettest areas.

As the core was taken from a valley mire, the component of local pollen derived from vegetation growing on the mire itself may be quite significant in the pollen record (see section 5.1). However, the pollen catchment area of the site is also likely to be affected by the presence of the stream which may deposit pollen from vegetation on the nearby slopes, and potentially older pollen eroded out of sediments. The catchment area of the stream flowing through the mire is estimated to be around 2 km^2.

The coring site lies 400 m northwest and 700 m southeast respectively of the Neolithic chambered cairns of Barp Frobost and Reineval. The remains of a hut circle and loch dun complex can also be found 600 m to the northwest of the site, in and around Loch Cnoc a' Buidhe.

7.2 The Profile

A 283 cm long core was extracted from an area towards the center of the mire. The core was described in the field as follows:

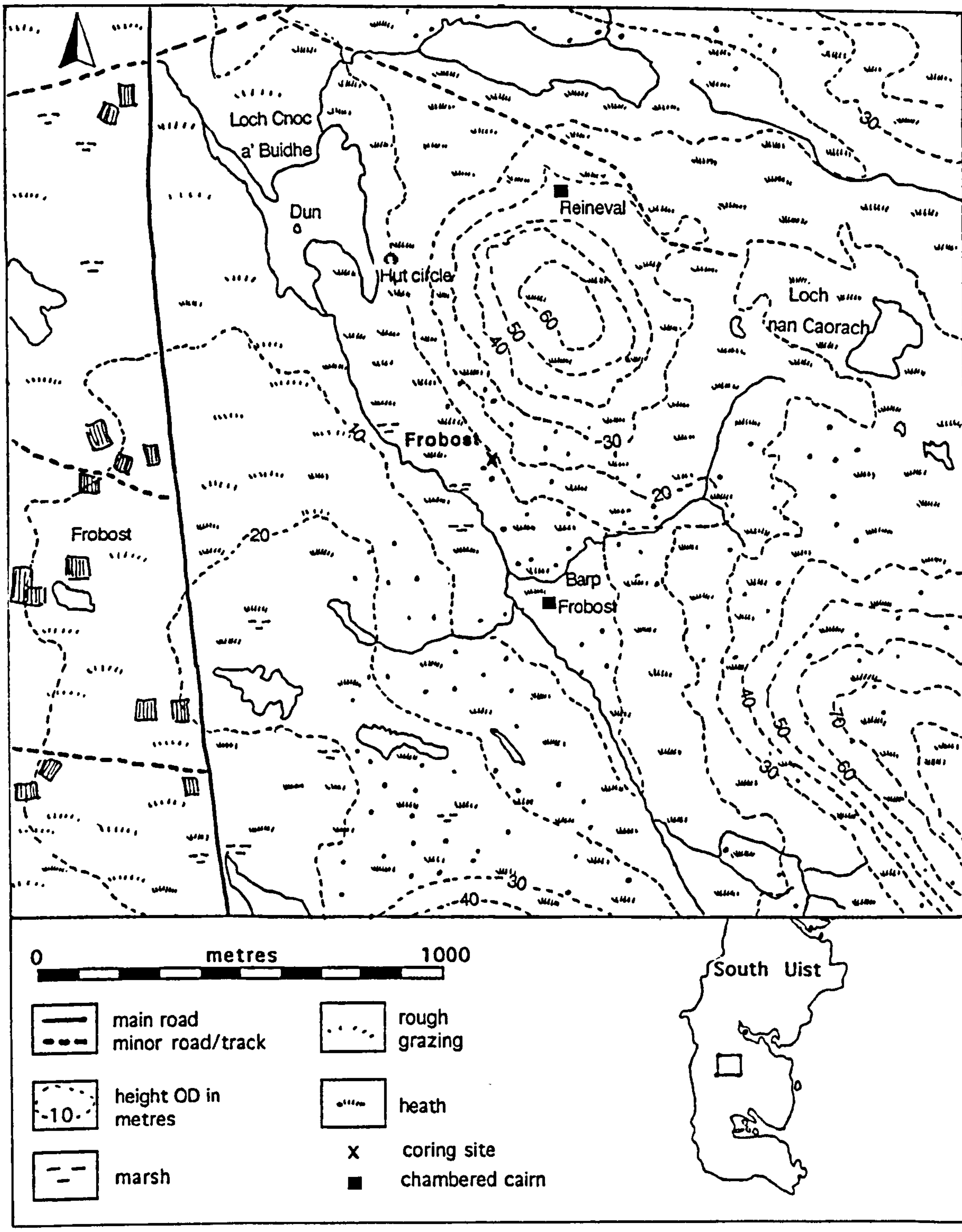


Fig. 7.1 Frobost and surrounding area

0-23 cm	Wet, unconsolidated peat with fragments of Cyperaceae and rootlets.
23-135 cm	Brown peat
135-257 cm	Dark brown peat
257-273 cm	Dark brown peat with sandy inclusions
273-276 cm	Coarse grey sand
276-283 cm	Grey clay

7.3 Radiocarbon Dates

Three samples were taken for radiocarbon dating, and the results are listed below, and displayed on the time-depth profile (Fig. 7.2).

Lab. no.	Depth (cm)	^{14}C dates (BP)	Calibrated dates (1 σ)
GU-4824	59.5-64.5	1740±50 BP	1710-1570 cal BP; 240-380 cal AD
GU-4823	178.0-186.0	6070±50 BP	6990-6800 cal BP; 5040-4860 cal BC
GU-4822	264.5-272.5	9130±90 BP	10400-10210 cal BP; 8450-8260 cal BC

The top of the core is assumed to date to AD 1995 and the base of the core has an extrapolated date of 9640 BP.

7.4 Pollen Preservation (Fig. 7.6)

Between 7% and 42% of the pollen grains showed signs of deterioration, of which 'corroded' was the largest category. On average 20% of the pollen grains in each sample were deteriorated, with the highest frequencies of deteriorated grains recorded towards the bottom of the profile (274 cm).

Betula and *Corylus* grains tended to be corroded, particularly in the middle section of the diagram, where 57% of the *Betula* grains and 47% of the *Corylus* grains were found to be affected. *Calluna vulgaris* grains were also frequently characterised by corrosion (reaching a peak value of 80% at 174 cm), except in the top section of the diagram. *Pinus* grains were often broken or corroded, while Poaceae and Cyperaceae grains were often crumpled and/or corroded, with crumpled grains particularly frequent in the bottom three samples of the profile.

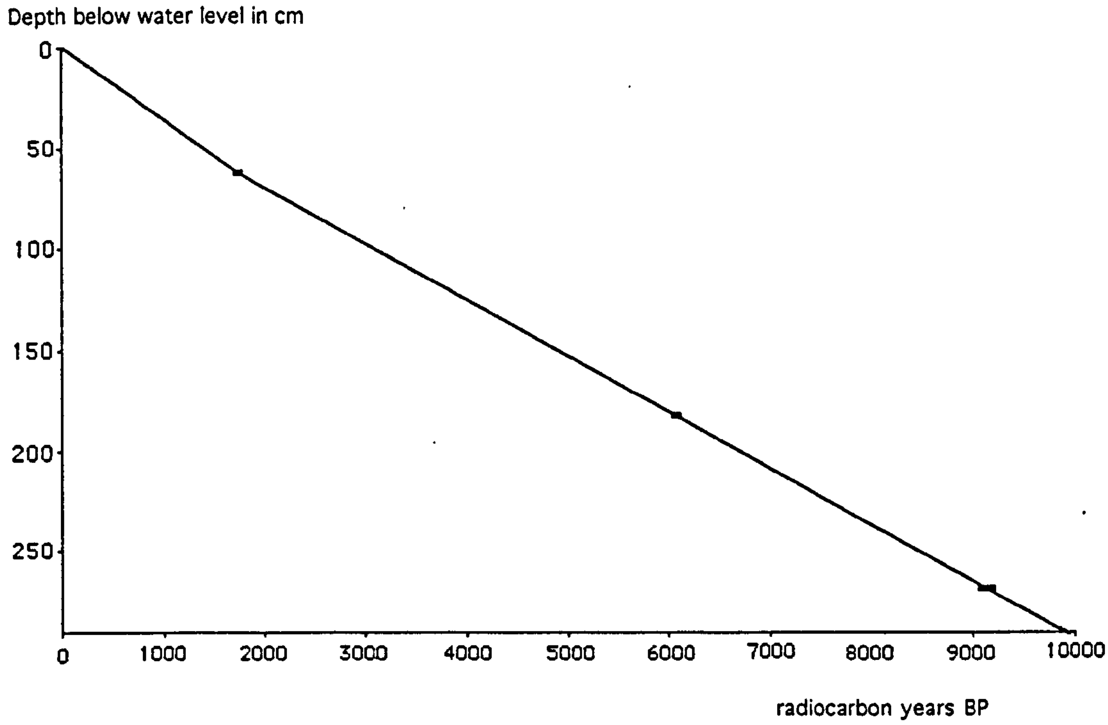


Fig. 7.2 Frobost: time-depth curve

7.5 Local pollen zones

The percentage diagram (Fig. 7.3) was divided into 6 local pollen zones with the help of the constrained cluster analysis programme CONISS (Grimm, 1987). Zones 2 and 4 were further subdivided into subzones. The pollen zones are described as follows:

FRO-1

282-272 cm 9610-9250 BP

Percentage diagram (Fig. 7.3)

The basal zone is dominated by *Empetrum nigrum*-type pollen, which reaches a maximum of 64% TLP. Tree and shrub pollen frequencies are very low. *Betula* and *Pinus* frequencies are less than 5%, while *Salix* values reach a maximum of 8%. *Corylus avellana*-type pollen is present from 278 cm, but the curve remains low throughout the zone. Herb taxa include Poaceae (maximum 25%) and Cyperaceae (maximum 14%), as well as *Cichorium intybus*-type, Lactuceae indet., *Epilobium*-type and *Filipendula*. Aquatic frequencies, consisting primarily of *Myriophyllum alterniflorum* and *Potamogeton*, are low, but rising to 3% towards the top of the zone. *Polypodium* (up to 8%) and *Huperzia selago* (4-9%) reach their highest levels, and *Pteridium aquilinum* and Pteropsida (monolete) indet. spores were also recorded.

Concentration and accumulation rate diagrams (Fig. 7.4 and 7.5)

Total pollen and spore concentrations range from 1.9 to 7.2 $\times 10^4$ grains cm^{-3}, while accumulation rates are between 512 and 1983 grains cm^{-2} $year^{-1}$.

Charcoal (Fig. 7.4 and 7.5)

Charcoal concentrations (4.7 - 15.7 x 10^{-4} cm^2 cm^{-3}) and charcoal accumulation rates (1.3-4.3 x 10^{-5} cm^2 cm^{-2} $year^{-1}$) are both low.

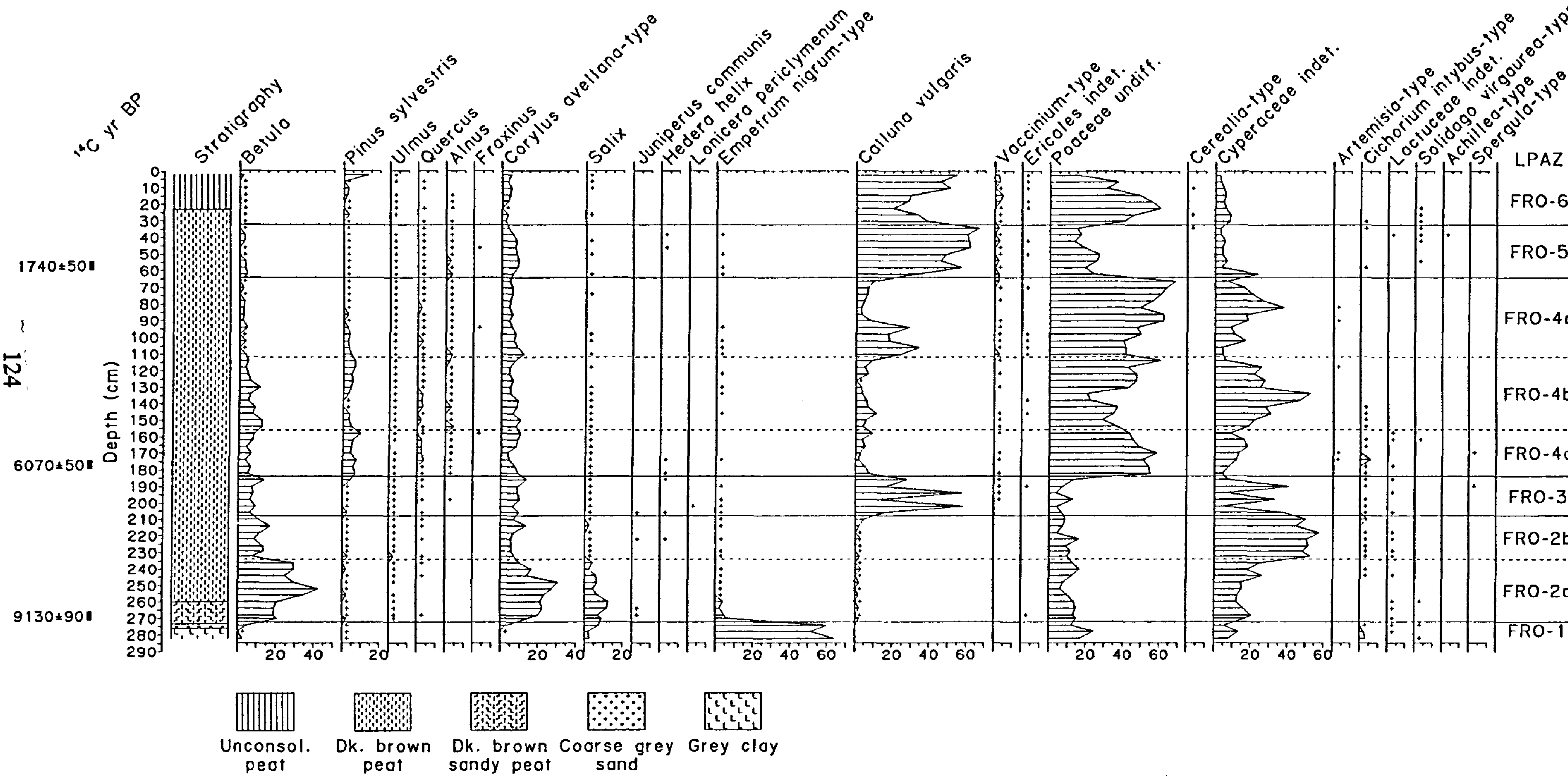


Fig. 7.3 Pollen and spore percentage diagram from Frobost (+ = <2%). Shaded curves are exaggerated x10.

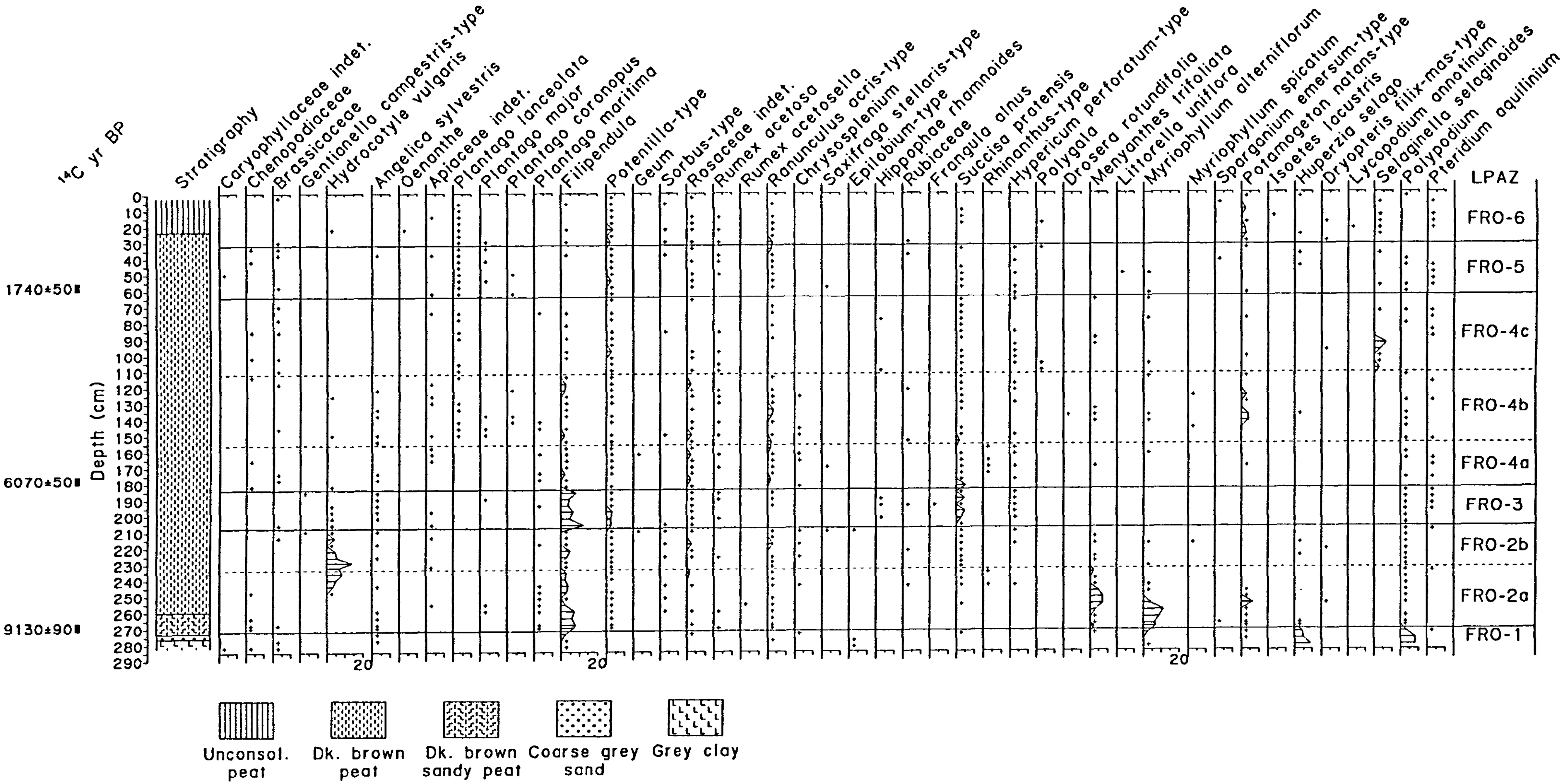


Fig. 7.3 (continued)

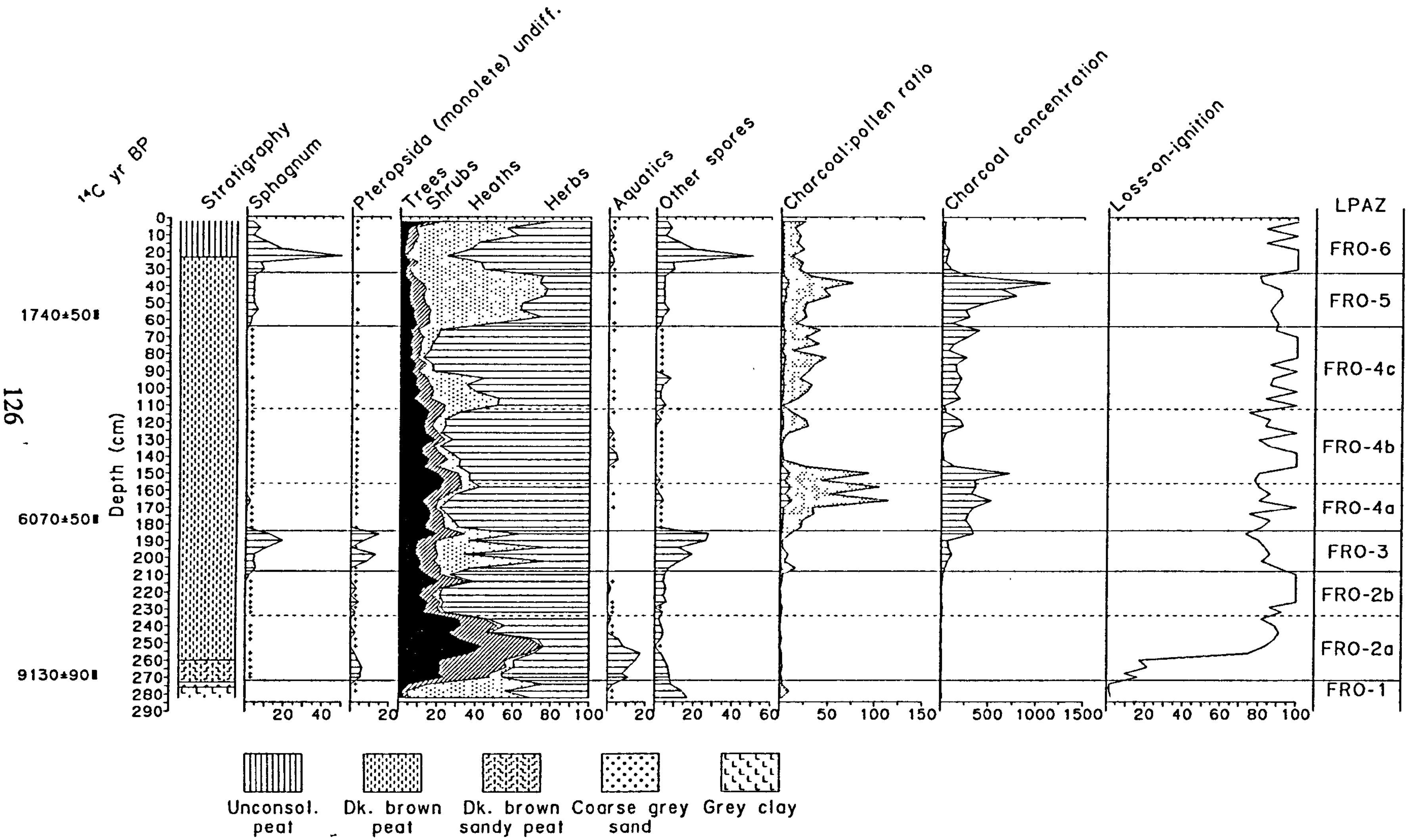


Fig. 7.3 (continued)

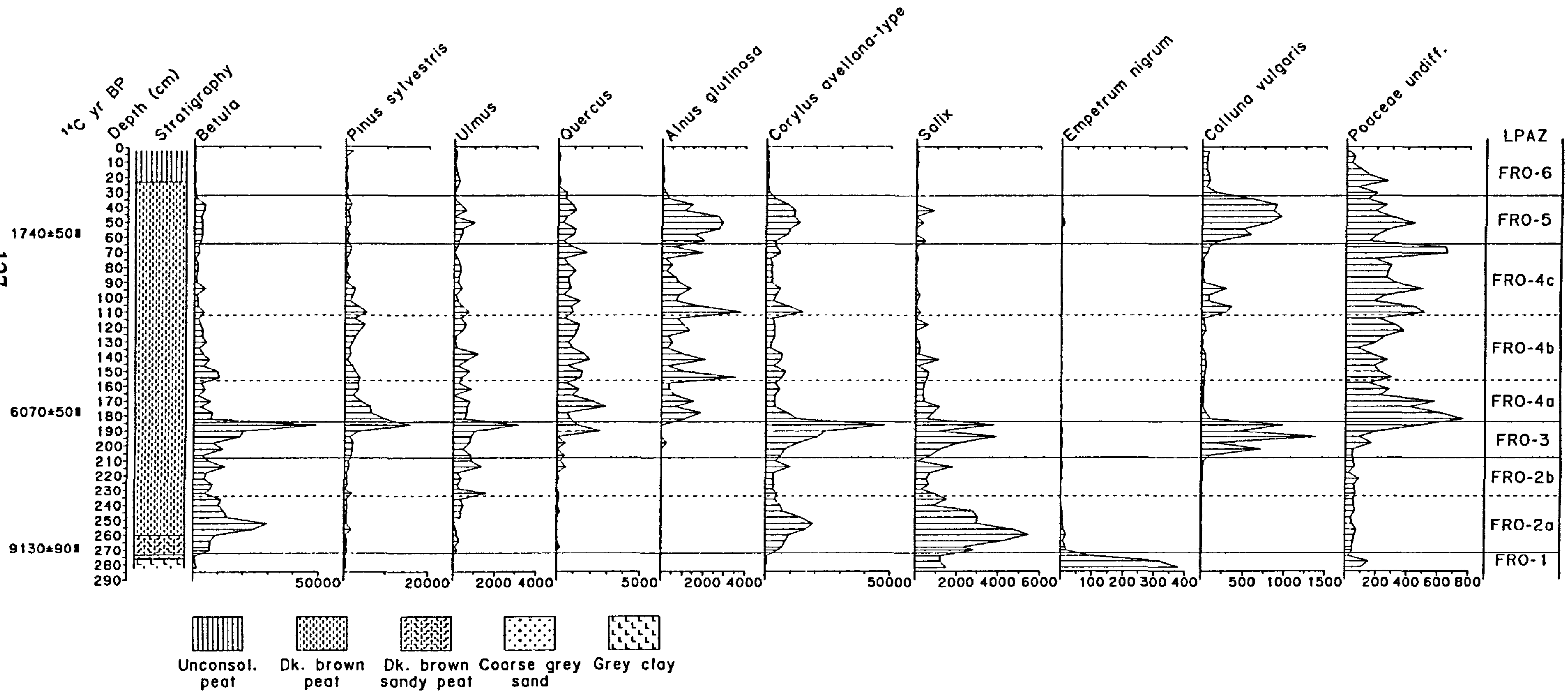


Fig. 7.4 Pollen and spore concentrations (grains cm^{-3}) and charcoal concentrations (cm^2 cm-3) at Frobost. Shaded curves are exaggerated x10. Note the variable horizontal scale.

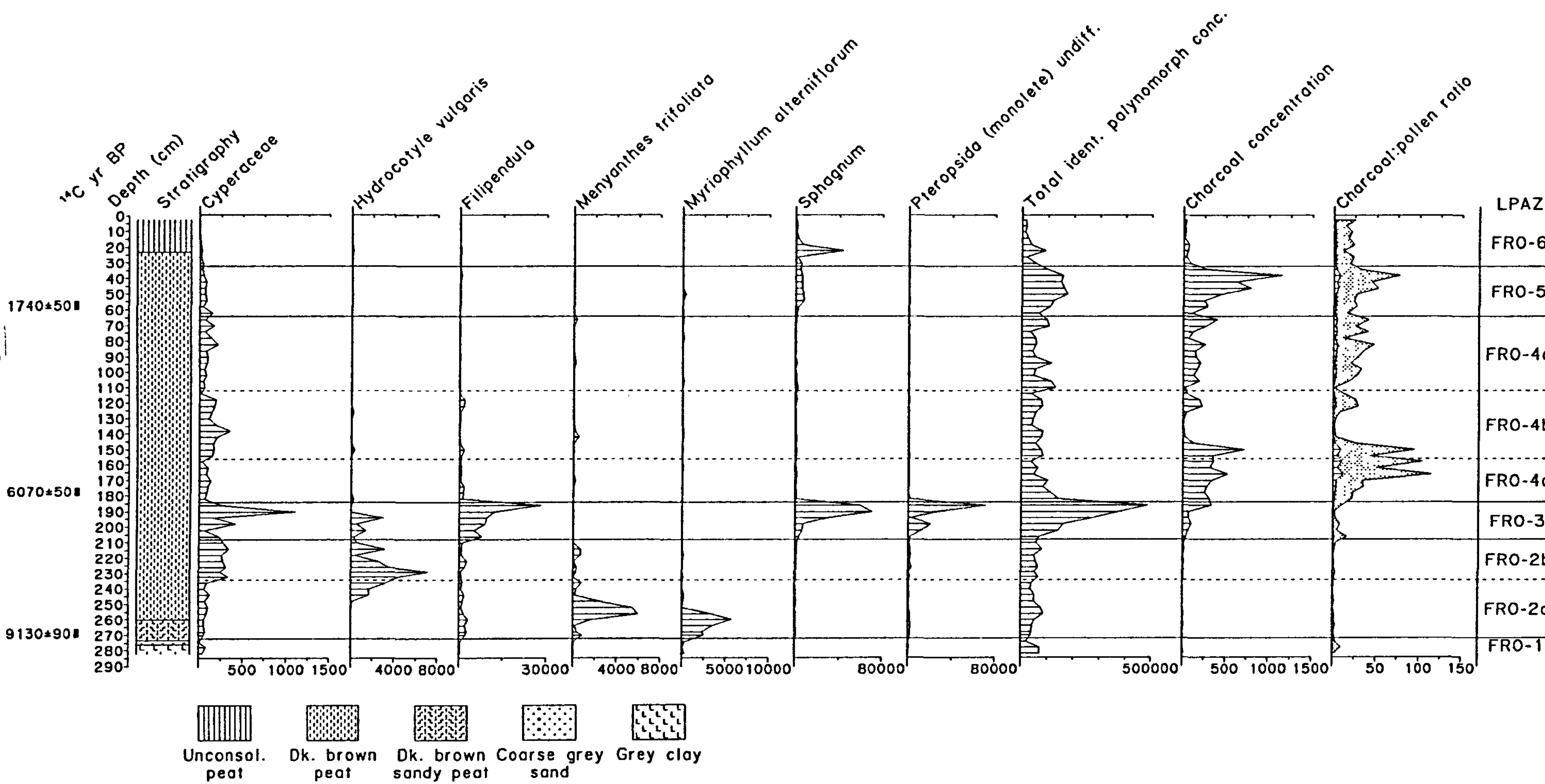


Fig. 7.4 (continued)

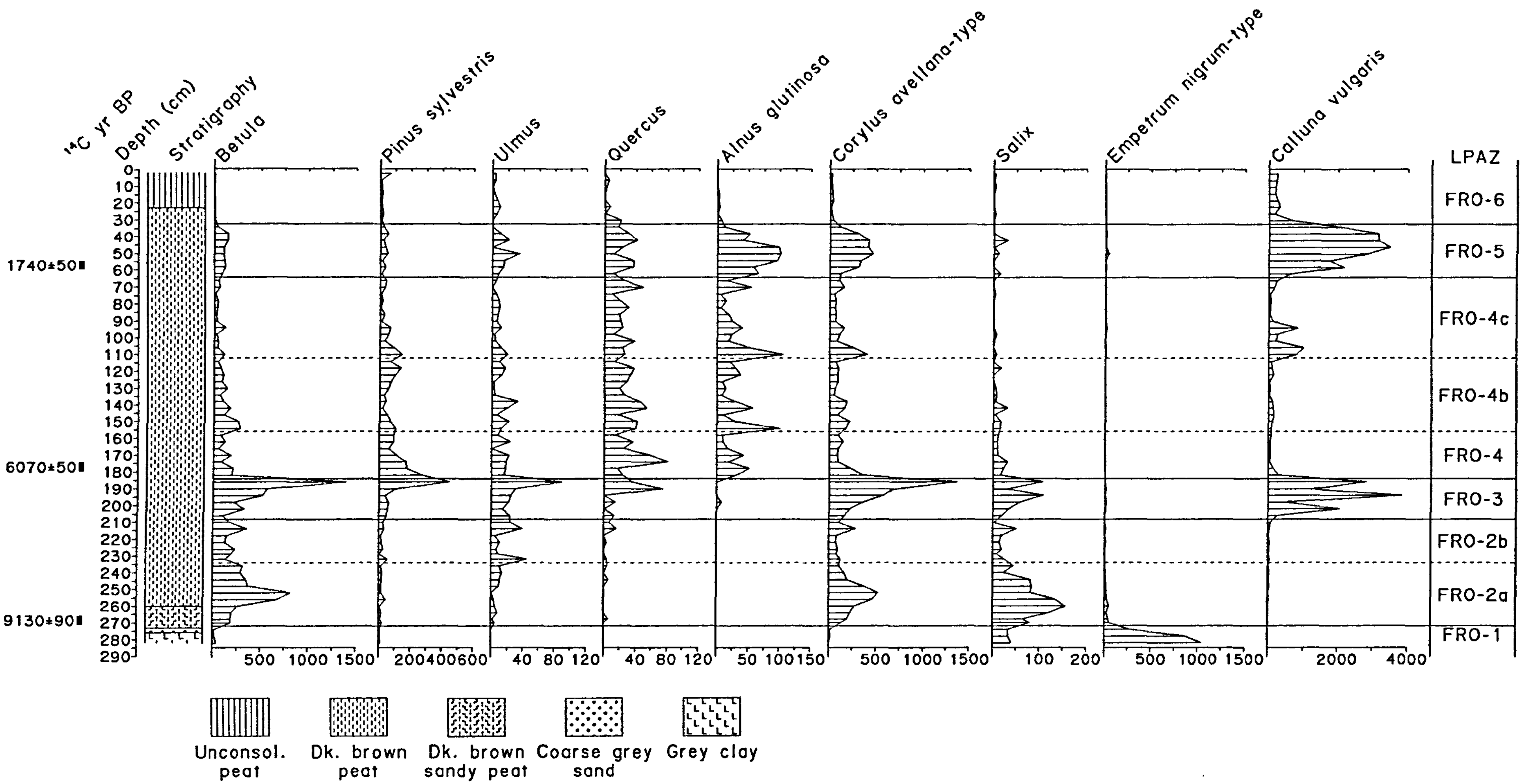


Fig. 7.5 Pollen and spore accumulation rates (grains cm^{-2} yr^{-1}) and charcoal accumulation rates (cm^{2} cm^{-3} yr^{-1}) at Frobost. Selected taxa. Shaded curve exaggerated x10. Note the variable horizontal scale.

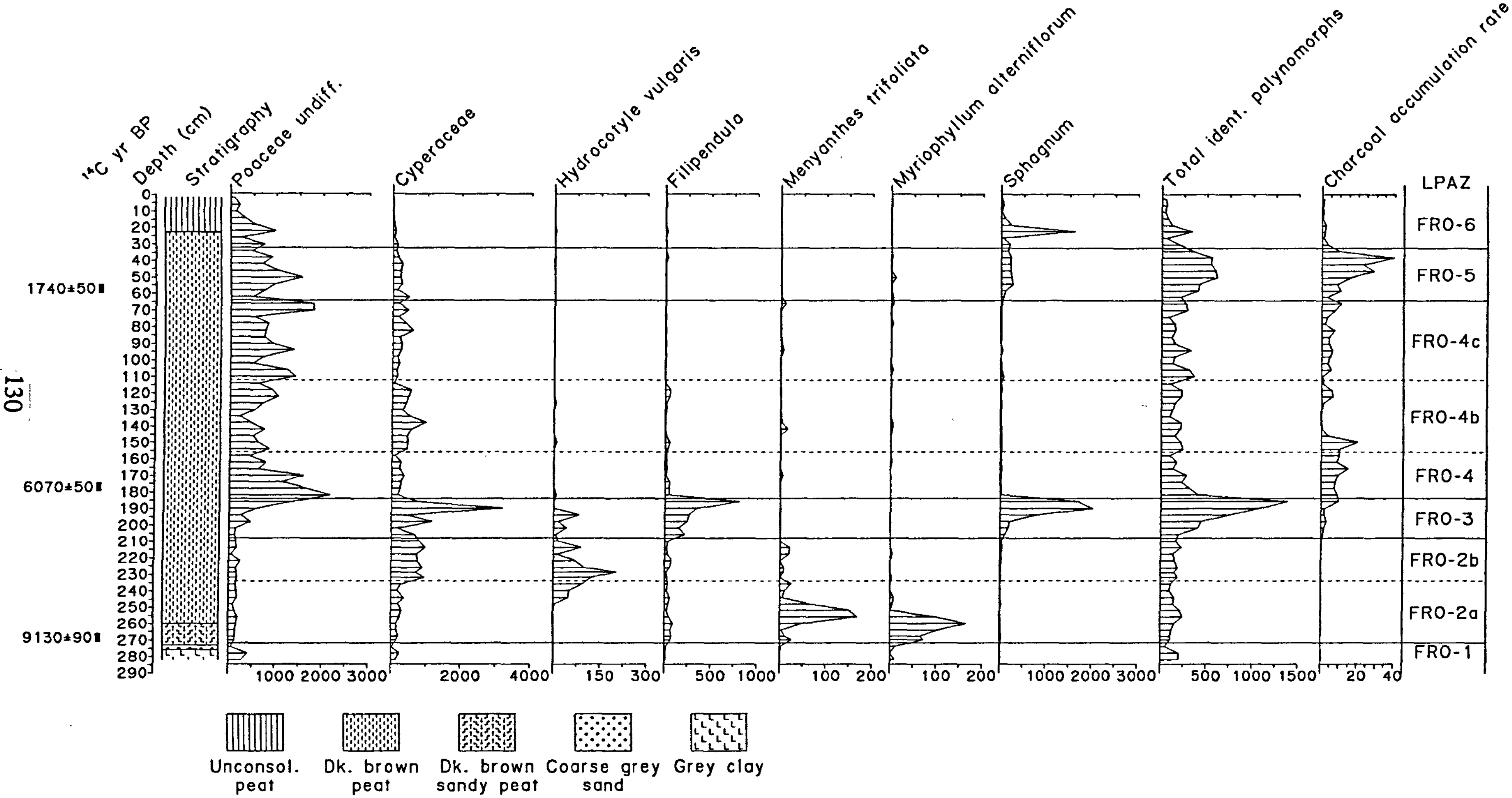


Fig. 7.5 (continued)

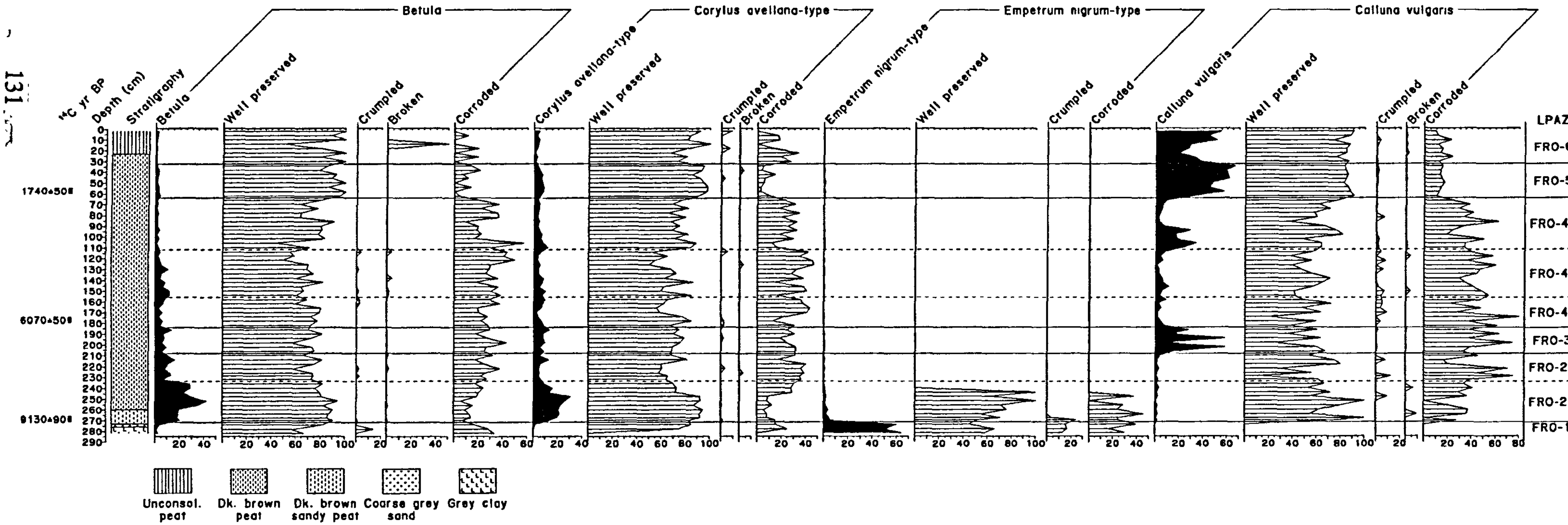


Fig. 7.6 Preservation diagram for major pollen types and TLP at Frobost. The black silhouettes are expressed as % TLP, the other graphs are a percentage of the individual taxa.

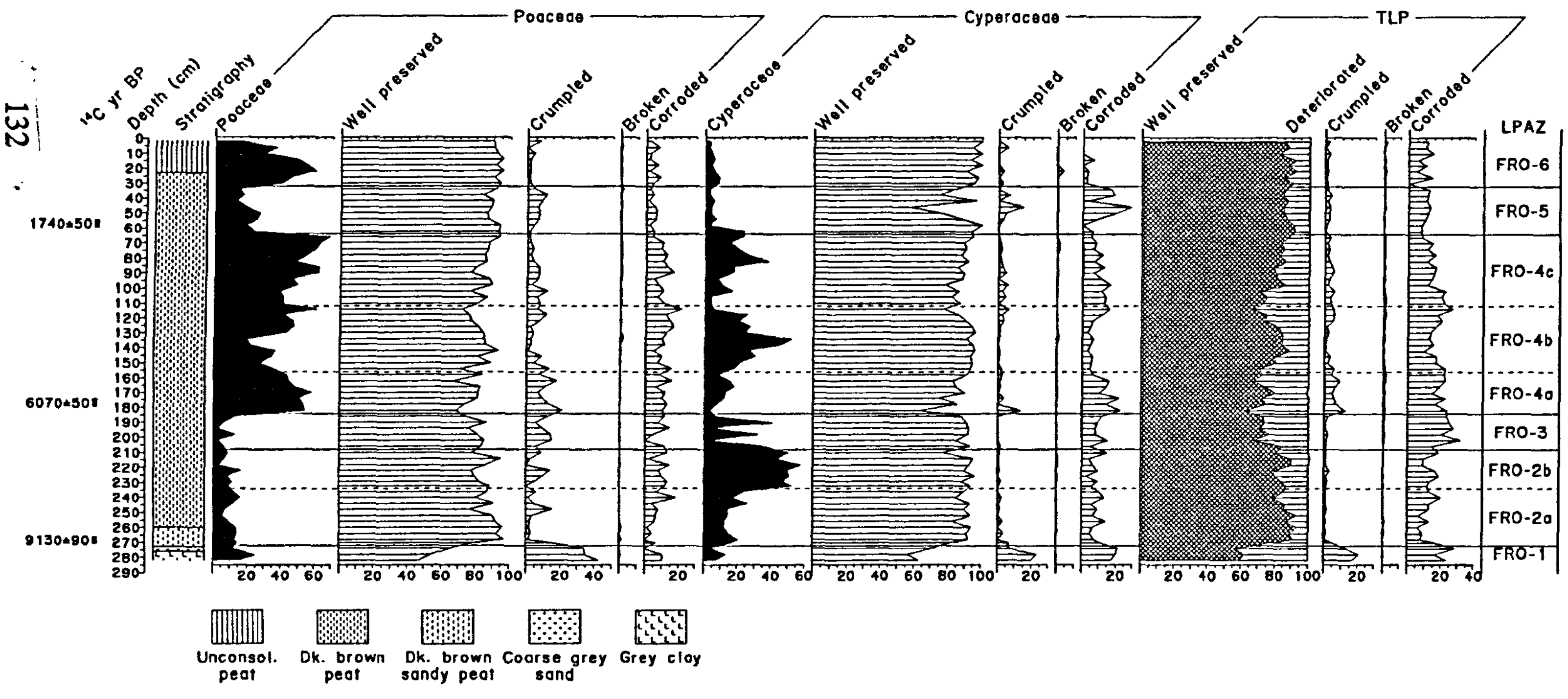


Fig. 7.6 (continued)

Loss-on-ignition (Fig. 7.3)

Loss-on-ignition values range from 1.3% to 2.4%, the lowest for the profile.

Deterioration diagram (Fig. 7.6)

Preservation of pollen grains in this zone was rather poor. Between 38% and 42% of pollen grains were found to show signs of deterioration. Crumpled and corroded Cyperaceae, crumpled Poaceae, and corroded *Empetrum* grains (up to 40% at 274 cm) were particularly common.

FRO-2a

272-234 cm 9250-7910 BP

Percentage diagram

This subzone is characterised by an increase in tree and shrub pollen to a maximum of 75%, and a strong and rapid decline in *Empetrum nigrum*-type. *Betula* reaches a maximum of 43%, while the *Corylus* curve rises to 31%. *Salix* pollen is also prominent (4-12%). *Calluna vulgaris* and *Ulmus* appear for the first time at 270 cm, and *Quercus* at 268 cm. *Filipendula* pollen is abundant, as is *Hydrocotyle vulgaris* towards the top of the subzone. Other herb pollen taxa include *Potentilla*-type, Chenopodiaceae, *Ranunculus acris*-type, *Angelica sylvestris*, *Plantago maritima*, *Succisa pratensis* and *Menyanthes trifoliata* (max. 7%). Aquatics reach their highest level (11%) in this subzone, and are dominated by *Myriophyllum alterniflorum* and *Potamogeton*. *Sphagnum* appears for the first time at 270 cm, while *Polypodium* and *Huperzia selago* become more scarce.

Concentration and accumulation rate diagrams

Total pollen and spore concentrations (3.6 - 8.6 x10^4 grains cm^{-3}) are slightly higher than in the previous zone, as are accumulation rates (1036 - 2451 grains cm^{-2} $year^{-1}$).

Charcoal

Charcoal values remain very low: charcoal concentrations range from 0.9 to

1.34×10^{-4} cm^2 cm^{-3}, and charcoal accumulation rates from 0.2 - 0.3 x 10^{-5} cm^2 cm^{-2} year^{-1}.

Loss-on-ignition

Loss-on-ignition values rise to over 75% by 256 cm, and remain high throughout the rest of the profile.

Deterioration diagram

The frequency of deteriorated grains (7–22%) is much lower than in the previous zone. Corroded *Betula*, *Corylus* and *Empetrum* were the most commonly recorded deteriorated grains.

FRO-2b

234-208 cm 7910-6990 BP

Percentage diagram

Subzone FRO-2b is characterised by a general decline in arboreal pollen and a rise in Cyperaceae. Tree and shrub frequencies fluctuate between 17% and 36%. The *Betula* and *Corylus* curves decline to 7% and 5% respectively, and *Salix* is reduced to very low frequencies (<1%). Both *Quercus* and *Ulmus* become more common, but their values remain low (<2%). *Empetrum* nigrum-type frequencies also decline to low levels, while the *Calluna vulgaris* curve remains low and steady (maximum 5%). Cyperaceae increases to reach a maximum of 58%. *Filipendula*, *Hydrocotyle vulgaris* and *Cichorium intybus*-type are regularly recorded. Aquatic frequencies fall to low levels (<2%). *Polypodium*, *Sphagnum* and Pteropsida (monolete) indet. are also present in low frequencies.

Concentration and accumulation rate diagrams

Total pollen concentration values (mean 6.4 x10^4 grains cm^{-3}) are similar to those in subzone 2a, as are accumulation rates (1338 - 2270 grains cm^{-2} year^{-1}).

Charcoal

Charcoal concentrations (0.8–15.8 x 10^{-4} cm^2 cm^{-3}) decrease, while accumulation rates (0.2 - 4.5 x 10^{-5} cm^2 cm^{-2} $year^{-1}$) are similar to those in the previous subzone.

Loss-on-ignition

Loss-on-ignition values remain high (85–100%).

Deterioration diagram

Between 10% and 22% of pollen grains were deteriorated. Corroded *Betula* grains (maximum 38% at 222 cm) and corroded *Corylus* grains (maximum 40% at 218 cm) were particularly common, but crumpled and corroded Poaceae and corroded Cyperaceae grains were also recorded.

FRO-3

208-184 cm 6990-6140 BP

Percentage diagram

The zone is characterised by the alternating domination of *Calluna vulgaris* and Cyperaceae. Arboreal pollen values are similar to those in subzone FRO-2b (19-35%). *Alnus* appears for the first time at 198 cm, and a few grains of *Hedera helix* and *Lonicera periclymenum* were recorded. *Calluna vulgaris* frequencies increase rapidly and then fluctuate between 13% and 58%. Cyperaceae pollen values fluctuate between 5% and 33%, alternating with *Calluna vulgaris*, while Poaceae pollen frequencies are slightly lower than in the previous subzone. Other herb taxa recorded include *Filipendula*, *Angelica sylvestris*, *Succisa pratensis* and *Potentilla*-type. Aquatic taxa were not recorded at all, while *Sphagnum* and Pteropsida (monolete) indet. frequencies are high, reaching 19% and 14% respectively.

Concentration and accumulation rate diagrams

Total pollen and spore concentrations increase markedly to 48.4 x10^4 grains

cm^{-3} (mean 27.6 $x10^4$ grains cm^{-3}), a four-fold increase. Accumulation rates are also higher, rising from 1930 grains cm^{-2} $year^{-1}$ to 13841 grains cm^{-2} $year^{-1}$.

Charcoal

Charcoal values are increased. Charcoal concentrations range between 3.9 and 3.4 x 10^{-4} cm^2 cm^{-3}, and charcoal accumulation rates are between 11.1 and 9.7 x 10^{-5} cm^2 cm^{-2} $year^{-1}$.

Loss-on-ignition

Loss-on-ignition values decrease from 91% at the bottom of the zone to 73% at the top.

Deterioration diagram

Deterioration rates range from 16% to 33%, and corrosion rates are quite high among *Betula* (maximum 43% at 198 cm), *Corylus* (maximum 31% at 206 cm) and *Calluna vulgaris* grains (maximum 58% at 194 cm).

FRO-4a

184-156 cm 6140-5130 BP

Percentage diagram

Poaceae is the dominant pollen taxon in this subzone, reaching a maximum of 58%. *Betula* and *Corylus* pollen frequencies decline slightly, but there is an increase in *Pinus*, *Quercus* and *Alnus*. *Hedera helix* was recorded in two levels. *Calluna vulgaris* representation is much lower than in zone FRO-3. Cyperaceae values are low at the bottom of the zone, but increase to 18% towards the top. *Cichorium intybus*-type pollen features prominently, reaching a peak of almost 6% at 174 cm, while *Filipendula* and *Potentilla*-type are less commonly recorded. Aquatic taxa were recorded occasionally, and there is a significant decline in *Sphagnum* and Pteropsida (monolete) indet. *Pteridium* and *Polypodium* spores are recorded in low numbers.

Concentration and accumulation rate diagrams

Total pollen and spore concentrations fall from 11.3 $x10^4$ grains cm^{-3} at the bottom of the subzone to 3.4 $x10^4$ grains cm^{-3} at the top. Accumulation rates similarly decline from 3104 grains cm^{-2} $year^{-1}$ to 962 grains cm^{-2} $year^{-1}$.

Charcoal

Charcoal concentrations rise, reaching a maximum of 531.4 x 10^{-4} cm^2 cm^{-3} at 166 cm. Charcoal accumulation rates range from 78.4 - 146.7 x 10^{-5} cm^2 cm^{-2} $year^{-1}$.

Loss-on-ignition

Loss-on-ignition values range between 80 and 100%, slightly higher than in zone FRO-3.

Deterioration diagram

Between 20% and 37% of the pollen grains were found to be corroded. This includes corroded *Betula*, *Corylus* (up to 44% at 166 cm), Cyperaceae and *Calluna vulgaris* grains (maximum 62% at 182 cm), as well as an increase in crumpled Poaceae grains.

FRO-4b

156-112 cm 5130-3540 BP

Percentage diagram

Poaceae and Cyperaceae alternately dominate during this subzone. Tree and shrub frequencies fluctuate (17-32% TLP), but are on average similar to those in the previous subzone. *Pinus sylvestris* pollen frequencies fall to 1% in the middle of the subzone, but rise once again to 5% by the top. *Betula* falls to 3% towards the top of the zone. *Calluna vulgaris* values remain low (2-9%). Poaceae and Cyperaceae fluctuate: as Poaceae declines to 21% in the middle of the subzone Cyperaceae pollen frequencies increase to 52%, and the process is reversed towards the top. *Plantago lanceolata* appears for the first time at 150 cm. Other prominent herb taxa include *Filipendula*, *Ranunculus acris*-type and *Succisa pratensis*. *Potamogeton natans*-type is abundant among the aquatics, but *Myriophyllum alterniflorum* is also recorded. *Sphagnum* levels remain low, while *Pteridium* and *Polypodium* spores are also present.

Concentration and accumulation rate diagrams

Total pollen and spore concentrations range from 3.6 to 8.3 $x10^4$ grains cm^{-3}, while accumulation rates are between 1003 and 2369 grains cm^{-2} $year^{-1}$.

Charcoal

Charcoal concentrations are decreased, falling from 719.7 to 4.5 x 10^{-4} cm^2 cm^{-3} at 134 cm, while accumulation rates fall from 198.6 to 1.2 x 10^{-5} cm^2 cm^{-2} $year^{-1}$ at 134 cm.

Loss-on-ignition

Loss-on-ignition values fluctuate between 75 and 100%.

Deterioration diagram

Between 11% and 33% of pollen grains showed signs of deterioration. Corroded *Betula*, *Corylus* and *Calluna* (maximum 60% at 126 cm) grains were common. The frequencies of crumpled and corroded Poaceae and Cyperaceae grains are lower than in the previous subzone.

FRO-4c

112-64 cm 3540-1810 BP

Percentage diagram

The subzone is characterised by high frequencies of Poaceae, along with

Cyperaceae and in particular *Calluna vulgaris*, whose frequencies increase to 34% before declining to 3%. Poaceae pollen fluctuates between 40% and 68%, and Cyperaceae between 7% and 38%. *Betula*, *Pinus* and *Corylus* decline, while *Alnus*, *Ulmus* and *Quercus* remain relatively stable. Arboreal frequencies in general decline from 24% to 9%. Chenopodiaceae and Brassicaceae become more common, while *Plantago lanceolata* is less commonly recorded. Also recorded are *Succisa pratensis*, *Potentilla*-type and *Hypericum perforatum*-type. *Selaginella selaginoides* frequencies reach their highest levels (6.5%). Aquatic taxa are very rare.

Concentration and accumulation rate diagrams

Total pollen and spore concentration values range from 3.1 to 12.9 $x10^4$ grains cm^{-3}. Accumulation rates fluctuate between 866 and 3566 grains cm^{-2} $year^{-1}$, similar to the previous two subzones.

Charcoal

Charcoal concentrations range from 24.6 to 393.6 x 10^{-4} cm^2 cm^{-3}, and accumulation rates from 6.8 to 108.7 x 10^{-5} cm^2 cm^{-2} $year^{-1}$.

Loss-on-ignition

Loss-on-ignition percentages remain high (83%–100%).

Deterioration diagram

In this subzone 23 to 29% of pollen grains were deteriorated. Corroded *Corylus* and *Calluna vulgaris* grains were most commonly recorded, but some corroded Cyperaceae, and crumpled and corroded Poaceae grains were also present.

FRO-5

64-32 cm 1810-900 BP

Percentage diagram

An increase in *Calluna vulgaris* pollen characterises this zone. *Betula*, *Ulmus* and *Quercus* frequencies remain low, and *Pinus* falls further, while *Corylus* and *Alnus* values increase slightly. The *Calluna vulgaris* curve rises rapidly and dominates the zone. Poaceae and Cyperaceae decrease to 13% and 3% respectively. Cerealia-type pollen is recorded for the first time at 34 cm. *Solidago virgaurea*-type, *Cichorium intybus*-type, *Achillea*-type, Chenopodiaceae and Brassicaceae are all represented, while *Plantago lanceolata* becomes more prominent. Other herb taxa include *Plantago major*, *Potentilla*-type and *Hypericum perforatum*-type. Aquatic taxa remain rare, while *Sphagnum* frequencies increase to 6%.

Concentration and accumulation rate diagrams

Total pollen and spore concentrations in this zone are high (mean value 119.2 $x10^4$ grains cm^{-3}), as are accumulation rates (2100 - 6010 grains cm^{-2} $year^{-1}$).

Charcoal

Charcoal values fluctuate, reaching peaks at 46 cm and 38 cm. Charcoal concentrations range from 102.9 to 1141.2 x 10^{-4} cm^2 cm^{-3}, and charcoal accumulation rates rise from 32.9 to 396.9 x 10^{-5} cm^2 cm^{-2} $year^{-1}$ at 38 cm.

Loss-on-ignition

Loss-on-ignition values range from 80% to 92%.

Deterioration diagram

Preservation of pollen in this zone was quite good: between 8% and 16% of all pollen grains showed signs of deterioration. Corroded *Corylus*, *Betula*, Cyperaceae and *Calluna vulgaris*, as well as some crumpled Poaceae grains, made up most of the deteriorated category.

FRO-6

32-2 cm 900-60 BP

Percentage diagram

Calluna vulgaris and Poaceae alternate to dominate this zone. *Betula*, *Ulmus*, *Quercus* and *Corylus* pollen frequencies are very low (<2% each), and *Alnus* pollen has disappeared from the record by 10 cm. *Pinus* reaches a peak of 13% at the very top of the profile. *Calluna vulgaris* declines to 22% before increasing to 55% by the top of the zone. Poaceae frequencies rise to 60% as *Calluna* frequencies fall, before decreasing to 16% as *Calluna* values rise again. Cyperaceae frequencies remain low (< 10%). Cerealia-type grains were recorded in two levels. Other herb taxa include *Plantago lanceolata*, Brassicaceae, *Filipendula*, *Potentilla*-type, *Ranunculus acris*-type and *Succisa pratensis*. Aquatic frequencies rise slightly, mainly due to an increase in *Potamogeton natans*-type pollen. *Sphagnum* values also rise and reach a peak of 50% at 22 cm.

Concentration and accumulation rate diagrams

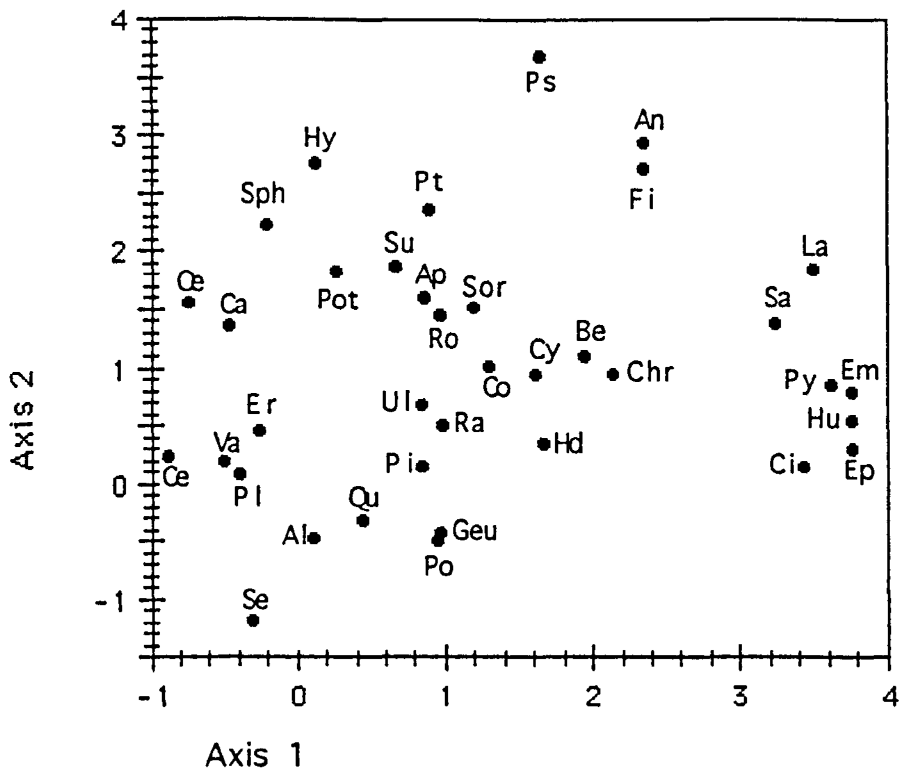
Total pollen concentrations (9 - 11.9 x10^4 grains cm^{-3}) and accumulation rates (435 - 3278 grains cm^{-2} $year^{-1}$, mean 1158 grains cm^{-2} $year^{-1}$) are significantly lower than in the previous zone.

Charcoal

Charcoal values are considerably lower than in zone FRO-5. Charcoal concentrations range from 16.7 to 91.3 x 10^{-4} cm^2 cm^{-3}, and accumulation rates from 7.1 to 22.8 x 10^{-5} cm^2 cm^{-2} $year^{-1}$.

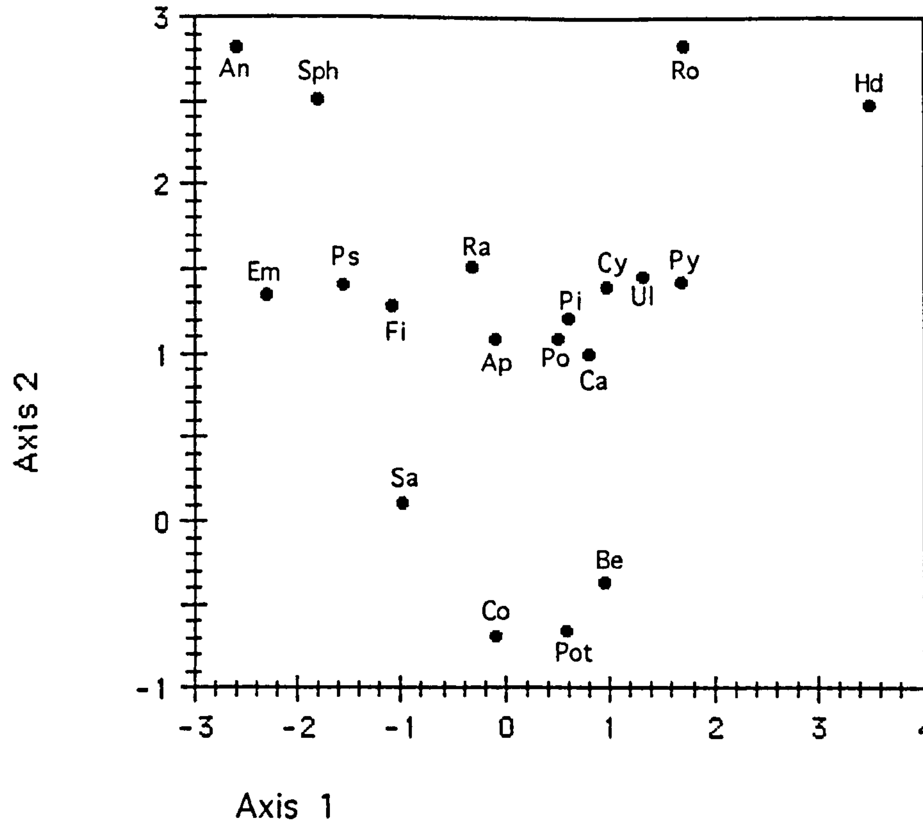
Loss-on-ignition

Loss-on-ignition values are high: 83% to 100%.



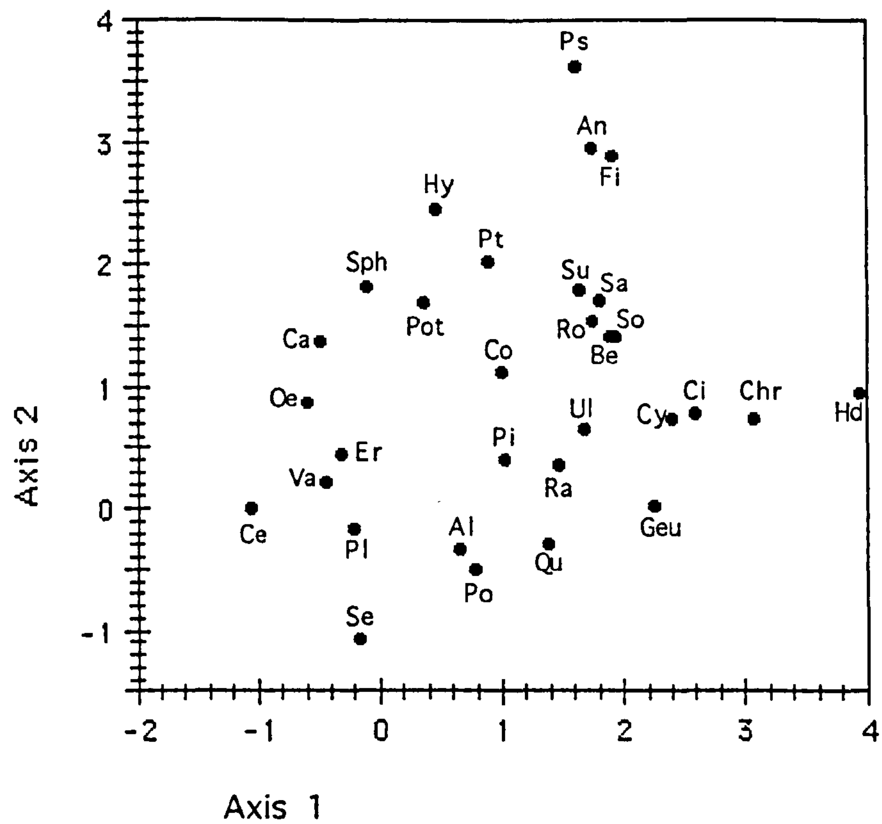
Key:
(Al) *Alnus*; (An) *Angelica sylvestris*; (Be) *Betula*; (Ca) *Calluna vulgaris*; (Ce) Cerealia-type; (Chr) *Chrysosplenium*; (Ci) *Cichorium intybus*-type; (Co) *Corylus avellana*-type; (Cy) Cyperaceae; (Em) *Empetrum nigrum*-type; (Er) Ericales indet.; (Fi) *Filipendula*; (Geu) *Geum*; (Hu) *Huperzia selago*; (Hd) *Hydrocotyle vulgaris*; (La) Lactuceae indet.; (Oe) *Oenanthe*; (Pi) *Pinus sylvestris*; (Pl) *Plantago lanceolata*; (Po) Poaceae; (Pot) *Potentilla*-type; (Pt) *Pteridium aquilinium*; (Ps) Pteropsida (monolete) indet.; (Py) *Polypodium*; (Qu) *Quercus*; (Ra) *Ranunculus acris*-type; (Ro) Rosaceae indet.; (Sa) *Salix*; (Se) *Selaginella selaginoides*; (Sor) *Sorbus*-type; (Sph) *Sphagnum*; (Su) *Succisa pratensis*; (Ul) *Ulmus*; (Va) *Vaccinium*-type.

Fig. 7.7 Frobost: DCA, entire profile



Key:
(Al) *Alnus*; (An) *Angelica sylvestris*; (Be)*Betula*; (Ca) *Calluna vulgaris*; (Ce) Cerealia-type;(Chr) *Chrysosplenium*; (Ci) *Cichorium intybus*-type; (Co) *Corylus avellana*-type; (Cy) Cyperaceae; (Em) *Empetrum nigrum*-type; (Er) Ericales indet.; (Fi) *Filipendula*;(Geu) *Geum*; (Hu) *Huperzia selago*; (Hd) *Hydrocotyle vulgaris*; (La) Lactuceae indet.; (Oe) *Oenanthe*; (Pi) *Pinus sylvestris*; (Pl) *Plantago lanceolata*; (Po) Poaceae; (Pot) *Potentilla*-type; (Pt) *Pteridium aquilinium*; (Ps) Pteropsida (monolete) indet.; (Py) *Polypodium*; (Qu) *Quercus*; (Ra) *Ranunculus acris*-type; (Ro) Rosaceae indet.; (Sa) *Salix*; (Se) *Selaginella selaginoides*; (Sor) *Sorbus*type; (Sph) *Sphagnum*; (Su) *Succisa pratensis*; (Ul) *Ulmus*; (Va) *Vaccinium*-type.

Fig. 7.8 Frobost: DCA, bottom of profile excluding Lateglacial (272-234 cm)



Key:
(Al) *Alnus*; (An) *Angelica sylvestris*; (Be)*Betula*; (Ca) *Calluna vulgaris*; (Ce) Cerealia-type;(Chr) *Chrysosplenium*; (Ci) *Cichorium intybus*-type; (Co) *Corylus avellana*-type; (Cy) Cyperaceae; (Em) *Empetrum nigrum*-type; (Er) Ericales indet.; (Fi) *Filipendula*;(Geu) *Geum*; (Hu) *Huperzia selago*; (Hd) *Hydrocotyle vulgaris*; (La) Lactuceae indet.; (Oe) *Oenanthe*; (Pi) *Pinus sylvestris*; (Pl) *Plantago lanceolata*; (Po) Poaceae; (Pot) *Potentilla*-type; (Pt) *Pteridium aquilinium*; (Ps) Pteropsida (monolete) indet.; (Py) *Polypodium*; (Qu) *Quercus*; (Ra) *Ranunculus acris*-type; (Ro) Rosaceae indet.; (Sa) *Salix*; (Se) *Selaginella selaginoides*; (Sor) *Sorbus*type; (Sph) *Sphagnum*; (Su) *Succisa pratensis*; (Ul) *Ulmus*; (Va) *Vaccinium*-type.

Fig. 7.9 Frobost: DCA, top of profile (234 cm - top)

Deterioration diagram

Between 7.4% and 17.6% of all pollen grains were found to be deteriorated. Most of these were corroded *Corylus*, and *Calluna vulgaris* grains, as well as, to a lesser extent, crumpled Poaceae and corroded Cyperaceae.

7.6 Detrended Correspondence Analysis (DCA)

Three ordination plots were created using detrended correspondence analysis. Figure 7.7 reflects the changing vegetation patterns over the entire profile. To the right of the ordination plot is a cluster of taxa which were prominent during the Lateglacial and very early Holocene, including *Empetrum nigrum*-type, *Huperzia selago*, *Cichorium intybus*-type and *Polypodium*. In the middle are the woodland taxa (such as *Corylus avellana*-type, *Betula*, *Pinus* and *Ulmus*) that dominated the next phase (subzone FRO-2a), associated with taxa such as *Ranunculus acris*-type, *Geum*, *Hydrocotyle vulgaris* and *Chrysosplenium*, which may have formed the rather damp woodland understorey, or alternatively contributed to nearby wet grasslands. Taxa typical of peat bogs (e.g. *Sphagnum*, *Hypericum perforatum*-type and *Potentilla*-type) pull out to the top left of the graph, with heathland taxa and potential anthropogenic indicator taxa (Cerealia-type and *Plantago lanceolata*) just below them. These last three groups are all prominent in the uppermost two zones of the profile.

Figure. 7.8 is based on data from the woodland phase of the profile. The bottom middle of the plot shows a cluster of trees and shrubs that were prominent at the time, and are assumed to have been growing locally. The close proximity of *Potentilla*-type to these trees and shrubs could suggest that it was an understorey herb. Virtually all the other taxa in the diagram, with the exception of *Pinus* and *Ulmus* (neither of which is considered to have been present locally at this time) favour wet environments, such as damp grassland and peat bog. *Calluna vulgaris* is present throughout this phase in low values and this is reflected in its very central position.

Figure 7.9 demonstrates the changing vegetation patterns after the decline in trees and shrubs at Frobost. To the middle right of the plot is a cluster of taxa typical of streamsides and marshes (e.g. Cyperaceae, *Chrysosplenium* and *Hydrocotyle vulgaris*) prominent during the early part of this phase. Taxa of woodland remnants can be found in the middle, while taxa typical of peat bog and wet pastures can be found towards the top middle of the graph. To the bottom left are seen the possible anthropogenic indicator taxa *Plantago lanceolata* and Cerealia-type, quite closely associated with heathland taxa, and prominent during the last two zones of the profile.

7.7 Inferred vegetation history

9610-9250 BP (*c.* 10940-10390 cal BP)

The basal layers of the profile suggest an open, virtually treeless landscape in the area around the site. The vegetation was dominated by *Empetrum nigrum* heath, probably interspersed with some patches of willow scrub as well as grasses and ferns such as *Huperzia selago* and *Polypodium*. The presence of Cyperaceae suggests that there were wetter areas in the vicinity, which may also have provided a suitable environment for *Potamogeton* and *Menyanthes trifoliata*. Taxa of disturbed ground, such as *Cichorium intybus*-type, Chenopodiaceae and *Epilobium*-type are also represented.

The taxa that are common in the basal zone at Frobost are typical of Lateglacial spectra at many sites on the islands (Edwards and Whittington, 1994; Brayshay and Edwards, 1996), and despite the dates, which have been extrapolated downwards, it is possible that this phase represents a remnant of Lateglacial vegetation. This is also suggested by the nature of the sediment, which consists of coarse grey clay. The discrepancy could be explained by the fact that the extrapolated dates (between 9320 and 9610 BP) do not take into account what may well be very different sedimentation rates in the clay.

Preservation of pollen grains in zone FRO-1 is poor, with frequencies of deteriorated pollen ranging from 38% to 42%, and corroded *Empetrum* particularly frequent (up to 40%). This could indicate that some of the pollen in this zone has been eroded out of older sediments and redeposited at the coring site (Walker and Lowe, 1990; Edwards and Whittington, 1994).

9250-6990 BP (*c.* 10390-7990 cal BP)

The formation of peat at the site began around 9250 BP (10390 cal BP). Loss-on-ignition levels start to increase around the same time (to 16%), but do not rise significantly until *c.* 8690 BP (9630 cal BP) when they reach 75%, suggesting that there may be some mixing of sediments in the lower part of the profile.

Sphagnum appears for the first time in the pollen and spore record at 9180 BP (10320 BP) and its appearance is accompanied by an increase in the percentages and concentrations of *Menyanthes trifoliata*, *Potamogeton* and *Myriophyllum alterniflorum*, which may reflect the growth of local aquatic communities on wetter parts of the mire, and/or the survival of deeper pools nearby. A wetter environment in the vicinity of the coring site could also be reflected in the preservation data. Wetness is likely to lead to better preservation of pollen, and deterioration values at this time are relatively low (7-22%).

During this phase *Empetrum* heath declined, as indicated by both the percentage and absolute data, and was replaced by woodland and scrub. *Corylus* and *Betula* arrived almost simultaneously around 9300 BP (10490 cal BP) and by 8550 BP (9530 cal BP) arboreal pollen accounts for 75% of total land pollen. The arrival of *Betula* is quite late compared to most other sites on the Outer Hebrides, and it is possible that the lowest radiocarbon date is somewhat young. This is a typical problem of peat, because the layers include rootlets from plants that grew above them. On the other hand, the arrival of *Corylus* in the area is not exceptionally late - at Loch an t-Sìl the *Corylus* rise is dated to 9020 BP (10210 cal BP) while at the nearby site of Reineval it is even later, at around 7990 BP (8890 cal BP) (Brayshay and Edwards, 1996).

Willow is likely to have been present in the birch-hazel woodland at this time - *Salix* frequencies reach 12.3% at 8830 BP (9350 cal BP) and as it is generally considered to be poorly represented in the pollen record (Bradshaw, 1981), it may have formed quite a prominent woodland component, or was locally abundant. *Pinus* *sylvestris* frequencies remain low (<3%) and it is unlikely that pine trees were growing in the immediate area. *Ulmus* and *Quercus* appear for the first time at 9180 BP (10320 cal BP) and 9110 BP (10240 cal BP) respectively, but their pollen curves remain low and discontinuous, and the pollen is therefore likely to derive from long-distance sources. Woodland cover was probably not complete, and there was enough light to allow the growth of grasses, as well as tall-herb communities that included *Filipendula* and *Angelica sylvestris*. *Calluna vulgaris* appears for the first time in the profile at 9180 BP, but did not become important in the landscape until 6920 BP (7740 cal BP).

The woodland phase at Frobost did not last very long, and by 8260 BP (9270 cal BP) the trees and shrubs had started to decline, accelerating after 7910 BP (8780 cal BP) when arboreal pollen frequencies fall from 45% to 21%. Arboreal pollen concentrations and accumulation rates are also significantly reduced. The woodland regenerated to some extent around 7200 BP (8040 cal BP) (arboreal pollen frequencies reach 36%, mainly *Betula* and *Corylus*) but never recovered its former prominence. *Salix* in particular suffered a decline, and willow seems to have disappeared locally by 7840 BP (8610 cal BP) but birch and hazel were also severely reduced.

There is no reason to suggest that people were involved in the woodland decline at this site. In the traditional view of Mesolithic people's impact on the landscape, it is generally argued that hunter-gatherers set fire to the woodlands in order to increase browse for animals (Smith, 1970, 1984; Simmons, 1975; Simmons and Innes, 1987). This could be reflected in the pollen record by a decrease in trees and shrubs, and an increase in charcoal and species encouraged by fire, such as *Calluna vulgaris* (Edwards, 1990; Edwards *et al.*, 1995). As mentioned in Chapter 3, decreases in arboreal pollen associated with an increase in charcoal have been interpreted as possible signs of Mesolithic human impact at Loch Lang (*c.* 9000 BP [10200 cal BP]; Bennett *et al.*, 1990), Reineval (*c.* 6000 BP [6810 cal BP]), and Loch an t-Sìl (*c.* 8000 BP [8890 cal BP]) (Edwards *et al.*, 1995), all on South Uist. But at Frobost, despite its proximity to Reineval, there is neither an increase in charcoal values nor in *Calluna vulgaris* at this stage, and there is no evidence for an increase in other anthropogenic indicator species. The changes are therefore likely to be of natural rather than anthropogenic origin. There is a significant increase in Cyperaceae during this phase, visible in both the percentage and absolute data, as well as a slight rise in *Sphagnum*. It may be proposed that the area around the site was becoming wetter, and the mire may have been spreading, making tree and shrub growth difficult and encouraging the growth of wet-loving taxa such as sedges and *Hydrocotyle vulgaris*.

6990-6140 BP (*c.* 7790-7010 cal BP)

This period was characterised in the pollen profile by rapidly fluctuating percentages of *Calluna vulgaris* and Cyperaceae pollen. *Calluna vulgaris* increased markedly in importance and by 6780 BP (7630 cal BP) had reached a peak, before being largely replaced by Cyperaceae by 6640 BP (7540 cal BP) Then, as the sedges declined, *Calluna vulgaris* once again became prominent, and the process repeated itself. These changes are also evident in the concentration and accumulation data, which show similar fluctuations. It is possible that *Calluna* and Cyperaceae were both growing on nearby slopes, but rapid fluctuations in peat deposits can also be indicative of changes in local vegetation on the mire itself (Jacobsen and Bradshaw, 1981), with *Calluna vulgaris* perhaps occupying locally drier areas, and Cyperaceae ocurring in wetter patches. These patterns of wetness and vegetation may have shifted on the surface of the mire over time.

In order to test whether the records of either *Calluna*, Cyperaceae or both are likely to reflect deposition of on-site pollen, an experiment was conducted. The abundance of taxa growing on-site is likely to fluctuate more than those derived from regional vegetation, and these fluctuations are likely to have an important effect on the pollen record of other taxa, since a percentage increase in one taxon will automatically lead to a decrease in the other. Additional percentage diagrams were thus created, removing first Cyperaceae and then *Calluna vulgaris* from the pollen sum. In both cases the remaining taxon continued to fluctuate, suggesting that the two taxa had both fluctuated in abundance in the past, and therefore may both have been growing on-site. Additional evidence may be provided by the preservation data, which could potentially be affected by wet/dry phases. In general, total deterioration frequencies are lower in phases when Cyperaceae frequencies are high, while preservation is not as good during *Calluna* peaks.

Woodland had gone into decline but trees and shrubs had not disappeared altogether. Arboreal pollen frequencies remain relatively steady (19- 35%), and it is likely that there were still pockets of birch and hazel woodland in the area. *Hedera helix* and *Lonicera periclymenum* pollen grains were recorded during this phase, and may have been present as understorey plants, along with *Filipendula*. *Alnus* appears for the very first time at 6640 BP (7540 cal BP), but the *Alnus* curve does not become continuous until 6070 BP (6870 cal BP) and frequencies remain low, so that it may never have grown locally. Only one *Fraxinus excelsior* pollen grain was recorded in the entire profile, making it unlikely that there were any ash trees in the vicinity of the site.

6140–1810 BP (c. 7010–1720 cal BP)

The vegetation during this time was dominated by damp, species-rich grassland (including Poaceae, *Ranunculus acris*-type, *Succisa pratensis*, *Hypericum perforatum*-type and *Selaginella selaginoides*), interspersed with brief periods when alternately *Calluna vulgaris* and Cyperaceae became more important. Again, experiments were conducted to determine whether one or all of these taxa were primarily growing on-site. *Poaceae*, *Calluna* and *Cyperaceae* were eliminated from the pollen sum in turn. In each case the two remaining taxa continued to fluctuate, and thus it appears that the pollen records of all three taxa may reflect primarily the local vegetation on the mire itself. Again, preservation levels tend to be poorer when *Calluna* is prominent.

Sphagnum spore frequencies were very low during this time, indicating perhaps that the mire itself was no longer spreading. In the surrounding area the extent of woodland declined gradually, and there are signs that the composition of the remaining woodland may also have changed. *Betula* and *Corylus* declined in importance (although Betula sees a slight regeneration around 4200 BP [4770 cal BP]), a change that is particularly clear in the concentration diagram. On the other hand, there was an increase in *Pinus*, as well as *Quercus* and *Alnus*, which had occurred only sporadically until this time. *Pinus sylvestris* frequencies generally exceed 5% between 6070 and 5060 BP (6870-5820 cal BP) while *Pinus* concentrations and accumulation rates are also higher, and there may have been scattered individuals growing in the area during this period (see Chapters 6 and 11 for longer discussions on pine in the Outer Hebrides). Both *Quercus* and *Alnus* pollen frequencies increase, but they remain below 3%, which may not be high enough to argue for local presence with any confidence. The increase in the frequencies of these taxa may instead reflect greater diversity in woodlands in other parts of the island.

Around 6140 BP (7010 cal BP) charcoal values start to increase, but whether this represents an increase in the incidence of anthropogenic rather than natural fire is hard to say. There were no drastic reductions in tree and shrub percentages at this time (although concentrations and accumulation rates do show a decline), and no expansion in *Calluna vulgaris* or other taxa favoured by fire, or indeed any increase in anthropogenic indicator species. On the other hand, the rise in the charcoal curves could reflect the presence of domestic fires perhaps at some distance from the coring site. The charcoal curves fall again around 4770 BP (5530 cal BP) and remain relatively low until around 1290 BP (1220 cal BP).

Plantago lanceolata appears for the first time at 4920 BP (5630 cal BP) although the pollen curve does not become continuous until 1740 BP (1640 cal BP). The appearance of this species may reflect the presence of Neolithic people in the landscape, although there are few other clear indicators of anthropogenic activity. Charcoal values are rather low, and there is no evidence for cereal cultivation. *Plantago lanceolata*, however, can be considered as an indicator of pasture (Behre, 1981) and the area may well have been used for grazing.

1810-0 BP (1720-0 cal BP)

During the last phase in the vegetation history of this site the landscape was dominated alternately by *Calluna vulgaris* and Poaceae. The absolute and percentage data suggest that by 1630 BP (1530 cal BP) heathland dominated the landscape, while the extent of grassland was greatly reduced. The roles were reversed around 620 BP (600 cal BP) when Poaceae became the dominant taxon, before *Calluna* once again gained prominence, although this is not as clear in the absolute data. Cyperaceae values remain low, and sedges were no longer an important component of the vegetation. The area was probably quite suitable for rough grazing.

In terms of woodland taxa, *Corylus avellana*-type frequencies recover slightly, but the other tree and shrub taxa continue to decline. Arboreal pollen values are generally lower than 16%, suggesting that very little woodland was now present in the landscape. By 1040 BP (940 cal BP) arboreal frequencies have fallen below 13%, lower than the percentage recorded by Fossitt (1994a) for tree and shrub pollen on the virtually treeless islands today (mean 13.8%). At the very top of the profile, however, tree and shrub percentages rise to 22%, due primarily to a surprisingly high peak in *Pinus* pollen (13%). This peak is hard to explain, as there are no pine trees growing near the site today, nor have there been in the recent past. It is, however, conceivable that the increase in *Pinus* pollen reflects the creation of commercial plantations on the mainland of Scotland or the Inner Hebrides (Bramwell and Cowie, 1983) during the last two centuries.

Corylus frequencies remain relatively high until 1070 BP (960 cal BP) and the concentration and accumulation rates are even slightly increased between 1810 and 1070 BP (1720-960 cal BP) suggesting that some hazel scrub may still have been present until this time. It is also possible, though, that the *Corylus avellana*-type pollen in this period reflects the presence of the bog species *Myrica gale* rather than hazel, as the pollen of these two species cannot readily be told apart. This may also be supported by an increase in mire taxa at this time. *Sphagnum* values increase from 1740 BP (1650 cal BP) onwards, reaching a strong peak in the percentage and absolute diagrams at 620 BP (600 cal BP) and *Potentilla*-type values are also increased.

Plantago lanceolata rises from 1740 BP (1650 cal BP) onwards, along with charcoal values, while Cerealia-type pollen appears for the first time at 950 BP (860 cal BP). The presence of the latter, if indeed produced by cereals, is the first clear sign of arable agriculture in the area, perhaps on neighbouring slopes, and is accompanied by other indicators of arable activity such as Brassicaceae, Chenopodiaceae, and *Achillea*-type. It appears, therefore, that while pastoral agriculture may have been practised in the area for several millennia, arable agriculture arrived rather làte.

The two peaks in charcoal values at 1290 and 1070 BP (1220 and 960 cal BP) are hard to interpret. *Calluna vulgaris* values are high at this time, but had already risen before the increase in charcoal, thus making the use of fire to manage heathland unlikely. After 900 BP (830 cal BP) charcoal values are generally low, which is quite surprising, considering that the area around Frobost was probably inhabited during the last 1000 years (see Chapters 4 and 11), and at the other sites in this study charcoal values are generally high during the last millennium. One explanation is that the mire was generally inefficient in recruiting microscopic charcoal. On the other hand, charcoal accumulation rates throughout the profile are no lower than at other sites in this study.

In summary, the landscape in this most recent phase at Frobost was dominated by *Calluna vulgaris* heathland and, to a lesser extent, by grassland. The area may well have been used for rough grazing, and there is also evidence for arable agriculture in the vicinity of the site during the last 1000 years. The pollen spectra from the top of the profile quite accurately reflect the vegetation today: virtually treeless and dominated by heathland and mire.

7.8 Summary

Between 9610 and 9250 BP (10940-10390 cal BP) the landscape at Frobost was open and treeless. *Empetrum nigrum* heath dominated, interspersed with patches of willow scrub and grassland. The radiocarbon dates suggest that this phase falls within the early Holocene, but the nature of the vegetation and the sediment could be seen as typical of a Lateglacial landscape. Woodland taxa, in the form of *Corylus* and *Betula*, invaded the area around 9320 BP (10590 cal BP) and woodland extent was greatest around 8550 BP (9530 cal BP) when arboreal pollen frequencies reach 75% TLP. By 7910 BP (8780 cal BP), however, the trees and shrubs were in decline, possibly because the valley mire was expanding. The woodland did not disappear altogether from the surrounding area, and may even have become more diverse between 6070 and 5060 BP (6870-5820 cal BP), with *Pinus* possibly growing locally in small stands or as scattered individuals. The local vegetation around the coring site may have been dominated alternately by *Calluna vulgaris*, Poaceae and Cyperaceae. The first evidence for the impact of people at the site could be the appearance of *Plantago lanceolata* pollen at around 4920 BP (5630 cal BP), although other anthropogenic indicator species were scare at this time, and charcoal values remain low. The first evidence for cereals does not appear until 950 BP (860 cal BP) and it is possible that during the previous 4 millennia the area was primarily used for grazing.

Chapter 8

LOCH AIRIGH NA H-ACHLAIS

8.1 Location

Loch Airigh na h-Achlais (NGR NF 808388) is a small loch located along the road leading to the harbour of Lochskipport, on the eastern side of South Uist. The loch, at a height of 25 m OD, lies at the foot of two substantial hills: Ben Tarbert (168 m OD) and Glac a' Bhodaich (*c.* 130 m OD) to the north of the site. Immediately to the south the land is flatter and dotted with small lochs. The nearest reach of the east coast, in the form of the sea loch of Loch Skipport, is about 2.5 km away. To the southwest of the site lies the National Nature Reserve of Loch Druidibeg, which includes islands with some of the few remaining sites with natural or semi-natural woodland in the Outer Hebrides. There are no known prehistoric sites in the immediate area.

The present-day vegetation around the loch is dominated by *Calluna vulgaris*, but also includes Poaceae spp., Cyperaceae spp. (including *Eriophorum vaginatum* and *E. angustifolium*), *Potentilla* spp. *Polygala serpyllifolia*, *Drosera rotundifolia*, *D. intermedia*, *Prunella vulgaris*, *Dactylorhiza* spp., *Pinguicula vulgaris*, and *Pteridium aquilin um. Sphagnum* spp. can be found growing in wetter areas around the loch.

The surface area of the loch measures *c.* 2.3 ha (approximately 150 m x 200 m at its widest points). Two streams flow into the loch from the north and northwest respectively, and there is an outflow towards the southeast (Fig. 8.1). The streams, which have a combined catchment area of *c.* 0.4 km^2, are likely to bring in pollen from vegetation growing on the hill-sides to the north of the site, adding an extra-local pollen component to the airborne regional and long distance component deposited in the loch itself (see section 5.1).

A core was extracted from about halfway between the northern and southern banks of the loch, and one third of the way from the eastern side. The water depth at

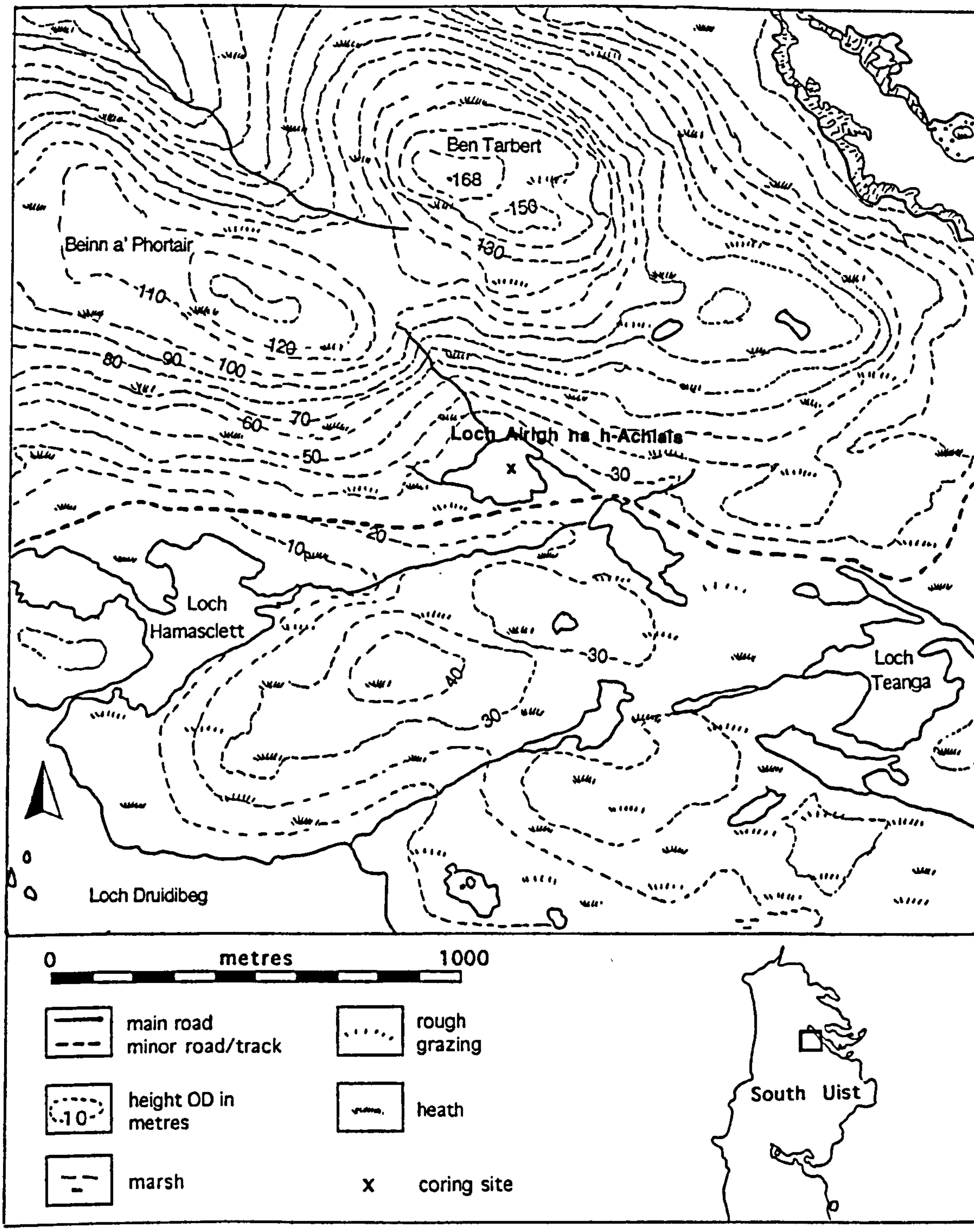


Fig. 8.1 Loch Airigh na h-Achlais and surrounding area

the coring site was approximately 118 cm.

8.2 The profile

A 345 cm long core was extracted (125-470 cm below water level), leaving approximately 7 cm of unsampled surface muds. The sedimentary record was described in the laboratory as follows:

125-468 cm Brown gyttja

468-470 cm Green-grey clay

8.3 Radiocarbon dates

Five conventional radiocarbon dates were obtained from the profile, which are listed below:

Lab. no.	Depth (cm)	^{14}C dates (BP)	Calibrated dates (1 σ)
GU-4816	187-197	1480±70	1410-1300 cal BP; 540-650 cal AD
GU-4815	223-233	3200±120	3570-3270 cal BP; 1620-1320 cal BC
GU-4814	259-269	4860±140	5730-5470 cal BP; 3780-3520 cal BC
GU-4813	363-373	7610±220	8600-8180 cal BP; 6650-6230 cal BC
GU-4812	443-453	9910±130	11550-11200 cal BP; 9600-9250 cal BC

Despite the large standard deviation values, the central values of the radiocarbon dates permitted the construction of a satisfactorily linear time-depth curve (Fig. 8.2).

8.4 Preservation

Frequencies of deteriorated grains vary between 5.6% and 53.1%, and on average 20.1% of the pollen grains in each sample showed some sign of deterioration, of which corrosion was the most common form. Corroded *Betula*, *Corylus* and *Calluna* grains were frequent throughout the profile, and were particularly prominent in zones LAA-6 and LAA-7. Total corroded pollen percentages reached a maximum of 48.2% at 150 cm. Corroded *Empetrum nigrum*-type pollen grains were also common in the two lowest levels of the profile. *Pinus*

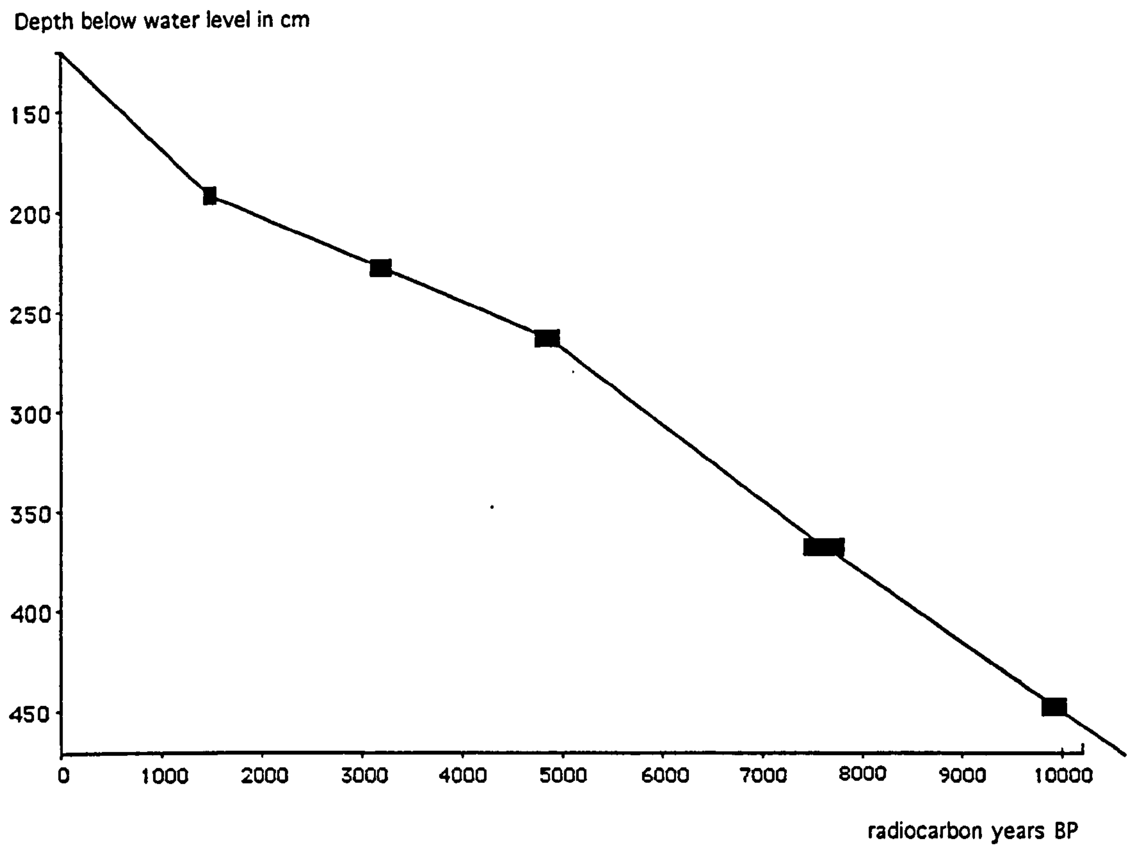


Fig. 8.2 Loch Airigh na h-Achlais: time-depth curve

grains tended to be broken, but in general the number of broken or crumpled grains in the profile was low.

8.5 Local pollen zones

Aided by constrained cluster analysis (CONISS; Grimm, 1987) the pollen percentage diagram at Loch Airigh na h-Achlais was divided into 7 local pollen zones, with zone LAA-6 divided into 2 subzones. These zones are described as follows:

LAA-1

469-464 cm 10540-10400 BP

Percentage diagram (Fig. 8.3)

The basal zone is dominated by *Empetrum nigrum*-type pollen, which reaches a maximum of 83% TLP at the bottom of the zone, before declining to 56% at the top. Arboreal percentages are low (5%–17%) and include *Betula*, *Pinus* and *Salix*. *Corylus avellana*-type is recorded for the first time at 469 cm. Poaceae frequencies are between 6% and 8%, while Cyperaceae values (up to 13%) are the highest for the diagram. Quantities of other herb taxa are low but include *Cichorium intybus*-type, *Filipendula*, *Rumex acetosa,* and *Ranunculus acris*-type. Common spore taxa include *Huperzia selago* and *Pteridium aquilinium*, while *Selaginella selaginoides* and Pteropsida (monolete) indet. appear in low frequencies. *Sphagnum* appears for the first time at 466 cm. Aquatic frequencies, consisting almost entirely of *Myriophyllum alterniflorum*, rise from 2% to 21%.

Concentration and accumulation rate diagrams (Fig. 8.4 and 8.5)

Total pollen and spore concentrations range from 3.9 to 8.1 x10^4 grains cm^{-3} (mean 6 x10^4 grains cm^{-3}) in this zone, while accumulation rates vary between 1191 and 2461 grains cm^{-2} $year^{-1}$ (mean 1830 grains cm^{-2} $year^{-1}$). These values are high when compared to the rest of the diagram.

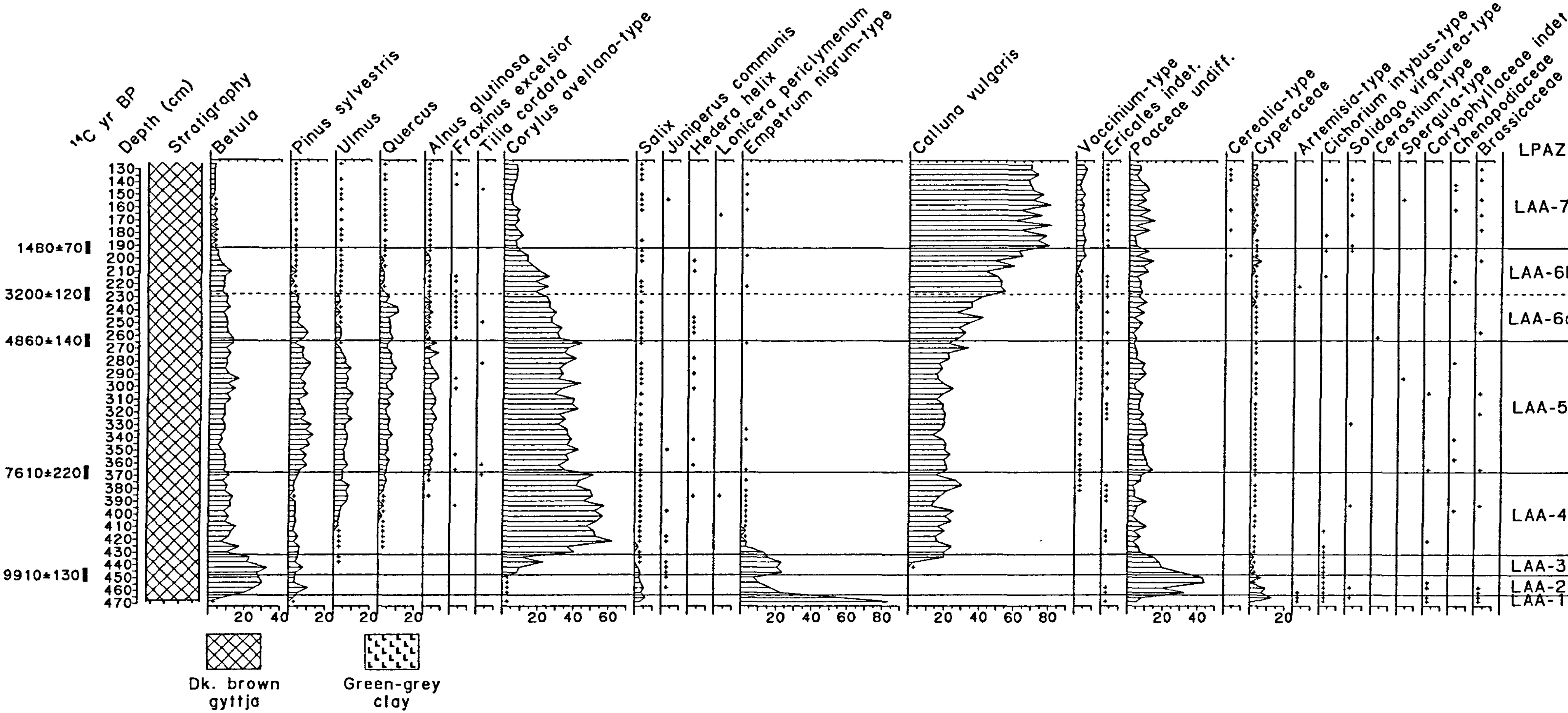


Fig. 8.3 Pollen and spore percentage diagram from Loch Airigh na h-Achlais (+ = <2%). Shaded curves are exaggerated x10.

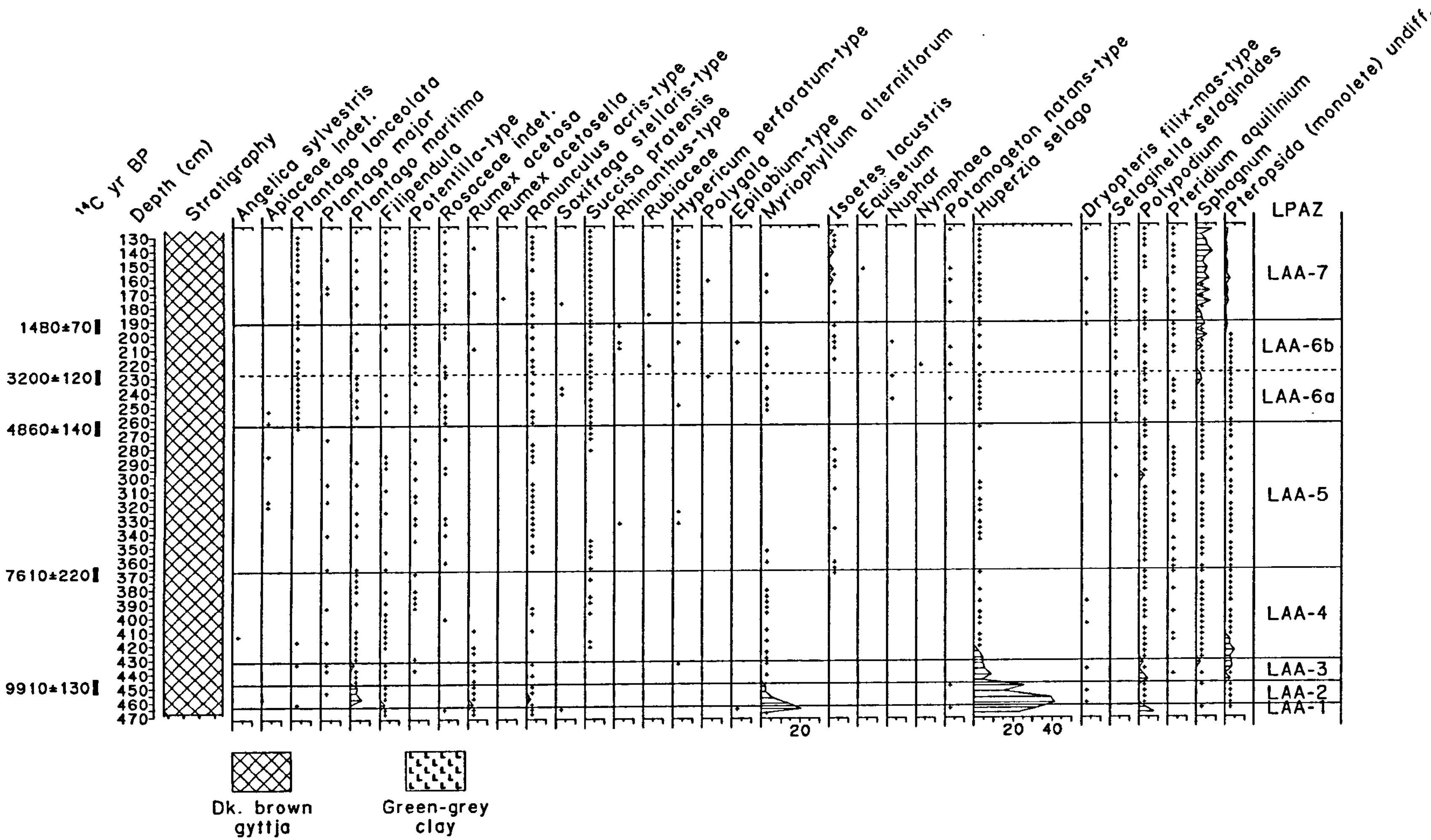


Fig. 8.3 (continued)

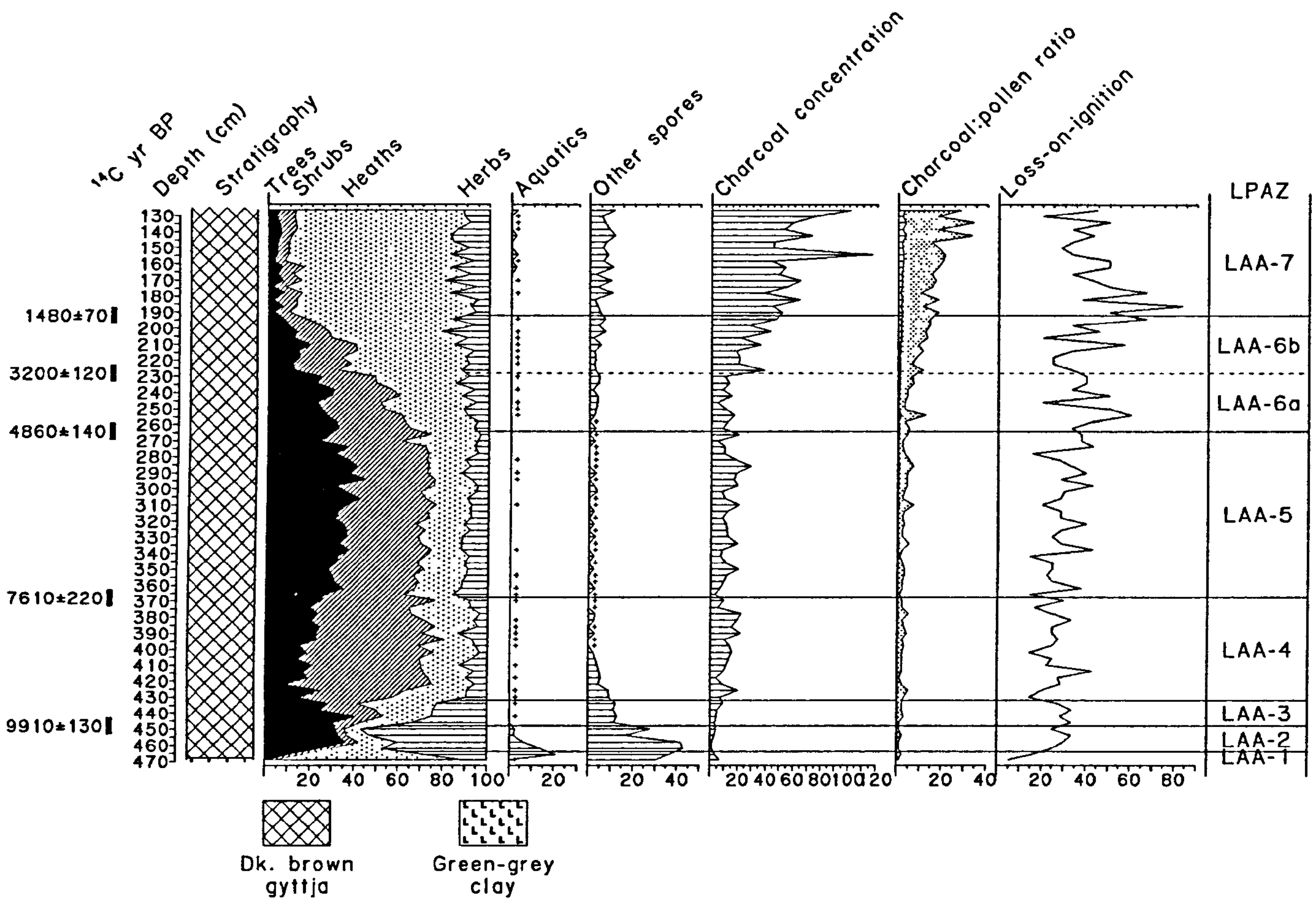


Fig. 8.3 (continued)

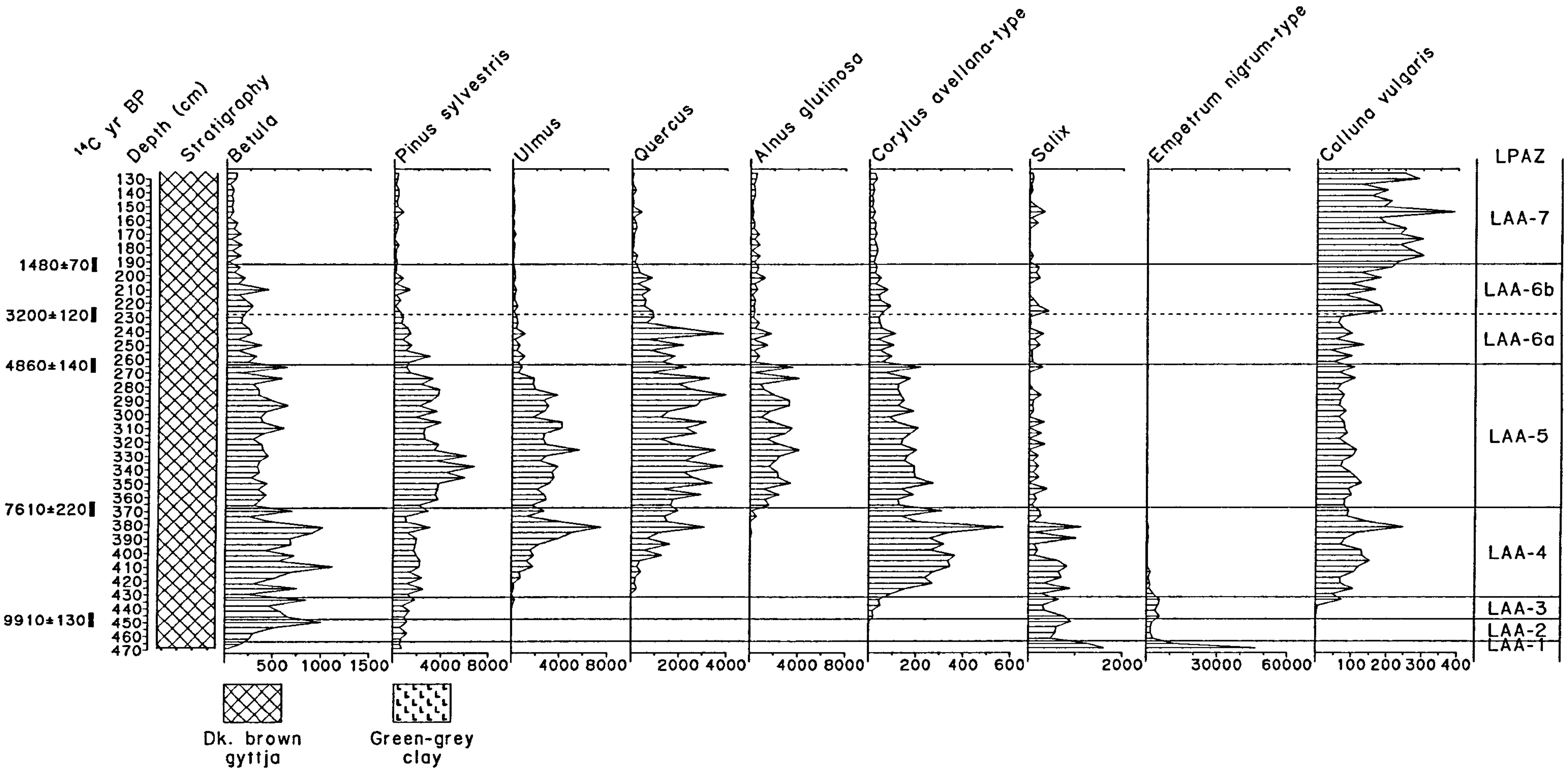


Fig. 8.4 Pollen and spore concentrations (grains cm^{-3}) and charcoal concentrations (cm^2 cm-3) at Loch Airigh na h-Achlais. Selected taxa. Shaded curves are exaggerated x10. Note the variable horizontal scale.

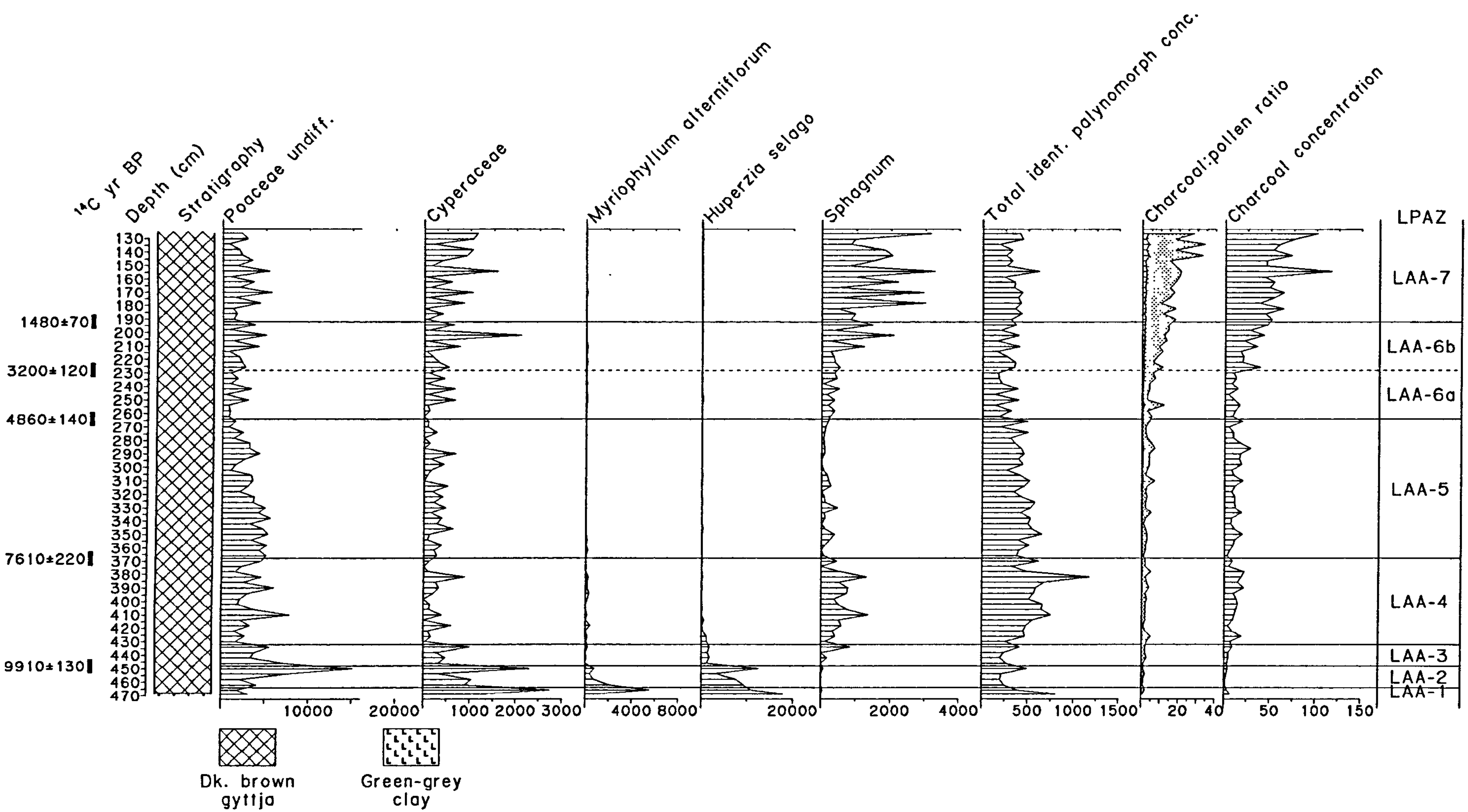


Fig. 8.4 (continued)

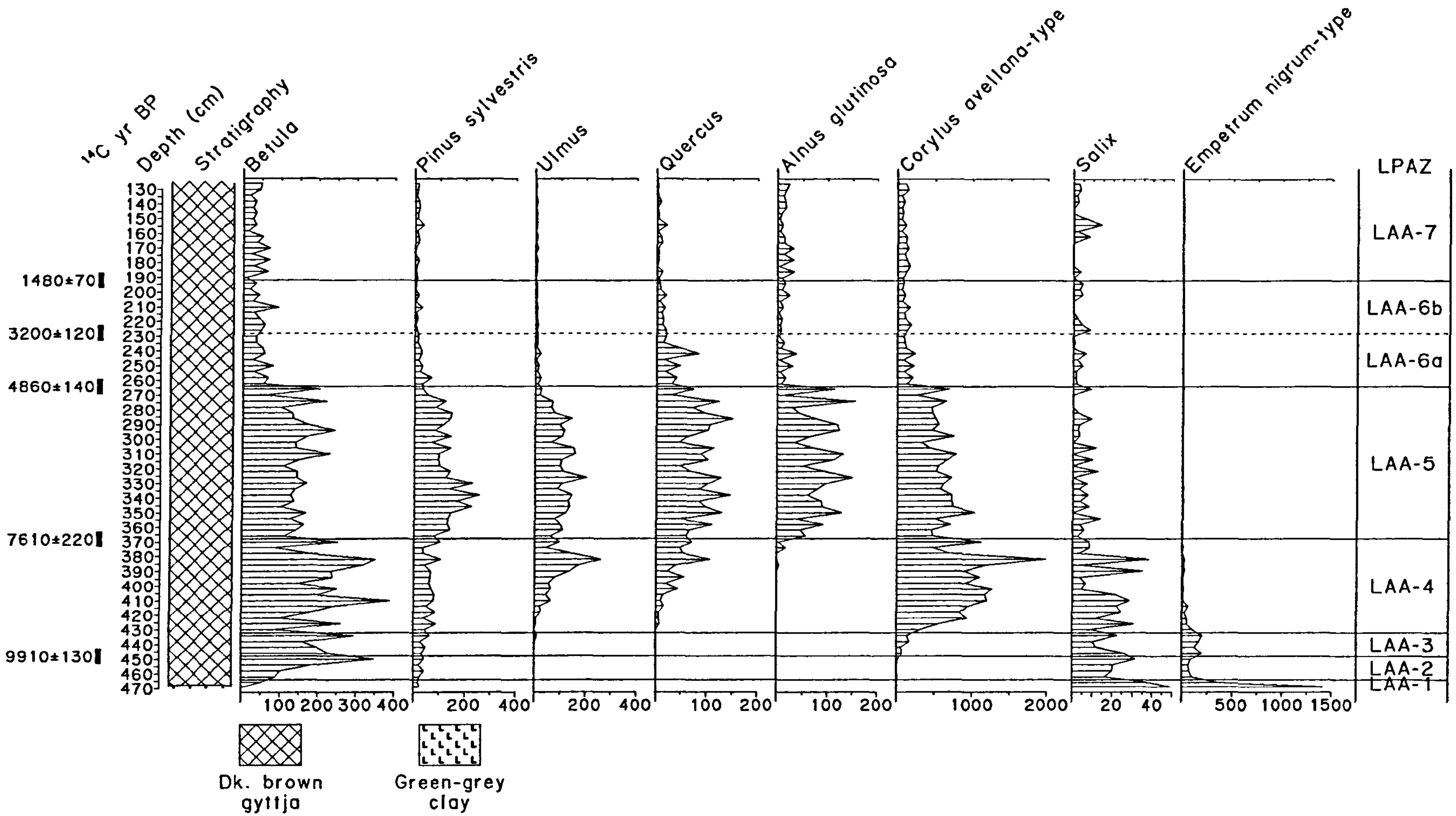


Fig. 8.5 Pollen and spore accumulation rates (grains cm^{-2} yr^{-1}) and charcoal accumulation rates (cm^2 cm^{-3} yr^{-1}) at Loch Airigh na h-Achlais. Selected taxa. Shaded curves are exaggerated x10. Note the variable horizontal scale.

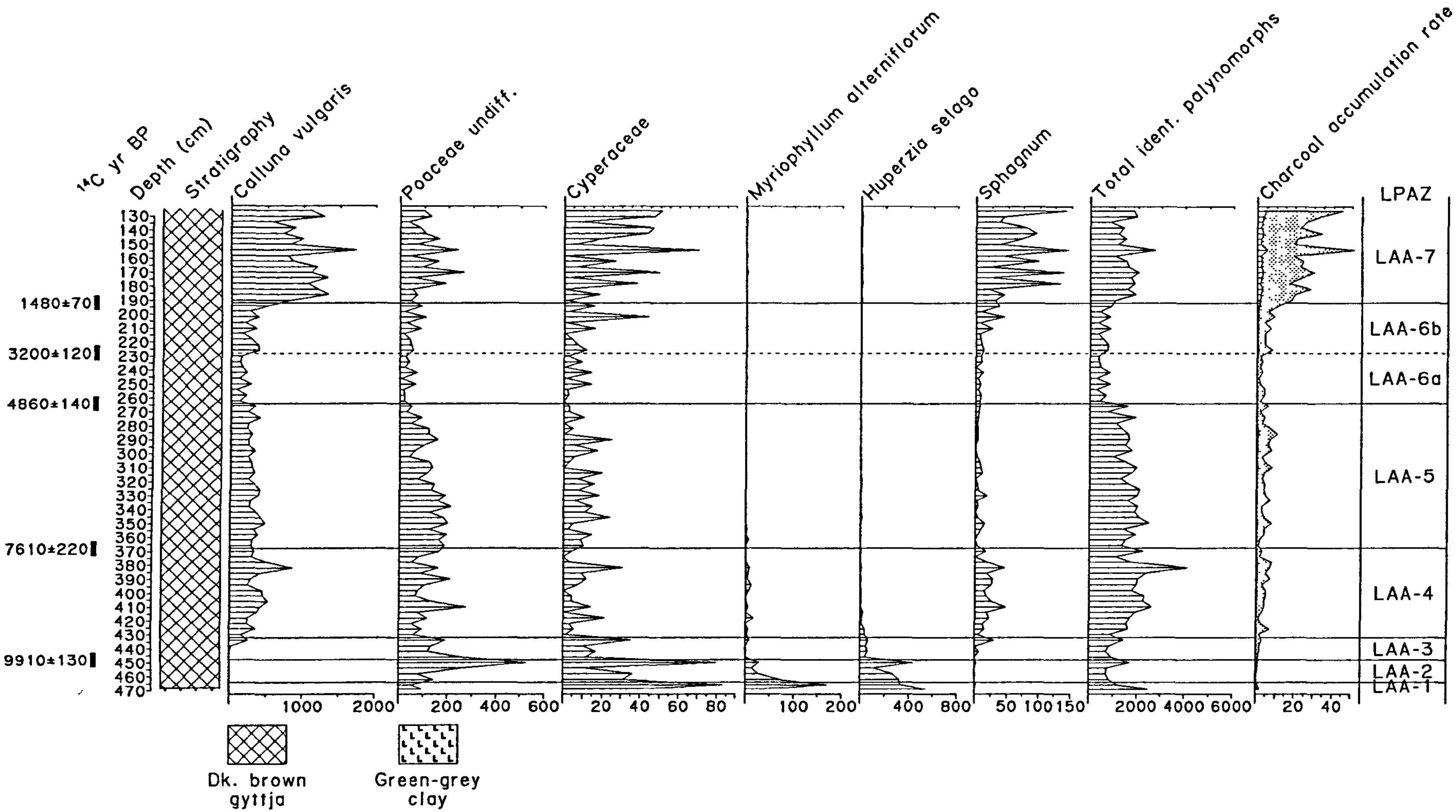


Fig. 8.5 (continued)

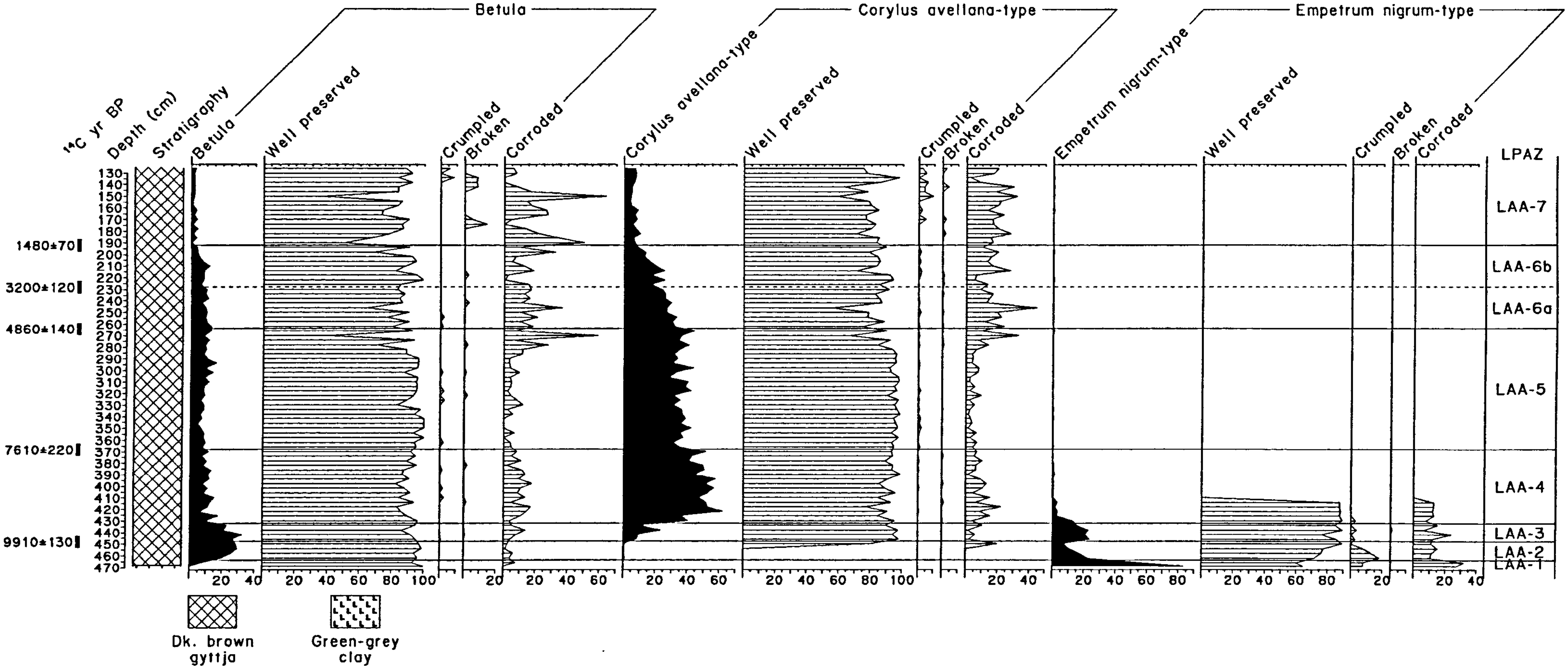


Fig. 8.6 Preservation diagram for major pollen types and TLP at Loch Airigh na h-Achlais. The black silhouettes are expressed as %TLP, the other graphs are a percentage of the individual taxa.

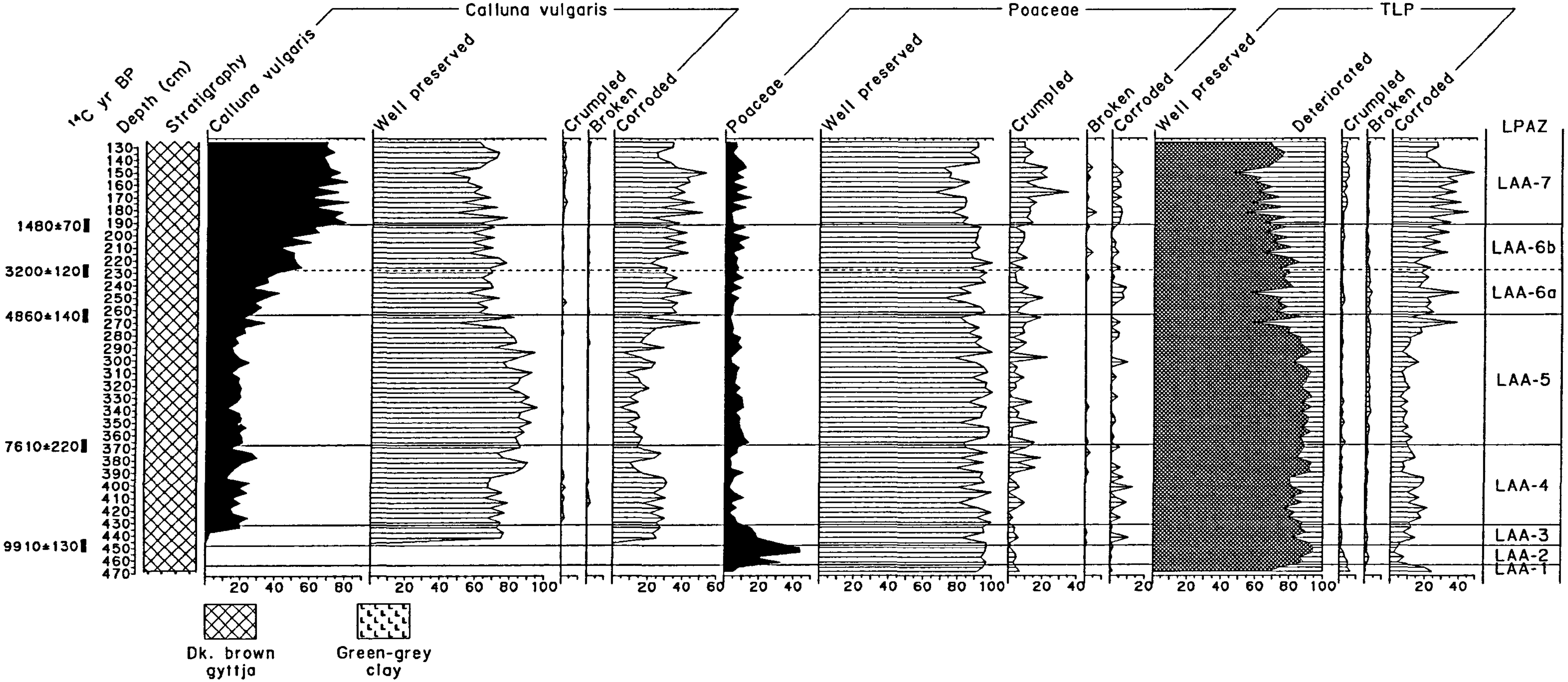


Fig. 8.6 (continued)

Charcoal (Fig. 8.4 and 8.5)

Charcoal values are very low. The mean value for charcoal concentrations is 5.3×10^{-4} cm^2 cm^{-3}, while charcoal accumulation rates range from 1.1 to 2.2×10^{-5} cm^2 cm^{-2} $year^{-1}$.

Loss-on-ignition (Fig. 8.3)

Loss-on-ignition values range from 5% at the bottom to 15% at the top of the zone, the lowest for the diagram.

Deterioration diagram (Fig. 8.6)

Deterioration values are quite high. Between 24% and 32% of the pollen grains counted show some sign of deterioration, including a considerable number of corroded *Empetrum nigrum*-type pollen grains (up to 32% of total *Empetrum* grains), and a few grains of corroded and broken *Pinus* and crumpled Poaceae grains.

LAA-2

464-448 cm 10400-9910 BP

Percentage diagram

Zone 2 is characterised by a decrease in *Empetrum nigrum*-type pollen to 7%, and a rise in the frequencies of Poaceae and tree pollen, in particular *Betula*, which reaches 42% at 458 cm. *Pinus* also increases, and *Corylus avellana*-type and *Juniperus communis* are present in low numbers (<1%). Poaceae rises from 20% to 44% by the top of the zone, while Cyperaceae falls slightly (maximum 9%). Other herb taxa include *Plantago maritima*, *Filipendula*, *Rumex acetosa*, *Ranunculus acris*-type and *Cichorium intybus*-type. *Huperzia selago* spores reach their highest level in this zone (42%). *Polypodium* and Pteropsida (monolete) indet. spores are also present, and *Sphagnum* and *Dryopteris filix-mas*-type spores appear sporadically. Aquatic frequencies, still made up almost entirely of *Myriophyllum alterniflorum* spores, decrease steadily to 2%.

Concentration and accumulation rate diagrams

Total pollen and spore concentrations are on average lower than in the previous zone, falling to 2×10^4 grains cm^{-3} by 458 cm, before reaching 4.9×10^4 grains cm^{-3} by the top of the zone. Accumulations rates are also lower on average, ranging from 698 to 1732 grains cm^{-2} $year^{-1}$.

Charcoal

Charcoal values are lower than in zone LAA-1. The mean value for charcoal concentrations is 2.3×10^{-4} cm^2 cm^{-3}, and charcoal accumulations range from 0.3 to 1.4×10^{-5} cm^2 cm^{-2} $year^{-1}$.

Loss-on-ignition

Loss-on-ignition frequencies are higher than in the previous zone, fluctuating between 25 and 33.3%.

Deterioration

Between 6% and 14% of pollen grains were deteriorated, consisting primarily of corroded *Empetrum nigrum*-type and *Betula* grains, as well as some broken *Pinus sylvestris* and crumpled Poaceae grains.

LAA-3

448-432 cm 9910-9450 BP

Percentage diagram

This zone is characterised by a rise in *Corylus avellana*-type and *Calluna vulgaris*, as well as a resurgence in *Empetrum nigrum*-type pollen. Arboreal frequencies in general continue to rise, reaching almost 53% at 442 cm. *Corylus avellana*-type pollen increases in frequency starting at 446 cm, and reaches 20% by 438 cm. *Ulmus* appears for the first time at 438 cm, and then occurs sporadically, as does *Juniperus communis* . *Empetrum* values increase to 23%, before declining to 16%. *Calluna vulgaris* pollen appears for the first time at 442 cm, and rises quickly to 20% by the top of the zone. Poaceae decreases to 15% during this phase and Cyperaceae frequencies also continue to decrease. *Cichorium intybus*-type, *Plantago major* and *Filipendula* were also recorded. Frequencies of *Huperzia selago* decline to 4%, while *Polypodium* and Pteropsida indet. are quite common. *Sphagnum* decreases, and *Pteridium* and *Dryopteris filix-mas*-type spores are recorded in low numbers. Occasional grains of *Myriophyllum alterniflorum* make up the very low quantities of aquatic taxa.

Concentration and accumulation rate diagrams

Total pollen and spore concentrations are similar to the previous zone, ranging between 4.2 and 2 $x10^4$ grains cm^{-3}, while accumulation rates fluctuate between 699 and 1461 grains cm^{-2} $year^{-1}$.

Charcoal

The charcoal curves remain quite low: a mean value of 5.7×10^{-4} cm^2 cm^{-3} for charcoal concentrations, while accumulation rates range from 1.2 to 3.1×10^{-5} cm^2 cm^{-2} $year^{-1}$.

Loss-on-ignition

Loss-on-ignition frequencies range from 27% to 33.3%, similar to the previous zone.

Deterioration

Between 8 and 18% of all pollen grains were found to be affected by deterioration. Corroded *Empetrum*, *Betula*, and, at the top of the zone *Corylus*, as well as broken *Pinus* and crumpled Poaceae made up most of the deteriorated grains.

LAA-4

430-368 cm 9450-7610 BP

Percentage diagram

Zone LAA-4 is characterised by high frequencies of tree and shrub pollen, reaching a maximum of 82%, the highest for the profile. This is primarily due to a strong increase in *Corylus avellana*-type pollen which reaches its highest level (62%) in this zone. *Pinus* and *Betula* values are slightly lower than in the previous zone, while *Ulmus* expands to reach over 8% at 374 cm. *Quercus* pollen appears for the first time at 426 cm and *Alnus* at 386 cm. *Salix* falls to less than 2%, and *Empetrum* frequencies fall to negligible values. *Calluna* frequencies fluctuate between 13% and 30%. *Plantago maritima* remains common among the herb taxa, and *Plantago lanceolata* was also recorded. *Huperzia selago* falls from 4% to nil. Pteropsida, *Sphagnum* and *Polypodium* feature among the spores. Aquatic values remain low, and include *Isoetes lacustris*.

Concentration and accumulation rate diagrams

Total pollen and spore concentrations increase, reaching a peak of 11.8 $x10^4$ grains cm^{-3} (mean 7.2 $x10^4$ grains cm^{-3}). Accumulation rates also rise, to between 884 and 2491 grains cm^{-2} $year^{-1}$ at 382 cm, the highest for the profile.

Charcoal

Charcoal concentrations increase slightly to a mean value of 12.7 x 10^{-4} cm^2 cm^{-3}, as do charcoal accumulation rates (1.4 to 7.8 x 10^{-5} cm^2 cm^{-2} $year^{-1}$).

Loss-on-ignition

Loss-on-ignition values fluctuate quite strongly, between 14 and 43%.

Deterioration

Between 7 and 20% of pollen grains were found to be deteriorated, consisting primarily of corroded *Betula*, *Corylus* and *Calluna vulgaris*, as well as a few broken and corroded *Pinus* grains.

LAA-5

368-264 cm 7610-4860 BP

Percentage diagram

Arboreal pollen percentages remain high, but frequencies of *Corylus avellana*-type pollen fall, while other tree and shrub taxa increase in abundance. *Pinus* increases to reach a maximum of 12%. *Ulmus* and *Quercus* values are also relatively high, reaching maxima of 10% and 9% respectively, before *Ulmus* drops to less than 2% by the top of the zone. The *Alnus* curve rises to 8%. Poaceae values are slightly higher than in the previous zone (maximum 14% at 366 cm), and Cyperaceae remain scarce. The *Plantago lanceolata* curve becomes continuous from 366 cm onwards. Among the spores, *Polypodium*, *Pteridium* and Pteropsida are well represented, while *Sphagnum* and *Huperzia* are more rare. Aquatic values are very low, and only *Isoetes lacustris* and *Myriophyllum alterniflorum* are occasionally recorded.

Concentration and accumulation rate diagrams

Total pollen and spore concentrations range between 1.9 and 6.5 $x10^4$ grains cm^{-3}, and accumulation rates between 737 and 2481 grains cm^{-2} $year^{-1}$, in both cases lower than in the previous zone.

Charcoal

Charcoal concentrations (mean value 12.6 x 10^{-4} cm^2 cm^{-3}) are slightly higher than those in zone LAA-4, as are accumulation rates, which rise from 1.2 x 10^{-5} cm^2 cm^{-2} $year^{-1}$ at the bottom of the zone to 10.9 x 10^{-5} cm^2 cm^{-2} $year^{-1}$ towards the top.

Loss-on-ignition

Loss-on-ignition values are similar to those in zone LAA-4, fluctuating between 14 and 43%.

Deterioration

Between 7 and 41% of all pollen grains were deteriorated, on average slightly more than in the previous zone. A peak of deteriorated pollen occurred at 270 cm, where 59% of *Betula*, 33% of *Corylus*, and 50% of *Calluna vulgaris* grains were found to be corroded.

LAA-6a

264-228 cm 4860-3200 BP

Percentage diagram

Arboreal pollen frequencies start to decline, from 64% at the bottom of the subzone to 49% at the top. This is primarily due to a decline in *Corylus avellana*-type pollen from 33% to 24%. *Betula*, *Pinus* and *Quercus* values remain quite high, but *Ulmus* and *Alnus* decrease to 1.4% and 1.3% respectively. *Calluna vulgaris* pollen rises steadily to 42%, and *Vaccinium*-type is now also more commonly recorded. Poaceae levels are similar to the previous zone (5-10%), while Cyperaceae remains low (< 3%). Other herb taxa include *Plantago lanceolata*, *P. maritima*, *Ranunculus acris*-type, Rosaceae indet. and *Succisa pratensis*. *Sphagnum* increases slightly, while aquatic taxa include sporadic occurrences of *Myriophyllum alterniflorum*, *Nuphar* and *Potamogeton*.

Concentration and accumulation rate diagrams

Total pollen and spore concentrations (1.3 - 3.9 x10^4 grains cm^{-3}), are considerably lower than in the previous zone, as are the accumulation rates (289 - 853 grains cm^{-2} year^{-1}).

Charcoal

Charcoal concentrations are slightly increased (mean value of 10.6 x 10^{-4} cm^2 cm^{-3}), but charcoal accumulation rates decline, to between 0.9 and 4.4 x 10^{-5} cm^2 cm^{-2} $year^{-1}$.

Loss-on-ignition

Loss-on-ignition values are on average slightly higher than in the previous zone (20–60%).

Deterioration

Levels of deterioration were quite high in this subzone (18–44%). A peak in deterioration levels was reached at 246 cm, where 45% of *Calluna vulgaris*, 44% of *Corylus*, and 36% of *Betula* grains were found to be corroded. Broken and corroded *Pinus* and crumpled Poaceae grains were also recorded.

LAA-6b
228-192 cm 3200-1480 BP

Percentage diagram

Subzone 6b sees a fall in arboreal pollen frequencies to 18%.Virtually all tree and shrub taxa are now involved in the decline. *Calluna vulgaris* values increase significantly, reaching a peak of 65% at 198 cm, and the *Vaccinium*-type curve rises to over 5%. Poaceae and Cyperaceae also increase slightly, to 14% and 6% respectively, while other common herb taxa include *Succisa pratensis*, *Plantago lanceolata* and *Potentilla*. Cerealia-type pollen appears for the first time at 198 cm. The *Sphagnum* curve continues to rise slightly. Aquatic frequencies remain low, and include *Isoetes lacustris* and *Nymphaea*.

Concentration and accumulation rate diagrams

Total pollen and spore concentrations range from 1.5 to 4 x10^4 grains cm^{-3}, while accumulation rates are between 331 and 881 grains cm^{-2} $year^{-1}$, similar to the values in the previous subzone.

Charcoal

Charcoal concentrations increase to between 17.4 and 46.8 x 10^{-4} cm^2 cm^{-3}. Accumulation rates increase from 3.7 x 10^{-5} cm^2 cm^{-2} $year^{-1}$ to 11.3 x 10^{-5} cm^2 cm^{-2} $year^{-1}$ at the top of the subzone.

Loss-on-ignition

Loss-on-ignition values fluctuate between 20% and 66.7.

Deterioration

Between 14% and 36% of pollen grains were found to be deteriorated in this subzone. Corroded grains of *Betula*, *Corylus* and *Calluna vulgaris* were particularly common, and crumpled Poaceae pollen grains were also recorded.

LAA-7

195-125 cm 1480-0 BP

Percentage diagram

By the uppermost zone of the profile arboreal pollen frequencies have fallen to very low levels (8-16% TLP). All tree and shrub taxa are in decline, and *Pinus*, *Ulmus* and *Quercus* disappear from the record before the top of the zone. *Calluna vulgaris* now dominates, exceeding 60% in all levels, and reaching over 80% at its peak at 158 cm. *Vaccinium-type* continues to rise, reaching its highest levels for the profile (6%). The *Plantago lanceolata* curve is virtually continuous, but frequencies remain low. *Potentilla*-type, *Hypericum perforatum*-type and *Succisa pratensis* are among the more commonly recorded herb taxa. *Sphagnum* increases to over 8%, its highest level in the profile. *Selaginella selaginoides* and Pteropsida (monolete) indet. also feature prominently. Aquatics increase slightly, and *Isoetes lacustris* in particular becomes more important. *Potamogeton*, *Myriophyllum alterniflorum* and

Equisetum were also recorded.

Concentration and accumulation rate diagrams

Total pollen and spore concentrations rise to a maximum of 6.1 $x10^4$ grains cm^{-3} (mean 4 $x10^4$ grains cm^{-3}), while accumulation rates range between 823 and 2723 grains cm^{-2} $year^{-1}$ (mean 1586 grains cm^{-2} $year^{-1}$).

Charcoal

The charcoal values are higher than in any other zone. The highest charcoal concentrations (116.5×10^{-4} cm^2 cm^{-3}) and accumulation rates (51.8×10^{-5} cm^2 cm^{-2} $year^{-1}$) were recorded at 154 cm.

Loss-on-ignition

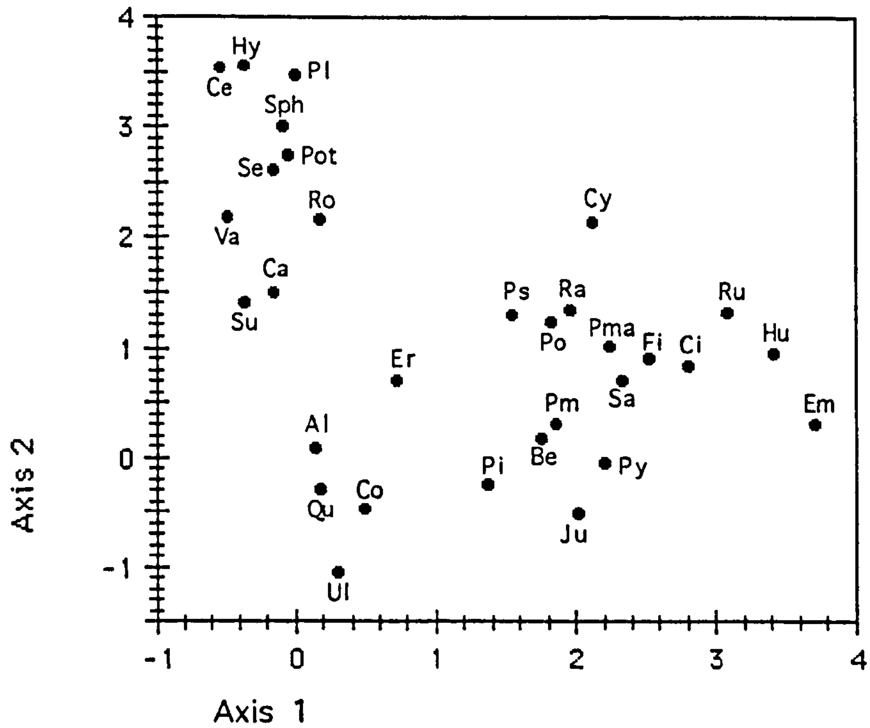
Loss-on-ignition values fluctuate between 20 and 83%.

Deterioration

Deterioration levels range from 22% to 53%. Most of the deteriorated grains consisted of corroded *Calluna vulgaris* and, to a lesser extent, crumpled Poaceae.

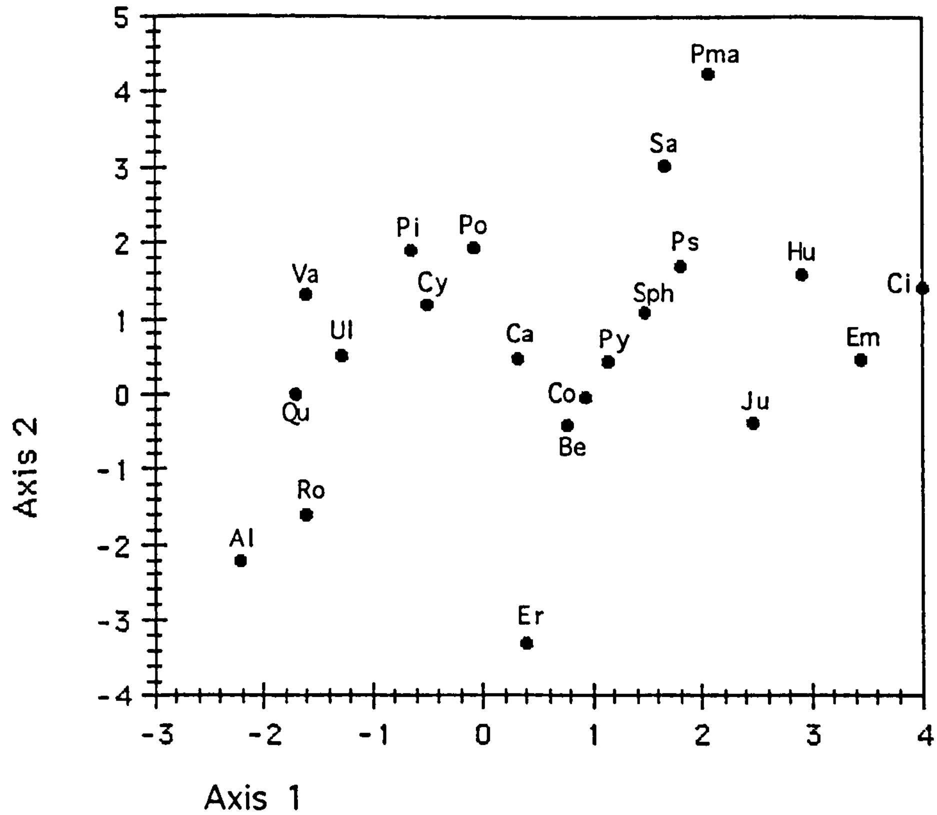
8.6 Detrended Correspondence Analysis (DCA)

DCA was used to inform general trends in the vegetation patterns at Loch Airigh na h-Achlais. Figure 8.7 reflects the changes in the local environment throughout the profile, and in general confirms the trends described in this chapter. There are three clusters in the graph: towards the middle right of the plot are taxa of the Lateglacial and very early Holocene environments (such as *Empetrum nigrum*-type, *Huperzia selago*, *Rumex acetosa* and *Cichorium intybus*-type), generally reflecting open vegetation and disturbed ground. Towards the middle there is a cluster of trees and shrubs that were prominent in the early Holocene (e.g. *Betula*, *Pinus* and *Salix*), and to the left of these are arboreal taxa that were more prominent at a later date (e.g. *Alnus*, *Quercus*, *Ulmus* and *Corylus*). Towards the top left are



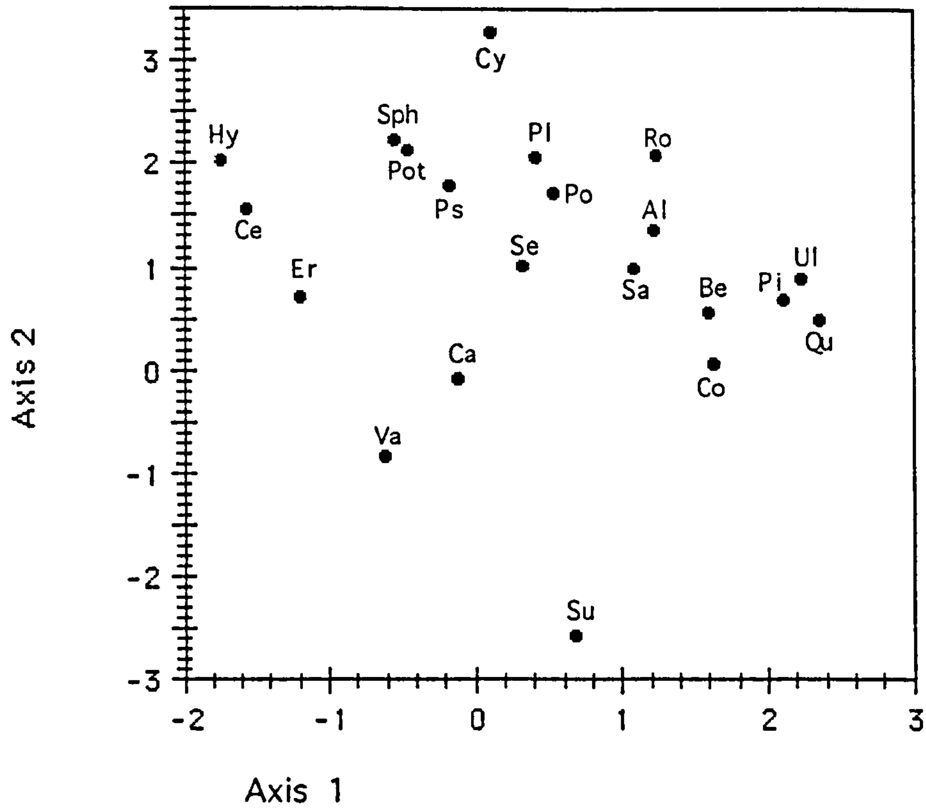
Key:
(Al) *Alnus*; (Be)*Betula*; (Ca) *Calluna vulgaris*; (Ce) Cerealia-type; (Ci) *Cichorium intybus*-type; (Co) *Corylus avellana*-type; (Cy) Cyperaceae; (Em) *Empetrum nigrum*-type; (Er) Ericales indet.; (Fi) *Filipendula*; (Hu) *Huperzia selago*; (Hy) *Hypericum perforatum*-type; (Ju) *Juniperus communis*; (Pi) *Pinus sylvestris*; (Pl) *Plantago lanceolata*; (Pm) *Plantago major*, (Pma) *Plantago maritima*; (Po) Poaceae; (Pot) *Potentilla*-type; (Pt) *Pteridium aquilinium*; (Ps) Pteropsida (monolete) indet.; (Py) *Polypodium*; (Qu) *Quercus*; (Ra) *Ranunculus acris*-type; (Ro) Rosaceae indet.; (Ru) *Rumex acetosa*; (Sa) *Salix*; (Se) *Selaginella selaginoides*; (Sph) *Sphagnum*; (Su) *Succisa pratensis*; (Ul) *Ulmus*; (Va) *Vaccinium*-type.

Fig. 8.7 Loch Airigh na h-Achlais: DCA, entire profile



Key:
(Al) *Alnus*; (Be)*Betula*; (Ca) *Calluna vulgaris*; (Ce) Cerealia-type; (Ci) *Cichorium intybus*-type; (Co) *Corylus avellana*-type; (Cy) Cyperaceae; (Em) *Empetrum nigrum*-type; (Er) Ericales indet.; (Fi) *Filipendula*; (Hu) *Huperzia selago*; (Hy) *Hypericum perforatum*-type; (Ju) *Juniperus communis*; (Pi) *Pinus sylvestris*; (Pl) *Plantago lanceolata*; (Pm) *Plantago major*, (Pma) *Plantago maritima*; (Po) Poaceae; (Pot) *Potentilla*-type; (Pt) *Pteridium aquilinium*; (Ps) Pteropsida (monolete) indet.; (Py) *Polypodium*; (Qu) *Quercus*; (Ra) *Ranunculus acris*-type; (Ro) Rosaceae indet.; (Ru) *Rumex acetosa*; (Sa) *Salix*; (Se) *Selaginella selaginoides*; (Sph) *Sphagnum*; (Su) *Succisa pratensis*; (Ul) *Ulmus*; (Va) *Vaccinium*-type.

Fig. 8.8 Loch Airigh na h-Achlais: DCA, bottom of profile, excluding Lateglacial (432-264 cm)



Key:
(Al) *Alnus*; (Be)*Betula*; (Ca) *Calluna vulgaris*; (Ce) Cerealia-type; (Ci) *Cichorium intybus*-type; (Co) *Corylus avellana*-type; (Cy) Cyperaceae; (Em) *Empetrum nigrum*-type; (Er) Ericales indet.; (Fi) *Filipendula*; (Hu) *Huperzia selago*; (Hy) *Hypericum perforatum*-type; (Ju) *Juniperus communis*; (Pi) *Pinus sylvestris*; (Pl) *Plantago lanceolata*; (Pm) *Plantago major*; (Pma) *Plantago maritima*; (Po) Poaceae; (Pot) *Potentilla*-type; (Pt) *Pteridium aquilinium*; (Ps) Pteropsida (monolete) indet.; (Py) *Polypodium*; (Qu) *Quercus*; (Ra) *Ranunculus acris*-type; (Ro) Rosaceae indet.; (Ru) *Rumex acetosa*; (Sa) *Salix*; (Se) *Selaginella selaginoides*; (Sph) *Sphagnum*; (Su) *Succisa pratensis*; (Ul) *Ulmus*; (Va) *Vaccinium*-type.

Fig. 8.9 Loch Airigh na h-Achlais: DCA, top of profile (264 cm - top) encountered taxa of heathland (such as *Vaccinium*-type and *Calluna vulgaris*) and mire (e.g. *Sphagnum* and *Potentilla*-type), which dominated during the second half of the Holocene. Also in this cluster are Cerealia-type and *Plantago lanceolata*, taxa which could be indicative of anthropogenic impact .

Figure 8.8 covers the tree and shrub phase in the profile. Remnants of the Lateglacial open landscape (taxa such as *Juniperus*, *Cichorium intybus*-type, *Empetrum nigrum*-type and *Huperzia selago*) pull out to the right of the ordination plot. To their left is a small cluster of taxa that tend to occur in wet conditions (such as *Sphagnum* and *Salix*), along with *Polypodium* and Pteropsida (monolete) indet. The left side of the diagram is dominated by tree and shrub taxa, together with taxa that may have formed a woodland understorey or grown between patches of trees at this time (e.g. *Calluna vulgaris*, Poaceae, Rosaceae indet.).

Finally, Figure 8.9 shows the last phase at Loch Airigh na h-Achlais, following the decline in woodland taxa. The trees and shrubs tend to pull out to the right of the diagram. Taxa of wetter habitats, such as Cyperaceae, *Sphagnum* and *Potentilla*-type are found towards the top of the graph, while the heathland taxa are centre-left. Cerealia-type and *Hypericum perforatum*-type, taxa which appear primarily in zone LAA-7, appear towards the top left of the graph.

8.7 Inferred vegetation history

10540-9450 BP (*c.* 12590-10670 cal BP)

The record at Loch Airigh na h-Achlais starts during the Lateglacial, around 10540 BP (12590 cal BP). The vegetation in the basal levels was dominated by *Empetrum*, which reach a maximum of 83% at the start of this phase. Grasses and sedges were also present, although not very widespread. Frequencies of corroded *Empetrum* grains are quite high (up to 32% at 10430 BP [12400 cal BP]), suggesting that some of the *Empetrum* pollen may have eroded out of older sediments (cf. Edwards and Whittington, 1994), and grasses and sedges may have been more prominent than they appear from the diagram. Tree and shrub pollen values are generally very low, but *Betula* and *Salix* may have formed small patches of scrub in the area. *Juniperus communis* pollen is rare, and there is no evidence at this time for the local presence of juniper. Other typical Lateglacial taxa such as *Rumex acetosa* and *Cichorium intybus*-type were also present. *Huperzia selago*, and to a lesser extent *Polypodium*, were prominent and may have occupied nearby rocky slopes.

In many ways the vegetation at this time resembles that at the sites of Loch a' Phuinnd and Loch Lang (Fossitt, 1996; Bennett *et al.*, 1990). At Loch a'Phuinnd, where the pollen record starts much earlier at around 13,300 BP, *Empetrum nigrum*-type, *Huperzia selago*, *Rumex*, *Salix*, and *Polypodium* occurred during the Lateglacial, with *Empetrum* becoming more prominent after 10,900 BP (12940 cal BP) (Fossitt, 1996). At Loch Lang the record starts at around 10,900 BP (12940 cal BP), at which time, like at Loch a'Phuinnd, the vegetation was dominated by *Empetrum*, but also included grasses, sedges, *Huperzia selago*, *Rumex acetosa* and *Polypodium* (Bennett *et al.*, 1990).

Empetrum nigrum heathland decreased in extent from 10430 BP (12400 cal BP) onwards, as *Betula* and Poaceae began to expand, a change that can be seen in the percentage, concentration and accumulation rate diagrams. The transition from Lateglacial to Holocene conditions is marked by a rise in *Betula* (probably tree birch) to 20% around 10310 BP (12140 cal BP). At around the same time the sediment record shows a change from clay to gyttja, and loss-on-ignition values rise to 25%. This extrapolated date for the start of the Holocene is very early, although similar to that at Loch Airigh na h-Aon Oidhche (*c.* 10,340 BP [12400 cal BP]; Brayshay and Edwards, 1996), and there is a possibility that the lowermost radiocarbon date (9910$\pm$130 BP) is too old. Even if it is assumed to be accurate, the date has a large standard deviation, and the actual age of the sample may well be closer to the upper (younger) end of the range. The other possibility is that there was a certain amount of mixing of sediments in this part of the profile. This is not supported, however, by the loss-on-ignition values, which had already shown a signifcant rise at 10310 BP, or the deterioration frequencies, which are low, suggesting that there was little input of older pollen.

Between 10400 and 9910 BP (12340–11260 cal BP) herb-rich grassland and patches of *Betula* dominated the vegetation. *Empetrum* regenerated to a certain extent between 9850 and 9390 BP (11220-10620 cal BP) at the expense of Poaceae, creating a mosaic of heath and birch woodland, but by 8820 BP (9940 cal BP) *Empetrum* was no longer a component of the local vegetation. Birch reached its greatest extent (42%) at 9740 BP (11170 cal BP) after which it declined gradually as hazel moved in, although this is less obvious in the concentration and accumulation rate diagrams.

Salix scrub, never very extensive, started to contract from 10080 BP (11670 cal BP) onwards, and had soon disappeared from the local landscape. *Juniperus communis* pollen frequencies increase slightly, and it is possible that scattered juniper shrubs were growing locally along the woodland margin between 10200 BP and 9620 BP (11930-10960 cal BP). *Pinus* pollen frequencies are also comparatively high during this period, fluctuating between 3% and 10%. It is difficult, however, to interpret these figures as evidence of local pine growth, because it would suggest that pine arrived on South Uist by 10,000 BP (11410 cal BP), a date which is very early indeed. Even if the lowermost radiocarbon date is taken to be 9650 BP (two standard deviations from the centroid of 9910 BP), the occurrence of pine (at around 9960 BP [11260 cal BP]) would remain very early. Pine is generally thought to have arrived in Scotland around 8000 BP (8890 cal BP) (Bennett, 1984), although Birks (1989) argues that pine may have expanded independently in northwestern Scotland between 8500 and 8000 BP (9510 and 8890 cal BP), and the date for likely colonisation of pine in the Outer Hebrides has been given as 7500 BP (8280 cal BP) (Bennett, 1984). Because the frequency of pine pollen needed to argue for local presence of the species is still under dispute (see Chapters 3, 6 and 11), it is difficult to determine if and when the tree arrived at individual sites. At Loch Lang, *Pinus* pollen frequencies are highest (5-10%) between 7200 and 4100 BP (8040-4660 cal BP) although the authors are not convinced that it was present locally (Bennett *et al.*, 1990), while Fossitt (1996) suggests that pine may have become established locally at Loch a' Phuinnd between 6000 and 4000 BP (6810-4460 cal BP) (mean pollen value 5.8% TLP). In Lewis, where unlike on South Uist pine macrofossils have established the presence of the species beyond a doubt, Lomax (1997) argues for local presence at Loch Bharabhat and Loch na Muilne from *c.* 7500 BP (8280 ca BP). In all these cases the percentages are similar to those at Loch Airigh na h-Achlais, but the dates are far later.

Corylus avellana invaded the birch woodland around 9850 BP (11220 cal BP) around the same time as at Loch Airigh na h-Aon Oidhche (Brayshay and Edwards, 1996), and by 9390 BP (10620 cal BP) hazel had become the most prominent woodland taxon. *Calluna vulgaris* first appears in the record at 9740 BP (11170 cal BP) and expanded quickly to become quite widespread by 9510 BP (10870 cal BP)

The lake itself was colonised at the beginning of this phase by *Myriophyllum alterniflorum*, which reached its highest levels at 10430 BP (12400 cal BP) before declining and disappearing by 9390 BP (10620 cal BP). The expansion of *Myriophyllum alterniflorum* at this early date also appears to suggest that the lowermost radiocarbon date is too old, as the increase in this taxa is usually associated with Postglacial warming. A small amount of *Potamogeton* pollen was also recorded, and this taxon may have been growing in the lake, or in nearby streams.

9450-7610 BP (*c.* 10670-8400 cal BP)

Hazel and birch woodland now dominated the landscape, with hazel the most important woodland element. *Corylus avellana*-type pollen frequencies register 62% at 9160 BP (10300 cal BP) and *Corylus* percentages, concentrations and accumulation rates remain high until 7560 BP (8380 cal BP). *Pinus* percentages, on the other hand, decline to less than 6%, although this decline is not evident from the absolute pollen data, and its curve becomes quite smooth, which could suggest long-distance input of pollen rather than local presence. *Ulmus* is first recorded at 9620 BP (10960 cal BP) and frequencies increase gradually to 7% by 8240 BP (9200 cal BP) by which time elm may have been growing locally. *Quercus* pollen appears for the first time at 9280 BP (10460 cal BP) and frequencies generally exceed 3% by 8010 BP (8910 cal BP), which also may indicate local presence. However, it does not appear that *Quercus* and *Ulmus* ever became important woodland components at Loch Airigh na h-Achlais, and they probably occurred either as small isolated stands, or as scattered individuals. *Alnus* is recorded for the first time at 8130 BP (9040 cal BP) but its frequencies remain low, and it is unlikely that alder was part of the local vegetation during this time.

During this period (zone LAA-4) woodland reached its maximum extent. Tree and shrub frequencies are never lower than 57%, and reach a maximum of 80% at 8360 BP (9400 cal BP). The woodland remained quite open, allowing the growth of fern-rich grassland, including Pteropsida, *Pteridium aquilin.um* and *Polypodium*, as well as patches of *Calluna vulgaris*. The *Sphagnum* curve, which starts at 10430 BP (12400 cal BP), also becomes continuous at this time, while *Potentilla*-type pollen appears for the first time at 9620 BP (11210 cal BP). Some of the typical blanket peat bog plants were thus already present by 9500 BP.

7610-4860 BP (c. 8400-5600 cal BP)

Tree and shrub taxa continued to dominate the vegetation (61-77% TLP), but there was a change in woodland composition. *Corylus* percentages, concentrations and accumulation rates decline, while the frequencies of *Betula* remain steady, and *Pinus*, *Ulmus*, *Quercus* and *Alnus* values all increase. *Pinus* pollen now reaches a maximum of 12%, which may well indicate a significant local presence. *Ulmus* and *Quercus* also became more prominent in the woodland, and *Alnus* trees probably appeared locally around 7560 BP (8380 cal BP). This date for the local presence of *Alnus* is quite early when compared to other sites on the island. At the moment, dates for the appearance of alder range from 7000 BP at Loch Airigh na h-Aon Oidhche to 4910 BP at the inland site of Reineval (Brayshay and Edwards, 1996). The present study has widened this range even further: *Alnus* may have arrived as late as 4630 BP (5380 cal BP) at Frobost (see Chapter 7). However, this fairly wide temporal range should not be surprising, as the spread of *Alnus* is notoriously asynchronous on the British mainland as well, and seems to be primarily influenced by local conditions rather than more general climatic trends (Chambers and Elliott, 1989; Bennett and Birks, 1990). Only a few grains of *Fraxinus excelsior* were recorded and it seems unlikely that this taxon was growing locally.

Ulmus was the first tree to witness a decline (both in terms of percentage and absolute data), from 5440 BP (6240 cal BP) onwards, a date which is rather too early for the general elm decline, traditionally dated to *c.* 5100 BP (Birks, 1989). Other arboreal taxa frequencies remain high during this phase, with the exception of *Pinus*, which declines to a low of 2% at 4910 BP (5630 cal BP) before recovering again, a change which is also visible in the concentration and accumulation rate diagrams, although less markedly so. This brief decline in pine at 4910 BP is hard to explain. There is no evidence for a major decline in pine trees in Scotland at this time, and the rather erratic nature of the pine curve may give credence to the theory of local pine growth.

Hedera helix may have been an understorey shrub in the woodland, along with grasses, *Filipendula*, *Ranunculus*, ferns and bracken, although these may also have occurred in more open areas. *Calluna vulgaris* remained an important and consistent component in the vegetation, probably forming patches of heathland between the clusters of trees. *Sphagnum* values are very low, and although there may have been peat bog communities in the area, it appears that they were not expanding at this time. In the lake itself *Isoetes lacustris* may have been growing, although frequencies remain low.

There are no signs of any changes that could be interpreted as indications of anthropogenic activity during the Mesolithic. Arboreal frequencies remain high, and there are no significant increases in charcoal values or other cultural indicators.

4860-1480 BP (*c.* 5600-1360 cal BP)

After 4860 BP (5600 cal BP) there was a gradual decline in trees and shrubs at Loch Airigh na h-Achlais, which is evident in both the percentage and absolute data. Not all taxa were affected at the same time. *Corylus* and *Alnus*, and to a lesser degree *Betula*, started to decline at 4770 BP (5530 cal BP), followed by *Pinus* at 4210 BP (4840 cal BP) and *Quercus* at 3480 BP (3760 cal BP). There was another general decline in arboreal taxa around 3200 BP (3420 cal BP), and by 3100 BP (3310 cal BP) *Pinus*, *Ulmus*, *Quercus* and *Alnus* frequencies had all fallen to background levels. *Betula* values remained quite high until 2150 BP (2130 cal BP) when they too started their final decline. By 1600 BP (1520 cal BP) the area was probably virtually treeless.

Paradoxically, *Fraxinus excelsior* frequencies are higher between 4770 and 3100 BP (5530- 3310 cal BP) than at any other time, and ash may have been present locally. *Fraxinus* is quite a light-demanding tree (Göransson, 1987), and may have taken advantage of the opening of the woodland caused by the reduction in other taxa. It disappears from the record after 2530 BP (2680 cal BP).

The decline in *Pinus* pollen at 4210 BP (4840 cal BP) is similar in age to a general decline in pine on the mainland of Scotland and Ireland, which is usually dated to around 4100 BP (4660 cal BP) (Bennett, 1984; Birks, 1989). The changes in the pine curve at Loch Airigh na h-Achlais may therefore reflect the changing fortunes of pine elsewhere, but this does not rule out local presence on the eastern side of South Uist. The theories as to what led to this general pine decline include a deterioration in climate (Bennett, 1984; Bridge *et al.*, 1990; Gear and Huntley, 1991); a combination of climatic and anthropogenic factors (Birks, 1989); and the acidic effects of volcanic ash attributed to the Hekla-4 eruption which took place around this time in Iceland (Blackford *et al.*, 1992). The latter hypothesis may not be supported by data from Ireland, where Hall *et al.* (1994) argue that there is no correlation between the appearance of tephra and the decline in pine trees, although further tephra studies in conjunction with palynology might clarify this issue (Edwards *et al.*, 1996). A general reduction in pine over a large area could suggest climatic factors were involved, perhaps exacerbated by volcanic fall-out, rather than anthropogenic impact, since the latter would imply the rather unlikely situation that pine was deliberately 'targeted' by people over a large area at virtually the same time.

The decline in trees and shrubs at 4860 BP (5600 cal BP) is the earliest sign of significant woodland reduction in the area. Although this falls well within the Neolithic, there is little evidence to suggest that people played a large part in this decline. *Plantago lanceolata* is recorded more frequently, but its frequencies remain low and the curve never becomes continuous. Charcoal:pollen ratios and charcoal concentrations increase only slightly and gradually, rising more markedly only after 3200 BP (3420 cal BP). There is no evidence for arable agriculture at the start of this phase: potential indicators of cultivation, such as Chenopodiaceae, are not recorded until after 2720 BP (2810 cal BP) while the first cereal-type pollen grain is not recorded until 1770 BP (1670 cal BP).

Perhaps the hillsides around Loch Airigh na h-Achlais were used for rough grazing during the Neolithic, which may have gradually inhibited the regeneration of trees and shubs, but the decline in woodland could also be attributed to changes in environmental conditions near the site. There may have been a gradual natural deterioration in soils, and it is possible that blanket peat started to encroach on the area, creating unfavourable conditions for trees and shrubs. The expansion of blanket peat may also explain why some arboreal taxa disappeared before others. Areas with marginal, nutrient-poor soils would be likely to be affected first so that *Corylus* and *Pinus* began to decline before *Quercus*, which would have occupied more favourable sites. On the other hand, this would not explain the early decline of *Ulmus*, which presumably also grew in favourable areas, and the late decline of *Betula*, a taxon which is likely to occupy the more marginal sites.

Evidence for human impact appears to increase after 3200 BP (3420 cal BP) with a rise in the charcoal curves and the more frequent recording of potential anthropogenic indicator taxa such as *Artemisia*-type, *Cichorium intybus*-type, *Solidago virgaurea*-type, Chenopodiaceae and Brassicaceae.

Calluna vulgaris heath expanded as the trees and shrubs continued to decline, and by 1580 BP (1470 cal BP) heathland dominated the landscape. Although the percentage diagram reveals an increase in *Calluna* from 4800 BP (5540 cal BP) onwards, the absolute data suggest that the main expansion occurred from 3200 BP (3420 cal BP). Charcoal values increase in parallel with *Calluna vulgaris*, suggesting that fire may have been used to manage heathland. The occasional burning of heather releases nutrients and tends to make the heathland more productive for grazing (Hobbs and Gimingham, 1987). Until recently this method of improving grazing was used in Scotland (Stevenson *et al.*, 1993), and it may well be that prehistoric people knew about this method and used it to their advantage. *Vaccinium*-type pollen frequencies increase after 2350 BP (2420 cal BP) and *Erica* or *Vaccinium* may have been heathland components at this time.

The high loss-on-ignition values and relatively poor pollen preservation in zones LAA-6 and LAA-7 (up to 53% of *Calluna* grains were corroded, suggesting that some of the pollen may have been reworked) may suggest increased erosion of peat into the loch. The causes of peat erosion may be various, but can include rising water levels eroding peat along the loch edge, as well as over-burning.

The *Sphagnum* curve also rises, and other potential mire indicators, such as *Potentilla*-type, are more commonly recorded, which may suggest an expansion of blanket bog in the area. There is a slight increase in Cyperaceae, while herb-rich grassland taxa, including *Succisa pratensis*, *Plantago maritima*, *Ranunculus* and *Potentilla*, were also present, although neither grasses nor sedges were very prominent in the vegetation. Aquatics are represented by *Nuphar*, *Nymphaea*, *Potamogeton*, and *Isoetes lacustris*.

1480–0 BP (*c.* 1360–0 cal BP)

The landscape was now virtually treeless, and almost entirely dominated by *Calluna vulgaris* heathland. Arboreal pollen percentages fluctuate between 8% and 16%, while *Calluna* frequencies are very high (61–80%), as are *Calluna* concentrations and accumulation rates. Cerealia-type pollen is recorded sporadically during this phase, along with crop indicators such as *Spergula*-type and Chenopodiaceae, suggesting that there was some arable agriculture in the vicinity of the site during the last 1500 years. Charcoal frequencies and concentrations are higher than at any other time and this could also reflect the increase in anthropogenic activity in the area, including possibly heathland management. However, human impact is never likely to have been very strong. Anthropogenic indicator taxa are recorded less frequently than during similar periods at Frobost and Loch Olabhat, and the continued low presence of *Isoetes lacustris* and high loss-on-ignition values suggest that little minerogenic soil erosion into the loch was taking place (Vuorela, 1980).

Grasses and sedges remain uncommon, but prominent herb taxa include *Potentilla*-type, *Succisa pratensis*, *Hypericum perforatum*-type, and *Selaginella selaginoides*, which can all be indicators of rather damp pasture. *Sphagnum* expands, both in the percentage and absolute data, and blanket peat may have continued to spread.

This type of landscape that is still very much in evidence today: rather barren and dominated by expanses of *Calluna* heath. The area has been used primarily for rough grazing in the recent past, (there are several shielings in the vicinity of the site) and this may have been the case for a long time.

8.8 Summary

The record at Loch Airigh na h-Achlais starts during the Lateglacial at around 10540 BP (12590 cal BP) when the vegetation was dominated by *Empetrum nigrum* heathland, and to a lesser extent grasses and sedges, possibly interspersed with small patches of *Salix* and *Betula* scrub. *Huperzia selago* occupied the rocky slopes surrounding the site. Between 10,400 and 9910 BP (12360-11260 cal BP) Poaceae and *Betula* came to dominate the landscape, before *Empetrum nigrum* heath regained some of its former importance at the expense of the grasses. The date for the start of the Holocene (around 10430 BP [12400 cal BP]) appears to be rather too early, perhaps due to dating uncertainties. *Corylus* invaded the birch woodland around 9850 BP (11220 cal BP) and became an important component of the woodland by 9390 BP (10620 cal BP) as *Betula* started to decline. By 8000 BP (8890 cal BP) *Ulmus* and *Quercus* had arrived, while *Pinus* and *Alnus* may have appeared around 7560 BP (8380 cal BP). The woodland remained open, allowing the growth of tall herb and fern communities, as well as patches of *Calluna vulgaris*. There is no evidence of the presence of Mesolithic people in the landscape: there are no significant increases in charcoal or declines in tree and shrub values at this time. The woodland phase lasted until 4860 BP (5600 cal BP) when a gradual decline in trees and shrubs started, possibly due to an expansion in blanket bog, although low levels of human impact (perhaps in the form of grazing) could also have played a rôle. From 3200 BP (3420 cal BP) onwards anthropogenic indicator taxa are more frequently recorded, while *Calluna vulgaris* became more dominant, and there may be evidence of heathland management by fire. By 1600 BP (1520 cal BP) the area was effectively treeless and dominated by heathland. The first likely evidence for arable agriculture at the site is a cereal-type pollen grain recorded at 1770 BP (1670 cal BP), although the area may have been used for rough grazing starting at a much earlier date.

Chapter 9

LOCH OLABHAT

9.1 Location

Loch Olabhat (NGR NF747 754) is located close to the northwest coast of the island of North Uist (Fig. 9.1). The loch lies at a low altitude (8 m OD), but there are hills to the northwest and southwest of the site, reaching 88 m and 117 m respectively. The rocky west coast is 2 km to the west of the site, the north coast is 1 km distant, and the sandy beaches of the Vallay Sound lie 1 km to the east and northeast. The present-day vegetation surrounding the loch is species-poor grassland and heath dominated by *Calluna vulgaris*, Poaceae and Cyperaceae spp.

Loch Olabhat has an inflow from Ben Scolpaig to the west, and a stream flowing out into the Vallay Sound towards the northeast (Fig. 9.1). The loch has a water surface area of around 13 ha, which is much larger than either Loch a' Chabhain (1.2 ha) or Loch Airigh na h-Achlais (2.3 ha). Loch Olabhat is thus likely to have a higher proportion of regional and long-distance pollen in its sediments than the other two loch sites (Jacobsen and Bradshaw, 1981; see Chapter 5). However, this may be mitigated to some extent by local and extra-local pollen brought into the loch by the stream. The hydrological catchment area of the lake (water run-off brought directly into the loch and via the stream) is around $1km^2$ (1000 ha).

The area around Loch Olabhat is very rich in both prehistoric and historic sites. Many of these were discovered and excavated in the early part of this century by Erskine Beveridge, an antiquarian who lived on the nearby island of Vallay. The following brief archaeological survey only includes sites within 3 km of the coring site at Loch Olabhat.

Loch Olabhat itself is the site of the Neolithic settlement of Eilean Domhnuill (Armit, 1986, 1987, 1988a, 1990a, 1992b), which is described in more detail in Chapter 10. On a peninsula in the loch lies the site of Eilean Olabhat, formerly an island, which has evidence of occupation from the Iron Age to at least the Norse period. To the west of Loch Olabhat, at Druim nan Dearcag, are a series of

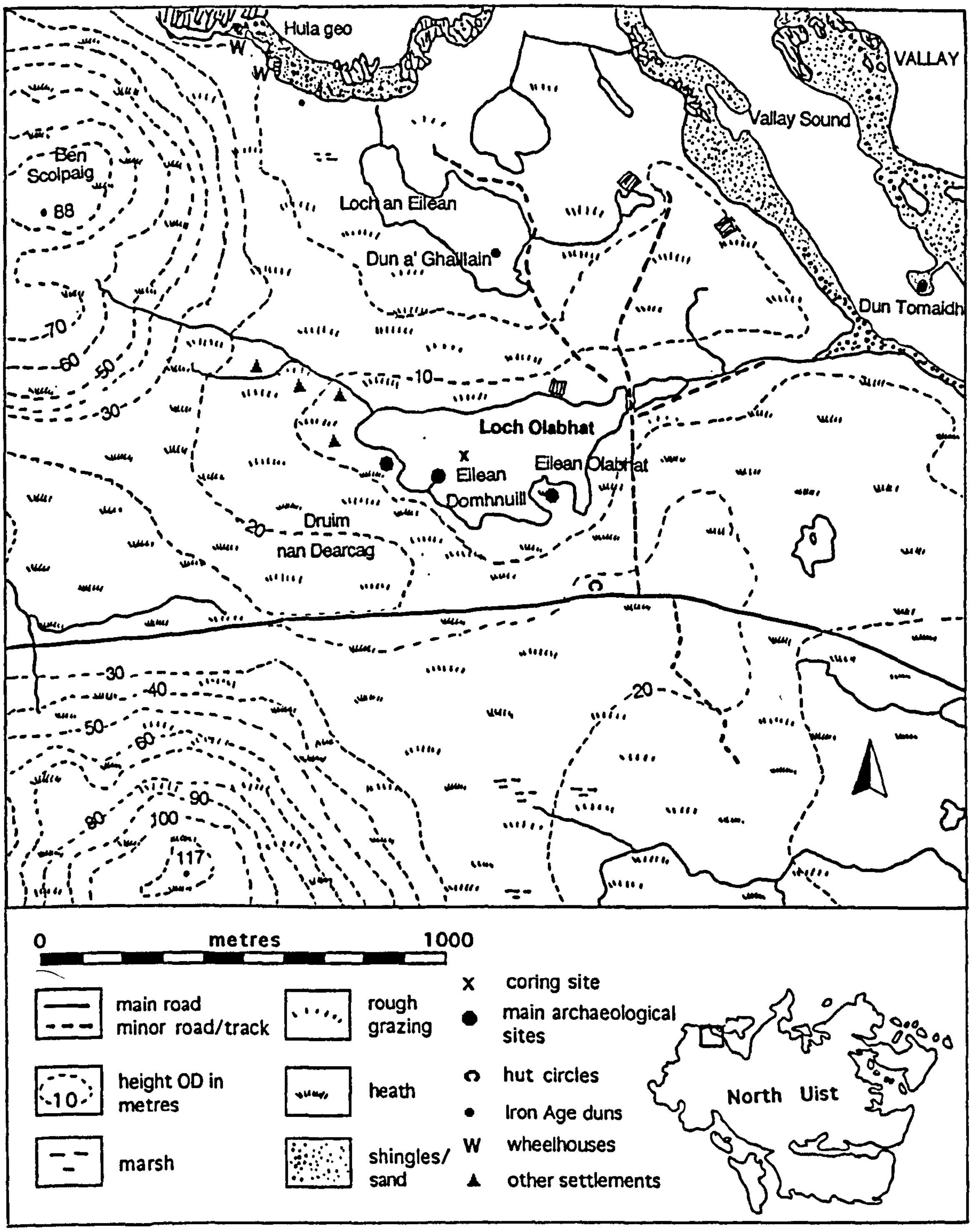


Fig. 9.1 Loch Olabhat and surrounding area

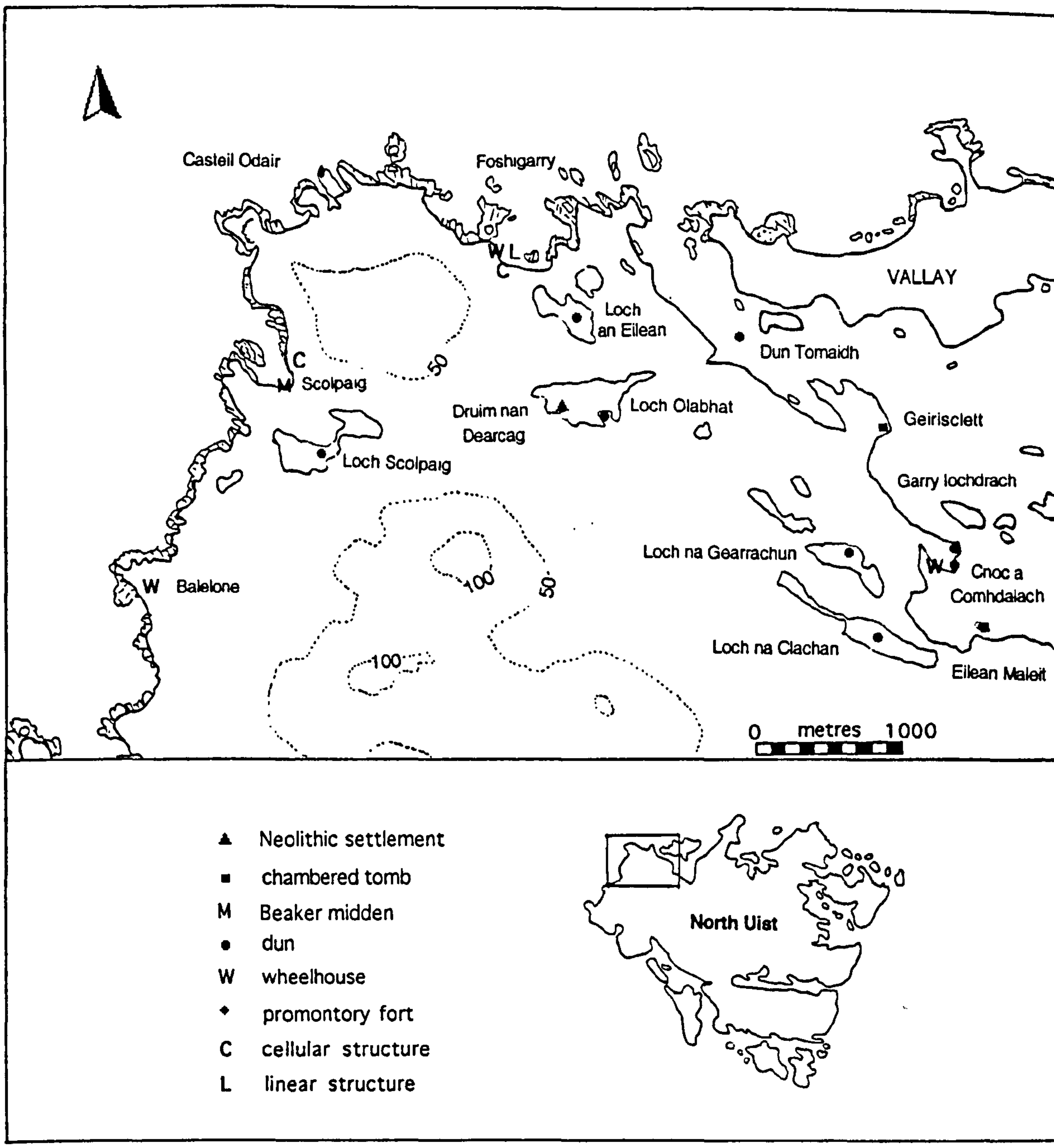


Fig. 9.2 Archaeological sites near Loch Olabhat

probable settlement sites which may be medieval and post-medieval in date, as well as a number of lazy-beds (Armit, 1989) (Fig. 9.1). Loch an Eilean, just to the north of Loch Olabhat, contains a dun (Dun a Ghallain) as well as cellular structures of probable Iron Age date. Other Iron Age structures include Dun Tomaidh, 1.5 km to the northeast of Loch Olabhat in the Vallay Sound, and duns in Loch na Gearrachun and Loch nan Clachan, 2 km and 2.5 km southeast of Loch Olabhat respectively (Fig. 9.2). 0.5 km east of Loch na Gearrachun lie the dun and wheelhouse of Cnoc a Comhdalach, and just to the east of these, the dun at Garry Iochdrach and the dun and wheelhouse complex of Eilean Maleit. Scolpaig, on the west coast 2 km from Loch Olabhat, has evidence of Iron Age cellular structures and a Beaker age midden, and nearby Loch Scolpaig contains yet another Iron Age dun (Armit, 1992a). Casteil Odair, a promontory fort (RCAHMS, 1928) can be found along the northwestern coastline, along with two wheelhouses at Hula-geo, and cellular and linear structures at Foshigarry, 1 km northwest of Loch Olabhat (Armit, 1992a). Finally, 2 km to the east of the loch lies the Neolithic chambered cairn of Geirisclett (Henshall, 1972).

9.2 Profile

A core was taken from a coring point approximately 75 m northeast of the edge of Eilean Domhnuill. The water in this part of the lake was about 123 cm deep. The core is 270 cm long (123-393 cm below water level), of which the top 9 cm consisted of unconsolidated muds which were not sampled. The sedimentary profile was described in the laboratory as follows:

123-180 cm	Dark brown gyttja
180-223 cm	Yellow-grey silty clay
224-280 cm	Brown gyttja
280-340 cm	Grey brown mud
340-393 cm	Green-grey clay

9.3 Radiocarbon dates and time-depth curve

Seven AMS dates were obtained from Loch Olabhat:

Lab. no.	Depth (cm)	^{14}C dates (BP)	Calibrated dates (1 σ)
AA-22192	175.5-176.5	1750± 40	1710-1570 cal BP; 240-380 cal AD
AA-22191	190-191	1775±45	1730-1610 cal BP; 2120-340 cal AD
AA-22190	223-224	4800±50	5590-5470 cal BP; 3640-3530 cal BC
AA-22189	241.5-242.5	5175±50	5990-5910 cal BP; 4040-3960 cal BC
AA-22188	278.5-279.5	8235±60	9400-9030 cal BP; 7450-7080 cal BC
AA-22187	308.5-309.5	9200±60	10480-10240 cal BP; 8530-8290 cal BC
AA-22186	337.5-338.5	9810±70	11230-11170 cal BP, 9280-9240 cal BC

A time-depth cuve, constructed using the uncalibrated radiocarbon dates, is presented in Figure 9.3. The two most recent radiocarbon dates were statistically indistinguishable from each other, and the uppermost date of 1750±40 BP was disregarded for the purposes of describing the phases of the profile. The alternative curve for this part of the diagram has been indicated by a dashed line. The top of the profile (123 cm) was assumed to date to 1995, while the base of the time-depth curve (393 cm) is extrapolated back to 10970 BP.

Between 222 and 180 cm below water level, the sediment in the profile consists of yellow-grey silty clay, which between 222 and 191 cm contained virtually no pollen or spores. This deposit may have had a very different sedimentation rate to the gyttja below and above it, but potential problems in interpolation in this part of the profile were avoided by bracketing the minerogenic layer with two radiocarbon dates (4800±50 BP and 1775±45 BP).

9.4 Preservation

Preservation of pollen grains in the Loch Olabhat samples was not quite as good as in the other loch and peat cores described in this thesis. Frequencies of deteriorated grains varied between 4% and 62.5%, and the average was 25.7%. Most of the deteriorated grains were corroded, but there were also considerable numbers of crumpled grains, up to 36%, between 344 and 352 cm. These crumpled grains were mostly made up of *Empetrum*. *Betula* and *Corylus* grains tended to be corroded, particularly in the levels just above the erosional phase which contained no pollen (between zones OVT-4 and OVT-5). The frequency of corroded *Betula* grains reached a maximum of 66.7% in these levels. *Calluna vulgaris* pollen also showed a

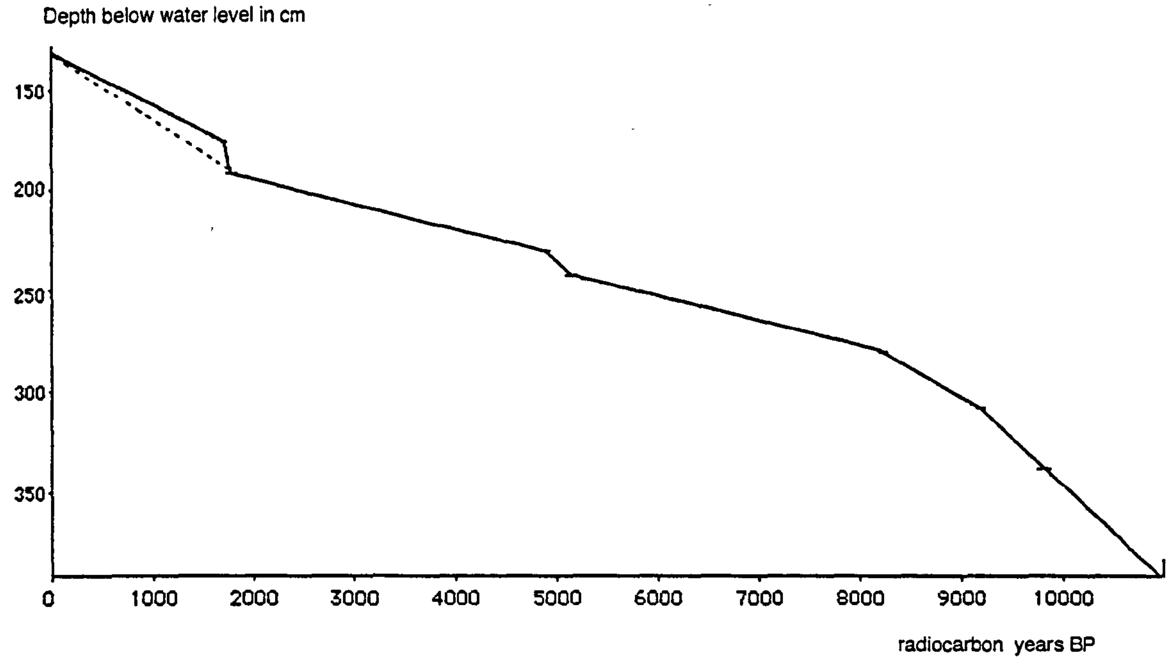


Fig. 9.3 Loch Olabhat: time-depth curve

significant amount of corrosion, particularly between 274 and 298 cm. *Pinus* grains were often broken as well as corroded. Poaceae grains were not very badly affected by deterioration, with moderate numbers of crumpled grains recorded.

9.5 Local Pollen Zones

The percentage diagram (Fig. 9.4) was divided into 5 local pollen zones, with zones OVT-1 and OVT-3 further divided into 2 subzones. Between zones OVT-4 and OVT-5 there is a largely minerogenic stratum with insufficient pollen grains to be included in the diagram. The zones are described as follows:

OVT-1a

392-354 cm 10950-10150 BP

Percentage diagram (Fig. 9.4)

Subzone OVT-1a is characterised by consistently high frequencies of *Empetrum nigrum*-type pollen (31-42% TLP), along with somewhat lower representations of Poaceae and Cyperaceae (maxima of 33% and 46% respectively). Arboreal frequencies are low (11-17%), but *Betula, Pinus sylvestris, Salix* and *Juniperus communis* are all represented. Other herb taxa besides Poaceae and Cyperaceae include *Cichorium intybus*-type, *Artemisia*, Chenopodiaceae, Apiaceae, *Filipendula, Potentilla*-type, *Rumex acetosa, Ranunculus acris*-type and *Plantago maritima*. Aquatics occur infrequently, and are made up almost entirely of *Myriophyllum alterniflorum*. Amongst the non-aquatic spores *Huperzia selago* and *Polypodium* were recorded. *Sphagnum* is recorded for the first time at 372 cm.

Concentration and accumulation rate diagrams (Fig. 9.5 and 9.6)

Concentrations and accumulation rates in this subzone are quite high. Total pollen and spore concentration values range from 3.5 to 6.2 $\times 10^4$ grains cm^{-3}, and accumulation rates from 1666 to 2986 grains cm^{-2} $year^{-1}$.

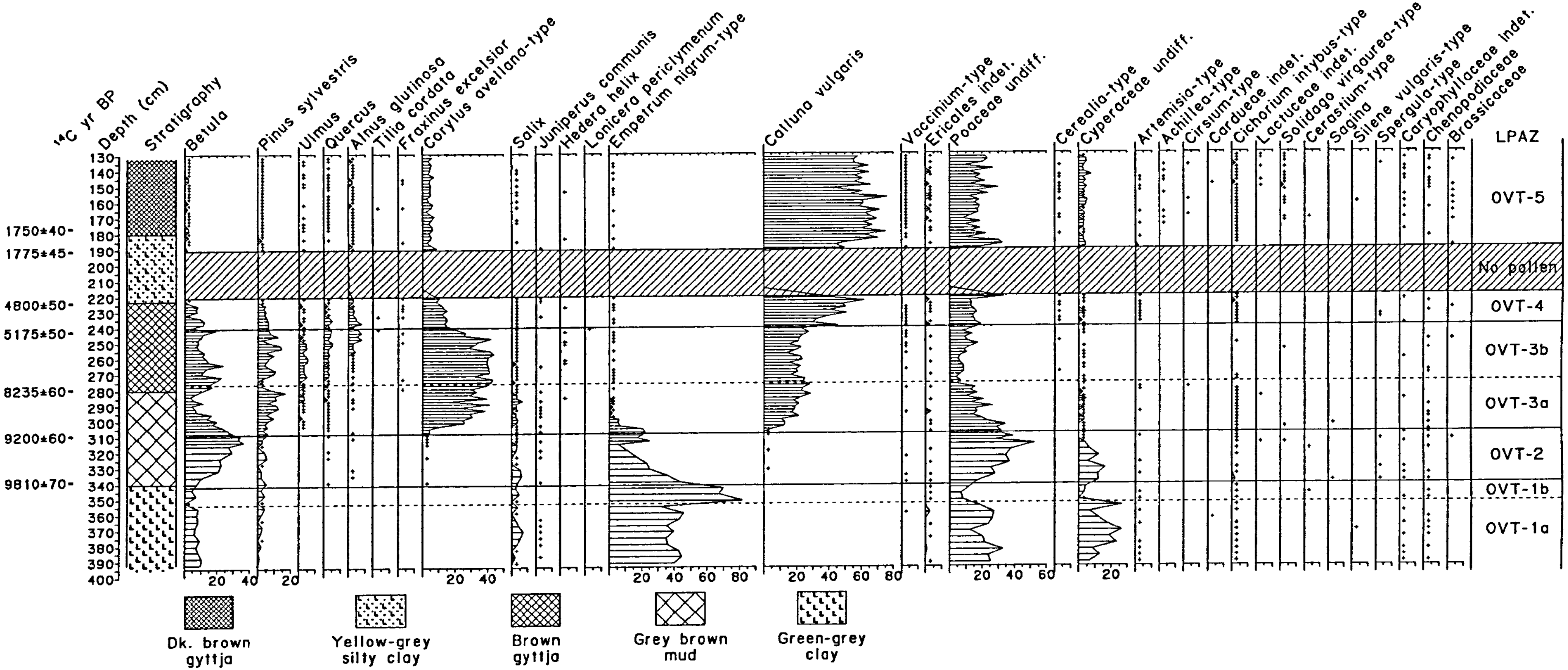


Fig. 9.4 Pollen and spore percentage diagram from Loch Olabhat (+ = <2%). Shaded curves are exaggerated x10.

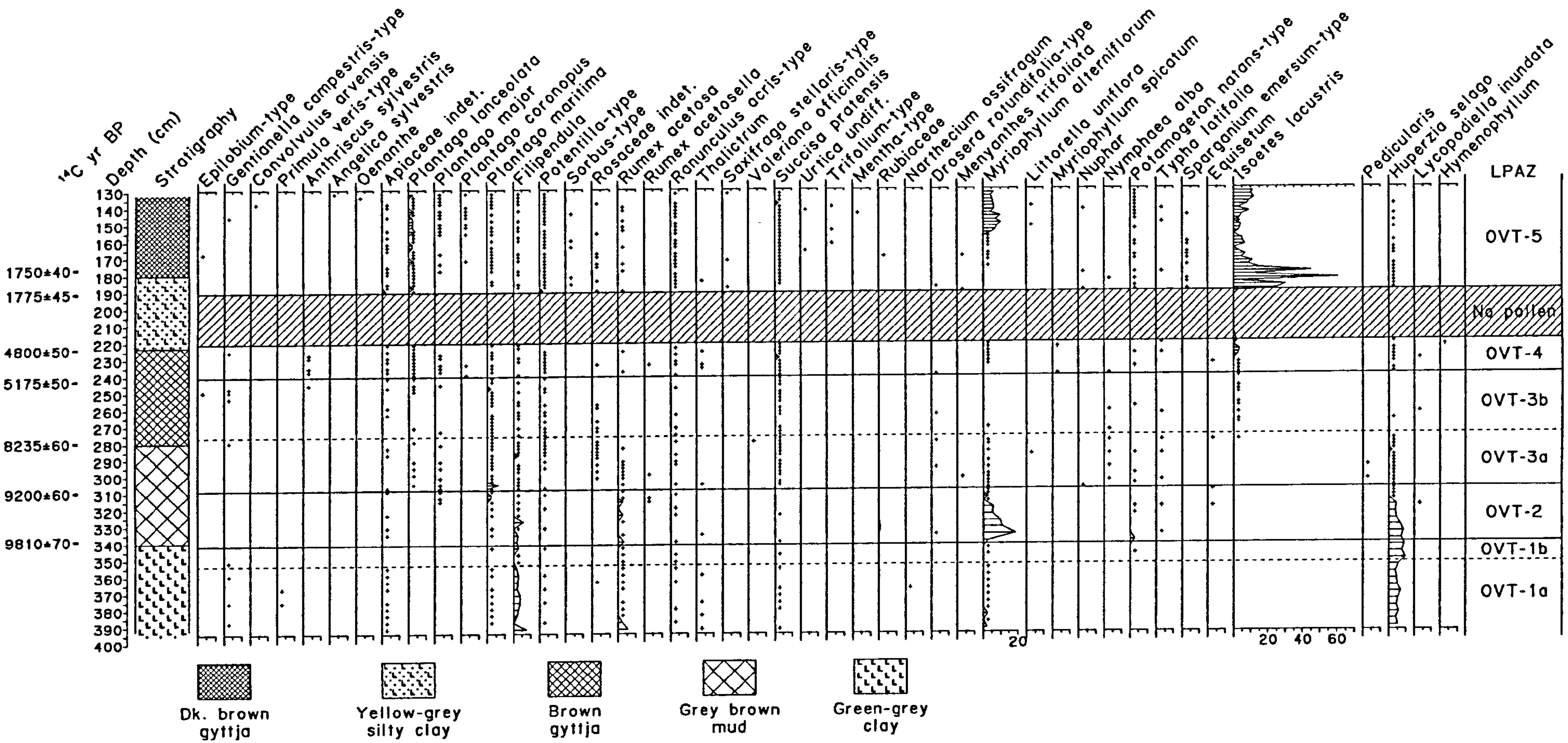


Fig. 9.4 (continued)

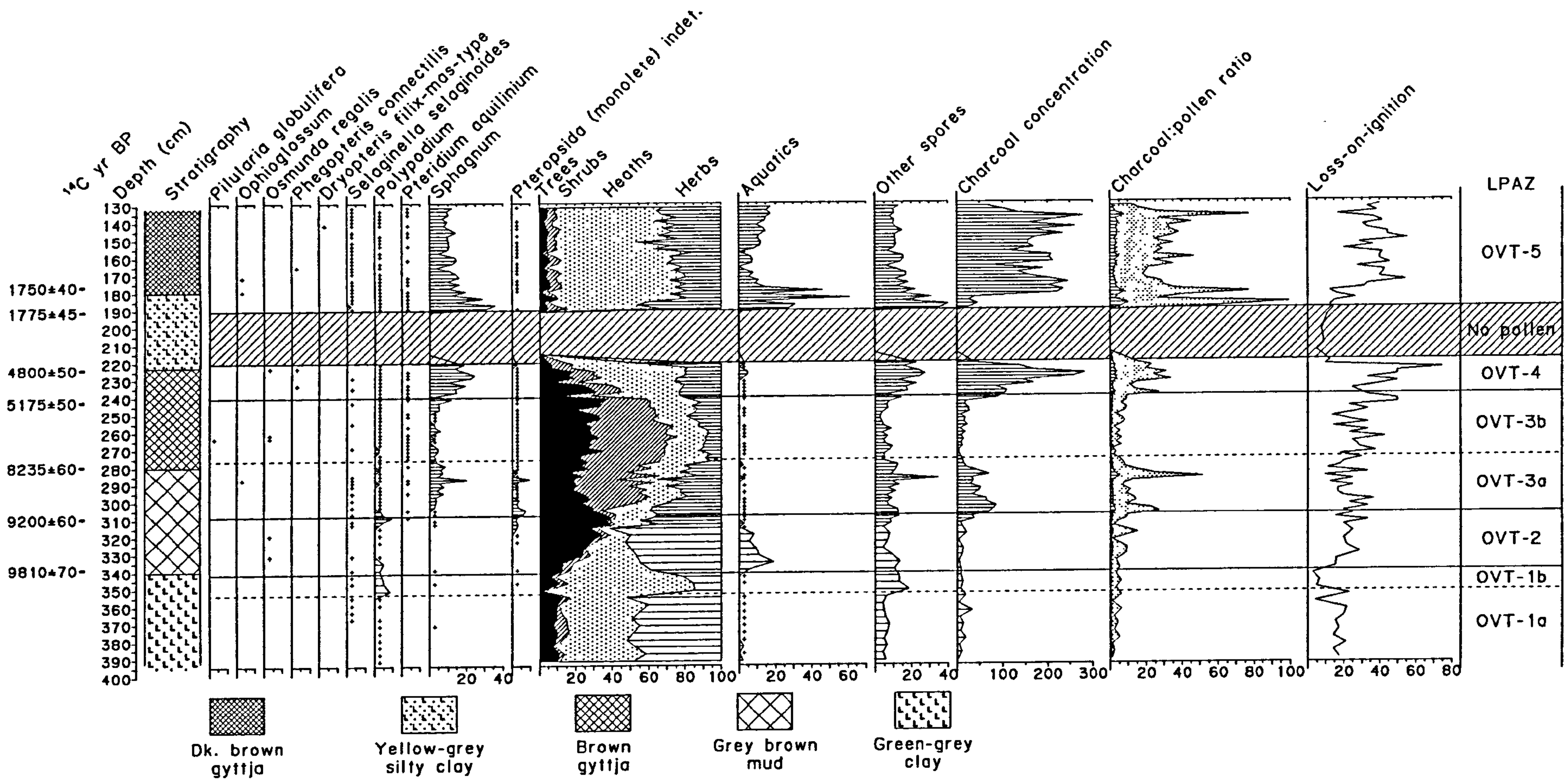


Fig. 9.4 (continued)

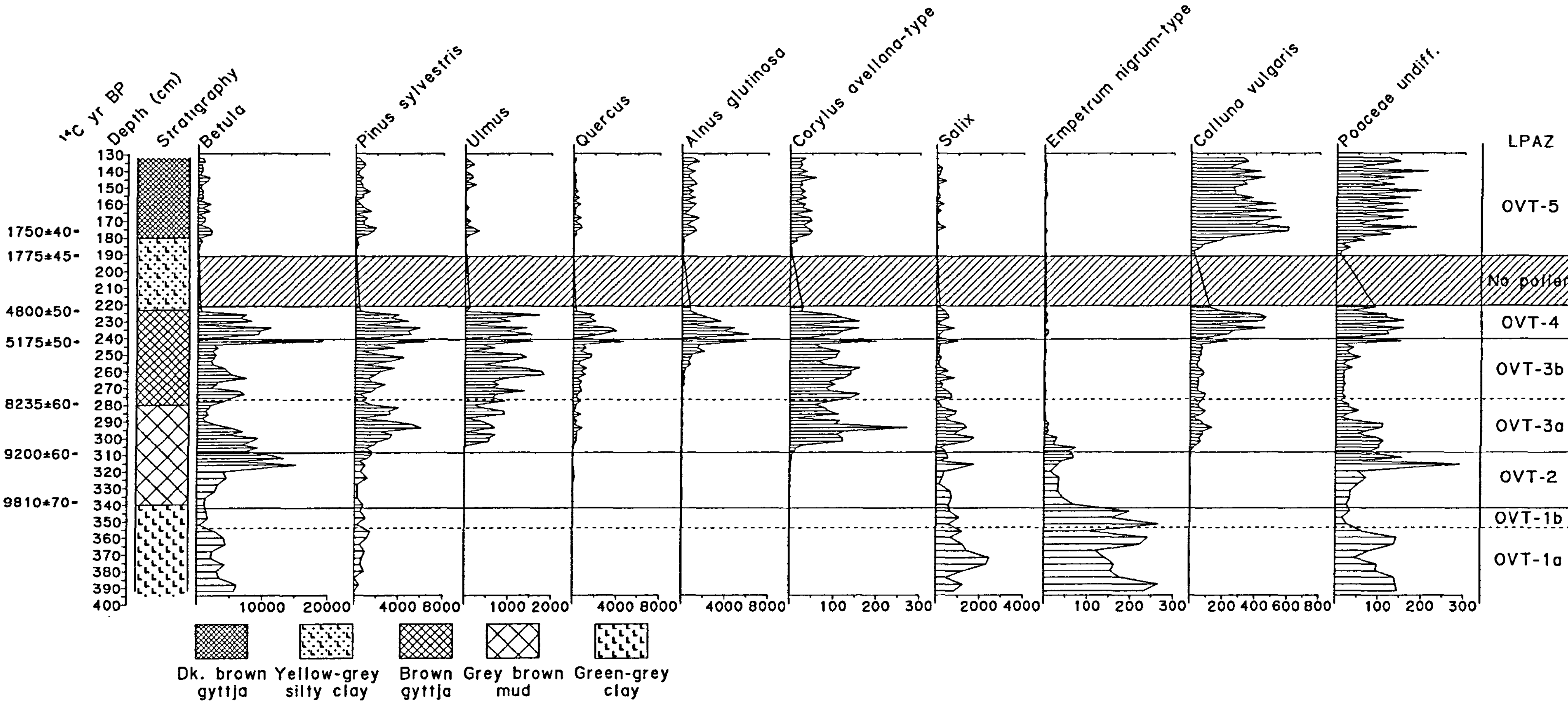


Fig. 9.5 Pollen and spore concentrations (grains cm^{-3}) and charcoal concentrations (cm^2 cm^{-3}) at Loch Olabhat. Selected taxa. Shaded curves are exaggerated x10. Note the variable horizontal scale.

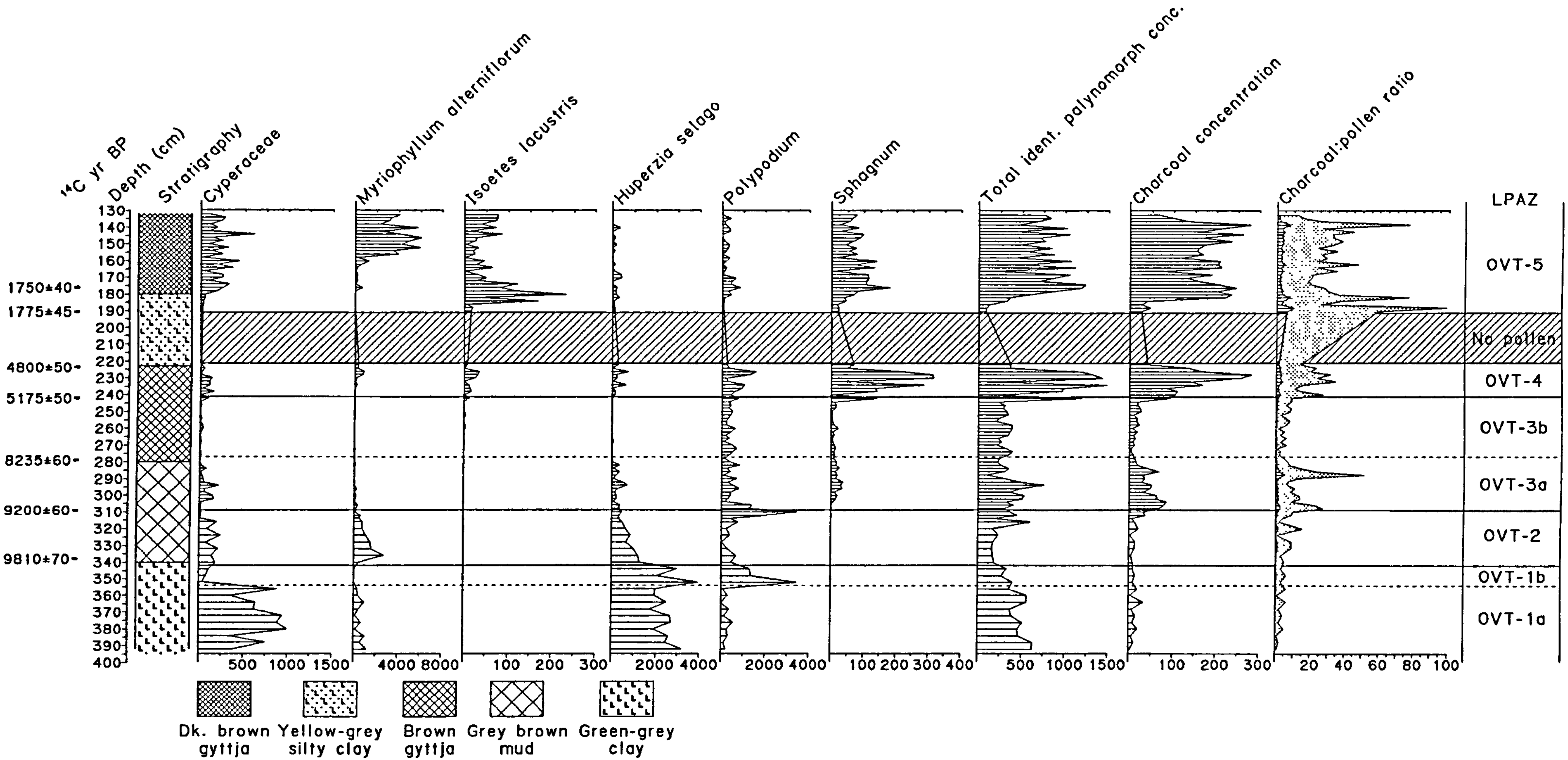


Fig. 9.5 (continued)

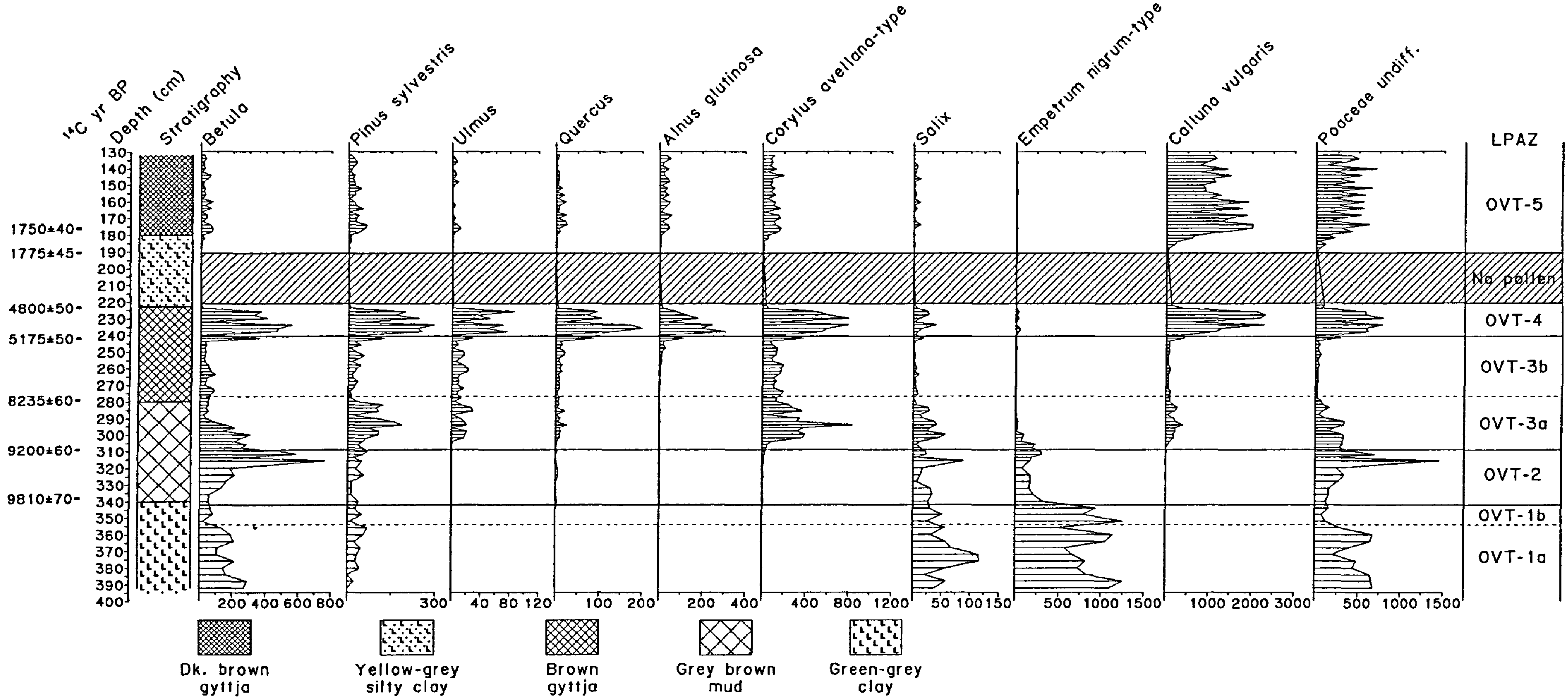


Fig. 9.6 Pollen and spore accumulation rates (grains cm^{-2} yr^{-1}) and charcoal accumulation rates (cm^2 cm^{-3} yr^{-1}) at Loch Olabhat. Selected taxa. Shaded curves are exaggerated x10. Note the variable horizontal scale.

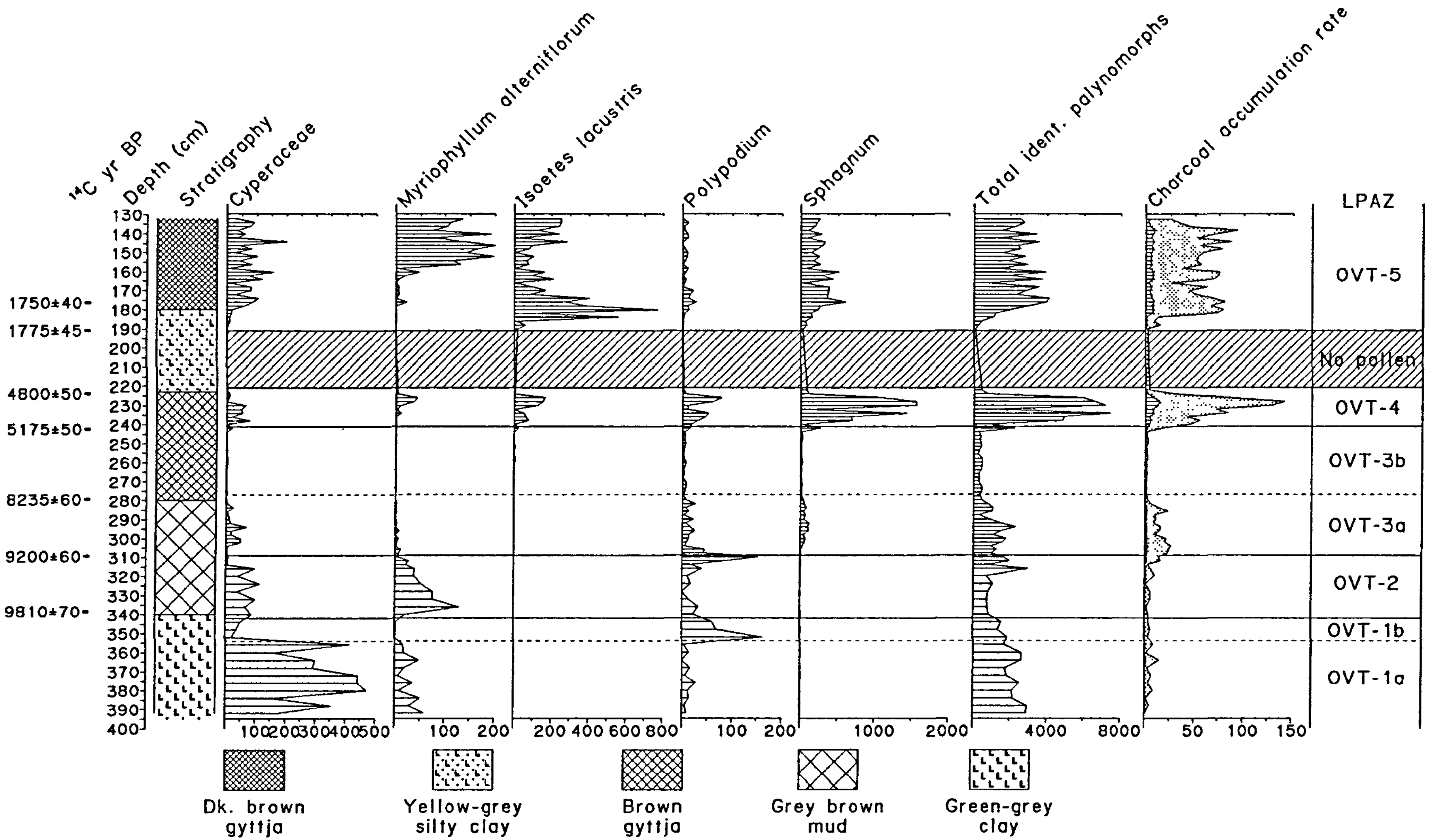


Fig. 9.6 (continued)

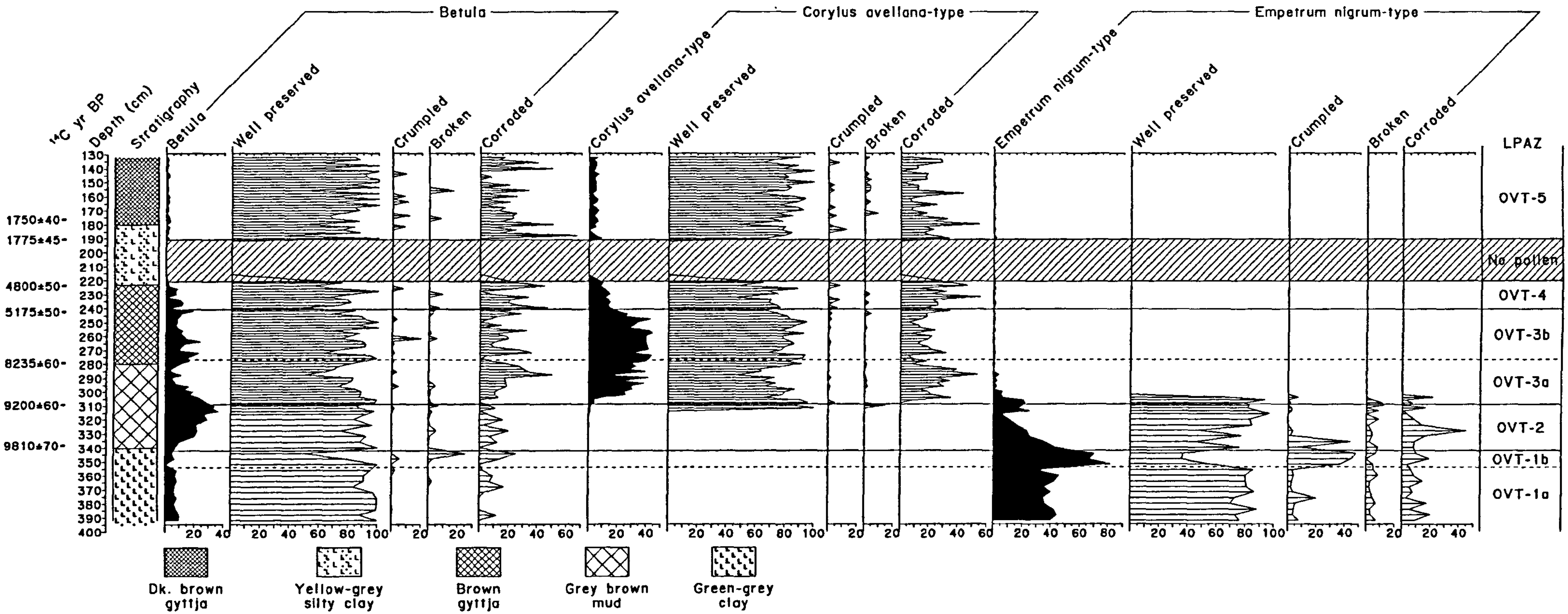


Fig. 9.7 Preservation diagram for major pollen types and TLP at Loch Olabhat. The black silhouettes are expressed as %TLP, the other graphs are a percentage of the individual taxa.

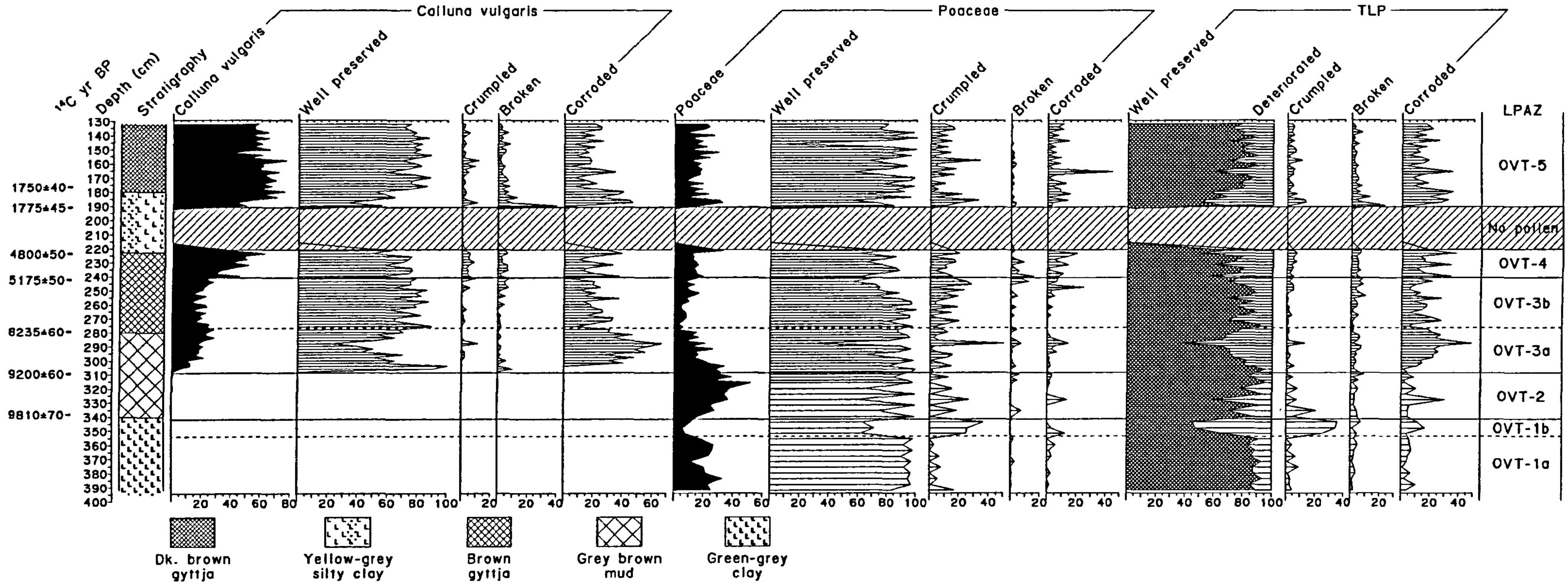


Fig. 9.7 (continued)

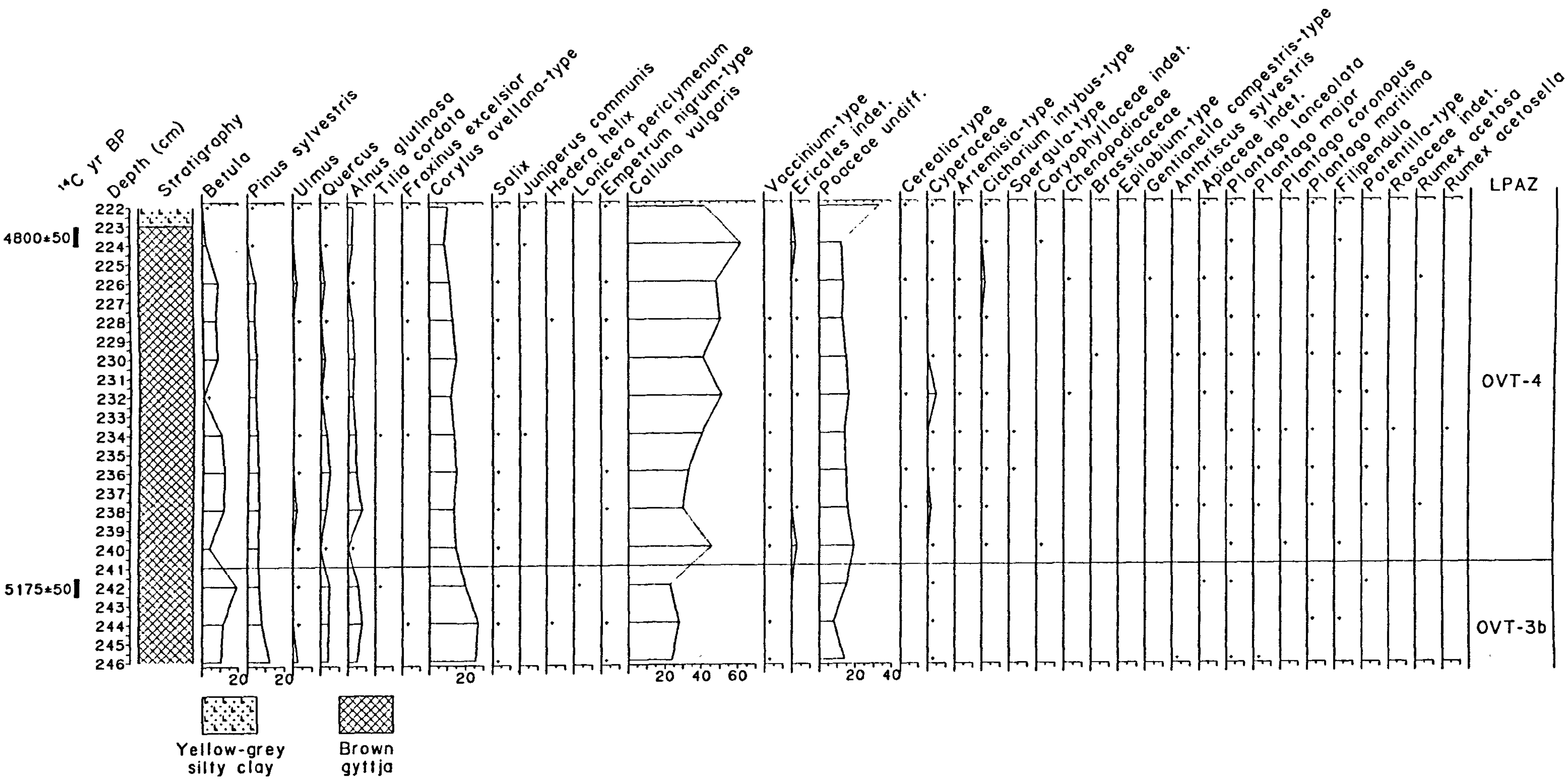


Fig. 9.8 Extract of pollen and spore percentage diagram (zone OVT-4) from Loch Olabhat (+ = <2%).

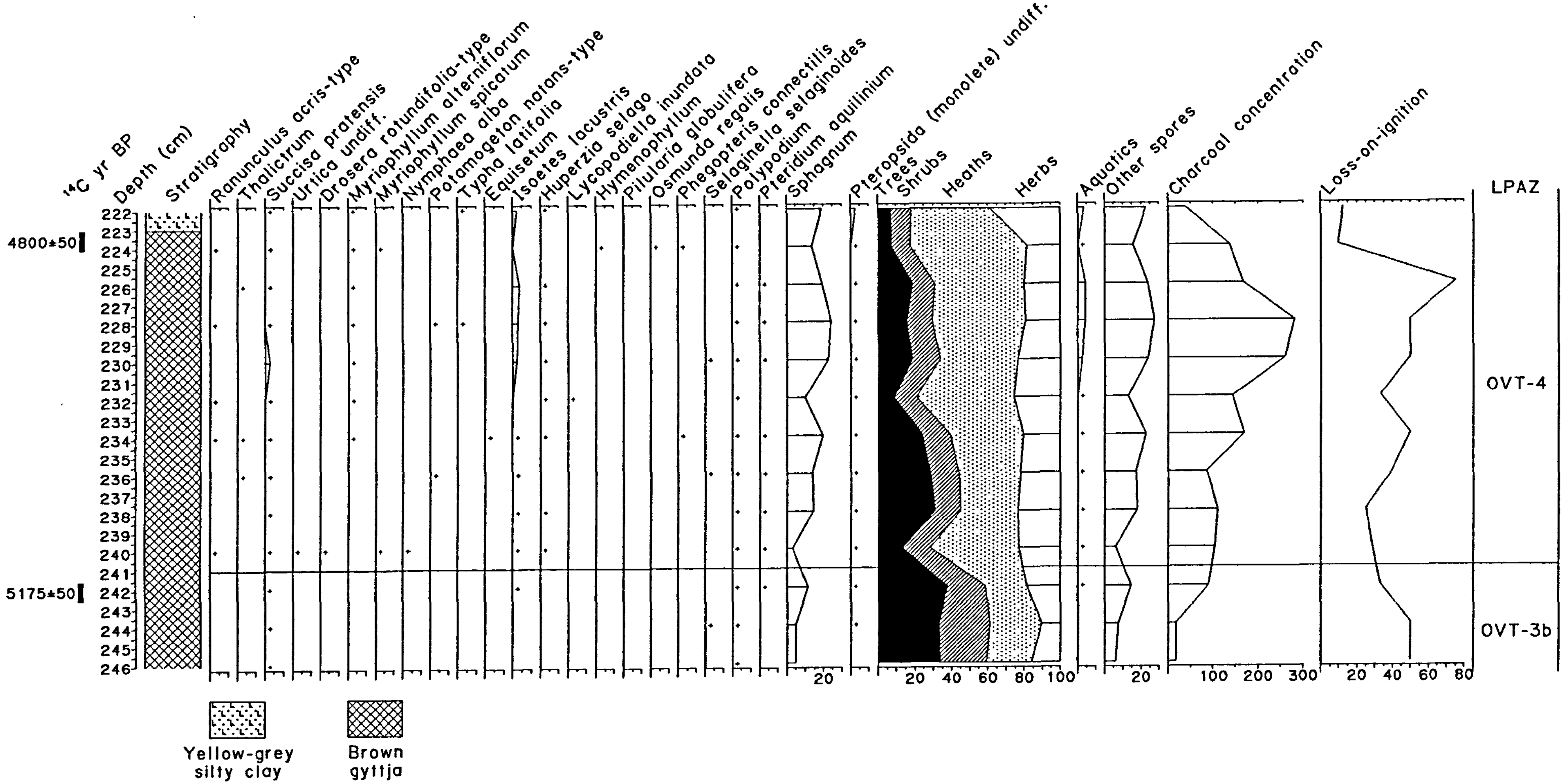


Fig. 9.8 (continued)

Charcoal (Fig. 9.5 and 9.6)

Charcoal values are low: charcoal concentrations range from 2.6 to 32.1 x 10^{-4} cm^2 cm^{-3}, and accumulation rates range from 1.2 to 15 x 10^{-5} cm^2 cm^{-2} $year^{-1}$.

Loss-on-ignition (Fig. 9.4)

Loss-on-ignition values are low, fluctuating between 4% and 23%.

Deterioration diagram (Fig. 9.7)

Between 6% and 16% of the pollen grains in this subzone show signs of deterioration. This includes crumpled, broken and corroded *Empetrum*, corroded *Betula*, and crumpled and corroded Poaceae grains.

OVT-1b

354-338 cm 10150-9810 BP

Percentage diagram

Subzone 2b is characterised by a strong increase in *Empetrum nigrum*-type to 82%, before declining to 46% at the top of the subzone. Poaceae and Cyperaceae values are correspondingly lower. Tree and shrub pollen frequencies are on average also slightly lower (4–17%), with *Juniperus* and *Betula* in particular showing a decline. *Corylus avellana*-type appears for the first time in low frequencies at 340 cm. Commonly appearing herb taxa are similar to the previous subzone, with the exception of Apiaceae, which has declined in frequency. Aquatic frequencies are even lower than before, but besides *Myriophyllum alterniflorum* include *Potamogeton natans*-type. *Huperzia selago* values remain high (>7%), while *Polypodium* increases to 9%.

Concentration and accumulation rate diagrams

Total pollen and spore concentrations are lower than in the previous subzone (mean 1 x10^4 grains cm^{-3}), as are accumulation rates (864–1877 grains cm^{-2} $year^{-1}$, mean 1411 grains cm^{-2} $year^{-1}$).

Charcoal

Charcoal values remain low. Charcoal concentrations are between 7.9 and 13 x 10^{-4} cm^2 cm^{-3}, and accumulation rates between 3.7 and 6.5 x 10^{-5} cm^2 cm^{-2} $year^{-1}$.

Loss-on-ignition

Loss-on-ignition values are the lowest for the diagram at 2–4%.

Deterioration diagram

Deterioration rates are considerably higher in this subzone, with between 14% and 54% of pollen grains recorded as deteriorated. This included a high percentage of crumpled grains, in particular of *Empetrum* and Poaceae. Corroded *Empetrum*, Poaceae, *Betula* and *Pinus* grains were also recorded.

OVT-2

338-309 cm 9810-9200 BP

Percentage diagram

This zone is characterised by an increase in *Betula* and Poaceae, and a decline in *Empetrum nigrum*-type. *Betula* rises gradually to a peak of 36% at the top of the zone. *Corylus avellana*-type pollen is recorded sporadically, but in very low frequencies. *Empetrum nigrum*-type falls to 6% by 316 cm, before rising again to 20% by the top of the zone. *Calluna vulgaris* pollen is recorded for the first time at 332 cm. Poaceae frequencies increase to a peak of 52%, and Cyperaceae fluctuates between less than 1% and 16%. The other common herb taxa remain the same as in the previous zone. *Myriophyllum alterniflorum* frequencies remain high for some time, increasing to 19% at the bottom of the zone before declining to less than 1%. *Potamogeton*, *Equisetum*, *Typha latifolia* and *T. angustifolia* were also recorded. *Huperzia selago* declines from 9% to 1%, while *Polypodium* remains prominent and *Pteridium aquilinum* appears for the first time at 310 cm.

Concentration and accumulation rate diagrams

Total pollen and spore concentrations increase to a peak of 5.9 $x10^4$ grains cm^{-3} towards the top of the zone (mean 3.7 $x10^4$ grains cm^{-3}). Accumulation rates peak at 2972 grains cm^{-2} $year^{-1}$ (mean 1291 grains cm^{-2} $year^{-1}$).

Charcoal

Charcoal concentrations fluctuate between 1.8 and 37 x 10^{-4} cm^2 cm^{-3} (mean 15.3 x 10^{-4} cm^2 cm^{-3}), and charcoal accumulation rates range from 0.8 to 1.6 x 10^{-5} cm^2 cm^{-2} $year^{-1}$.

Loss-on-ignition

Loss-on-ignition values (15-33.3%) are significantly higher than in subzone OVT-1b.

Deterioration diagram

Deterioration rates range from almost 5% to 40%. Corroded *Betula* and *Empetrum* and crumpled Poaceae grains were the most commonly recorded deteriorated pollen grains.

OVT-3a

309-279 cm 9200-8235 BP

Percentage diagram

Subzone OVT-3a is characterised by a rise in the *Corylus* curve to a maximum of 41%, as well as a strong increase in *Calluna vulgaris*. Arboreal pollen frequencies in general fluctuate between 34% and 66%. *Pinus* increases gradually to 17%. The *Quercus* curve becomes continuous and reaches almost 3% by 278 cm, while *Ulmus* appears for the first time at 304 cm, and rises to 4% by the top of the subzone. *Alnus glutinosa* is recorded for the first time at 308 cm. *Betula* values are lower, decreasing from 29% to 4% by the middle of the subzone before recovering slightly to reach 17% by the top. *Empetrum nigrum*-type frequencies decline to nil, while the *Calluna* curve rises rapidly to reach a maximum of 28%. There is a gradual decline in Poaceae from 34% to 4%, and Cyperaceae values are markedly reduced (to <5%). Chenopodiaceae, *Plantago maritima*, and *Succisa pratensis* are amongst the most commonly recorded herb taxa. *Plantago lanceolata* appears for the first time at 308 cm, and is recorded sporadically throughout this subzone. Aquatic taxa are very rare. The *Sphagnum* curve becomes continuous, and frequencies increase significantly to a maximum of 20% at 288 cm, while *Pteridium* is also recorded more commonly.

Concentration and accumulation rate diagrams

Total pollen and spore concentrations in this subzone fluctuate between 1 and 7.5 $x10^4$ grains cm^{-3}, while accumulation rates range from 298 to 2321 grains cm^{-2} $year^{-1}$ (mean 1119 grains cm^{-2} $year^{-1}$).

Charcoal

Charcoal values are considerably higher. Charcoal concentrations range from 13.8 to 85.5 x 10^{-4} cm^2 cm^{-3}, and accumulation rates from 1.6 to 26.3 x 10^{-5} cm^2 cm^{-2} $year^{-1}$.

Loss-on-ignition

Loss-on-ignition values fluctuate between 10% and 36%.

Deterioration diagram

Deterioration rates in this subzone were quite high, reaching a peak of 62% at 288 cm, including corroded *Betula*, *Corylus*, and *Calluna vulgaris* grains, as well as crumpled Poaceae and broken and corroded *Pinus* grains.

OVT-3b

277-241 cm 8070-5150 BP

Percentage diagram

Arboreal pollen frequencies remain consistently high, between 59% and 75%, while *Calluna* and Poaceae values are slightly lower and Cyperaceae is rare. The *Alnus* curve becomes continuous at 268 cm, and by the top of the zone has reached 8%. Cerealia-type pollen appears for the first time at 270 cm, and the *Plantago lanceolata* curve becomes continuous at 242 cm. *Cichorium intybus*-type is less frequently recorded than before, but Chenopodiaceae, *Plantago maritima*, *Potentilla*-type and *Succisa pratensis* are still relatively prominent. Aquatic taxa remain very rare, and consist primarily of *Isoetes lacustris* spores. Amongst the other spores *Polypodium*, *Pteridium aquilin um* and Pteropsida (monolete) indet. are recorded in low frequencies, and *Sphagnum* values have declined to less than 12%.

Concentration and accumulation rate diagrams

Total pollen and spore concentration values are on average slightly lower than in the previous zone before increasing to a peak of 11.8 x10^4 grains cm^{-3} at the top of the subzone. Accumulation rates increase from 247 to 2254 grains cm^{-2} $year^{-1}$.

Charcoal

Charcoal concentrations are lower than in zone OVT-3a, before they increase to 90.8 x 10^{-4} cm^2 cm^{-3} at 242 cm. Charcoal accumulation rates range from 0.5 to 17.3 x 10^{-5} cm^2 cm^{-2} $year^{-1}$.

Loss-on-ignition

Loss-on-ignition values fluctuate quite strongly between 14% and 50%.

Deterioration diagram

Deterioration rates (7-30%) are slightly lower than in the previous subzone. Corroded *Betula*, *Corylus* and *Calluna vulgaris* grains were still commonly recorded, and broken and corroded *Pinus* and crumpled Poaceae grains were also present.

OVT-4

241-222 cm 5150-4460 BP

Percentage diagram (see also Fig. 9.8)

Tree and shrub pollen frequencies start to fall during this zone, in a rather erratic fashion, from 45% to 17%. All arboreal pollen taxa are included in the decline. *Calluna vulgaris* increases to a maximum of 62%, while Poaceae frequencies are also slightly higher (maximum 33%). *Cichorium intybus*-type features prominently among the herbs, along with *Artemisia*, *Plantago maritima*, *Potentilla*-type, *Ranunculus acris*-type and *Succisa pratensis*. Aquatic taxa increase in frequency, and include *Myriophyllum alterniflorum*, *Nymphaea*, *Potamogeton* and *Isoetes lacustris*. *Sphagnum* values increase strongly to 24%.

Concentration and accumulation rate diagrams

Total pollen and spore concentrations are high, fluctuating between 2.1 and 14.8 $\times 10^4$ grains cm^{-3}. Accumulation rates fluctuate strongly between 410 and 7398 grains cm^{-2} $year^{-1}$ (mean 4010 grains cm^{-2} $year^{-1}$).

Charcoal

Charcoal values are high. Charcoal concentrations show a significant increase, to a peak of 281.5 cm^2 cm^{-3} at 228 cm (mean 149.4 x 10^{-4} cm^2 cm^{-3}), while charcoal accumulation rates reach a maximum of 140.7 x 10^{-5} cm^2 cm^{-2} $year^{-1}$.

Loss-on-ignition

Loss-on-ignition values reach a peak of 75% before dropping to 8% at the top of the zone.

Deterioration diagram

Between 20% and 50% of pollen grains in this subzone showed signs of deterioration. There were high percentages of corroded pollen grains, in particular *Corylus* (up to 55%), *Betula* and *Calluna vulgaris*, as well as broken and corroded *Pinus*, and crumpled and corroded Poaceae grains.

No pollen

222-191 cm 4660-1840 BP

Loss-on-ignition measurements were taken from 5 samples in this part of the profile. They ranged from 5% to 14%.

OVT-5

191-132 cm 1840-200 BP

Percentage diagram

Calluna vulgaris dominates the uppermost zone, rising to a maximum of 76%. Tree and shrub pollen frequencies in total are very low, fluctuating between 4% and 16%. Cyperaceae values are slightly higher than in the previous zone (maximum 7%). *Cichorium intybus*-type, Lactuceae indet., *Solidago virgaurea*-type, Chenopodiaceae, Brassicaceae, Apiaceae, *Plantago coronopus*, *P. maritima*, *Potentilla*-type, *Ranunculus acris*-type and *Succisa pratensis* are all commonly recorded. *Plantago lanceolata* frequencies are at their highest, reaching a maximum of almost 4%. *Sphagnum* values are high, up to 36% at the bottom of the zone, but decline to 12% at the top. *Isoetes lacustris* spores dominate the aquatic taxa, with a peak of 61% at 184 cm. *Myriophyllum alterniflorum* also rises towards the top of the zone to reach 10%.

Concentration and accumulation rate diagrams

Total pollen and spore concentrations increase from 0.8 $x10^4$ grains cm^{-3} at the bottom of the zone to a maximum of 12.2 $x10^4$ grains cm^{-3} at 174 cm.

Accumulation rates also increase, from 96 to 1079 grains cm^{-2} $year^{-1}$ at 184 cm, and then fluctuate between 789 and 4079 grains cm^{-2} $year^{-1}$ (mean 2262 grains cm^{-2} $year^{-1}$).

Charcoal

Charcoal concentrations rise from 25.3 to 278 x 10^{-4} cm^2 cm^{-3} at 182 cm, and then fluctuate between 67.5 and 260.2 x 10^{-4} cm^2 cm^{-3}. Charcoal accumulation rates fluctuate between 2.9 and 92.6 x 10^{-5} cm^2 cm^{-2} $year^{-1}$.

Loss-on-ignition

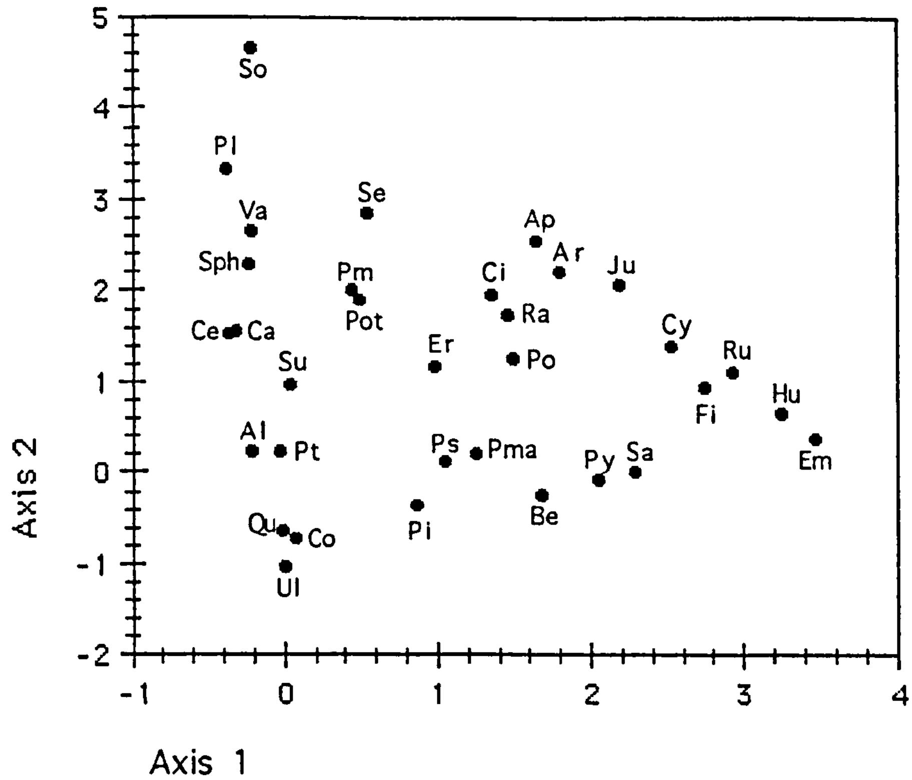
Loss-on-ignition values fluctuate between 12.5% and 34%.

Deterioration diagram

Between 9% and 48% of pollen grains were deteriorated. Corroded *Calluna vulgaris* and crumpled Poaceae grains were the largest contributors to this group.

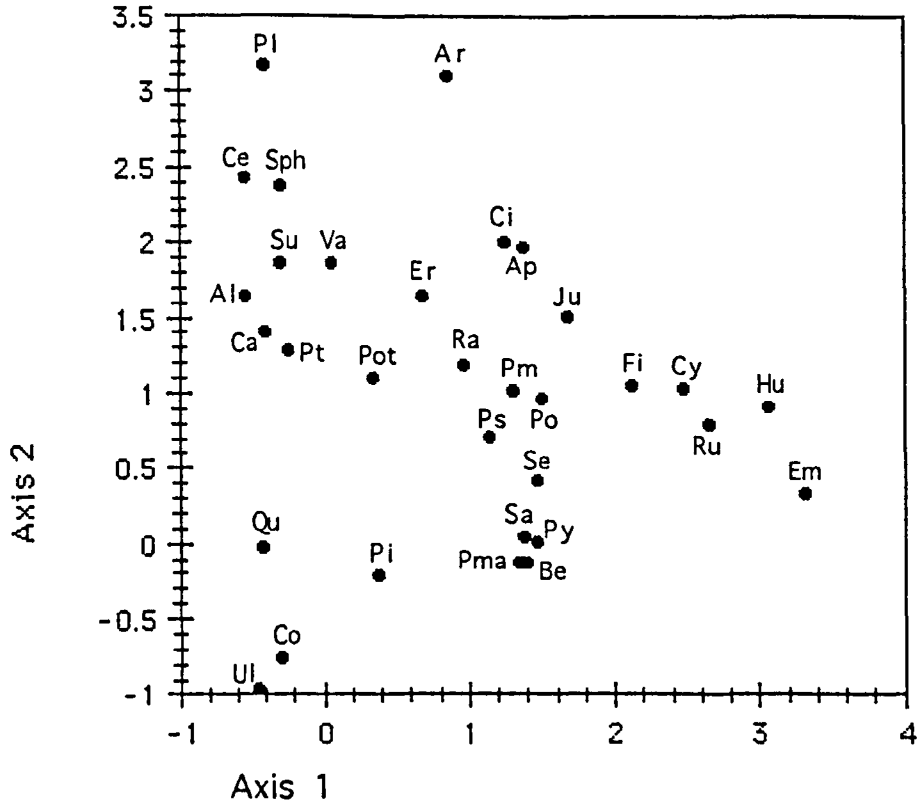
9.6 Detrended Correspondence Analysis (DCA)

The pollen and spore percentage data from Loch Olabhat were subjected to DCA in order to inform the vegetation history of the area. Figure 9.9 reflects the general trends in vegetation change recorded in the entire profile. To the right of the diagram are taxa that are characteristic of an open environment typical of the Lateglacial period (e.g. *Empetrum nigrum*-type, *Huperzia selago*, *Rumex acetosa*, Cyperaceae and *Filipendula*). Towards the bottom middle are found trees and shrubs (such as *Betula* and *Salix*) and other taxa typical of the very early Holocene. To their left is a cluster of trees that occurred primarily during the main woodland phase of the first half of the Holocene (*Quercus*, *Ulmus*, *Corylus avellana*-type, *Pinus* and *Alnus*). The proximity of *Pteridium aquilinium* to these trees might indicate that it was primarily growing as an understorey plant at this time. In the top left hand corner there are taxa typical of wet pasture, moorland and peat bog (e.g. *Calluna vulgaris*, *Vaccinium*-type, *Selaginella selaginoides*, *Plantago maritima*, *Sphagnum* and *Potentilla*-type) as well as potential indicators of anthropogenic activity



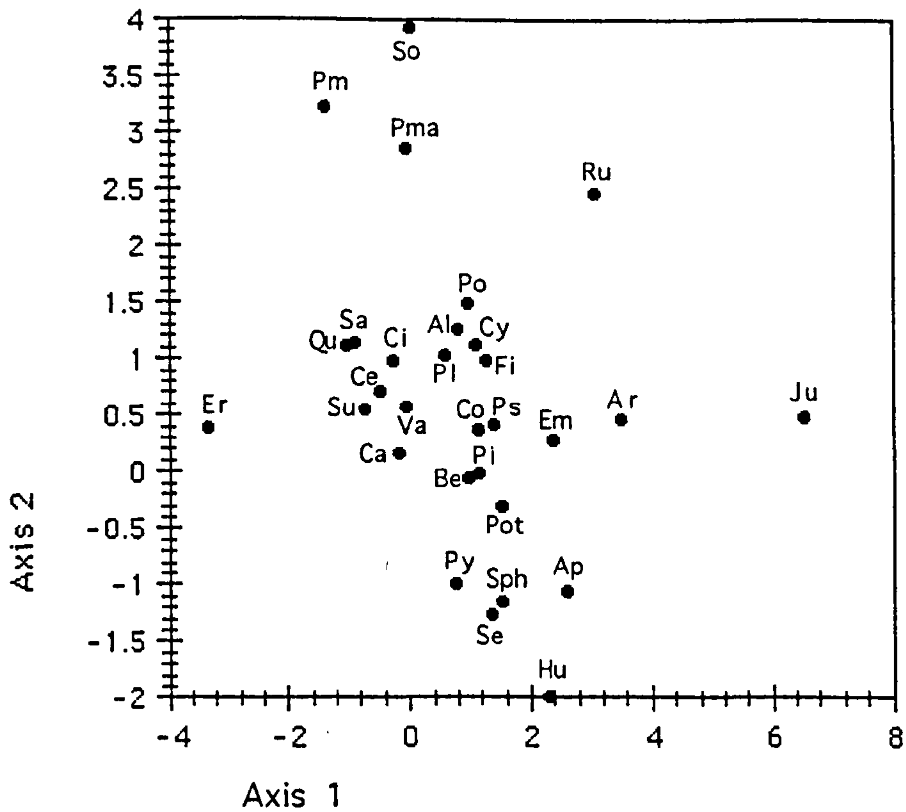
Key:
(Al) *Alnus*; (Ap) Apiaceae; (Ar) *Artemisia*-type; (Be)*Betula*; (Ca) *Calluna vulgaris*; (Ce) Cerealia-type; (Ci) *Cichorium intybus*-type; (Co) *Corylus avellana*-type; (Cy) Cyperaceae; (Em) *Empetrum nigrum*-type; (Er) Ericales indet.; (Fi) *Filipendula*; (Hu) *Huperzia selago*; (Ju) *Juniperus communis*; (Pi) *Pinus sylvestris*; (Pl) *Plantago lanceolata*; (Pm) *Plantago major*; (Pma) *Plantago maritima*; (Po) Poaceae; (Pot) *Potentilla*-type; (Pt) *Pteridium aquilinium*; (Ps) Pteropsida (monolete) indet.; (Py) *Polypodium*; (Qu) *Quercus*; (Ra) *Ranunculus acris*-type; (Ru) *Rumex acetosa*; (Sa) *Salix*; (Se) *Selaginella selaginoides*; (So) *Solidago virgaurea*-type; (Sph) *Sphagnum*; (Su) *Succisa pratensis*; (Ul) *Ulmus*; (Va) *Vaccinium*-type.

Fig. 9.9 Loch Olabhat: DCA, entire profile



Key:
(Al) *Alnus*; (Ap) Apiaceae; (Ar) *Artemisia*-type; (Be) *Betula*; (Ca) *Calluna vulgaris*; (Ce) Cerealia-type; (Ci) *Cichorium intybus*-type; (Co) *Corylus avellana*-type; (Cy) Cyperaceae; (Em) *Empetrum nigrum*-type; (Er) Ericales indet.; (Fi) *Filipendula*; (Hu) *Huperzia selago*; (Ju) *Juniperus communis*; (Pi) *Pinus sylvestris*; (Pl) *Plantago lanceolata*; (Pm) *Plantago major*; (Pma) *Plantago maritima*; (Po) Poaceae; (Pot) *Potentilla*-type; (Pt) *Pteridium aquilinium*; (Ps) Pteropsida (monolete) indet.; (Py) *Polypodium*; (Qu) *Quercus*; (Ra) *Ranunculus acris*-type; (Ru) *Rumex acetosa*; (Sa) *Salix*; (Se) *Selaginella selaginoides*; (So) *Solidago virgaurea*-type; (Sph) *Sphagnum*; (Su) *Succisa pratensis*; (Ul) *Ulmus*; (Va) *Vaccinium*-type.

Fig. 9.10 Loch Olabhat: DCA, bottom of profile excluding Lateglacial (338-220 cm)



Key:
(Al) *Alnus*; (Ap) Apiaceae; (Ar) *Artemisia*-type; (Be)*Betula*; (Ca) *Calluna vulgaris*; (Ce) Cerealia-type; (Ci) *Cichorium intybus*-type; (Co) *Corylus avellana*-type; (Cy) Cyperaceae; (Em) *Empetrum nigrum*-type; (Er) Ericales indet.; (Fi) *Filipendula*; (Hu) *Huperzia selago*; (Ju) *Junipèrus communis*; (Pi) *Pinus sylvestris*; (Pl) *Plantago lanceolata*; (Pm) *Plantago major*; (Pma) *Plantago maritima*; (Po) Poaceae; (Pot) *Potentilla*-type; (Pt) *Pteridium aquilinium*; (Ps) Pteropsida (monolete) indet.; (Py) *Polypodium*; (Qu) *Quercus*; (Ra) *Ranunculus acris*-type; (Ru) *Rumex acetosa*; (Sa) *Salix*; (Se) *Selaginella selaginoides*; (So) *Solidago virgaurea*-type; (Sph) *Sphagnum*; (Su) *Succisa pratensis*; (Ul) *Ulmus*; (Va) *Vaccinium*-type.

Fig. 9.11 Loch Olabhat: DCA, top of profile (190 cm - top)

(*Plantago lanceolata*, *Solidago virgaurea*-type, and Cerealia-type), characteristic of the top half of the profile. In the very middle of the diagram there is a cluster of taxa, including Ericales indet., Poaceae, and *Ranunculus acris*-type, which were present fairly consistently throughout the profile.

The second diagram (Fig. 9.10) reflects the vegetation patterns of the woodland phase at the site (zones OVT-2 - OVT-4). Towards the right of the ordination plot are taxa that form remnants of an open Lateglacial environment (e.g. *Empetrum nigrum*-type, *Huperzia selago*, *Rumex acetosa* and Cyperaceae). Woodland taxa that were prominent throughout this period (e.g. *Corylus*, *Quercus* and *Ulmus*) can be found to the bottom left. Towards the middle left section of the diagram there are taxa of wet grassland (such as Ranunculaceae, *Plantago maritima*, Poaceae and *Selaginella selaginoides*), and just to the left of these, taxa of moorland and mire (e.g. *Calluna vulgaris*, *Potentilla*-type and *Sphagnum*). In the very top left corner are the potential anthropogenic indicator taxa Cerealia-type and *Plantago lanceolata*, which start to appear towards the end of this phase.

Figure 9.11 covers the phase following the decline of trees and shrubs. The data set comes from zone OVT-5, which is located above the erosional phase in the profile and therefore does not follow on immediately from the woodland period . Towards the bottom middle of the diagram there is a cluster of taxa that were slightly more prominent at the very start of this phase (e.g. *Sphagnum*, *Potentilla*-type, Apiaceae indet., and *Huperzia selago*). There is a cluster with a large number of taxa in the centre of the diagram, taxa which were consistently, although sometimes in very low frequencies (e.g. *Corylus*, *Calluna vulgaris*, *Filipendula*, *Plantago lanceolata*, Poaceae and Cyperaceae). At the very top of the diagram are found taxa typical of the very top of the profile, some of which can be pastoral or ruderal indicators (e.g. *Rumex acetosa* and *Plantago major*).

9.7 Inferred vegetation history

10950-9890 BP (*c.* 12990–11240 cal BP)

The pollen record at Loch Olabhat starts during the Lateglacial, when the area around Loch Olabhat was characterised by a fairly open landscape, dominated by *Empetrum* heathland, grassland and sedges. Patches of *Betula*, *Salix*, and to a lesser extent, *Juniperus* scrub (probably dwarf and prostrate forms) were also present, perhaps occupying the better soils. The grassland was herb-rich, and is likely to have included Apiaceae, *Filipendula*, *Potentilla*-type, *Ranunculus acris*-type, *Succisa pratensis* and *Plantago maritima*. Pioneer taxa characteristic of broken ground such as *Rumex acetosa* and *Artemisia* were also present, and the ferns *Huperzia selago* and *Polypodium* may have occupied rocky slopes nearby. *Sphagnum* is recorded for the first time at 10530 BP (12590 cal BP), one of the earliest occurrences of this taxon in the Outer Hebrides. Productivity in the lake itself was low, and aquatic growth consisted primarily of *Myriophyllum alterniflorum*.

Between 10150 BP and 9890 BP (11820-11240 cal BP) (subzone OVT-1b) loss-on-ignition values and pollen concentrations fall, and there is a decrease in the frequencies and concentrations of most pollen taxa, including Poaceae, Cyperaceae, *Juniperus* and *Betula* (which may derive from *Betula nana*). *Empetrum* values, on the other hand, increase strongly, with percentages reaching 82% by 10100 BP (11750 cal BP), although this change is not as clear from the absolute data. *Huperzia selago* and *Polypodium* also become more prominent with frequencies rising to 10% and 8.6% respectively by 10100 BP (11750 cal BP). *Empetrum* heath appears to have dominated the landscape until 9890 BP (11240 cal BP). During this phase lake productivity was even lower than before, but besides *Myriophyllum* now also included *Potamogeton natans*-type.

Subzone OVT-1b appears to bear a close resemblance to a Lateglacial zone in the profile from the undated profile of Loch Bharahbhat 1 in Lewis (Edwards and Whittington, 1994), which the authors suggest may reflect the Loch Lomond Stadial (Younger Dryas) cold phase that has traditionally been dated to *c.* 11000-10000 BP (13020-11410 cal BP) (Gray and Lowe, 1977; Walker and Lowe, 1990). Edwards and Whittington (1994) also argue that the prominence of *Empetrum* (60%) at Loch Bharabhat during this phase may not be an accurate reflection of the vegetation: high levels of deteriorated *Empetrum* pollen suggest that much of the *Empetrum* may be of secondary origin, derived from the erosion of interstadial soils and redeposited in the basin (Walker and Lowe, 1990; Edwards and Whittington, 1994). Deterioration rates are also high at Loch Olabhat - between 40 and 54% of *Empetrum* grains were found to be crumpled and/or corroded in subzone OVT-1b. Thus, although some *Empetrum* heath is likely to have occurred in the area, grassland with Cyperaceae, *Huperzia selago* and *Polypodium* may have been more prominent than they appear from the diagram.

If OVT-1b does correspond to the Loch Lomond Stadial, then OVT-1a may date to the preceding Allerød interstadial, which could explain the existence of a scrub flora. In any event, this suggests that the interpolated dates below the Holocene section of the profile, are too young.

9890-9200 BP (*c.* 11240–10330 cal BP)

The Lateglacial/Holocene boundary in the profile is not very distinct. The first sign of the start of the Holocene appears to be a slight rise in the loss-on-ignition curve to 15% at 9850 BP (11220 cal BP). This is followed by a change in the sediment from green-clay to grey-brown mud at 9810 BP (11210 cal BP) and an expansion in *Betula* (probably tree birch) and Poaceae, while *Empetrum nigrum* heath is seriously reduced. *Myriophyllum alterniflorum* frequencies and concentrations increase markedly at 9770 BP (11190 cal BP) suggesting that the climate was getting warmer.

The start of sediment and vegetation change delineating the transition to the Holocene would appear to be quite late at Loch Olabhat. At most sites in the Outer Hebrides the transition from Lateglacial to Postglacial conditions occurs sometime between 10200 and 10000 BP (11930 and 11410 cal BP) (Brayshay and Edwards, 1996; Fossitt, 1996; Lomax, 1997), while it occurs as early as 10310 BP (12140 cal BP) at Loch Airigh na h-Achlais (this study; see Chapter 8) and 10360 BP (12160 cal BP) at Loch Airigh na h-Aon Oidhche (Brayshay and Edwards, 1996). At Loch Olabhat the expansion in *Betula*, which normally characterises the start of the Postglacial period, does not occur until just before 9810 BP (11210 cal BP). One possible explanation is the radiocarbon date is not accurate enough to provide a reliable extrapolated date. Another could be that the Lateglacial/Holocene boundary is actually located further down in the sediment record (perhaps at the rise of the loss-on-ignition curve to 23% at 10190 BP [11930 cal BP]) but that this has been obscured by sediment mixing. This may also explain the fluctuating loss-on-ignition values between 10440 BP and 9850 BP (12470 and 11220 cal BP).

Betula pollen frequencies rise gradually to 36%, and by 9220 BP (10380 cal BP) birch woodland is an important part of the local vegetation, along with herb-rich grassland. *Salix* scrub, on the other hand, is slightly reduced in extent, while *Juniperus* remains rare. *Corylus* is first recorded at 9850 BP (11220 cal BP) and *Calluna vulgaris* at 9680 BP (11150 cal BP). *Empetrum* heath re-expanded briefly between 9310 and 9100 BP (10500–10230 cal BP) but never re-attained its former prominence. As competition increased *Huperzia selago* was also gradually reduced in extent, while *Polypodium* became more prominent.

9200-8235 BP (*c.* 10330–9200 cal BP)

Woodland cover increased strongly in this phase (max. 69% at 8270 BP [9270 cal BP]), and initially consisted of birch and hazel. *Corylus* arrived locally by 9170 BP (10310 cal BP) and rose rapidly to prominence by 9040 BP (10210 cal BP), dominating the landscape for the rest of zone OVT-3. In the meantime, *Betula* appears to have suffered under the competition from hazel and declined in extent; *Betula* concentrations and accumulation rates decline, and frequencies fall as low as 4% by 8460 BP (9500 cal BP), before recovering slightly. *Salix* scrub may have been growing in wetter areas, or on the edge of the woodland, but probably disappeared locally by 8400 BP (9400 cal BP). *Pinus* values increase gradually (both in terms of percentage and absolute data), with frequencies reaching a maximum of 17% at 8330 BP (9350 cal BP). This figure is relatively high compared to other sites on the islands, and it is possible that pine trees were present locally at this time. At Port Caol, on the west coast of South Uist, pine pollen frequencies reach similar levels, and at Loch Hellisdale the figure is as high as 28%, but at most other sites pine pollen frequencies are considerably lower (Brayshay and Edwards, 1996). As discussed in Chapter 8, pine is generally thought to have arrived on the islands around 7500 BP (8280 cal BP) (Bennett, 1984), and the rise in pine at Loch Olabhat appears to be considerably earlier. The question of the local presence of pine in North Uist remains a disputed issue. Beveridge (1911: 5) mentions the finding of 'fir' (pine) remains in peat off the island of Vallay, but in a recent study Fossitt (1994a) found no evidence to confirm such findings (see also Chapter 11).

The *Quercus* curve becomes continuous at 9100 BP (10230 cal BP) while *Ulmus* is recorded for the first time at 9040 BP (10210 cal BP), its curve becoming continuous at 8970 BP (10170 cal BP). *Quercus* and *Ulmus* frequencies remain low (< 4%), and it is unlikely that either of these taxa were growing in the area at this time.

Woodland cover was extensive during subzone OVT-3a, but probably not continuous. Poaceae remained an important, albeit declining, element in the landscape, probably forming part of the understorey, as well as growing in open areas between the woodland. The grassland was herb-rich, with *Cichorium intybus*-type, *Filipendula, Potentilla*-type and *Succisa pratensis* commonly present. *Polypodium* and undifferentiated ferns are likely to have formed a part of the understorey vegetation, along with the climbing shrub *Hedera helix*. Patches of heath also occurred in the landscape. *Calluna vulgaris*, which arrived around 9100 BP (10230 cal BP), gradually expanded, replacing *Emptrum nigrum*-type as the main heathland taxon.

The *Sphagnum* curve becomes continuous around 9170 BP (10310 cal BP), and rises to a strong peak at 8520 BP (9270 cal BP) although this is less obvious in the absolute data. A pollen grain of *Drosera rotundifolia* was recorded at 9170 BP (10310 cal BP), and *Potentilla*-type, another indicator of mire vegetation, had been present since the start of the profile. Blanket mire may thus have been forming in the area from at least 9100 BP (10230 cal BP) onwards.

Lake productivity was very low. *Myriophyllum alterniflorum* frequencies are greatly reduced, and there are only sporadic occurrences of *Potamogeton, Typha latifolia* and *Equisetum*.

At 8270 BP (9270 cal BP) there was a change in the stratigraphy from grey-brown mud to brown gyttja. Preservation of pollen improved and loss-on-ignition values start to increase slightly at this time, indicating that the sediment was becoming more organic. There do not appear to be any significant changes in the pollen record associated with the change in sediment.

8235-5150 BP (*c.* 9200-5910 cal BP)

Woodland cover reached its maximum extent between 8235 and 5150 BP (9200-5150 cal BP) when arboreal pollen frequencies fluctuate between 59% and 75%. The woodland also became more diverse: beside *Betula* and *Corylus*, a case can be made for the local presence of *Pinus* and *Alnus*, and possibly *Quercus* and *Ulmus*. *Pinus* frequencies fluctuate between 1% and 14% (at 6170 BP [7080 cal BP]), and although this is not exceptionally high, the fact that the curve is not smooth could suggest that the pollen derives primarily from local pine trees. *Ulmus* and *Quercus* both expanded around 7660 BP (8410 cal BP), after which time their frequencies are generally over 3%. They may have become part of the local woodland, but if they were present they were never very important, occurring either as scattered individuals or very small clusters on the better soils, and they probably disappeared from the area around Loch Olabhat after 5800 (6600 cal BP) and 5000 BP (5730 cal BP) respectively. The *Alnus* curve becomes continuous at 7880 BP (8620 cal BP) and rises to 8% by 5670 BP (6440 cal BP) (a change also visible in the absolute data), which may be high enough to suggest that alder, too, was growing locally.

As in the previous phase, woodland cover was extensive, but open enough to allow the growth of grass, ferns and tall-herb communities, as well as the climbing shrubs *Hedera helix* and *Lonicera periclymenum*. *Calluna vulgaris* heath, too, formed a prominent part of the landscape. Lake productivity remained very low, but for the first time *Isoetes lacustris* spores were recorded.

There are very few signs of anthropogenic activity in the diagram during this, or any previous, phase. Cerealia-type pollen is recorded for the first time at 7490 BP (8280 cal BP) but is likely to represent large grass pollen grains such as *Glyceria* rather than cultivated cereals (Andersen, 1979; Dickson, 1988; Edwards and Whittington, 1997). *Plantago lanceolata* is also represented, but it can grow as part of the natural vegetation on the islands, and is therefore not a definitive indicator of the presence of people. There are no signs of increased erosion that may have been caused by human interference in the landscape; loss-on-ignition values are average, as are deterioration levels, and *Isoetes lacustris* (which can thrive in nutrient rich conditions resulting from the inwash of minerogenic deposits; Vuorela, 1980) is present only in low frequencies. Charcoal values are generally low, although there is a small peak in frequency at 8460 BP (9500 cal BP). In the absence of other indicators of anthropogenic activity this might suggest the occurrence of natural fire, rather than the possible presence of Mesolithic people.

5150 BP–4660 BP (*c.* 5910–5390 cal BP) (Fig. 9.8)

From 5150 BP onwards woodland extent was greatly reduced at Loch Olabhat (zone OVT-4). All the arboreal taxa appear to have been affected, and tree and shrub frequencies decline from 45% to 17%. This decline is, however, not clearly reflected in the concentration and accumulation rate diagrams, as total pollen and shrub concentrations are generally very high at this time. The decline in trees and shrubs is rather erratic, with several brief phases of regeneration at 5090-5010 BP (5830-5740 cal BP) and 4930-4850 BP (5640-5590 cal BP), when arboreal pollen frequencies rise to 45% and 34% respectively (Fig. 9.8). It is largely *Betula* that increases during these periods, but *Pinus*, *Ulmus*, *Quercus* and *Alnus* values are also higher. *Corylus* declines more gradually throughout the zone, and shows no sign of regeneration.

There is no clear evidence for the presence of a classic 'elm decline' at Loch Olabhat. *Ulmus* representations were never high, and the most significant decline (from 4.1% to 0.4%) occurs at 5670 BP (6440 cal BP) long before the traditional date for the elm decline of *c.* 5100 BP (5840 cal BP) (Birks, 1989).

As the trees and shrubs declined *Calluna vulgaris* expanded into the area, and by 4660 BP (5390 cal BP) *Calluna* heath dominated the landscape, reaching frequencies of over 60%. *Sphagnum*, too, became more prominent, suggesting that peat bog formation in the area was accelerating. Herb-rich grassland also expanded slightly, but sedges remained rare.

The decline in trees and shrubs and the spread of heath and mire communities could have occurred in response to natural changes, such as a deterioration in climate and increased leaching and soil acidification. On the other hand, the uncertainty of the radiocarbon determinations could easily place these events close to the traditional date for the start of the conventional Neolithic at *c.* 5000 BP (5730 cal BP), and many of the changes indicated by the fossil record could reflect human impact. Cerealia-type pollen is recorded more frequently and other taxa characteristic of arable or pastoral habitats (such as *Plantago lanceolata*, *Artemisia*, *Cichorium intybus*-type, Apiaceae, Poaceae and *Pteridium aquilin um*) appear or expand, suggesting that both cultivation and pastoral agriculture were taking place near the site. Charcoal frequencies and concentrations also show a significant increase, and a rise in the *Calluna* curve at the same time suggests that there may be evidence of the use of fire in heathland management, as well burning asociated with domestic fires.

With the Neolithic settlement site of Eilean Domhnuill actually located on an island in the loch itself (see Chapter 10), there is irrefutable evidence for the presence of Neolithic people at Loch Olabhat, and their influence must have been felt. In an estimated 600 radiocarbon calendar years the area was practically denuded of woodland. Trees may have been cut down to provide land for arable or pastoral agriculture, or to provide firewood and building timber for local settlements. Aside from the pollen evidence, arable activity is also suggested by the presence of a saddle quern at the site as well as macrofossils; barley grains (*Hordeum* undiff.), and a smaller number of wheat grains (*Triticum aestivum/compactum*) were recovered at the site (P. Grinter, pers. comm.). Eilean Domhnuill was abandoned on at least one occasion during the Neolithic (Armit, 1992b), and the regeneration phases of trees and shrubs that can be seen in the pollen diagram may reflect times when the island was unoccupied. At the moment this cannot be proven, since the different settlement phases on the island have not been dated.

Aside from changes in vegetation, there are also increasing signs of disturbance of the catchment soils in the loch profile in zone OVT-4. The increase in *Calluna* values at 5130 BP (5910 cal BP) could at least in part reflect increased erosion of peat into the loch (cf. Stevenson *et al.*, 1990), which may also be supported by an increase in loss-on-ignition values, which peak at 75% at 4850 BP (5590 cal BP). A rise in *Isoetes lacustris* and increase in deteriorated pollen frequencies towards the top of the zone could indicate an increase in the erosion of mineral soil into the lake, which may have been caused or accelerated by agricultural activity and woodland clearance in the area.

4660-200 BP (*c.* 5390–220 cal BP)

Between zones OVT-4 and OVT-5 there appears to be a marked erosional phase in the profile, starting at around 4660 BP (5390 cal BP) and lasting until around 1760 BP (1670 cal BP). At 4790 BP the sediment changes from gyttja to a yellow-grey silty clay, and loss-on-ignition values decline to between 5 and 14%. Between 4660 BP and 1910 BP (5390–1850 cal BP) the deposit is largely sterile, and no adequate pollen counts could be made to create percentage or concentration diagrams. After 1910 BP (1950 cal BP) the loss-on-ignition curve starts to rise, suggesting increased organic material in the loch, pollen concentrations increase, and the pollen record returns, although there is no visual change in the sediment at this time. The sediment record shows a revertance to gyttja at around 1760 BP (1670 cal BP).

The silty clay layer forms a massive deposit, apparently covering a period of about 2900 radiocarbon years (3740 calendar years), and obscuring the palaeoenvironmental record of the later Neolithic, Bronze Age and Iron Age. It is impossible to determine whether the deposit derives from a single event followed by a long hiatus, or a series of erosional episodes, but it may be connected with the evidence of an apparent inundation deposit in the profile at Eilean Domhnuill (Chapter 10). Armit (1992b) suggests that the removal of woodland near Loch Olabhat would have led to changes in the natural hydrological systems around the lake, which in turn would have led to increased erosion, a rise in lake water levels, and eventually the inundation of Eilean Domhnuill. The island was abandoned for a period of time, and the archaeological deposits were sealed beneath a layer of silt (Armit, 1992b). The postulated rise in loch levels could be reflected in the Loch Olabhat record by a sharp increase in Poaceae at 4810 BP (5540 cal BP), reflecting the expansion of *Phragmites australis* into new wet habitats. Although the erosional phase at Loch Olabhat and inundation deposit at Eilean Domhnuill may be connected, they did not necessarily occur simultaneously - the erosion of minerogenic soils into the loch may have occurred long before water levels rose to a point where the island was inundated. Nevertheless, both the start of the erosional phase and the inundation of the site appear to have taken place within the Neolithic (Armit, 1992a; Chapter 10).

If the deposition of minerogenic material was a continuous event, it may have resulted from increased agricultural activity pushing what may already have been rather poor soils beyond a threshold of erosional sensitivity. Although the palaeoecological record from Loch Olabhat cannot be reconstructed for this period, archaeological evidence suggests that the northwestern corner of North Uist was quite heavily settled between the Neolithic and the Iron Age (Armit, 1992b,1996; see Fig. 9.2), and it seems likely that cultivation was taking place near the site throughout this time.

The possibility cannot be discounted that a change in climate contributed to the changes in the sedimentary profile at Loch Olabhat. An increase in precipitation may have led to increased runoff, erosion and higher loch levels. However, if the radiocarbon dates are taken on trust, these changes (at around 4700 BP [5440 cal BP]) are somewhat early for the start of widespread cimatic deterioration that may have occurred between 4300-4000 BP (4850-4460 cal BP) (Birks and Williams, 1983; Birks, 1991), and are certainly too early for the postulated climatic deterioration between 3900 and 3500 BP (4350-3770 cal BP) (Anderson *et al.*, 1998).

When the pollen record returns during the early Historic period, at an extrapolated date of 1910 BP (1850 cal BP), the picture is that of an open, virtually treeless landscape. Poaceae frequencies are relatively high between 1760 BP and 1650 BP (1670-1540 cal BP), but *Calluna* heath and/or blanket peat dominated after that, a landscape which persists to the present day. Arboreal pollen frequencies in this phase range between 4% and 16%, low enough to argue that there were few trees or shrubs growing in the area (Fossitt, 1994a). *Sphagnum* frequencies are high, but declining towards the top of the diagram, suggesting that peat formation was perhaps slowing. There are abundant signs of the presence of people: charcoal values are quite high, and *Plantago lanceolata* values reach their highest levels in the diagram (4%). Herb taxa include Cerealia-type and other arable indicators such as Brassicaceae, Chenopodiaceae, *Artemisia*, *Solidago virgaurea*-type, *Spergula*-type, *Achillea*-type and *Convolvulus arvensis*. But there are also pastoral indicators, including Poaceae, *Anthriscus sylvestris*, *Angelica sylvestris*, *Apiaceae* indet., *Filipendula*, *Ranunculus acris*-type and *Succisa pratensis*, and it is likely that both pastoral and arable agriculture were practised in this region during the last 2000 years. The high values of *Isoetes lacustris* indicate that there may have been a certain amount of erosion of minerogenic material occurring in the catchment area.

One interesting aspect of the Neolithic as well as of the last 2000 years of the profile, is the abundance of charcoal in conjunction with the very high frequencies of *Calluna vulgaris*. The charcoal may simply be a reflection of the use of domestic fires in the area, or the clearance of woodland, but it could also be evidence of the deliberate burning of heathland, as has been suggested, for example, for western Norway (Kaland,1986), Denmark (Odgaard, 1988, 1994) and possibly the Outer Hebrides (Edwards *et al.*, 1995).

9.9 Summary

The profile at Loch Olabhat starts during the Lateglacial at around 10950 BP (12990 cal BP), or even earlier, with a phase of fairly open vegetation, dominated by *Empetrum*, grasses and sedges, with small patches of *Betula*, *Salix* and *Juniperus* scrub. This was followed by possible evidence of a colder phase (perhaps the Loch Lomond Stadial) when *Empetrum*, *Huperzia selago* and *Polypodium* became more prominent, although some of the *Empetrum nigrum*-type pollen may derive from the erosion of older sediments. The start of the Holocene is not clearly visible in the profile. An expansion in *Betula* and grassland takes place around 9810 BP (11210 cal BP) but the actual Lateglacial/Holocene transition is likely to have occurred rather earlier - the lowermost radiocarbon date could be somewhat young, and it is possible that mixing of sediments has taken place. *Corylus* invaded the birch woodland by 9170 BP (10310 cal BP) and by 9040 BP (8260 cal BP) had taken over as the dominant woodland taxon. *Salix* scrub may have been growing in wetter areas, or along the woodland edge, and scattered pine trees may also have been growing locally. Woodland cover was quite extensive, but probably never continuous, and reached its maximum extent between 8070 and 5150 BP (9010-5910 cal BP). *Corylus* and *Betula* remained the most important taxa, but *Alnus* and *Pinus*, and from 7660 BP (8410 cal BP) *Quercus* and *Ulmus*, may also have been present locally.

From *c*. 5150 BP (5910 cal BP) woodland cover was greatly reduced, and in about 600 radiocarbon years the area was denuded of trees and shrubs. This may have been the result of anthropogenic activity, such as the deliberate clearance of woodland for use as arable or pastoral land, or the use of the timber for building purposes. Neolithic people are known to have settled on an island in the loch, but the exact date of their arrival is not known. Aside from evidence for pastoral and arable agriculture, there may be indications of heathland management by fire.

Woodland removal and agricultural activity may have contributed to a rise in lake levels and the inundation of the archaeological site (Eilean Domhnuill; Chapter 10) some time during the Neolithic. It is possible that this correlates with an erosional phase at Loch Olabhat in which very little pollen was preserved, and the start of which has been dated to around 4660 BP (5390 cal BP). This period with no recorded pollen ends around 1910 BP (1850 BP), by which time the landscape was open, virtually treeless, and dominated by *Calluna vulgaris* heathland. There is palynological evidence for both pastoral and arable agriculture, as well as possible heathland mangement, during the past 2000 years.

CHAPTER 10

EILEAN DOMHNUILL

10.1 Location

Eilean Domhnuill (NGR NF 748753) is a Neolithic settlement site located on a small island close to the southwestern shore of Loch Olabhat, in the northwest corner of North Uist (Fig 10.1; see also Chapter 9). The site lies in an area of blanket peat and heathland, but close to the machair system of the Vallay Strand. The island was excavated between 1986 and 1990 by Ian Armit and a team from the University of Edinburgh (Armit 1986, 1987, 1988a, 1990a, 1992b).

10.2 Archaeology

The island of Eilean Domhnuill is an artificial construction, composed primarily of human settlement debris, and linked to the shore of Loch Olabhat by a substantial stone causeway. The neighbouring site of Eilean Olabhat (now a peninsula, but at one time a walled islet) contains evidence of Iron Age and later occupation, and for many years Eilean Domhnuill was thought to be an Iron Age dun, presumably because of the shape of the site and its location in a loch. Eilean Domhnuill was partially excavated by Erskine Beveridge (1911), who did not publish any descriptions or pictures of the pottery he found, nor did he note any major differences between the ceramic assemblage at Eilean Domhnuill and his finds at other Iron Age sites. The Royal Commission survey (RCAHMS 1928, no. 180) duly recorded the site as 'Dun Olabhat', an island dun of the later prehistoric period. In 1985 the site was re-examined as part of a survey which set out to identify possible antecedents of Iron Age island sites. What had been thought to be the outlines of a dun turned out to be collapsed rubble around the periphery of a small artificial island, with superficial evidence of one slight structure, and a large number of pottery sherds which placed the site firmly in the Neolithic (Armit, 1986).

The site was excavated over five field seasons, revealing the remains of several successive structures, representing three major episodes of occupation. In all,

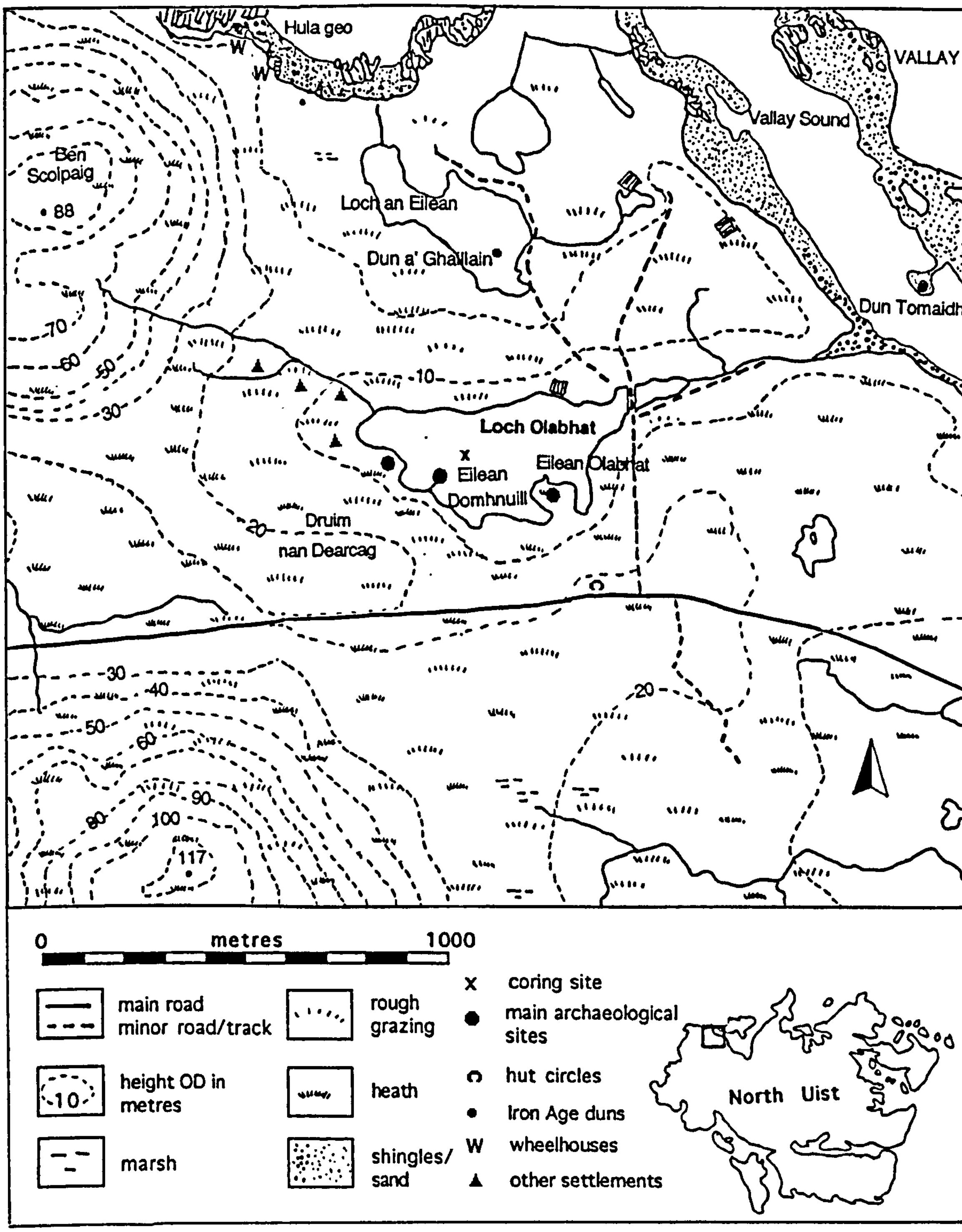


Fig. 10.1 Eilean Domhnuill and surrounding area

11 structural phases were uncovered within these episodes. The lower, waterlogged levels of the site have yet to be fully explored, although limited underwater excavations have revealed the presence of preserved timber and wattlework (Armit, 1992b).

The earliest excavated levels are described as phases 11-5, and represent a long period of occupation during which time a succession of houses was built on the site and substantial midden deposits accumulated. This episode is associated with a timber causeway and an elaborate entrance facade, which was rebuilt and realigned several times during this period, probably as a response to changes in the loch level. The house structures were of slight construction. There is no evidence of substantial stone walls; instead the buildings may have consisted of turf walls laid on stone footings (Armit, 1992b, 1996). With the construction of each house, its predecessor appears to have been destroyed and the building materials reused, resulting in poor preservation of the structures. The structures were rectilinear or elongated oval in shape, with hearths in the central floor space, but few other internal features. The largest structure measured about 6.8 x 4.4 m internally and the smallest 5.2 x 3.2 m. During this early period the loch level apparently rose, until the site was finally completely submerged, forcing abandonment, and sealing the earlier deposits under a thin layer of grey silty clay (Armit, 1992b).

During the second major episode the site was reoccupied and another successive series of slight structures (phases 4-2) were built, associated with a stone causeway. These structures contained many post-holes of a more substantial nature than found previously. Again, there are indications of further fluctuations in loch levels during this period, and there may have been minor flooding (Armit, 1992b)

The final episode is represented by the remains of two substantial and conjoined rectilinear buildings with stone and earth walls, associated with a stone causeway. The ceramics from this period suggest a later Neolithic date, and the site was abandoned, probably due to a rise in loch level, still within the Neolithic, never to be resettled (Armit, 1992b). Unfortunately the site has not been radiocarbon dated, so the exact dates of occupation, and the duration that the island was in use cannot be determined.

Around 20,000 sherds of round-based pottery were found at the site,

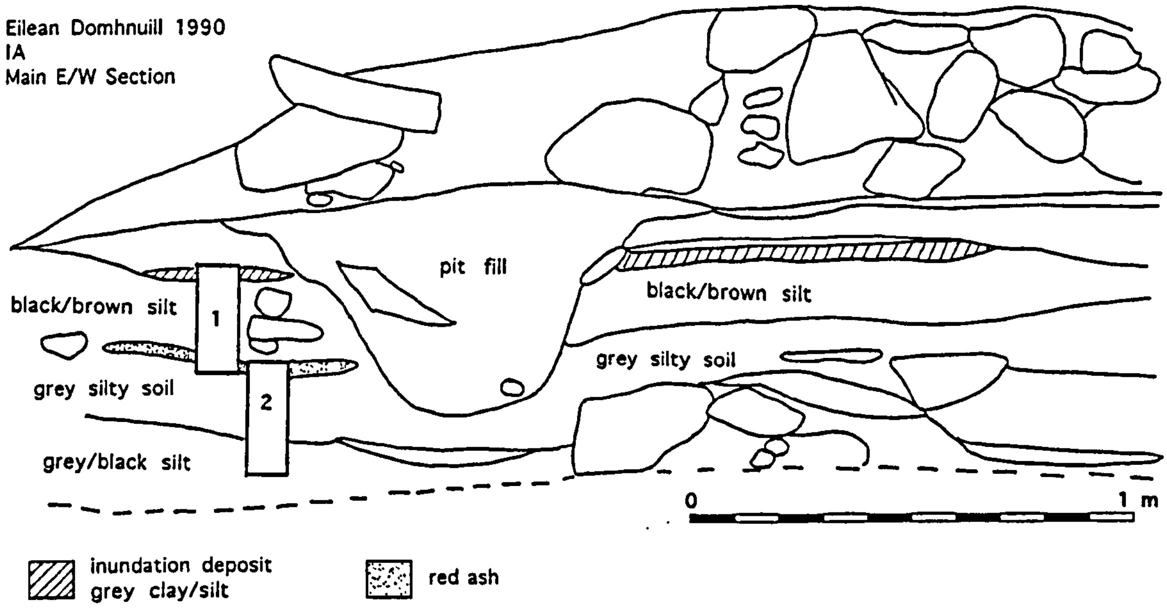


Fig. 10.2 Eilean Domhnuill: extract of section drawing (main E-W section) showing location of pollen monoliths (1 and 2) and archaeologist's determination of deposits in the field

including Unstan Ware, Hebridean Ware and Plain Bowls. Stone artefacts were fewer in number but included a stone axe (Armit, 1996). Plant remains found at the site include cereals (primarily *Hordeum*, but also including *Triticum aestivum/compactum*) (P. Grinter, pers. comm.), and the presence of a saddle quern found *in situ* in floor deposits suggests that grain was processed on site (Armit, 1992b). A few burnt bone and antler finds have also been recovered, including cattle and a primitive domesticated sheep as well as a single pig bone. These domesticated animals well may have been slaughtered on site (Hallén, 1992 in Armit, 1996). Wild animals exploited included sea-birds and whale, but very little deer. Fish bones, too, were virtually absent, but this may be due to problems of survival (Armit, 1996).

Four types of wood have been found in the waterlogged levels at the site: birch, hazel, willow and larch (Armit, 1996: 65). Larch is likely to have arrived on the Outer Hebrides as driftwood from North America (Dickson, 1992), and it is possible that wood was already in short supply, at least by the end of occupation at Eilean Domhnuill (Armit, 1996). On the other hand, the use of driftwood such as larch may simply be opportunistic. Wood is likely to have been used as building material, while fuel for domestic fires probably consisted primarily of peat.

Armit (1992b) has interpreted Eilean Domhnuill as a small-scale farming settlement, occupied by a single household, with one principal building in use in each phase. However, he argues that the location of the site on an island, with a causeway and elaborate entrance suggests that 'it served more than a mundane practical purpose' (Armit 1992b: 119). He also points out there was no evidence of pottery production, wood-working or flint-knapping at the site, nor were there any signs of trampling which might have suggested that animals were kept on the island for any length of time. The island, he argues, may thus have been one of a number of distinct activity areas (Armit, 1992b; Armit and Finlayson, 1992), with Eilean Domhnuill perhaps as a permanent base, while other activities were taking place at various machair and peatland sites (Armit, 1996).

10.3 Profile

Two overlapping monoliths were taken from the main south facing profile (east-west section) (Fig. 10.2) in the summer of 1996. The stratigraphy of the profile is 39 cm long (there was a 11 cm overlap between the two monoliths) and was described in the laboratory as follows:

0 - 2 cm	Grey clay
2 - 15 cm	Grey-black silt with root inclusions
15-20 cm	Red ash
20-24 cm	Grey-black silt
24-32 cm	Grey-black silt with sandstone inclusions
32-37 cm	Grey-black silt
37-38 cm	Red ash
38-39 cm	Grey-black silt

The very top of the profile taken for pollen analysis (0-2 cm), contains a layer of grey clay that has been interpreted by the archaeologist as being laid down while the site was submerged, between occupation phases 5 and 4 (Armit, 1992b). Below this (2-15 cm) is a layer of darker silt, which comes from a deposit that has been interpreted as the heavily disturbed remains of several successive floors in Phase 5. The base of Phase 5 is marked by a deposit of red ash (15-20 cm), while the grey/black silty soil below represents deposits from Phase 6, and have been interpreted as midden debris from an adjacent structure (Armit, pers. comm.). The thin deposit of what appears to be 'red ash' between 37-38 cm is not present in the section drawing.

No samples were taken from the profile for radiocarbon dating.

10.4 Pollen Preservation

Compared to the loch and peat sites examined in this study, the pollen preservation at Eilean Domhnuill was quite poor - a not unexpected situation for minerogenic material obtained from archaeological contexts (Dimbleby, 1985). With the exception of the uppermost level, the frequency of deteriorated pollen grains in the levels was consistently over 50%. Deterioration usually took the form of 'corroded' grains, but 'crumpled' grains were also common. The category 'broken grains' was quite small. *Calluna vulgaris* and *Corylus avellana*-type were both badly affected by corrosion, while Poaceae grains tended to be crumpled and/or corroded.

The frequencies of deteriorated pollen grains remained relatively steady throughout the profile, with the exception of the uppermost level, where the pollen was relatively well preserved (15.9% was deteriorated), perhaps because this layer was formed by inundation. The worst affected level occurred at 5 cm, where 83.1% of all pollen grains showed signs of damage.

10.5 Pollen concentrations

Despite the relatively poor preservation, pollen and spore concentrations were quite high, and it was possible to count at least 500 terrestrial pollen grains for each sample. Because no samples were taken for radiocarbon dating it is impossible to construct an accumulation rate diagram.

10.6 Local pollen zones

Pollen and spores in archaeological profiles may not possess the same stratigraphic integrity as those in peat and lake deposits. Pollen in soil profiles and archaeological occupation deposits, can be mobile (Dimbleby, 1985; Kelso, 1994), so that pollen of different ages can be found in the same level, resulting in a smoothed pollen record. In highly minerogenic profiles there is also a more marked decline in pollen concentrations and taxa with depth; the longer the pollen lies in the deposits the more it is attacked by bacteria, and the more chance it has to move downwards (Dimbleby, 1985). The use of local pollen zones in this context could be quite misleading (cf. Edwards and Whittington, 1998). Nevertheless, in order to facilitate description and discussion, and with the aid of the constrained cluster analysis programme CONISS (Grimm, 1987) the pollen profile was divided into 2 local

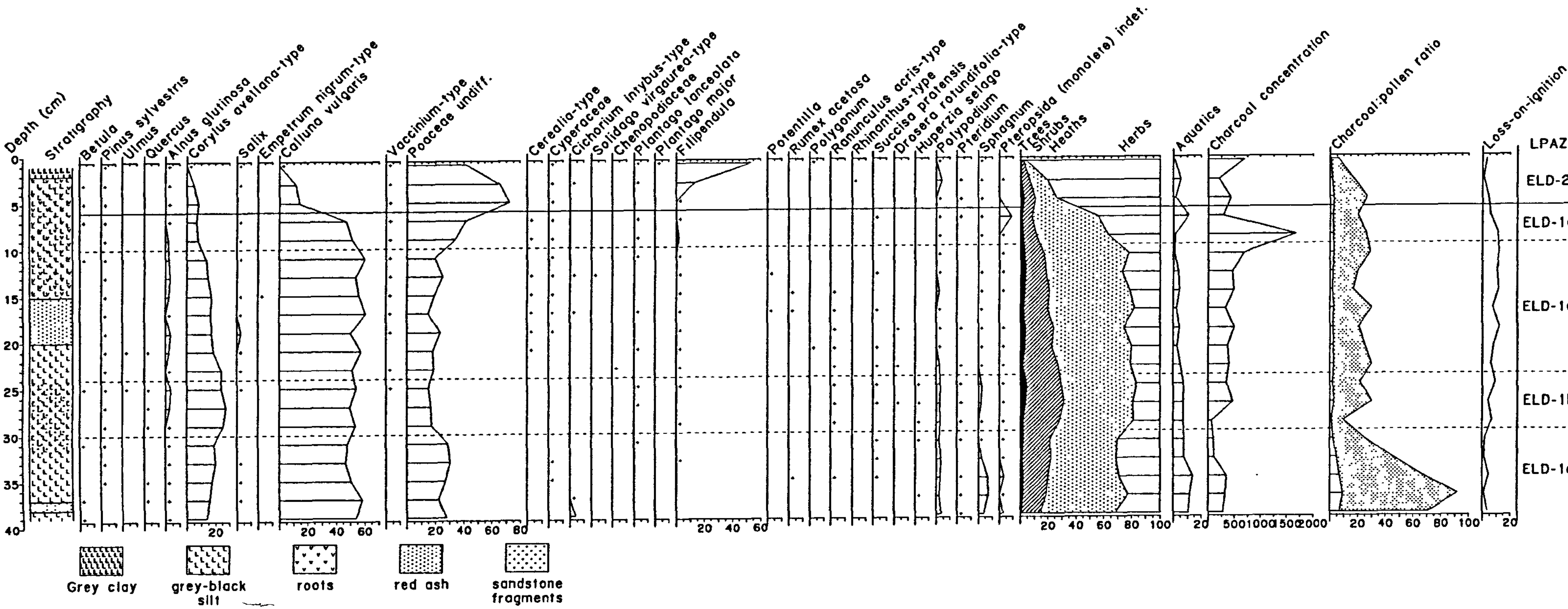


Fig. 10.3 Pollen and spore percentage diagram from Eilean Domhnuill (+ = <2%). Shaded curves are exaggerated x10.

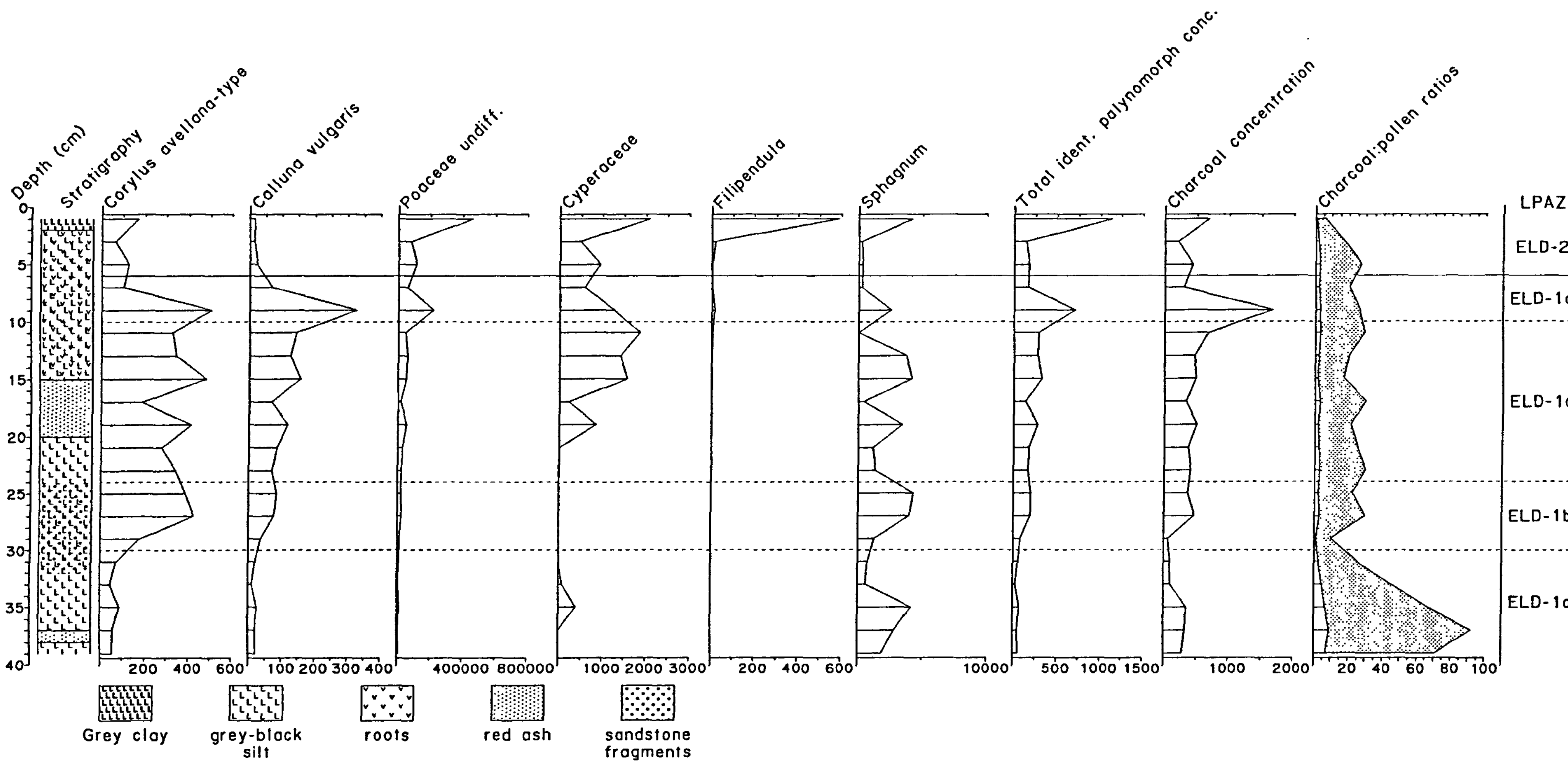


Fig. 10.3 Pollen and spore percentage diagram from Eilean Domhnuill (+ = <2%). Shaded curves are exaggerated x10.

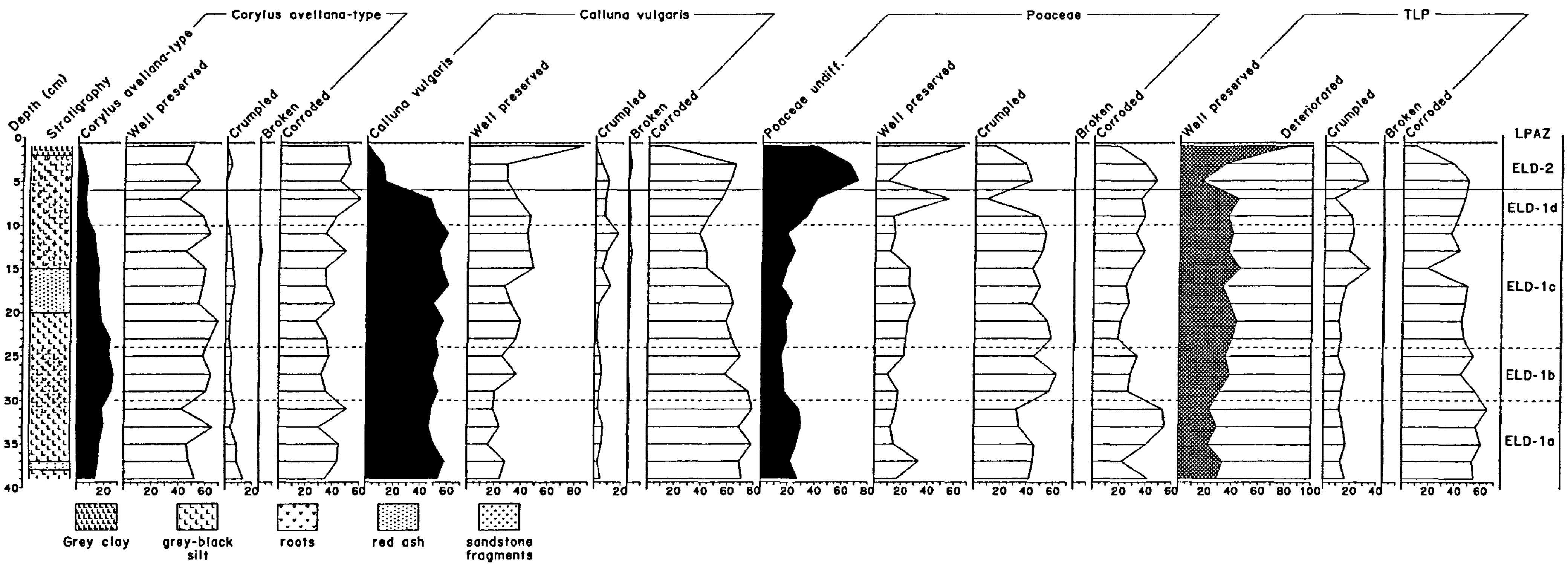


Fig. 10.5 Preservation diagram for major pollen types and TLP at Eilean Domhnuill. The black silhouettes are expressed as %TLP, the other graphs are a percentage of the individual taxa.

pollen zones, with zone ELD-1 further divided into 4 subzones. The local pollen zones are described as follows:

ELD-1a 39-30 cm

Percentage diagram (Fig. 10.3)

The basal subzone is dominated by *Calluna vulgaris* pollen, which reaches a maximum of 58%TLP at 37 cm. Poaceae frequencies are also high, ranging from 22% to 30%. Tree and shrub pollen frequencies are generally low (between 15% and 22%) and are made up almost entirely of *Corylus avellana*-type. Frequencies of other tree and shrub pollen types are minimal, and beside *Corylus* only *Alnus glutinosa* grains are consistently recorded. Commonly recorded herb taxa include *Filipendula*, *Rumex acetosa*, *Ranunculus acris*-type and *Succisa pratensis*, while *Plantago lanceolata* appears towards the top of the zone. *Huperzia selago*, *Polypodium* and *Pteridium* spores are quite common, and *Sphagnum* spore frequencies reach their highest level in this zone (7%). No aquatics were recorded in the entire profile.

Concentration diagram (Fig. 10.4)

Total pollen and spore concentrations are lower than in any part of the diagram, ranging from 2.5 to 7.6 $x10^4$ grains cm^{-3}.

Charcoal (Fig. 10.4)

Charcoal concentrations are relatively low (mean 20.5 x 10^{-4} cm^2 cm^{-3}).

Loss-on-ignition (Fig. 10.3)

Loss-on-ignition values are very low: 1% - 6.9%.

Deterioration (Fig. 10.5)

Between 66.3% and 77.4% of all pollen grains in this zone exhibited signs of deterioration, of which corrosion was the most common type. *Corylus avellana*-

type, *Calluna vulgaris* and Poaceae all had significant corrosion (up to 78.2%, 50.5% and 53.8% respectively).

ELD-1b 30 - 24 cm

Percentage diagram

Subzone ELD-1b sees an increase in tree and shrub values, ranging from 27.9 to 29.4% TLP, the highest for the profile. *Corylus avellana*-type frequencies increase to 27.3% at 27 cm, while *Alnus glutinosa* rises to 3.5% at 25 cm. *Quercus* is also more frequently recorded, and *Ulmus* appears for the first time at 25 cm. *Calluna vulgaris* values remain steady (49.5 to 53.7%), while Poaceae falls to 15% at 25 cm. *Plantago lanceolata*, *Ranunculus acris*-type and *Succisa pratensis* are recorded amongst the herb taxa. *Huperzia selago* and *Polypodium* also appear, while *Sphagnum* reaches 2.5%.

Concentration diagram

Pollen and spore concentrations start to rise during this subzone, from 7.59 to 17.2 $\times 10^{4}$ grains cm^{-3}.

Charcoal

Charcoal concentrations increase to 473.1 $\times 10^{-4}$ cm^{2} cm^{-3} at 27 cm.

Loss-on-ignition

Loss-on-ignition values rise to 9.2% at 25 cm.

Deterioration diagram

Between 44.5 and 66.7% of all pollen grains were deteriorated. The corroded category consisted primarily of *Corylus avellana*-type and *Calluna vulgaris* grains, while frequencies of crumpled Poaceae were also high (up to 62.3% at 27 cm).

ELD-1c 24 - 10 cm

Percentage diagram

Tree and shrub pollen values fall gradually to 17.7% at 11 cm. This is primarily due to a decrease in *Corylus avellana*-type, to 13.6% by the top of the subzone. *Quercus* and *Ulmus* disappear from the record after 21 cm, but *Salix* reaches its highest frequency (2.9%) at 19 cm. *Calluna vulgaris* values fluctuate between 49.8 and 60.1% and Poaceae between 18 and 25%. Cyperaceae pollen is more commonly recorded than previously, but its frequencies remain below 1%. Cerealia-type pollen appears for the first time at 21 cm, and *Cichorium intybus*-type, *Solidago virgaurea*-type, Chenopodiaceae and *Polygonum* appear sporadically. *Ranunculus acris*-type and Succisa pratensis are still commonly recorded, while among the spores *Polypodium* and *Pteridium aquilinum* appear.

Concentration diagram

Pollen and spore concentrations fluctuate between 11.5 and 29.2 $x10^4$ grains cm^{-3}.

Charcoal

Charcoal concentrations increase gradually to 686.8 x 10^{-4} cm^2 cm^{-3}.

Loss-on-ignition

Loss-on-ignition values range from 7.6 to 12.1%.

Deterioration diagram

Between 53.6 and 75.3% of all pollen grains showed signs of deterioration. This included high frequencies of corroded *Corylus avellana*-type and *Calluna vulgaris* (up to 49.3% and 63.6% respectively), as well as crumpled Poaceae grains (up to 53.5% at 11 cm).

ELD-1d 10 - 6 cm

Percentage diagram

Calluna vulgaris starts to decline, falling to 47.2% TLP, while Poaceae becomes more prominent, reaching over 41% by the top of the zone. *Corylus avellana*-type continues to decline, to 6.8%,and *Alnus* frequencies are now also lower. *Filipendula* values rise to 2%, and Cerealia-type pollen, *Plantago lanceolata*, and *Succisa pratensis* are also recorded. *Sphagnum* is very low, while Pteropsida (monolete) indet. reaches a peak of almost 9% at 7 cm.

Concentration diagram

Pollen and spore concentrations are quite high, peaking at 64.4 $x10^4$ grains cm^{-3} at 9 cm (mean 40.4 $x10^4$ grains cm^{-3}).

Charcoal

Charcoal concentrations continue to increase, to 1674.6 x 10^{-4} cm^2 cm^{-3} at 9 cm, before declining again.

Loss-on-ignition

Loss-on-ignition values range from 5.6 to 11.3%.

Deterioration diagram

On average 59.2% of all pollen grains showed signs of deterioration. Corroded *Calluna vulgaris*, *Corylus avellana*-type, and to a lesser extent Poaceae, were particularly common.

ELD-2 6 - 0 cm

Percentage diagram

Calluna vulgaris values fall steeply, while Poaceae frequencies witness a marked rise to 72%. *Corylus avellana*-type falls to 1.5% by the top of the zone.

Filipendula sees a strong rise and in the uppermost level dominates the pollen spectrum (53%). *Polygala*, *Rhinanthus*-type and *Plantago lanceolata* are also recorded. *Polypodium* frequencies are higher than in any other zone (maximum 4.3%), and Pteropsida (monolete) indet. and *Sphagnum* are recorded in low frequencies.

Concentration diagram

Pollen and spore concentrations reach their highest level in this zone: 111.7 x10^4 grains cm^{-3} at the top of the diagram.

Charcoal

Charcoal concentrations range from 202.8 to 683.7 x 10^{-4} cm^2 cm^{-3}.

Loss-on-ignition

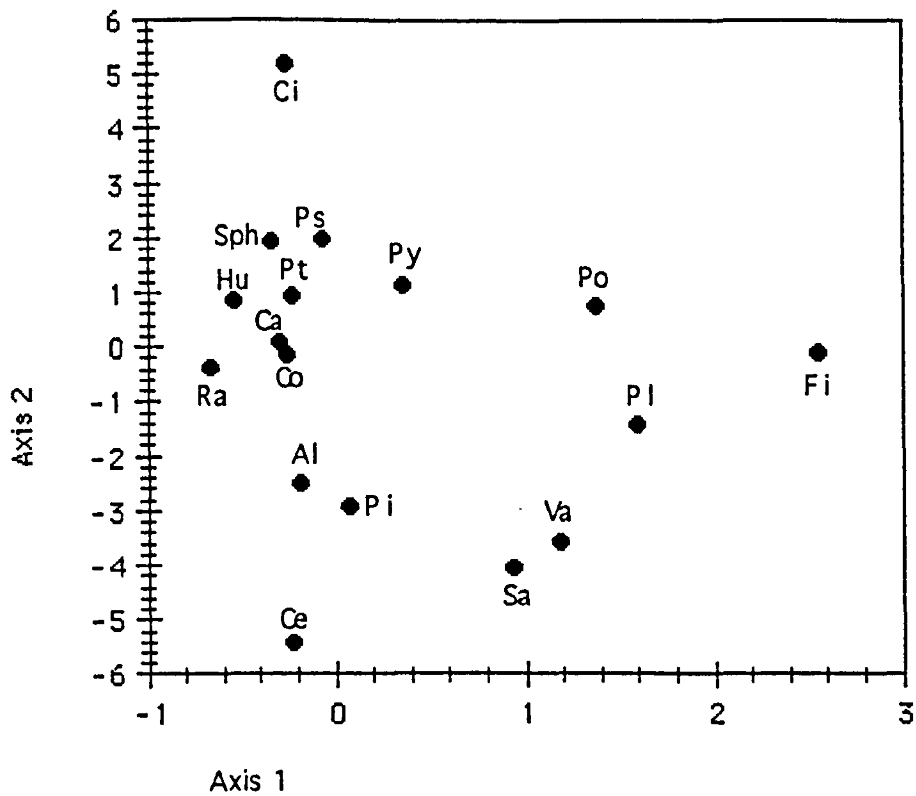
Loss-on-ignition values are lower than in any other part of the diagram, ranging from 1.2 to 4.3%.

Deterioration diagram

Deterioration rates range from 83.1% at the bottom of the zone, where corroded *Corylus avellana*-type, *Calluna vulgaris* and Poaceae are particularly common, to 15.9% at the very top.

10.7 Detrended Correspondence Analysis (DCA)

The pollen and spore percentage data from Eilean Domhnuill were analysed using DCA. Figure 10.6 presents the resulting plot, which in general reflects the local pollen zones. Towards the middle left of the graph there are a cluster of taxa associated with bog and moorland (e.g. *Sphagnum*, *Pteridium*, *Calluna vulgaris* and *Ranunculus acris*-type), which are particularly prominent in zone ELD-1. Tree and shrub taxa, always rare but slightly more important in subzones ELD-1b and 1c, pull out towards the middle bottom. To the right of the graph are taxa most prominent in zone ELD-2: Poaceae, *Plantago lanceolata* and *Filipendula*.



Key: (Al) *Alnus*; (Ca) *Calluna vulgaris*; (Ce) Cerealia-type; (Ci) *Cichorium intybus*-type; (Co) *Corylus avellana*-type; (Fi) *Filipendula*; (Hu) *Huperzia selago*; (Pi) *Pinus*; (Pl) *Plantago lanceolata*; (Po) Poaceae; (Ps) Pteropsida (monolete) indet; (Pt) *Pteridium aquilinium*; (Py) *Polypodium*; (Ra) *Ranunculus acris*-type; (Sa) *Salix*; (Sph) *Sphagnum*; (Va) *Vaccinium*-type.

Fig. 10.6 Eilean Domhnuill: DCA, entire profile

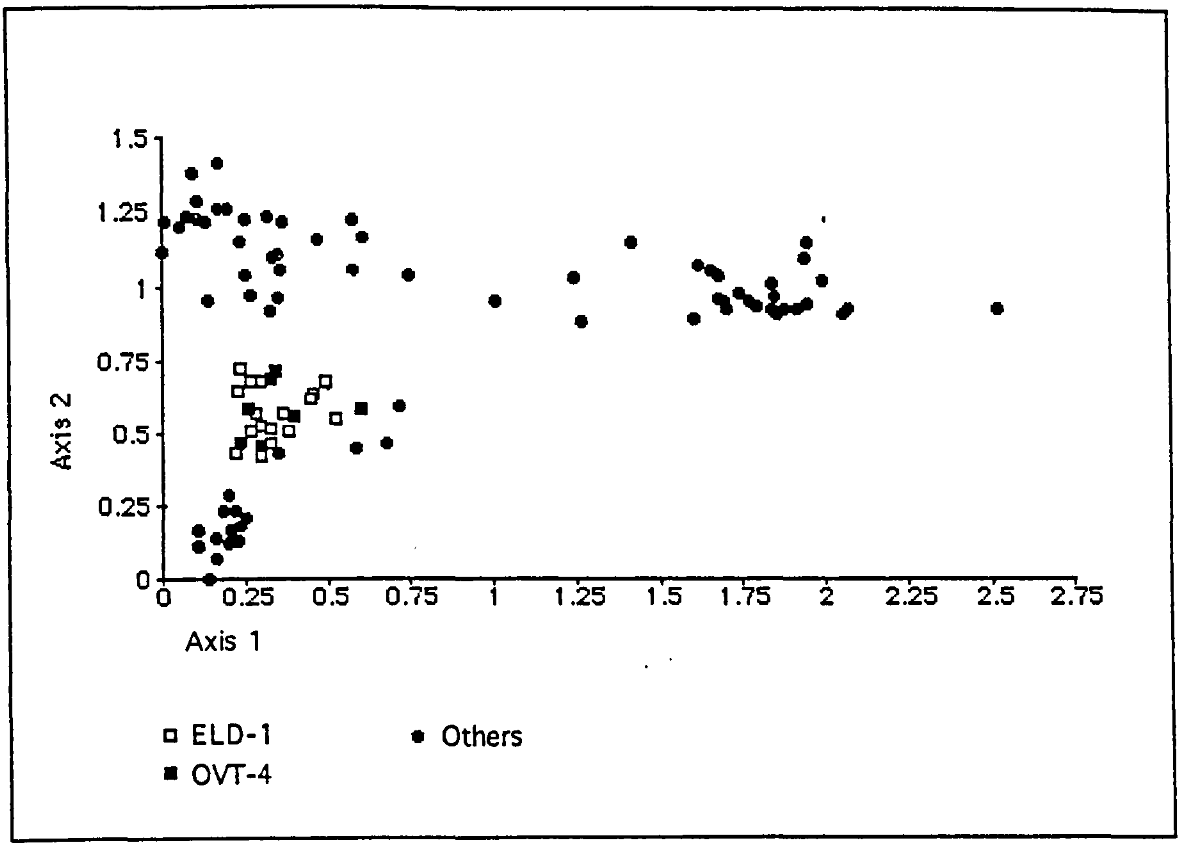


Fig. 10.7 DCA: sample scores from Loch Olabhat and Eilean Domhnuill

10.8 Comparison with Loch Olabhat

Although the sequence from Eilean Domhnuill derives from a site located in Loch Olabhat (Chapter 9) there is little obvious visual similarity between the two pollen diagrams. One reason may be that the taphonomic processes affecting the two types of deposits are different. Greater mobility of pollen in minerogenic matrices is one factor (Dimbleby, 1985; see above) and preservation may be another: many taxa that are present in the Loch Olabhat diagram may simply not have been preserved in the soils and archaeological occupation deposits at Eilean Domhnuill. A total of 87 taxa were recorded at Loch Olabhat, while at Eilean Domhnuill there were only 32. Moreover, pollen from settlement sites may reflect very local pollen deposition from plants growing in close proximity to the coring site, as well as from material that might have been deliberately brought into the sites, whereas a loch site is likely to present a more regional picture. These factors make comparison between the Loch Olabhat and Eilean Domhnuill profiles difficult.

In an effort to discern similarities between the data sets in a more objective manner the two profiles were compared statistically. DCA was carried out on the samples using the following taxa recorded in both profiles: *Alnus glutinosa*, *Corylus avellana*-type, *Calluna vulgaris*, Poaceae, *Cichorium intybus*-type, *Filipendula*, *Polypodium*, Pteropsida (monolete) indet. and Cerealia-type. The plot produced (Fig. 10.7) shows that the samples from local pollen assemblage zones ELD-1 and OVT-4 are graphically closely associated. The levels from OVT-4 have been dated to Neolithic times (5150-4660 BP [5910-5390 cal BP]; see Chapter 9), and thus appear to confirm that the deposits of ELD-1 at Eilean Domhnuill fall within the Neolithic. No such connections could be made between the scores of ELD-2 and the Loch Olabhat samples. However, the presence of deposits with artefacts of Neolithic date above the possible inundation layer in the archaeological profile would suggest that the deposits of ELD-2 also fall within the Neolithic.

The interpretation of pollen data from archaeological deposits is clearly difficult and cannot be viewed with the same degree of confidence as the evidence extracted from lake and peat sites. Nevertheless, keeping in mind these difficulties, the following interpretation is offered:

10.9 Inferred vegetation history

In subzone ELD-1a the pollen spectra suggest that the vegetation in the surrounding area was dominated by *Calluna vulgaris* heath with grassland forming an important secondary component. Arboreal pollen frequencies are very low, and with the possible exception of *Corylus avellana*, it is unlikely that any trees and shrubs were growing near the site at this time. As mentioned above, the statistical evidence also suggests that the start of the Eilean Domhnuill profile dates to a period after 5150 BP (5910 cal BP), when trees and shrubs started to disappear around Loch Olabhat and the area was becoming increasing dominated by heathland and blanket peat communities.

The herbs and cryptograms recorded in subzone ELD-1a include *Filipendula*, *Ranunculus acris*-type, *Succisa pratensis*, *Huperzia selago* and *Polypodium*, which can all be indicative of rather wet pasture, and this may have formed part of the surrounding countryside. The presence of *Sphagnum* could suggest that blanket bog communities were growing not far from the site. *Plantago lanceolata* is recorded for the first time towards the end of this phase. This may reflect human activity in the surrounding area, but could also come from the island itself.

Charcoal values are relatively high, when compared with the other sites in this study, and with the exception of one brief phase, remain high throughout the profile. The bulk of the charcoal may well derive from domestic fires in the settlement itself. However, *Calluna vulgaris* frequencies are also high throughout the profile, and the *Calluna* and charcoal curves decline together in subzone ELD-1d, so there is a possibility that fire was used to manage heathland near the site (see also Chapter 9).

In subzone ELD-1b tree and shrub frequencies reach their highest level (28–31%). This is primarily due to an increase in *Corylus avellana*-type to 27.3%, but *Alnus glutinosa* frequencies are also higher (max. 3.5%). This increase in trees and shrubs is also reflected in the concentration figures: *Corylus* concentrations rise from 0.7 to 4.3 $x10^4$ grains cm^{-3}, a six-fold increase, whereas the total concentration of pollen and spores increases four-fold. The percentage figures for arboreal pollen are higher than figures recorded on the Outer Hebrides today (about 14%; Fossitt, 1994a), and it is likely that there were some *Corylus* shrubs, as well as possibly *Alnus glutinosa*, growing in the vicinity of the site. It may be that this phase of slightly higher tree and shrub values correlates with one of the brief phases of woodland regeneration seen in the Loch Olabhat pollen profile between *c.* 5100 and 4800 BP (5840-5540 cal BP) (Chapter 9, Fig. 9.8), but this cannot be proven without dating evidence.

Calluna vulgaris heath remained an important component of the landscape in subzone ELD-1b, while grassland was somewhat reduced in extent, although this is not as clear in the concentration diagram. *Sphagnum* frequencies, too, declined, but other indicators of blanket bog (such as *Drosera rotundifolia*-type) are still recorded. Although charcoal concentrations and charcoal:pollen ratios are reduced at 31 cm, they increase again at 29 cm, and there is no clear evidence to suggest that the slight regeneration in trees and shrubs is due to an abandonment of the island at this time.

Cerealia-type pollen is recorded for the first time in subzone ELD-1c. This may be an indication that cereal cultivation was taking place near the site, or the pollen may come from cereals actually brought onto the island; macrofossil studies show that both barley (*Hordeum* undiff.) and wheat (*Triticum aestivum/compactum*)were present (P. Grinter, pers. comm.). The presence of saddle querns (Armit, 1990) suggests that the grain was being ground on the island, but threshing on site cannot be demonstrated. Cerealia-type values at Eilean Domhnuill are no higher than in the other profiles in this study, and one might expect vigorous handling such as threshing, which leads to a great dispersal of particulate matter, to result in higher frequencies of Cerealia-type pollen than just background levels (Hall, 1988). The presence of *Cichorium intybus*-type, *Solidago virgaurea*-type and Chenopodiaceae in the profile may be due to these plants being brought in with the crop as weeds of cultivation. Other herb taxa still appear to reflect the presence of wet pasture in the area.

Corylus avellana-type frequencies start to decline at 21 cm, and arboreal pollen frequencies fall to less than 18% by 11 cm, suggesting that the area was by now virtually treeless, although *Salix* frequencies are relatively high at 19 cm (2.9%), and a few willow trees may have been present at this time. *Sphagnum* frequencies are considerably lower during this phase, and peat formation in the area may have been slowing down.

It is perhaps interesting to note that, despite the presence of a deposit of 'red ash' (likely to derive from domestic fires using peat) at 15-20 cm, charcoal values are no higher at that stage than in other parts of the subzone, nor is there an apparent change in pollen spectra.

In subzone ELD-1d *Calluna vulgaris* values (both percentages and concentrations) start to decline as Poaceae became more prominent. *Filipendula* frequencies also increase. It is likely that the increase in Poaceae reflects the spread of *Phragmites australis* which, along with *Filipendula,* may have been encouraged by the rising lake levels that eventually resulted in inundation of the site. Cerealia-type pollen is recorded, but other anthropogenic indicators are sparse, and charcoal:pollen ratios are low, although there is a peak in the charcoal concentration curve.

The top of the profile (zone ELD-2) appears to present a totally different environment to the rest of the core: Poaceae dominates the spectra while *Calluna vulgaris* has gone into decline. This is apparent both in the percentage and concentration data. The high values for Poaceae may well reflect the abundance of *Phragmites australis*, taking advantage of an expansion of wetter habitats near the site, an interpretation which is reinforced by the layer of grey clay which may indicate inundation of the island. The most unusual feature of the last zone is the peak in *Filipendula*, which rises to 53.1% at the very top of the profile. This is much higher than one would expect to find in the general 'pollen rain', and one possible explanation is that the pollen derives from *Filipendula* plants brought into the site by people. High frequencies of *Filipendula* pollen have been reported from other archaeological sites, including several Bronze Age cists in Scotland, where they were found both within pottery vessels and in so-called 'body-stains' (Tipping, 1994b). However, at Eilean Domhnuill the deposits analysed were not sealed within an archaeological feature, and it is more likely that, like Poaceae, the high values of

Filipendula pollen reflect the expansion of the taxon due to higher water levels, or the very local deposition of pollen from *Filipendula* plants growing on-site.

Cerealia-type pollen is no longer recorded in zone ELD-2, and most other anthropogenic indicators have disappeared, although *Plantago lanceolata* and *Polygonum* are still present. The area around the loch was perhaps used primarily as pasture while arable agriculture may have moved elsewhere.

There appears to be very little continuity between the top of subzone ELD-1d (at 7 cm) and the basal level of ELD-2 (5 cm), and there is a possibility that the deposits of zone ELD-2 may have accumulated after a hiatus, although there is no clear visual evidence of this in the sedimentary record. Loss-on-ignition values are lower in zone ELD-2, and deterioration frequencies are considerably higher (up to 83.5% at 5 cm) compared to the previous subzone, and some of the dissimilarity may stem from differential preservation. One reason for the relatively sudden shift may be that the deposits in this last phase (occupation phase 5) have been heavily disturbed by continuous use (Armit, pers. comm.), and that the pollen record has been affected by this.

It is possible that the erosional phase seen at Loch Olabhat, the start of which is dated to around 4660 BP (Chapter 9), could be connected with the inundation layer at Eilean Domhnuill. Armit (1992b) has postulated that a removal of trees and shrubs in the area around Loch Olabhat would have led to increased erosion of material into the loch, rising loch levels, and eventually the temporary abandonment of Eilean Domhnuill. Cultivation of nearby soils may well have exacerbated the problem. Although this cannot be proven, the decline in woodland, and the subsequent erosional phase seen in the profile at Loch Olabhat could well herald the start of this process.

10.10 Summary

During the first phase in the profile (subzone ELD-1a) the vegetation in the area was dominated by *Calluna vulgaris* heath, and to a lesser extent Poaceae, which may have formed areas of wet pasture near the site. Arboreal pollen frequencies are generally low, and it appears that there was little in the way of woodland in the surrounding countryside. This suggests that the profile from Eilean Domhnuill starts after 5150 BP (5910 cal BP), when, according to the pollen diagram from Loch Olabhat, trees and shrubs started to disappear from the area. That the profile falls within the Neolithic is also supported by the archaeological evidence at the site, and by statistical comparison with the pollen and spore spectra from Loch Olabhat.

In subzone ELD-2b, trees and shrubs (in particular *Corylus avellana*-type) enjoyed a brief phase of regeneration, while *Calluna vulgaris* remained important in the landscape and grassland suffered a decline. Cerealia-type pollen is recorded for the first time. The cereal pollen could simply derive from nearby fields, but could also result from the processing of grain on-site.

Arboreal frequencies fall below 18% in the third phase (subzone ELD-1c), and very few trees and shrubs were probably present in the area. Towards the top of the diagram (subzone ELD-1d) grassland started to expand at the expense of heath, and by the last zone (ELD-2) Poaceae and *Filipendula* dominate, probably reflecting the expansion of reeds and meadowsweet as loch levels rose and the site was inundated.

CHAPTER 11

DISCUSSION: VEGETATION HISTORY AND SETTLEMENT IN THE OUTER HEBRIDES

In this chapter the evidence from the five pollen profiles in this study will be examined in a wider context, focusing in particular on the evidence for woodland, human impact on the vegetation, and the settlement history of the islands from the Mesolithic to the Iron Age. Figures 11.1a and 11.1b show the location of the sites mentioned in the text.

11.1 The Earlier Holocene *c.* 10100-5000 BP (11750-5730 cal BP)

At the end of the Lateglacial period the vegetation in the Outer Hebrides was dominated by *Empetrum nigrum*-dominated heath, along with herb-rich grasslands, sedges, *Huperzia selago*, and patches of birch, willow and juniper scrub (Edwards and Whittington, 1994; Brayshay and Edwards, 1996; see also Chapter 3). The change from Lateglacial to Postglacial is marked by rapid climatic warming around 10100 BP (11750 cal BP) which in a matter of decades resulted in temperatures similar to those of today (Atkinson *et al.*, 1987; Mayewski *et al.*, 1996). The increase in temperatures led to melting of the ice-caps and a eustatic rise in sea-level. By 9000-8000 BP (10200-8890 cal BP) maximum summer warmth may have been reached (Birks, 1988), with temperatures 1 to 2 °C higher than today, a situation which in Britain may have lasted until *c.* 4500 BP (5170 cal BP) (Simmons *et al.*, 1981).

The increase in temperatures had a marked effect on the vegetation. In the Outer Hebrides grassland and *Empetrum* heath were replaced by a mosaic of *Betula* and *Salix* woodland, grassland, and tall-herb communities, while *Myriophyllum* colonised the lochs (Brayshay and Edwards, 1996). In loch profiles the start of the Holocene is generally associated with a change from minerogenic to more organic sediments. This transition varied in time from *c.* 10430 BP (12400 cal BP) at Loch an t-Sìl (Brayshay and Edwards, 1996) and 10310 BP (12140 cal BP) at Loch Airigh

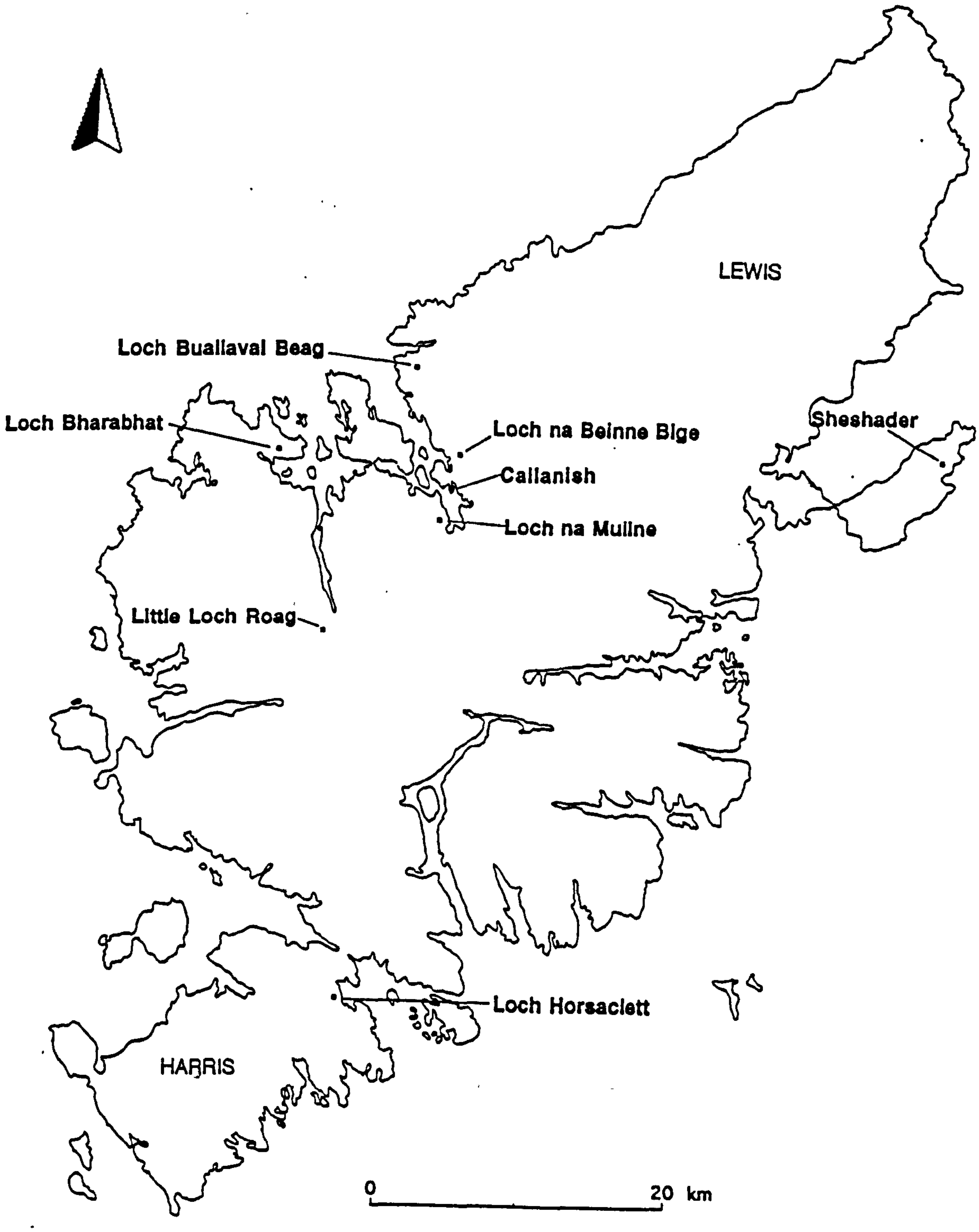


Fig. 11.1a Location of main sites in Lewis and Harris discussed in Chapter 11

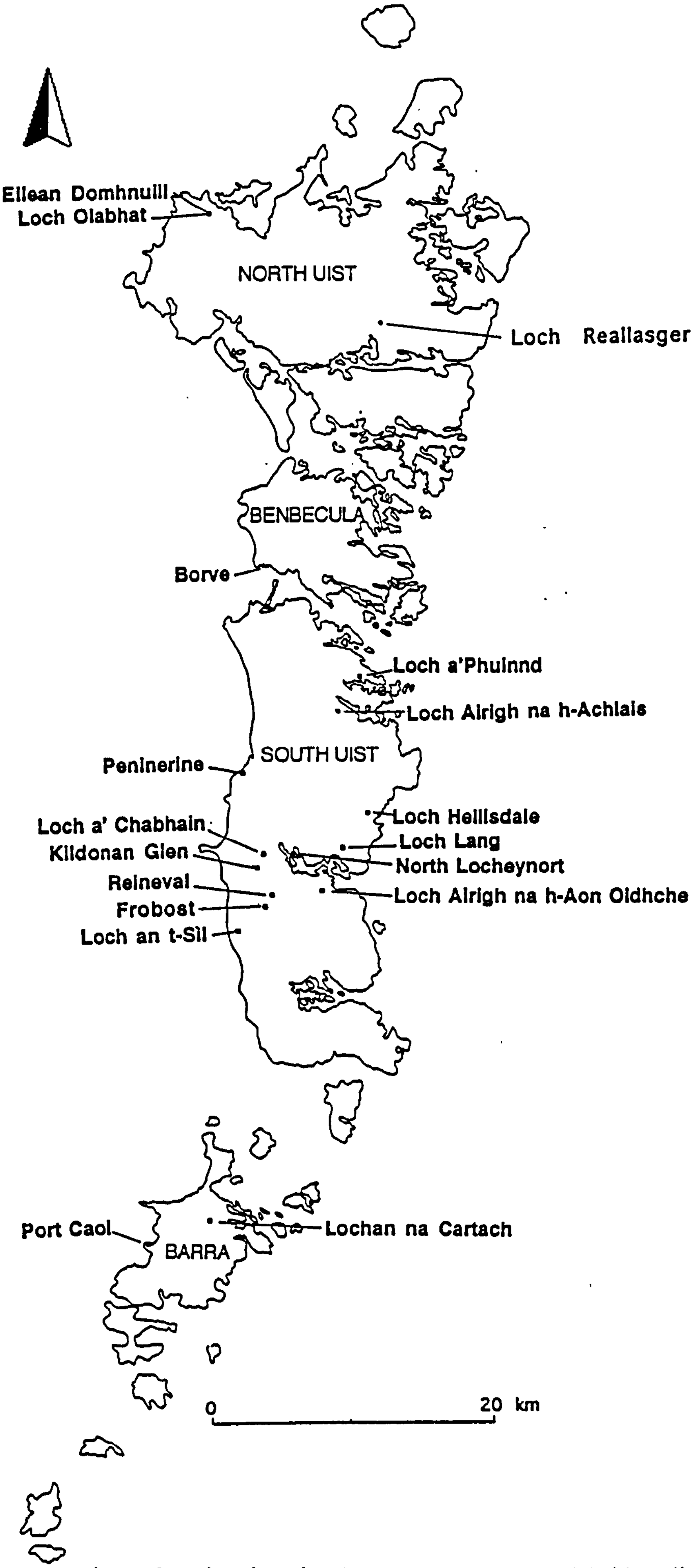


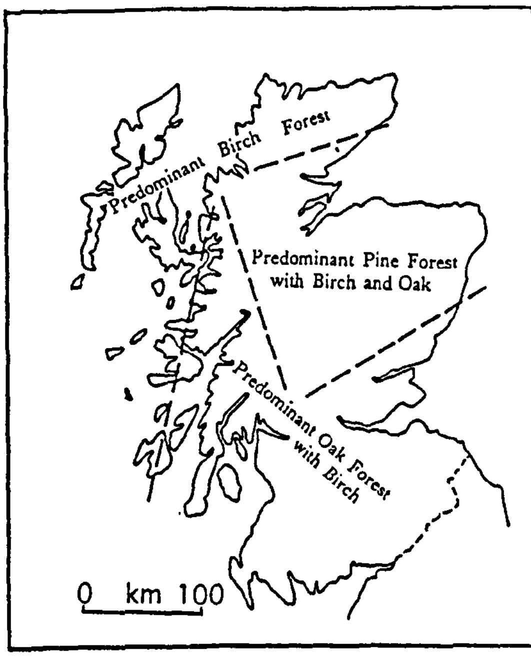
Fig. 11.1b Location of main sites in the southern Outer Hebrides discussed in Chapter 11

na h-Achlais, to as late as 9810 BP (11210 cal BP) at Loch Olabhat (this study), although this large range may be due to dating inaccuracies. At most sites the transition appears to have taken place sometime between 10200 and 10000 BP.

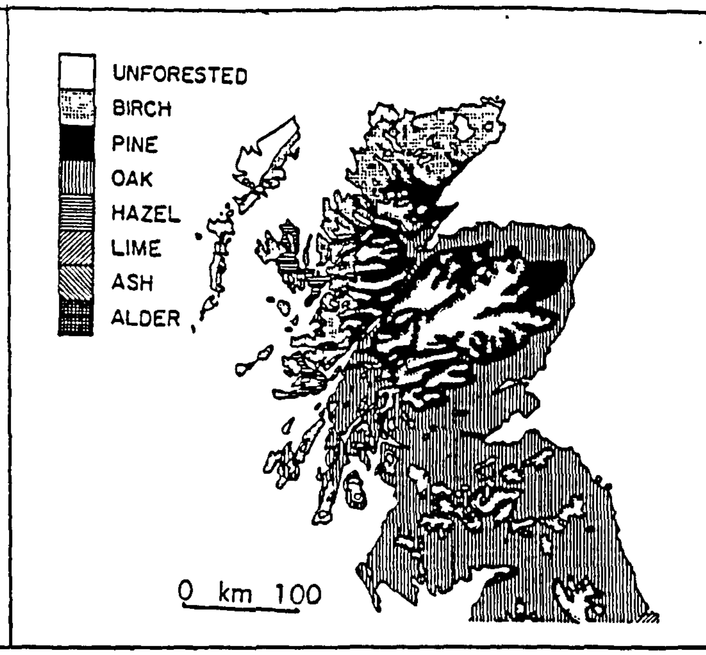
11.1.2 Woodland - composition and spread

At virtually all the sites on the islands, the start of the Holocene saw a period of tree growth. As discussed in Chapter 3, over the years there have been a number of revisions in the theories on the presence and extent of woodland on the islands. McVean and Ratcliffe (1962) suggested that islands only supported some birch and hazel scrub in the period before the impact of people (Fig. 11.2a). Birks and Madsen (1979) appeared to confirm this view with a pollen diagram from Little Loch Roag in Lewis, where tree and shrub frequencies never exceeded 30% TLP. However, Wilkins (1984) disputed the idea of a barren, treeless island, on the basis of the presence of considerable numbers of macrofossils of pine, birch and willow in Lewis, while Bohncke (1988) produced evidence of extensive birch woodlands at Callanish on the basis of a series of pollen diagrams and some birch fragments. Bennett *et al.* (1990) published a diagram from Loch Lang on the east coast of South Uist, and suggested that at least the eastern side of the island supported considerable woodland cover, including oak, elm and alder, but the western side of the islands was still considered to have been treeless (Bennett, 1989; Fig. 11.2b). In the last 10 years there have been a number of studies that have suggested that the western side of the southern islands also had trees and shrubs (Edwards, 1990, 1996; Edwards *et al.*, 1995, Brayshay and Edwards, 1996; Whittington and Edwards, 1997). The only exception appeared to be parts of western Lewis, where profiles from Little Loch Roag and Loch Buailaval Beag suggest that few trees ever grew (Birks and Madsen, 1979; Fossitt, 1996). However, Lomax (1997) has now produced three pollen diagrams with high tree and shrub frequencies from western Lewis, suggesting that even that area was at least partially wooded during the early Holocene. The latest map to be produced of woodland in Scotland *c.* 5000 BP (5730 cal BP) (Edwards and Whittington, 1997; Fig. 11.2c) suggests that there were trees and shrubs growing throughout the islands, with birch and hazel as the dominant species.

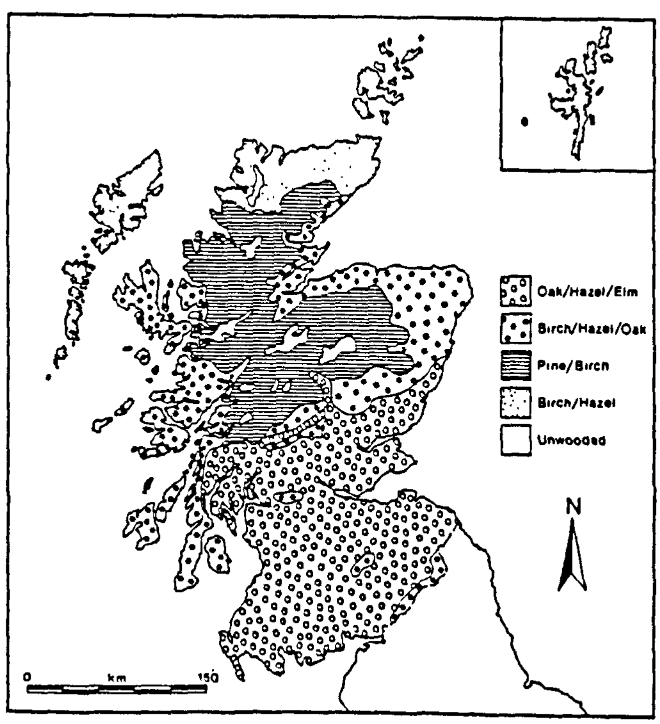
Woodland growth was probably not homogeneous across the islands and



11.2a Woodland distribution before large-scale human clearance (McVean and Ratcliffe, 1962)



11.2b Woodland in Scotland *c.* 5000 years ago (Bennett, 1989)



11.2c Woodland in Scotland *c.* 5000 years ago (Edwards and Whittington, 1997; modified after Tipping, 1994a).

there are differences between regions, both in terms of woodland composition and timing of the decline. As a general rule, *Ulmus*, *Quercus* and *Alnus* values are more prominent, and woodland in general survived for a longer period of time, on the eastern side of the southern isles (see below).

The pollen profiles from the present study generally confirm that the islands had considerable woodland cover during the early Holocene. At all four loch and peat sites, tree and shrub frequencies reached at least 75% during this period, figures which are very much in line with other research on the island.

Tree and shrub pollen frequencies at the site of Loch Airigh na h-Achlais, located close to the east coast, reach a maximum of 80.4% TLP, a figure which is very similar to that at Loch Hellisdale (80.7%), also in the east (Brayshay and Edwards, 1996). At other east coast sites the figures are somewhat lower: arboreal pollen frequencies reach 63.9% at Loch Airigh na h-Aon Oidhche (Brayshay and Edwards, 1996), 60% at Loch Lang (Bennett *et al.*, 1990), and 57.7% at Loch a'Phuinnd, but at all of these sites the researchers have argued for the presence of a considerable amount of tree and shrub cover. Loch a'Phuinnd is located only 3.5 km from Loch Airigh na h-Achlais, and it is interesting to note the differences between the two sites. The apparently greater extent of trees and shrubs at the latter (*Corylus* in particular is more prominent at Loch Airigh na h-Achlais) may be due to its relatively sheltered location, 3 km inland, while Loch a'Phuinnd is located in a more exposed area directly on the coast.

In western South Uist maximum tree and shrub pollen frequencies generally exceed 70% (Brayshay and Edwards, 1996), but there are some notable exceptions. Arboreal pollen values never reach more than 42.2% at Reineval, in the centre of South Uist (Edwards and Whittington, 1994), and an inter-tidal peat deposit at Peninerine produced only 38% (Edwards *et al.*, 1995). In contrast, the profiles from Frobost and Loch a' Chabhain produced arboreal pollen maxima of 75.1% and 78.1% respectively. What becomes evident is that the extent of woodland appears to have varied considerably on a local level: the site of Frobost is located less than 1 km from Reineval, but at the latter the pollen diagrams suggest there were far fewer trees and shrubs (Brayshay and Edwards, 1996). Presumably this is because Frobost is located in a relatively sheltered area, while Reineval lies at a higher altitude in the centre of a large, exposed basin.

On North Uist, too, there are indications that woodland was quite extensive during the early Holocene. At both Loch Reallasger and Loch Olabhat arboreal pollen frequencies reach a maximum of around 75%, although woodland composition at the two sites was not identical. *Betula* was quite prominent (up to 40%) at Loch Reallasger, while *Corylus* was more abundant at Loch Olabhat (Fossitt, 1990; this study).

Most of the apparent woodland cover on the islands during the early Holocene was made up of *Betula* and *Corylus avellana* populations, both of which spread rapidly at the start of the Holocene. *Betula* was already present on the islands by the start of the Holocene (before 10000 BP [11410 cal BP]), and was the first tree species to establish itself to any great extent, eventually reaching as much as 88% TLP at Port Caol in Barra (Brayshay and Edwards, 1996) and 80% at Callanish (Bohncke, 1988). At other sites birch woods were slower to get established - at Loch Buailaval Beag expansion of *Betula* did not take place until *c.* 9600 BP (10940 cal BP) (Fossitt, 1996) and at Frobost possibly not until *c.* 9320 BP (10590 cal BP).

Salix, which like *Betula* had been present in the Lateglacial, probably persisted for some time in many parts of the islands. The finding of *in-situ Salix* macrofossils in Lewis, North Uist and South Uist (Wilkins, 1984; Fossitt, 1996), establishes beyond a doubt that willow grew on the islands. *Salix* pollen is considered to be under-represented in the pollen record (Bradshaw, 1981), and although frequencies of *Salix* pollen on the Outer Hebrides are usually low (<5%), willow trees may well have been an important component of local woodland in the very early Holocene. At Frobost willow may even have been co-dominant with birch and hazel for some time - *Salix* frequencies reach as much as 12.3% at 8830 BP (9950 cal BP) at a time when *Betula* and *Corylus* frequencies are both around 20%, and willow is likely to have grown locally there until at least 7200 BP (8040 cal BP). At the other sites in this study *Salix* is far less common, and willow had probably virtually disappeared by 9000 BP (10200 cal BP) at Loch a' Chabhain and Loch Airigh na h-Achlais, and by 8400 BP (9400 cal BP) at Loch Olabhat.

Corylus avellana arrived not long after the spread of *Betula*. Birch is a shade-intolerant pioneer taxon which does not compete well with other tree species, and at many sites hazel soon became the dominant tree species, and remained so until final woodland reduction. The arrival of *Corylus* is an asynchronous event. The rational limit for *Corylus* ranges from *c.* 10170 BP (11900 cal BP) at Port Caol to *c.* 8500 BP (9510 cal BP) at Loch a'Phuinnd, and even possibly as late as 7990 BP (8690 cal BP) at Reineval in South Uist (Brayshay and Edwards, 1996). The spread of hazel also does not follow a clear geographical pattern: sites on South Uist with early *Corylus* rises occur both on the west coast (Port Caol) and the east coast: *c.* 9900 BP (9290 cal BP) at Loch Airigh na h-Aon Oidhche and *c.* 9850 BP (11220 cal BP) at Loch Airigh na h-Achlais (Brayshay and Edwards, 1996; this study). In the peat-covered centre of the island, rational limits are asynchronous even within a small area. *Corylus* probably arrived around 9180 BP (10320 cal BP) at Frobost, but possibly not until *c.* 7990 BP (8890 cal BP) at the nearby less-sheltered site of Reineval, more than 1400 calendar years later (Brayshay and Edwards, 1996). Thus although climatic changes will have initiated the general spread of *Corylus*, local shelter and probably edaphic conditions may have affected the arrival of the taxon in any given area.

Although hazel and birch were the dominant tree species on the islands throughout the early Holocene, an increasing number of researchers have argued that *Pinus*, *Ulmus*, *Quercus* and *Alnus* may also have been present. In a study of modern pollen on the islands, when tree and shrub pollen must have come almost exclusively from long-distance sources, mean *Pinus* pollen frequencies were 1%, *Ulmus* 0.2%, *Quercus* 0.8% and *Alnus* 1.8% (Fossitt, 1994a). In virtually all the pollen profiles investigated in the islands, frequencies for these trees and shrubs were much higher during the early part of the Holocene. On the other hand, these trees were growing on the Scottish mainland, and probably the Inner Hebrides, in far greater abundance during the early Holocene than they are today, and it could therefore be argued that the higher frequencies of these taxa on the Outer Hebrides in early prehistory are simply a reflection of a more abundant source area of long-distance pollen. Fossitt (1996) has suggested that the site of Loch Buailaval Beag in Lewis could be used as a control here: pine pollen frequencies never exceed 1.4% at this site, even during the early Holocene, and the values for *Alnus glutinosa*, *Quercus* and *Ulmus* are even lower (<1%). Any percentages higher than these figures could thus be indicative of local presence. On the other hand, the possibility that for some reason long-distance pollen was particularly poorly represented at Loch Buailaval Beag cannot be excluded.

There is no doubt about the presence of pine in Lewis - numerous Scots pine macrofossils have been found there (Wilkins, 1984; Fossitt, 1996) - but, although pine macrofossils from North Uist have been mentioned in the past (E. Beveridge, 1911: 5; G. Beveridge, 1926: 25), their presence in the Uists and Barra have yet to be confirmed by modern studies. *Pinus* pollen values are generally low (<10%) in the pollen diagrams from these islands, although there are exceptions (e.g. 28.1% at Loch Hellisdale, 16.8% at Port Caol [Brayshay and Edwards, 1996] 13% at Loch Airigh na h-Achlais, and 13.1% at Frobost). *Pinus* is generally considered to be over-represented in the pollen record, and Bennett (1984) has adopted a minimum value of 20% to indicate local presence. Gear and Huntley (1991) have even put this figure as high as 30%. However, there are some indications that these calculations do not necessarily apply in the Outer Hebrides. Despite the undoubted presence of pine trees on Lewis, pine pollen frequencies on that island are no higher than in other parts of the Outer Hebrides. At Little Loch Roag pine stumps were found not far from the coring site (Wilkins, 1984), but pine pollen frequencies in the diagram never exceeded 5% (Birks and Madsen, 1979). A similar percentage of pine pollen was encountered in a peat sample taken from directly below a pine stump on the island (Wilkins, 1984). In western Donegal in Ireland, samples from a profile which actually contained pine stomata produced only 3% *Pinus* pollen (Fossitt, 1994b). It thus appears that pine may be under-represented in the pollen record of the Outer Hebrides (and apparently parts of Ireland), perhaps due to the strong winds that blow almost continuously on the islands (Gearey and Gilbertson, 1997), or because pine is close to its climatic limits in this area and pollen production is lower (Bennett, 1984). This means that even quite low pollen values, say 5%, could indicate local presence.

At many sites in South Uist and Barra, including Loch Olabhat, pine pollen frequencies fluctuate markedly. If the pollen was derived entirely from long distance sources, the input could be expected to be more constant and the pine pollen curve to be smoother. Phases of high pine pollen values are also quite asynchronous. They start as early as 7660 BP (8410 cal BP) at Loch Olabhat, and as late as 5930 BP (6740 cal BP) at Loch a'Phuinnd, and end anywhere between 5040 BP (5800 cal BP) (Loch Horsaclett) and 4100 BP (6060 cal BP) (Loch Lang) (this study; Fossitt, 1990; Bennett *et al.*, 1990). Greater synchroneity between these sites would be expected if pine pollen were derived mostly from long-distance sources. Higher frequencies of pine pollen on the eastern side of the islands, closer to the Scottish mainland, might also be anticipated. Instead, sites with relatively high *Pinus* values are located on both sides of the islands, and there appears to be no great distinction between east and west.

If 5% is taken as the cut-off point for local growth of pine trees on the islands, then most sites in the Uists and Barra appear to have had some pine trees. Loch Reallasger, Loch a' Phuinnd, Borve, Kildonan Glen, Loch na h-Aon Oidhche, Loch Lang and Loch a' Chabhain all have maximum *Pinus* frequencies over 5% (Fossitt, 1990, 1996; Whittington and Edwards, 1997; Brayshay and Edwards, 1996; Bennett *et al.*, 1990), and at Loch Hellisdale, Lochan na Cartach, Port Caol (Brayshay and Edwards, 1996), Loch Olabhat, Loch Airigh na h-Achlais, and Frobost frequencies of over 10% were recorded.

The decline in *Pinus* on the islands was a gradual event, starting at around 5000 BP (5730 cal BP) in some areas, and not until 4100 BP (4660 cal BP) in others (Fossitt, 1990). One reason for this decline may be climatic. The macrofossil evidence from Lewis points to a decline in pine between 5000 and 4000 BP (5730-4460 cal BP), when *in-situ* pine stumps preserved in peat suggest that peat bogs expanded to overwhelm these areas (Fossitt, 1990,1996). A widespread and apparently sudden decline in pine in Scotland, and its apparent extinction in northern Scotland, around 4000 BP (4460 cal BP) (Bennett, 1984; Gear and Huntley, 1991) has also generally been attributed to climatic deterioration (Birks, 1977, 1988; Bridge *et al.*, 1990; Gear and Huntley, 1991), perhaps exacerbated, or even caused, by volcanic fall-out from the eruption of the volcano Hekla in Iceland, which took place around that time (Blackford *et al.*, 1992). In the Outer Hebrides, it appears that pine started to decline before the eruption of Hekla, and volcanic ash is thus unlikely to have been a factor. It is possible, however, that the decline of pine can at least in part be attributed to a shift to a more oceanic climate, which some argue occurred in Scotland between *c.* 4200 and 3900 BP (4770 and 4350 cal BP) (Birks and Williams, 1983; Dubois and Ferguson, 1985; Birks, 1988, 1991). Stable-isotope ratios (D/H) found in pine-stumps in the Cairngorms appear to point to a major increase in precipitation levels during this period (Dubois and Ferguson, 1985). Increased precipitation may have encouraged the spread of peat and inhibited pine regeneration (Birks, 1988). On the other hand, the decline of pine takes place during a period for which there is clear archaeological evidence of the presence of people in the Outer Hebrides, and human impact, perhaps in the form of grazing pressure and tree-felling, cannot be excluded (see below).

A few sites with *Alnus* macrofossils have emerged in Lewis (Fossitt, 1996), but to date there have been no confirmed finds of *in-situ* macrofossils of *Quercus* or *Ulmus* on any of the islands in the Outer Hebrides. However, the pollen of these taxa is frequently recorded, albeit in low frequencies. *Quercus*, *Ulmus* and *Alnus* are not generally considered to be over-represented in the pollen record, and it has been argued that even low frequencies (over 2%) may suggest local presence (Huntley and Birks, 1983). At most sites in the Outer Hebrides frequencies for these taxa are considerably higher than at the potential 'control site' of Loch Buailaval Beag, where the maximum values for these taxa were 0.6%, 1.2% and 0.9% for oak, elm and alder respectively (Fossitt, 1996). Bennett *et al.* (1990), for example, argue for the local presence of oak and alder at Loch Lang, where both taxa reach 15% TLP. *Quercus* and *Alnus* values are also quite high at Loch Airigh na h-Aon Oidhche (up to 11.3% and 15.4% respectively; Brayshay and Edwards, 1996), Loch Airigh na h-Achlais (10.4% and 8.3%) and Lochan na Cartach (5.4 and 6.5%; Brayshay and Edwards, 1996). Relatively high *Alnus* frequencies (>5%) are also found on the western side of the island, at Loch a' Chabhain and Loch an t-Sìl (Brayshay and Edwards, 1996). *Ulmus* values are highest at Loch Hellisdale (10.4%; Brayshay and Edwards, 1996) and Loch Airigh na h-Achlais (10.2%), both on the east coast of

South Uist. On the basis of a conservative estimate that 5% TLP is high enough to suggest local presence, *Quercus*, *Alnus* and *Ulmus* may thus have been present throughout much of South Uist, although perhaps more commonly on the eastern, more sheltered, side of the island. The pollen frequencies for these trees, however, never matched those of *Betula* and *Corylus*, and at no time are they likely to have been very prominent. They probably occurred as scattered individuals or small stands in the open wooded landscape.

At many sites in the islands *Quercus* and *Ulmus* arrived around the same time, with dates for their rational limits centering around 8000 BP (8890 cal BP) They may have appeared somewhat earlier at Loch Airigh na h-Aon Oidhche, at 8980 BP (10180 cal BP), perhaps due to the relatively sheltered nature of the site (Brayshay and Edwards, 1996), and in western Lewis, where both elm and oak may have grown locally by 8600 BP (9540 cal BP) (Lomax, 1997). A surprisingly early date comes from Loch a' Chabhain (this study), where the rational limit for *Ulmus* is reached by 9310 BP (10500 cal BP), although *Quercus* does not appear until 8640 BP (9570 cal BP). The timing of the disappearance of *Ulmus* and *Quercus* from local woodland is also variable. *Ulmus* and *Quercus* probably disappeared from the area around Loch Olabhat after 5800 and 5000 BP (6600 and 5730) respectively, while they lasted until 4210 BP and 3300 BP (4840 and 3510 cal BP) at Loch Airigh na h-Achlais. In many cases the decline in these trees may be related to human impact (see section 11.2.1).

In contrast to *Ulmus* and *Quercus*, the arrival of *Alnus* is very asynchronous. At Loch Airigh na h-Achlais and Loch Airigh na h-Aon Oidhche alder may have appeared as early as 7560 BP (8380 cal BP) and 7000 BP (7800 cal BP) respectively, while it does not reach a rational limit at Reineval until *c.* 4910 (5630 cal BP) and 4630 BP (5380 cal BP) at Frobost, after the start of the Neolithic (Brayshay and Edwards, 1996; this study). *Alnus* pollen is probably not very well dispersed (although this is contested for the Hebrides; Gearey and Gilbertson, 1997), and small populations of alder may have colonised many areas considerably earlier than can be detected in the regional pollen record (Chambers and Price, 1985). As in the rest of Britain, there is no clear geographical pattern to the expansion of the taxon in the

Outer Hebrides, suggesting that the spread of alder was influenced not so much by general climatic changes, but by the availability of suitable wet habitats on a local level (Chambers and Elliott, 1989; Bennett and Birks, 1990). Some researchers have even argued that alder may have needed a disturbance in the local vegetation in order to become fully established, and that the spread of alder may have been promoted by the activities of Mesolithic people (Smith, 1970; Simmons, 1975; see section 11.1.4).

Other tree taxa that were probably present on the islands during the first half of the Holocene, and sometimes in later phases as well, include *Fraxinus excelsior*, *Populus tremula*, and *Sorbus aucuparia*, although none are ever likely to have been important woodland components. *Fraxinus excelsior* and *Populus tremula* are both considered to be very under-represented in the pollen record (Andersen, 1967; Bradshaw, 1981; Hall, 1989) and the presence of even a few pollen grains could signify local presence, as Lomax (1997) has argued for western Lewis. *Fraxinus* expanded into southern Scotland by around 6000 BP (6810 cal BP) and probably arrived on the Outer Hebrides not long after that. *Fraxinus* pollen has been found in particularly early levels on the east coast of South Uist: *c.* 5510 BP (6300 cal BP) at Loch Airigh na h-Aon Oidhche, *c.* 5860 BP (6690 cal BP) at Loch Airigh na h-Achlais and even *c.* 6250 BP (7170 cal BP) at Lochan na Cartach (Brayshay and Edwards, 1996). An extremely early record at Loch a' Chabhain (*c.* 9040 BP [10210 cal BP]) may well be erroneous or due to contamination. At the other end of the scale, ash apparently did not appear at Callanish in western Lewis until *c.* 2520 BP (2640 cal BP) (Bohncke, 1988). *Populus tremula* pollen has been recorded throughout much of the Holocene, in particular at Lochan na Cartach, Loch Hellisdale, North Locheynort (Brayshay and Edwards, 1996), at several sites in western Lewis (Lomax, 1997), and at Loch Horsaclett in Harris (Fossitt, 1990).

Sorbus-type pollen, too, is under-represented in the pollen record (Andersen, 1967), but it has been recorded at many sites in the Outer Hebrides, in particular in central and eastern parts of the southern islands (at Loch Airigh na h-Aon Oidhche, Loch Hellisdale, Kildonan Glen and Lochan na Cartach), as well as at Loch Bharabhat, Loch na Muilne and Loch na Beinne Bige in western Lewis (Lomax, 1997). *Sorbus*-type wood (cf. rowan, a tree which still grows in the islands today) has also been found as charcoal fragments in the Neolithic settlement sites of Allt Chrisal in Barra (Boardman, 1995) and Bharpa Carinish in North Uist (Crone, 1993), although this does not in itself prove that it was growing on the island (Brayshay and Edwards, 1996). Other typical woodland elements that are likely to have been present in the islands include the climbing shrubs honeysuckle and ivy. Both *Lonicera periclymenum* and *Hedera helix* have been recorded in low frequencies at a number of sites, including Lochan na Cartach, Port Caol (Brayshay and Edwards, 1996), Frobost, Loch a' Chabhain and Loch Olabhat.

From the evidence presented here it appears that there was considerably more woodland on the islands than suggested by the oft-cited pollen diagram from Little Loch Roag (Birks and Madsen, 1979), and that these woods, although dominated by birch and hazel, did contain a variety of other species of trees, most of which no longer grow on the islands. However, the islands were probably never covered in the closed woodland that could be found in the lowlands of mainland Scotland at this time. The woodland is likely to have been quite open, with an understorey of grasses, tall-herbs such as *Filipendula* and *Angelica sylvestris*, ferns, and climbing shrubs such as *Lonicera periclymenum* and *Hedera helix*, as well as patches of *Calluna vulgaris*-dominated heathland.

11.1.3 The decline of woodland

Although both the eastern side and western sides of the islands had considerable woodland cover at some stage in the early Holocene, the timing for the decline of trees and shrubs is very different. On the eastern coast of South Uist woodland generally persisted until well into the Neolithic or later. At Loch Airigh na h-Achlais, for example, there is no sign of a significant decrease in trees and shrubs until *c.* 4860 BP (5600 cal BP), at Loch Lang this decline took place from *c.* 4300 BP (4850 cal BP) (Bennett *et al.*, 1990), while at Loch Airigh na h-Aon Oidhche there was an initial decline around 5390 BP (6230 cal BP) but a significant reduction did not occur until *c.* 3740 BP (4110 cal BP) (Brayshay and Edwards, 1996). In Barra, too, woodland appears to have persisted on the eastern side: at Lochan na Cartach the major reduction in arboreal taxa took place only from 4140 BP (4700 cal BP) onwards (Brayshay and Edwards, 1996)

On the western side of the islands the decline in trees and shrubs tended to take place much earlier. At Loch an t-Sìl birch and hazel were in decline from 7470 BP (8270 cal BP) onwards, and by *c.* 5240 BP (5970 cal BP) arboreal pollen values at this site had reached a general minimum. At North Locheynort, in the centre of the island, there is a reduction in trees and shrubs from around 7260 BP (8080 cal BP) (Brayshay and Edwards, 1996), while at Frobost an initial decline in trees and shrubs starts *c.* 8260 BP (9270 cal BP) and accelerates after *c.* 7980 BP (8880 cal BP). As the trees and shrubs declined *Calluna vulgaris*, Poaceae and Cyperaceae expanded to replace them, and at most sites, trees and shrubs never recovered and the landscape became progressively open and barren. There are exceptions, however, such as at Callanish, where there are several phases of tree growth and decline before the final disappearance of woodland in the area around 3500 BP (3770 cal BP) (Bohncke, 1988), although this pattern may reflect human impacts.

The decline in trees and shrubs during what elsewhere would be seen as Mesolithic times was an asynchronous event, and could be due to a number of different factors, including changes in climate, the progressive deterioration of soils, and human impact. At many sites the decline in trees and shrubs is rather gradual, which, as Brayshay and Edwards (1996) argue, could be indicative of climatic and pedogenic factors. At sites directly along the west coast, such as Port Caol and Loch an t-Sìl, as well as inter-tidal peat sites such as Peninerine and Borve, the appearance of sand in the stratigraphy suggest that the expansion of machair in that area may have had an effect on the vegetation, encouraging the growth of calcareous grasslands (Brayshay and Edwards, 1996; Whittington and Edwards, 1997). The primary taxa of blanket bog and heathland communities were already present on the island from the very start of the Holocene, and at many inland sites tree growth may simply have become unsustainable because of the progressive spread of peat in the area (Brayshay and Edwards, 1996). How and when this happened will have depended at least partly on local vegetation, topography and hydrology. There may have been a general shift to wetter climatic conditions in western Europe around 7000 BP (7800 cal BP) and this could have had a limiting effect on tree growth in the

Outer Hebrides (Bell and Walker, 1992).

The other factor that could be involved, however, is the possible activity of Mesolithic people in the Outer Hebrides. As discussed in Chapter 4, there is to date no archaeological evidence for the presence of people on the islands during the Mesolithic, although this may simply be because Mesolithic sites lie hidden beneath sea, machair and peat (Edwards *et al.*, 1995). However, in recent years several researchers have interpreted certain patterns in pollen diagrams from the Outer Hebrides as reflecting possible signs of the impact of hunter-gatherers on the landscape (Bohncke, 1988; Bennett *et al.*,1990; Edwards *et al.*, 1995).

11.1.4 The possible impact of Mesolithic people

Since the late 1960s there have been numerous suggestions that hunter-gatherer communities could, and did, have a significant impact on their environment, which can at times be detected in the pollen record. It has been noted, for example, that there were phases of woodland decline in many pollen diagrams long before there were farmers to burn or chop down woodland in order to create fields (Smith, 1970; Simmons, 1969, 1975, 1993, 1996; Jacobi *et al.*, 1976; Jones, 1976; Simmons and Innes, 1987).

There are numerous suggestions for the way in which human activity during the Mesolithic might be reflected in the microfossil record, but most of them centre on the apparent increase in charcoal at this time. Possible interpretations of this increase in fire frequency include: deliberate burning to open up the forest and attract game; the use of fire to encourage the spread of specific trees and shrubs which may have been of economic importance to hunter-gatherers (such as hazel, and understorey plants with edible fruits and berries); and heathland management using fire (Smith 1970; Edwards and Ralston, 1984; Edwards *et al.*, 1995; Edwards, 1996; Tipping, 1996).

Mesolithic impact in the Inner Hebrides

In contrast to the Outer Hebrides, there is clear evidence that Mesolithic hunter-gatherers were present on the islands of the Inner Hebrides (see Chapter 4), in what was probably a very similar environment, and it might therefore be informative to look at the palynological data from this area for the sake of comparison. Hirons and Edwards (1990) have, for example, presented a pollen sequence from Kinloch on Rhum, which is one of the earliest known occupation sites in Scotland to date (it has a radiocarbon date extending back to 8590±95 BP (9650-9450 cal BP)). A recently discovered site in Clydesdale in southeastern Scotland may be even older at 9075±80 BP (10050-9980 cal BP) (Anonymous, 1998). The pollen diagram at Kinloch starts at 7800 BP (8570 cal BP), too late to provide any information on early occupation at the site, but reveals signs of possible human activity during the late Mesolithic, in particular between 5950 and 5700 BP (6760 and 6470 cal BP). For this period the pollen diagram shows sharp reductions in *Alnus* and *Corylus avellana*-type, while Poaceae, *Pteridium* and charcoal values increase. A general decline in tree cover and an increase in charcoal between 6500 BP and 4000 BP (7430 and 4460 cal BP) could be due to repeated clearance by axe, as well as charcoal deriving from domestic fires (Hirons and Edwards, 1990). The length of these clearance phases has been estimated to be about 250 years (Hirons, 1990), with the clearances possibly kept open not so much by people as by grazing animals which prevented re-growth of trees and shrubs (cf. Buckland and Edwards, 1984).

The island of Islay also has archaeological evidence for Mesolithic occupation, and this may be reflected in a pollen diagram from Loch a'Bhogaidh (Edwards and Berridge, 1994). Between *c.* 7750 and 7310 BP (8500 and 8100 cal BP) and again from *c.* 7000 to 6500 BP (7800-7430 cal BP) there was a rise in charcoal, as well as *Betula*, *Pinus* and *Quercus* frequencies, while *Corylus* suffered a decline. This could reflect the deliberate clearance of hazel scrub, the authors argue, while the rise in charcoal may reflect the use of fire for clearing woodland, as well as domestic fires. The presence of charcoal even in the lowest section of the core, which has been dated to an estimated 12430 BP (14910 cal BP), has led Edwards and Mithen (1995) to suggest that human occupation on Islay may date back even further than the earliest currently known Mesolithic sites (Edwards and Mithen, 1995; Mithen and Lake, 1996), although the basal radiocarbon dates at Loch a'Bhogaidh may be too old (Sugden and Edwards, in press).

Fire and Hunting

One suggestion that is often made is that hunter-gatherers may have set fire to the forests in order to increase browse and attract large herbivores such as red deer into the area (Simmons, 1975; Mellars, 1976; Simmons et *al.*,1981; Edwards and Ralston, 1984). This could then be reflected in the pollen record by a decrease in trees and shrubs, an increase in charcoal, and an increase in taxa that are favoured by fire, such as *Calluna vulgaris*, and possibly anthropogenic indicator species (Edwards and Ralston, 1984; Edwards, 1990; Edwards *et al.*, 1995). Fire may also have been used by hunter-gatherers to herd game into particular areas where they could be culled, as may be suggested by the evidence for selective culling at some Mesolithic sites (Edwards and Ralston, 1984).

Perhaps the best case for human impact during the Mesolithic in the Outer Hebrides can be made at Callanish in Lewis, where Bohncke (1988) argues that a decrease in *Betula*, and an increase in charcoal, *Calluna vulgaris*, Poaceae and *Potentilla*-type *c.* 7000 BP (7800 cal BP), could be evidence of burning by hunter-gatherer communities in order to clear woodland and create browse. At North Locheynort in South Uist there is a sustained charcoal peak from 7280±40 to 4460±110 BP (*c.* 8090-5130 cal BP) associated with reductions in trees and shrubs, which may also be attributable to human impact (Edwards, 1990; Brayshay and Edwards, 1996), while at Loch an t-Sìl there may be evidence of two woodland clearance phases around 8040 and 7870 BP (9000 and 8620 cal BP) (Edwards *et al.*, 1995). Charcoal values are also high at Reineval, especially around 6000 BP (6810 cal BP). Again this is accompanied by reductions in tree and shrub taxa, and could form evidence for a Mesolithic presence (Edwards *et al.*, 1995). At Borve, an intertidal peat site on the west coast of Benbecula, there are significant increases in charcoal values and a decrease in hazel and birch woodland by 6190 BP (7100 cal BP) which the authors interpret as possible evidence for burning instigated by hunter-gatherers (Whittington and Edwards, 1997). Virtually all these changes take place after 8000 BP (8890 cal BP) at a time when the Inner Hebrides are known to have been settled, but Bennett *et al.* (1990) have suggested that decreases in arboreal taxa and a rise in the charcoal curve at a somewhat earlier date (*c.* 9000 BP; 10200 cal BP) at Loch Lang could potentially also reflect human activity.

Tipping (1996) has warned against interpreting all decreases in arboreal pollen associated with increased charcoal values as signs of the impact of hunter-gatherers. He argues that in regions of Scotland where the forests were already open, and in this he includes the Outer Hebrides, such tactics to increase browse would not have been necessary.

Fire and the spread of hazel and alder

The rapid rise and very high frequencies of *Corylus avellana*-type pollen during Mesolithic phases in many pollen diagrams has led some to suggest that Mesolithic people may have deliberately burnt areas of woodland in order to facilitate the spread of hazel, which, judging from archaeological evidence, may have been an important source of food at this time (Smith, 1970; Simmons *et al.*, 1975). *Corylus avellana* is supposedly more fire-resistant than other tree-species, it coppices freely after a fire, and is able to sprout and flower quickly (although this has been disputed by Rackham, 1980: 104), thus increasing its representation in the pollen record after a fire. Edwards (1990), however, has looked at several sites throughout Scotland, and with the possible exception of Kinloch on Rhum, could find no correlation between fire (either natural or anthropogenic in origin) and the rise of the *Corylus* curve, and no such evidence has been found in the sites in this study either.

Huntley (1993) considers it more likely that the prominence of *Corylus* during the Mesolithic is simply due to its greater climatic tolerance than other tree taxa, although he adds that the spread of *Corylus* may have been aided by increased natural fire frequency, which possibly occurred due to greater aridity at this time. The rapidity of expansion of the taxon at many sites could be partially explained by a plateau in the radiocarbon chronology between 10000 and 9500 BP (11410 and 10870 cal BP) (Huntley, 1993).

It has also been suggested that the spread of alder may have been promoted by the activities of Mesolithic people (Smith, 1970, 1984; Simmons, 1975). The argument is based on the idea that the removal by fire of other arboreal taxa, such as pine, birch and hazel, led to changes in hydrology, the flooding of valley bottoms, and the creation of new habitats for alder to occupy (Edwards and Ralston, 1984). At several sites in Scotland, including Kinloch, (Edwards, 1990) there appears to be an increase in charcoal immediately before, or at the same time as, a rise in *Alnus*, but a causal relationship could not be proven (Edwards, 1996). No relationship between alder and charcoal was found at any of the sites investigated in this study.

Fire and heathland

Edwards *et al.* (1995) have looked specifically at the possible relationship between *Calluna*-dominated heath and fire, suggesting that fire may have been used deliberately during the Mesolithic and later periods to increase the productivity of heathlands, as has been argued for western Norway (Kaland, 1986) and northern Denmark (Odgaard, 1988, 1994). The burning of heathland has been a well established practice in parts of Scotland in the last few centuries (Stevenson and Birks, 1995). It interrupts the ageing process of *Calluna vulgaris*, and as long as the fire is not too intense, the ash returns nutrients to the soil. Burning tends to make the heath more productive as grazing land, and at the same time prevents it turning to scrub or woodland. Heathland management by fire has to be carefully controlled in order to be beneficial; frequent burning can lead to the expansion of grassland (Hobbs and Gimingham, 1987), especially when combined with heavy grazing (Stevenson and Thompson, 1993). Burning can also increase the loss of nutrients and soil by increasing surface run-off, and may help accelerate peat growth, as the deposition of charcoal on the soil surface can reduce permeability, leading to increased wetness (Mallik *et al.*, 1984).

In the Outer Hebrides Edwards *et al.* (1995) found an association of peaks or rises in the charcoal and *Calluna* curves at Loch an t-Sìl between 8300 and 5000 BP (9280 and 5730 cal BP), at Peninerine from *c.* 7800 BP (8570 cal BP), and during later phases at Reineval (*c.* 4500 BP [5170 cal BP]) and Loch Airigh na h-Aon Oidhche (*c.* 1500 BP [1380 cal BP]). Although the creation of heathland at these sites was probably not initiated by burning, the authors argue that it may have been maintained by fire (Edwards *et al.*, 1995).

As far as the sites analysed in this study are concerned, the evidence for the use of fire to create or sustain heathland is variable. Despite its proximity to Reineval, there are is no relationship between the *Calluna vulgaris* curve and the charcoal curve at Frobost, either during the Mesolithic or the Neolithic. *Calluna* values during these periods are generally at their highest when charcoal values are at their lowest. Nor is there a clear correlation between charcoal and *Calluna* frequencies at Loch a' Chabhain. The charcoal rise which starts at *c.* 6240 BP (7160 cal BP) is not associated with an expansion in heath communities. However, fire may have played a part in the rise in *Calluna* at Loch Airigh na h-Achlais. As the charcoal curve starts to rise around 3200 BP (3420 cal BP) *Calluna* values also increase, suggesting that fire may have been used to promote heathland, although progressive soil deterioration may also have contributed to the gradual expansion of heath near the site.

Loch Olabhat has perhaps the best evidence in this study for a charcoal-heath relationship. Charcoal values are considerably higher than at the other sites. The charcoal and *Calluna* curves at Loch Olabhat both start to rise around 9200 BP, although a causal relationship cannot be proven, and both curves are very high during the early Neolithic between 5175 and 4800 BP (5920 and 5540 cal BP), as well as after 1910 BP (1850 cal BP) (there is no pollen record for the period in between). However, the site is located in an area which appears to have been inhabited from the Neolithic through to the present day (Armit, 1992b, 1996) and the high charcoal values during the last 5000 years could also reflect domestic fires.

Fire and climate

The use of charcoal as an indicator of Mesolithic activity is not without its critics, particularly in areas without archaeological evidence for the presence of people. Tipping (1996) has looked at the charcoal and pollen evidence from a number sites in Scotland, including 12 in the Outer Hebrides. He argues that, after a very low incidence of fire during the earliest part of the Holocene, fire frequencies double at *c.* 8000 BP (8890 cal BP) and remain high until about 5000 BP (5730 cal BP). The increase in charcoal during this phase, he argues, is found across the north and west of Scotland and was broadly synchronous. Tipping suggests that rather than being a sign of human impact, the increased fire frequencies may be due to climatic factors, namely reduced levels of precipitation throughout Europe at this time. According to his hypothesis, 'arid phases', when the climate was drier and the vegetation was thus more likely to catch fire, occurred before *c.* 9000 BP (10200 cal BP) between 8000 and 7000 BP (8890-7800 cal BP) and again starting around 6000 BP (6810 cal BP). The first dry phase, before 9000 BP, did not lead to a greater incidence of fire because suitable vegetation was lacking at this time. By the second 'dry phase' (8000-7000 BP [8890-7800 cal BP]), however, much of northern and western Scotland had developed quite extensive areas of heath, which provided a source of readily flammable material (Tipping, 1996).

In the Outer Hebrides the palynological evidence for regional 'dry phases' with increased fire frequency is certainly not unequivocal. A regional climatic event might be expected to manifest itself over a large area, but at several sites there is no increase in charcoal values at all at this time. For example, there are no indications of increased charcoal representation at Loch Airigh na h-Achlais (this study) or Loch Airigh na h-Aon Oidhche (Edwards *et al.*, 1995) during the second 'dry-phase' (8000-7000 BP). Charcoal values remain low at these sites until well into the Neolithic and Bronze Age respectively. Even at sites where there is a clear increase in charcoal values during the Mesolithic, these events are asynchronous even within small geographical areas, and often fall within Tipping's 'wetter phases'. At Loch an t-Sìl charcoal frequencies increase just after 7900 BP (8690 cal BP) (and thus within the 'dry phase'), but at Reineval, 3 km to the northeast, the charcoal peak occurs between 6400 and 6000 BP (7340 - 6810 cal BP) (Edwards *et al.*, 1995), and at Loch a' Chabhain at 6200 BP (7110 cal BP), outside the second and third 'dry phases'. At Frobost, on the other hand, Tipping's pattern fits: there is a small increase in charcoal *c.* 7000 BP (7800 cal BP), but the main increase starts around 6070 BP (6870 cal BP) and lasts until *c.* 4900 BP (5620 cal BP). At Loch Olabhat in North Uist charcoal values are quite high between *c.* 9200 and 8300 BP (10330-9280 cal BP), mostly outside the first 'dry phase', and the second rise takes place from 5100 BP (5840 cal BP) and is likely to be associated with the presence of Neolithic farmers in the immediate area rather than climatic changes.

Mesolithic impact at the sites investigated in this study

In summary, there are few changes in the pollen diagrams of the sites introduced in this study that could possibly be interpreted as the result of human interference during the Mesolithic. At none of the sites is there any evidence for a relationship between charcoal values and either *Corylus avellana* or *Alnus glutinosa*. The charcoal curve is generally also not associated with either woodland decline or the spread of *Calluna vulgaris* during the Mesolithic. The only site with marked decreases in arboreal pollen frequencies during the Mesolithic period is Frobost. Trees and shrubs start to decline here around 8200 BP (9170 cal BP), accelerating after 7910 BP (8780 cal BP) with a slight regeneration phase after 7200 BP (8040 cal BP), followed by a further decline. However, there is no increase in charcoal values in the diagram at this time, nor is there a rise in the *Calluna vulgaris* curve. It appears more likely that the decline in arboreal pollen is due to an expansion of the mire which made the growth of trees and shrubs in the immediate area of the site increasingly difficult. Conversely, charcoal frequencies increase around 6140 BP (7010 cal BP), at which time there are no significant reductions in trees and shrubs, nor are there increases in *Calluna vulgaris* or any anthropogenic indicator taxa. A similar situation occurs at Loch a' Chabhain, where charcoal frequencies increase *c.* 6240 BP (7160 cal BP) but arboreal pollen frequencies are not reduced, and *Calluna* values are if anything lower than before the charcoal rise.

The presence of charcoal simply indicates that something was burning, but how or why can only be inferred rather than proven. Furthermore, not every clearance is a sign of human impact. Clearances can be created by windfall and maintained by wild animals as well as by human beings.

11.2 Neolithic to the present *c.* 5000-0 BP (5730-0 cal BP)

11.2.1 The Neolithic

The Neolithic is the first period for which there is archaeological evidence for the presence of people in the Outer Hebrides (Chapter 4). However, looking for human impact in the pollen record of the Outer Hebrides for this period can be quite problematic. In much of Europe the effect of people on the landscape during the Neolithic and later periods has been interpreted on the basis of clearance phases in woodland, as well as increases in charcoal and pollen types that are indicative of pastoral or arable agriculture (such as Cerealia-type and *Plantago lanceolata*; Behre, 1981). In the Outer Hebrides, however, woodland had already disappeared in many areas during the Mesolithic, and detecting human impact then becomes considerably more difficult. The presence of cereal-type pollen in a pollen profile is usually considered to be a clear indication of arable agriculture, but cultivated plants and their associated weed floras are not always strongly represented in the islands (Brayshay and Edwards, 1996). Although cultivation of cereals almost certainly took place in the Outer Hebrides during the Neolithic (Crone, 1993; Boardman, 1995), Cerealia-type pollen is very poorly dispersed and therefore strongly under-represented in the off-site pollen record (Hall, 1988). Moreover, cereal-type pollen is indistinguishable from certain natural grasses such as *Glyceria fluitans* (Andersen, 1979; Dickson, 1988; Edwards, 1989), so that the presence of cereal-type pollen in the fossil record does not automatically prove that cultivation was taken place. Many herbaceous taxa associated with human activity (e.g. *Plantago lanceolata*) can also grow in natural maritime communities on the islands, and have been recorded since the very start of the Holocene (Birks, 1973; Walker, 1984; Brayshay and Edwards, 1996).

At Frobost there are no strong indications of the presence of people during the Neolithic, despite the location of two chambered tombs (Reineval and Barp Frobost; Henshall, 1972) within 1 km of the site. Woodland had already declined in this area before 7200 BP (8040 cal BP), and the vegetation by this time was dominated by grasses and sedges. What little woodland remained did not suffer any marked decline during the Neolithic. *Plantago lanceolata*, a potential indicator of pastoralism (Behre, 1981), appears for the first time at *c.* 4920 BP (5630 cal BP) but it remains rare and its pollen curve does not become continuous until *c.* 1740 BP (1650 cal BP). There are few other indicators of anthropogenic activity in the diagram at this time: there is no evidence for cereal cultivation, or the burning of heath to promote grazing. The only charcoal peak evident in the diagram, at *c.* 4920 BP (5630 cal BP) is not associated with a rise in *Calluna* pollen or any other marked changes in vegetation, and could potentially reflect the presence of domestic fires, or even just the incidence of natural fire, in the area. It appears that either the mire at Frobost was not suited to recruiting pollen taxa indicative of human activity, or that there was little such activity taking place in the immediate surroundings of the site, with the possible exception of rough grazing.

In some ways the profile from Frobost is quite similar to that at the nearby site of Reineval. Here, too, tree and shrub frequencies were low since 7000 BP (7800 cal BP) and the landscape was virtually treeless. At this site grasses and sedges formed the dominant vegetation until 4500 BP (5170 cal BP), when *Calluna*-dominated heathland becomes far more prominent, along with blanket bog and mire taxa such as *Sphagnum* and *Potentilla*. Unlike at Frobost, high charcoal values between 4500 and 2000 BP (5170-1960 cal BP) at Reineval could suggest that the heathland was being managed by fire in prehistoric times, or alternatively could simply reflect the presence of domestic fires in the area (Edwards *et al.*, 1995).

At Loch a' Chabhain there are no signs of strong or rapid changes in the vegetation during the Neolithic. Trees and shrubs start to decline around this time (from 5360 BP [6150 cal BP]), but this is a gradual process, suggesting that the decline may not have been due to deliberate clearance by people. There is also no correlation between the decrease in tree and shrub pollen and an increase in charcoal, suggesting that fire was not the reason behind the decline in woodland. Anthropogenic indicator species are scarce at this time, with the exception of two possible cereal pollen grains. As at Frobost, the area may have been used for rough grazing only, and the gradual disappearance of woodland could be attributable to progressive soil deterioration and blanket bog formation, perhaps exacerbated after *c.* 4300 BP (4850 cal BP) by a deterioration in the climate (Birks and Williams, 1983; Birks, 1991).

In comparison, at Loch an t-Sìl, also on the western side of South Uist, an increase in *Calluna* pollen at around 5000 BP (5730 cal BP), as well as an increase in charcoal and *Plantago lanceolata* could herald the presence of Neolithic people in that area, perhaps engaged in pastoral agriculture. Unlike at Loch a' Chabhain heathland remains uncommon and grasses and sedges dominate the vegetation, but this difference may be due to an influx of base-rich sand from the nearby machair (Edwards *et al.*, 1995).

At Loch Airigh na h-Achlais, Neolithic impact appears to have been very limited. Here, too, there was a gradual decline in trees and shrubs, which started at around 4860 BP (5600 cal BP), and a slight increase in *Plantago lanceolata* and charcoal, but these are not marked changes, and could, in the case of charcoal, reflect regional rather than local human presence. The continued low occurrences of *Isoetes lacustris* also suggests that erosion in the loch was limited, and thus extensive clearance appears unlikely. Again, the area may have been used for rough grazing, which could have contributed to the gradual decline in arboreal taxa, but natural factors may well have played a more important role than human ones in the changes in the vegetation at this site.

At both Loch a' Chabhain and Loch Airigh na h-Achlais there is possible evidence for an elm decline. At Loch a' Chabhain there is a decline in *Ulmus* pollen *c.* 5050 BP (5820 cal BP) from 4.1% to 2.1% TLP, after which elm frequencies remain low. At Loch Airigh na h-Achlais elm pollen frequencies drop from 5.7% to 3.6% at a slightly earlier date, around 5120 BP (5910 cal BP). A possible elm decline has also been identified at Loch na Beinne Bige and Loch Bharabhat in Lewis (Lomax,1997), Loch Horsaclett in Harris (Fossitt, 1990) and Loch Lang in South Uist (Bennett *et al.*, 1990), but because elm representation has never been particularly high on the islands, this traditional marker of the start of the conventional Neolithic, whether anthropogenic in origin or not, is hard to detect.

The only site in this study where there appears to be convincing evidence for Neolithic activity is at Loch Olabhat in North Uist. In this case the presence of people is well established by archaeological evidence. In the loch itself lies the Neolithic settlement site of Eilean Domhnuill (Armit 1992b), and although the date of initial occupation of this site is unknown, the inhabitants may well have produced the changes in the vegetation that are apparent in the pollen diagram from the early

Neolithic onwards.

Woodland at Loch Olabhat was greatly reduced from *c.* 5150 BP (5910 cal BP) onwards, a process which appears to have been far more rapid here than at Loch a' Chabhain and Loch Airigh na h-Achlais. At the same time there is a strong increase in charcoal in the sedimentary record, which is particularly evident in the charcoal concentration curves, with a peak between 4890 and 4850 BP (5610 and 5590 cal BP). It could be conjectured that the decline in trees and shrubs in the area was at least partly due to the activities of the settlers. The local community will have removed trees, not only to clear land for agriculture, but also as a source of building timber. The *Plantago lanceolata* curve becomes continuous around the same time as woodland declines, and along with other indicators of pastoral agriculture, suggests that the area around the site may have been used for grazing. That arable agriculture was also taking place is suggested by the presence of Cerealia-type pollen as well as arable weed indicators such as Brassicaceae, Chenopodiaceae, *Cichorium intybus*-type, *Spergula*-type and *Convolvulus arvensis*, and macrofossil evidence for wheat and barley from Eilean Domhnuill (P. Grinter, pers. comm.). While trees and shrubs declined, *Calluna vulgaris* heathland, as well as peat bog taxa such as *Sphagnum*, increased in prominence. It may well be that heath was deliberately managed by fire at this site. On the other hand, *Calluna* may simply have expanded into areas that had been opened up because of human interference.

The process of clearing woodland in the area may have had a significant impact on the loch itself. Starting around 4660 BP (5390 cal BP) there is a very obvious erosional phase in the sedimentary sequence at Loch Olabhat - gyttja is replaced by a silty clay in which very little pollen was preserved. At the same time loss-on-ignition values fall from 12.5% to 4.8%. It is entirely possible that the removal of trees by people who lived at Eilean Domhnuill led to changes in the natural hydrological systems in the area, which in turn led to increased erosion into the loch, and eventually a rise in loch levels. Cultivation of what may have already been rather poor soils, may also have contributed to the erosion. Eventually these changes appear to have affected Eilean Domhnuill itself. The settlement site was abandoned because of high water levels on at least one occasion during the Neolithic, and a deposit of clay and silt shows that the site was inundated (Armit, 1992b), although exactly when this event took place is not known.

The minerogenic sediment at Loch Olabhat forms an enormous deposit covering 3500 calender years, but whether it was deposited in one event followed by a long hiatus, or is the result of a series of erosional episodes (perhaps because of continued cultivation) cannot be determined. Unfortunately the pollen record from the rest of the Neolithic and Bronze Age and most of the Iron Age could not be reconstructed at Loch Olabhat, and there is thus no further evidence to trace prehistoric human impact on the vegetation in the area, but the archaeological evidence suggests that the northwest corner of North Uist remained well settled throughout this period and cultivation probably continued to take place in the area.

11.2.2 The development of heathland and peat bog

The development of heath and blanket peat in Scotland is a time-transgressive event dating back to the very start of the Postglacial period (Moore, 1975, 1993; Chambers, 1981). *Calluna vulgaris* has certainly been present in the Outer Hebrides since shortly after 10000 BP (11410 cal BP) and in many sites coexisted with woodland for several thousand years. At Loch Airigh na h-Achlais, for example, *Calluna* was probably well established by 9500 BP (10870 cal BP), and by 7900 BP (8690 cal BP) had reached frequencies of 30% in the pollen record. The early establishment of *Calluna* in the Outer Hebrides may be a purely natural phenomenon. The acidic nature of the bedrock on the islands has assisted progressive soil leaching and podzolisation, and gradually the growth of *Calluna* heath and peat bog, a process which is particularly prominent in an environment where rainfall has probably always exceeded transpiration and evaporation (Hudson, 1991).

Taxa typical of mire communities have also been present since the beginning of the Holocene. *Sphagnum* has been recorded as early as 10530 BP (12590 cal BP) at Loch Olabhat, and *Potentilla*-type (a taxon which includes species that may form part of the mire vegetation) was present *c.* 9620 BP (10960 cal BP) at Loch Airigh na h-Achlais, while *Drosera rotundifolia*-type appears from 9170 BP (10310 cal BP) at

Loch Olabhat. The characteristic elements of Hebridean vegetation today - heath and blanket peat - have thus already been present on the islands since the very beginning of the Holocene. However, the point at which blanket peat indicators in a pollen record represent the the local occurrence of blanket peat communities is more difficult to identify.

Peat growth probably occurred in the Outer Hebrides throughout the last 11000 calendar years, but inception and accelerated spread were not synchronous events. On the basis of macrofossil evidence in Lewis it appears that two major phases of peat growth occurred on the island, between 9200-7800 BP (10330-8570 cal BP) and 4900-4100 BP (5620-4660 cal BP), when peat appears to have overwhelmed several wooded sites (Wilkins, 1984; Fossitt, 1996). On the other hand, Lomax (1997) has suggested on the basis of palynological evidence that peat and heathland formation generally became important in western Lewis between *c.* 5900 and 5200 BP (6710-5950 cal BP). At Loch Olabhat in North Uist the first significant expansion in peat bog communities took place at around 9100 BP (10230 cal BP), with a further expansion at around 5100 BP (5840 cal BP). Indicators for peat bog growth at Loch Airigh na h-Achlais, however, do not increase until after 3200 BP (3510 cal BP). That the islands were not yet covered by great swathes of blanket mire during the Neolithic is suggested by the archaeological evidence: at most sites excavated to date (including two chambered tombs), the Neolithic overlay brown earth rather than peat (Henshall, 1972; Crawford, 1996).

Climatic change may have been a factor in peat formation on the islands. On the other hand, at many of these sites peat inception appears to have increased in conjunction with the appearance of people, and it is possible that human activity, such as the removal of woodland, burning of heathland and cultivation, led to local hydrological changes and soil deterioration which may then have contributed to the expansion of peat.

11.2.3 The Bronze Age

During the Bronze Age the decline in woodland and increase in heathland and mire continued, and areas which had not been seriously affected before now also saw significant changes. In parts of western Lewis, there was a significant reduction in woodland from around 3700 BP (4040 cal BP), at the start of the Bronze Age, and expansion of settlements into new areas may have taken place (Bohncke, 1988; Lomax, 1997). At Callanish, which had earlier seen declines and regenerations of local woodland, a regional decline in trees and shrubs is recorded from about 3500 BP (3770 cal BP) onwards. This decline in woodland is associated with increases in Poaceae, *Plantago lanceolata* and other indicators of pasture, as well as those of cultivation such as *Spergula arvensis* and *Convolvulus arvensis*, suggesting that the area was used for both grazing and arable at this time (Bohncke, 1988). Similar evidence comes from Loch Bharabhat on the Bhaltos peninsula. A decline in trees, an increase in the *Plantago lanceolata,* and *Hordeum*-type pollen recorded for the first time at *c.* 3600 BP (3910 cal BP) suggest that arable agriculture was now taking place. This is confirmed by the archaeological evidence in the form of ard marks found beneath a cairn dated to *c.* 3500 BP (3770 cal BP) at the nearby site of Cnip. There is, to date, no evidence for Neolithic occupation of the peninsula, and this may form the first evidence of the spread of people into that area (Lomax, 1997).

In South Uist the case for expansion into new areas is not as clear. At Loch Airigh na h-Achlais, on the eastern side of South Uist, there are some changes in the vegetation, but initially these are quite gradual. *Calluna vulgaris* frequencies gradually increase after *c.* 3200 BP (3420 cal BP), as do charcoal values, while arboreal pollen values continue to decline, down to around 33% by 2720 BP (2810 cal BP) at which time probably very little woodland remained in the area. There is no clear indication, that fire was used to clear the woodland - the decline in trees and shrubs started during the Neolithic and was a rather gradual affair, and there are no strong peaks in charcoal in association with significant declines in woodland. On the other hand, there may be a relationship between *Calluna vulgaris* and charcoal at this site - both start to increase *c.* 3200 BP (3420 cal BP) and remain high throughout the rest of the profile. Fire may well have been used to manage heathland at this site, also suggesting that the land was used for grazing. It is only later, around 2910 BP (3070 cal BP), that agricultural indicator taxa such as *Artemisia*-type, Chenopodiaceae, Brassicaceae and *Cichorium intybus*-type become more frequent, suggesting that arable farming may now also have been taking place close to the site. Cerealia-type pollen, on the other hand, is not recorded until the Iron Age.

At other sites on the eastern side of South Uist there are similar signs of gradual changes and possibly slightly increased human impact. At Loch a'Phuinnd the *Plantago lanceolata* curve becomes continuous *c.* 3800 BP (4190 cal BP). Woodland had started to contract at around 4000 BP (4460 cal BP), but this accelerated after 3400 BP (3660 cal BP) (accompanied by evidence of soil erosion), and, as at Loch Airigh na h-Achlais, the area was probably predominantly treeless by about 2700 BP (2810 cal BP) and covered in blanket peat (Fossitt, 1996). At Loch Airigh na h-Aon Oidhche there is an abrupt decline in arboreal pollen at *c.* 3740 BP (4110 cal BP) which may be due to human activity in the area, although the woodland regenerates to a certain extent after that date (Edwards *et al.*, 1995; Brayshay and Edwards, 1996).

At Frobost, in the centre of South Uist, changes in the vegetation are harder to trace because the pollen record appears to be dominated by the local mire vegetation. Trees and shrubs had already disappeared in this area during the Mesolithic, grassland dominates, and there are few signs of potential human impact at this time. There is no evidence of the burning of heathland, very few indicators of pastoralism or cultivation, and cereal-type pollen is not recorded until 950 BP (860 cal BP).

Unfortunately, no pollen record is available from Loch a' Chabhain from the Bronze Age onwards, and at Loch Olabhat the record is obscured by the deposition of minerogenic sediment that covers the late Neolithic to the early Historic period.

11.2.4 The Iron Age

During the Iron Age, human impact on the islands may have became very widespread. Trees and shrubs continued to decline and there is now evidence for cultivation of cereals at most pollen sites.

At Loch Airigh na h-Achlais woodland declined while *Calluna*-rich heathland became more prominent. Charcoal values also increased gradually. Cerealia-type pollen is recorded for the first time *c.* 1770 BP (1670 cal BP), and other arable indicator taxa are present, suggesting that cultivation was now taking place near the site itself. The date for the appearance of cereal-type pollen is quite late when compared to many other sites on the island, but not unusually so for sites on the eastern side. At Loch Lang cereal-type pollen appears even later, after 1480 BP (1360 cal BP) (Bennett *et al.*, 1990), and at Loch a' Phuinnd at *c.* 1400 BP (1300 cal BP) (Fossitt, 1996).

At Frobost, on the other hand, there are no indications that human impact increased at the start of the Iron Age. The vegetation was dominated by grassland and to a lesser extent sedges. Charcoal values are low, although the presence of low frequencies of pastoral indicator taxa such as *Plantago lanceolata*, *Achillea*-type and *Ranunculus acris*-type could suggest that grazing may have been taking place in the area. After 1840 BP (1770 cal BP) possible arable indicator taxa such as *Solidago virgaurea*, Brassicaceae and Chenopodiaceae, become somewhat more common, suggesting that there may have been an expansion of arable agriculture into areas close to the mire during the later Iron Age, although cereal-type pollen grains were still not recorded during this phase.

11.2.5 Pre-Norse period to the present

During the last 1600 years the islands have been virtually treeless. In many of the pollen diagrams that cover this period heath and blanket bog communities dominate the vegetation. At other sites, such as Loch Airigh na h-Aon Oidhche and Loch an t-Sìl in South Uist, grassland was also prominent (Edwards *et al.*, 1995).

One of the last sites where some woodland survived, Loch Airigh na h-Aon Oidhche, located in a fairly inaccessible place on the eastern coast of South Uist, saw a final decline in trees and shrubs at around 1500 BP (1380 cal BP). At the same time charcoal frequencies rise above background levels for the first time, and *Calluna* frequencies also increase. Although a causal relationship cannot be proven, fire may have been used to encourage the spread of heathland at this site (Edwards *et al.*, 1995).

A similar final decline in woodland also takes place at Loch Airigh na h-Achlais around 1500 BP (1380 cal BP). Arboreal pollen frequencies fall from 23%

to less than 10%, and the vegetation is completely dominated by *Calluna vulgaris* after this. *Sphagnum* frequencies are higher, suggesting that mire communities in the area may also have been expanding, and the area was probably used primarily for rough grazing. On the other hand, there is also evidence for cultivation. Cereal-type pollen and other arable indicator species are recorded with greater frequency during the last 1500 years than at any other time.

At Loch Olabhat *Calluna vulgaris* pollen completely dominates the uppermost zone, which is estimated to cover the last *c.* 1900 years (1850 calendar years). Charcoal frequencies are also very high, and it is possible that, here too, heathland may have been maintained by burning. On the other hand, judging by extensive archaeological evidence, the northwest corner of North Uist was probably well settled throughout this period (Armit, 1992b, 1996) and the high levels of charcoal in the profile could simply reflect the presence of household fires. Both pastoral and arable indicator taxa are recorded, and it is likely that both grazing and cultivation took place in the surrounding countryside.

At Frobost *Calluna*-rich heathland dominated the vegetation until around 620 BP (600 cal BP) when grassland became more important. *Sphagnum* frequencies also rise suggesting that peat formation in the area may have been accelerating. It is during this phase that cereal-type pollen is recorded for the first time (*c.* 950 BP [860 cal BP]), along with other arable indicator taxa, suggesting that cultivation may have been taking place in the area around the mire.

Agricultural activity is likely to have increased on the Outer Hebrides in the late 13th century when the area fell under the authority of the Scottish king and the population apparently increased. Population pressure eventually led to the use of lazy-beds in areas that were otherwise unsuitable for cultivation, and occasionally this is reflected in the pollen record. For example, a record of *Cannabis*-type pollen at Callanish suggests that hemp may have been cultivated in nearby lazy-beds at some stage during the last few hundred years (Bohncke, 1988).

11.3 Settlement Patterns

Changes in the vegetation and soils on the islands, caused by climatic change or anthropogenic activities, will have had an effect on the settlement and farming patterns of the people who lived there. It has been argued in particular that there was a shift in settlement patterns between the Neolithic and the Iron Age (Barber and Brooks, n.d.), and this appears to be confirmed by the distribution maps presented in Chapter 4 (Fig. 4.2-4.5). Most of the Neolithic sites (Fig. 4.2) have been found in peat-covered inland areas. By the end of the Iron Age period (Fig. 4.4), however, virtually all the sites are found along the coast, and in particular in the machair that fringes the western parts of the southern islands. This sections looks at the evidence for these changes, and the possible reasons behind them.

11.3.1 Neolithic settlement patterns

To date some 42 Neolithic chambered tombs have been discovered on the islands. The greatest concentration is on North Uist, where 19 tombs have been recorded. They tend to be located in the inland areas, usually on low hillsides (Henshall, 1972; Fig. 4.2), although four are located close to the coast, and Geirisclett in North Uist lies in what is now a tidal zone. There are no tombs in the hilly areas of the east side of the southern islands, but in Lewis there are four tombs along the east coast, in all cases close to, but not on, the relatively fertile farmland near Stornoway (Henshall, 1972), suggesting that the distribution of tombs here was related to the presence of good agricultural land (Sharples, 1992). Henshall (1972) suggests that the hilly ground around the tombs was covered in grass or scrub and that the area would have been primarily used as pasture land, perhaps with each cairn associated with a different grazing area. The standing stones and stone circles, which are likely to date to the Later Neolithic, are also found in inland locations, often in close proximity to the earlier burial chambers (Henshall, 1972).

The chambered tombs are monumental and constructed in stone, and are still very much visible in the landscape. Neolithic settlement sites, however, are far harder to find, and only six are known to date (see Chapter 4). Obviously many more must lie hidden. Henshall (1972) suggests that these domestic sites may have been located quite close to the tombs, because these were the areas with the best arable and pastoral land. Barber and Brooks (n.d.) argue that the eastern coasts of the islands would have had forests and rich, fertile soils during the Neolithic, while the west coast was considerably wetter, with large areas of coastal swamps and numerous lochs. The eastern side of the islands is therefore where the megalith builders are presumed to have had their permanent settlements, possibly near the chambered tombs. Sharples (1992), on the other hand, has suggested the exact opposite: the west coast would already have had little forest cover, and light, easily cultivatable soils would make this area more suitable for agriculture, and thus settlement. However, as the soils in these areas deteriorated, and expansion into what was already a barren hinterland was not possible, there will have been increasing pressure on resources, which may be reflected in the building of ever larger tombs (Sharples 1992).

The hypothesis proposed by Barber and Brooks (n.d.) is hard to sustain on current evidence. With the exception of four tombs on Lewis, none of the tombs are actually located on the eastern side of the islands and there are no indications that Neolithic settlements were primarily located there. The six settlement sites that have been located are all on the western side of the islands, including two in areas which are today sand-dunes or machair. This does not prove, however, that there were no domestic sites in the inland areas - one settlement site (Bharpa Carinish; Crone, 1993) was found in peat-covered hills after deliberate searching near a chambered tomb. The probable ephemeral nature of many of the settlement sites makes them hard to locate in such terrain, and it is likely that many more small-scale domestic sites lie buried beneath peat.

The palynological evidence also appears to indicate that the eastern side of South Uist was not the first to see extensive human settlement. At Loch a' Phuinnd and Loch Airigh na h-Achlais woodland survived well into the Bronze Age, and at Loch Lang and Loch Airigh na h-Aon Oidhche it may have persisted even into the Iron Age. There is no evidence of major clearance, severe erosional phases or high charcoal values during the Neolithic, and no sign of cereal cultivation until the Iron Age at most of these sites (Fossitt, 1996; Bennett *et al.*, 1990; Brayshay and Edwards, 1996). The east coast may have been used for grazing at this time, but extensive settlement and cultivation appears unlikely. The gradual decline in woodland and spread of blanket bog and heathland communities in these areas may have been primarily due to climatic changes and progressive soil deterioration, perhaps exacerbated by low levels of disturbance related to human activity.

Unfortunately detecting human impact on the vegetation on the western side of South Uist is more difficult, as woodland had already started to decline in this area during what would be considered as Mesolithic times, and at many sites, such as Reineval and Frobost, woodland was virtually absent by the Neolithic (Edwards *et al.*, 1995; this study). At a number of other sites on the islands, however, a good case can be made for human impact during the Neolithic. These include Callanish on Lewis (Bohncke, 1988) and Loch Olabhat. Both of these sites have indications that woodland went into decline at the start of the Neolithic. At Loch Olabhat this is associated with increases in charcoal and the erosional phase, while at Callanish there are indications of two separate clearance phases, and the presence of Cerealia-type pollen at both sites, along with other cultural indicators, suggests that mixed agriculture was taking place (Bohncke, 1988; this study; see also section 11.2.1).

Sharples' (1992) suggestion that peat formation was occurring during the Neolithic could be well founded, although it may not have become a problem for local farmers until the later Neolithic. Beveridge (1911) investigated a number of chambered tombs, but only two have seen detailed excavations (Clettraval and Unival; Scott, 1935; 1947). No peat was found underneath these tombs and it appears that they were built on soils formed on till or boulder clay, suggesting that extensive peat bogs had not yet begun to form when they were constructed. Peat bog and heathland communities had been present from the start of the Holocene, and their spread may have been encouraged in the Neolithic both by human impact and by climate changes; there have been suggestions that there was a shift to a more oceanic climate with more rainfall and stronger winds around 4000 BP (4460 cal BP) (Pennington *et al.*, 1972; Birks and Williams,1983; Birks, 1991), although others place this later at around 3900-3500 cal BP (see 11.3.2) (Anderson *et al.*, 1998). Evidence from a number of pollen sites on the island, as well as wood macrofossils in peat (Wilkins, 1984; Fossitt, 1996), suggest that peat formation had started to accelerate around 4000 BP, which must have limited the extent of cultivation in inland areas. On the Scottish mainland the geographical extent of pine was apparently reduced around this time (Gear and Huntley, 1991), perhaps as a consequence of this posited climatic change, while the expansion of *Plantago maritima* at Callanish could be evidence of increased sea-spray from stronger winds (Bohncke, 1988).

11.3.2 Bronze Age settlement patterns

Beaker and later Bronze Age sites (Fig. 4.3) tend to occur in similar locations to the Neolithic settlement sites: along the west coasts, and in the case of North Uist also along the north coast where they have often been found eroding from sand-dunes. Several of these sites (Allt Chrisal, Northton, and the Udal) were also occupied during the Neolithic (Foster, 1995; Simpson, 1966, 1976; Crawford, 1996) (see Chapter 4). But there is also archaeological evidence for the settlement of the eastern part of the islands, notably at Rosinish on the northeast coast of Benbecula (Shepherd, 1976).

In western Lewis and in eastern South Uist there are indications that human impact was increasing during the Bronze Age. At Callanish the area was probably used for pasture (Bohncke, 1988), while the Bhaltos peninsula may have been settled for the first time, and arable agriculture introduced (Lomax, 1997). As discussed in section 11.2.2, in the profiles of several sites on the east coast of South Uist, including Loch Airigh na h-Achlais, Loch a' Phuinnd, Loch Lang and Loch Airigh na h-Aon Oidhche, woodland decline begins or accelerates, charcoal frequencies increase (with possible evidence for heathland management at Loch Airigh na h-Achlais), and anthropogenic indicator species are more commonly recorded during this period. There is, however, no evidence for the cultivation of cereals at these sites during the Bronze Age (Fossitt, 1996; Bennett *et al.*, 1990; Brayshay and Edwards, 1996), and the area may have been used primarily for grazing.

In the meantime, heathland and peat bog continued to spread, and woodland decline intensified, and possibly not just because of human impact. Despite the traditional view of the Bronze Age as a climatically favourable period that led to intensified woodland clearance and the expansion of agriculture (Godwin, 1975;

Burgess, 1985), there are many indications, including macrofossil evidence from Lewis (Fossitt, 1996), that the climate may have suffered a deterioration in the early Bronze Age, in particular between 3900 and 3500 cal. BP (Barber, 1982; Dubois and Ferguson, 1985; Chambers *et al.*, 1997; Anderson *et al.*, 1998). This may have accelerated the decline of woodlands that were already under stress, and made the inland parts of the islands even less fertile than previously.

11.3.3 Iron Age and Pre-Norse settlement patterns

There is extensive evidence for settlement on the islands during the Iron Age (Fig. 4.4). The atlantic roundhouses of the earlier Iron Age, which often occupied small islands in lochs, appear to be concentrated to a large extent on the coastal areas, although generally not on the machair itself. The wheelhouses of the later Iron Age, on the other hand, have been found almost exclusively on the machair, where they were often revetted into sandhills for extra stability (Armit, 1992a). The east coasts were now also more heavily settled.

The shifting of settlements to the coasts may have been an economic necessity. By the beginning of the Iron Age (around 500 BC; 2450 cal BP) the inlands were probably covered in peat and were generally unsuitable for arable agriculture. The west coast, and in particular the machair plains, may have provided the only cultivable soils on the islands (Barber and Brooks, n.d.). That heath and peat bog communities dominated the vegetation on the islands by this time is also clear from the palynological evidence. With the exception of Loch Airigh na h-Aon Oidhche, where some woodland may have survived until as late as 1000 BP (Edwards *et al.*, 1995), the islands were probably virtually treeless, and covered in heath and blanket bog.

Meanwhile it appears that an expansion into the eastern side of the southern islands may also be indicated by the pollen profiles. At a number of sites in the east of South Uist, including Loch Airigh na h-Achlais (this study) and Loch a' Phuinnd (Fossitt, 1996), woodland saw a final decline during the Iron Age, while charcoal frequencies increased, and indicators of both arable and pastoral agriculture expanded. At Loch Airigh na h-Achlais cereal pollen is recorded for the first time towards the end of the Iron Age,.

A population shift to the west coast machair is harder to detect, as there are no pollen diagrams from the area for this period, and in any case woodland had already declined, making human impact more difficult to discern. It is unlikely that the central parts of the island were abandoned altogether, but the evidence for human impact in these areas during the Iron Age is mixed. *Plantago lanceolata* abundance at Reineval is low, but charcoal values reach a small peak at the beginning of the Iron Age. *Plantago lanceolata* values for this period are higher at Loch an t-Sìl near the coast, but the charcoal curve remains quite low (Edwards *et al.*, 1995). At Frobost anthropogenic indicator taxa remain rare, charcoal values are average, and the *Plantago lanceolata* curve does not become continuous until 1740 BP (1650 cal BP). On the other hand, anthropogenic indicator taxa at this site were never prominent, even during the Neolithic and Bronze Age, so although no argument can be made for intensified land-use and settlement, there are no clear indications that the central part of South Uist was abandoned. Extensive cultivation is perhaps not evident during the Iron Age, but the area may well have been used for rough grazing.

The reason that the inland areas became more and more unsuited to agriculture during the Iron Age may be partly climatic. Evidence from peat stratigraphy, in the form of recurrence surfaces, suggests that there was a marked deterioration in the climate in the period between 2800 and 2200 BP (2890-2230 cal BP) throughout much of western Europe (Godwin, 1975; Aaby, 1976; Barber, 1982; Blackford, 1993), and in Scotland in particular around 2600 BP (2750 cal BP) (Chambers *et al.*, 1997). This change was apparently characterised by a shift to wetter conditions, which may have led to accelerated leaching of soils, the development of acid podzolic soils (a process which had started in the Outer Hebrides much earlier) and progressive peat bog formation (Bell and Walker, 1992).

A possible further deterioration in climate of Britain at around 1300-1400 years ago (Dubois and Ferguson, 1985; Blackford and Chambers, 1991) would have made the lives of people during the pre-Norse period even more difficult. During this period the typical settlement appears to have been made up of small cellular structures that needed little wood for roofs, and were revetted into sand dunes or older structures for shelter (Armit, 1996). These settlements were located almost exclusively in coastal areas, including the east coast (Fig.4.5). It is during this period that the easterly sites of Loch a' Phuinnd and Loch Lang have their first evidence for cereal cultivation (Fossitt, 1996; Bennett *et al.*, 1990), suggesting settlement and agriculture in these areas as well.

11.3.4 Settlement patterns: conclusions

The question of where settlement sites were located during the Neolithic is hard to resolve. Most sites have been found along the west coast of the islands, but there may be many more buried beneath inland peat. In some areas, and in particular on the western side of the southern islands, woodland had already started to disappear during the Mesolithic, making human impact difficult to trace in the pollen record. For the moment, all that can be said is that the eastern side of South Uist was probably not subject to a great deal of human activity during the Neolithic, and thus extensive settlement of this area appears unlikely.

Although an expansion of settlement into certain areas during the Bronze Age and Iron Age might be reflected in the pollen record, notably on the Bhaltos peninsula (Lomax, 1997) and to a lesser extent in eastern South Uist, a supposed shift to the west coast of the islands during the Iron Age is not traceable, due to the fact that these areas had already seen woodland decline, and human impact during the Neolithic, if not earlier. On the other hand, there are no clear indications that the central part of South Uist was abandoned, and the area may well have been used for rough grazing. The general increase in blanket bog and heathland communities is reflected in many pollen diagrams, and on the whole supports the hypothesis that inland areas were becoming increasingly difficult to use for agriculture, and this may well have been the reason behind the increasing occupation of the machair. However, unlike today, the east coast of the islands was also relatively well settled, as suggested by both the archaeological and palynological evidence.

11.4 Summary

During the early Holocene most of the Outer Hebrides was covered in open woodland, dominated by *Betula* and *Corylus avellana*, but which probably also included small stands of *Ulmus*, *Quercus*, *Alnus*, and *Pinus*, and possibly *Fraxinus*, *Sorbus* and *Populus*. Woodland cover started to decline as early as 7900 BP (8690 cal BP) at some sites, but at others, notably the east coast of South Uist, trees and shrubs persisted into the Bronze Age and Iron Age. The early declines in woodland could be attributable to natural progressive soil deterioration exacerbated by climatic change, or in some cases possibly the impact of Mesolithic hunter-gatherers, for which, however, there is currently no archaeological evidence.

The activities of people during the Neolithic probably led to further woodland decline on the island. Trees will have been felled for timber as well as to clear land for agriculture, and there is some evidence that fire may have been used to maintain heathland at a number of sites. The Bronze Age saw a continuing decline in trees and shrubs and an expansion in heathland and peat bog communities. These changes are probably due to both climatic and anthropogenic factors. There is some evidence that human settlement expanded at this time, notably in western Lewis and to a lesser extent eastern South Uist. During the Iron Age, archaeological evidence for settlement is extensive, with numerous sites located along the east and west coasts of the islands. What little woodland remained now disappeared almost entirely, while cereal cultivation is indicated at most sites. Climatic change may have forced people to make increasing use of the machair. During the last 2000 years the islands have been almost entirely treeless and covered in heathland and blanket bog.

Chapter 12

CONCLUSIONS

12.1 Vegetation history

This study has examined the pollen and charcoal records from a geographically diverse group of sites in the Outer Hebrides. The aim was to reconstruct the vegetation, and in particular the presence of woodland on the islands, as well as to examine the rôle of human impact in the changing patterns of vegetation from the Mesolithic to the present day.

At Loch Olabhat and Loch Airigh na h-Achlais the Lateglacial vegetation was dominated by a mosaic of *Empetrum* heathland, herb-rich grassland, and sedges, along with patches of probably dwarf *Betula* and *Salix,* and to a lesser extent, *Juniperus* scrub. The transition to the Holocene, if the radiocarbon dates are accepted at face value, takes place as early as 10310 BP (12140 cal BP) at Loch Airigh na h-Achlais, and as late as 9820 BP (11210 cal BP) at Loch Olabhat, and was marked by a rise in *Betula* (presumably tree birch), followed by *Corylus avellana.* At all four loch and peat sites arboreal pollen frequencies are high (>75%) during the early Holocene and woodland was probably quite extensive. *Betula* and *Corylus* were the dominant taxa, but at a later stage *Alnus*, *Pinus*, *Salix*, *Ulmus* and *Quercus* are also likely to have been present at Loch Olabhat and Loch Airigh na h-Achlais. The exception is the soil monolith from Eilean Domhnuill, which yielded only very low counts of arboreal pollen. The profile appears to come entirely from deposits laid down within the Neolithic, when trees had already started to disappear from the area.

12.1.1 Woodland decline and human impact

Woodland decline took place at different times and possibly for different reasons at each of the sites in the study. As woodland declined, heath and blanket bog communities expanded, and by 2000 BP (1960 cal BP) the islands were virtually treeless.

At Frobost tree and shrubs frequencies are significantly reduced after 7900 BP (8690 cal BP), possibly because an expansion in the mire led to a decline in trees locally. Anthropogenic indicators are scarce throughout the profile, even during the Neolithic when two chambered tombs were in use in the area. Cerealia-type pollen at this site is not recorded until 950 BP (860 cal BP), but the area may have been used for rough grazing throughout prehistory.

At Loch a' Chabhain woodland start to decline gradually around 5300 BP (6080 cal BP), while at Loch Airigh na h-Achlais the first decline in trees and shrubs occurred *c.* 4860 BP (5600 cal BP), towards the start of the Neolithic, and accelerated around 3200 BP (3420 cal BP) in the Bronze Age. The changes at both these sites were gradual, while charcoal values remained low and anthropogenic indicators scarce, making woodland clearance by fire unlikely. The areas around both these sites may have been used primarily for grazing, and the changes in the vegetation could perhaps best be explained by progressive natural soil deterioration, possibly exacerbated by increased grazing pressures. At Loch Airigh na h-Achlais there may also be evidence of heathland management by fire after 3200 BP (3420 cal BP).

Loch Olabhat is the only site in this study with apparently clear signs of human impact at the start of the Neolithic. Tree and shrub frequencies fall rapidly around 5100 BP, charcoal values rise significantly and anthropogenic indicator taxa such as *Plantago lanceolata* and Cerealia-type increase in frequency. These changes are likely to be associated with the occupation of Eilean Domhnuill, a Neolithic settlement site located on small island in the loch itself. Clearance of woodland in the area, followed by cultivation, may have led to increased erosion in the catchment, and eventually to rising loch levels and the inundation of the islet.

12.1.2. A Mesolithic presence in the Outer Hebrides?

At none of the sites investigated in this study is there clear evidence for the presence of Mesolithic hunter-gatherers on the islands (Bennett *et al.*, 1990; Edwards, 1996; Lomax, 1997). The only site with evidence of a significant decline in woodland during the Mesolithic is Frobost. Edwards (1996) has argued for possible Mesolithic impact at the nearby site of Reineval, but the Frobost profile shows no increases in charcoal or *Calluna* at this time, and deliberate clearance of woodland to increase browse and attract animals thus seems unlikely. On the other hand, Tipping's (1996) suggestion that increased charcoal values during the Mesolithic can be explained by periods of drier climate was not supported by this study, either. High charcoal values at the four dated sites occurred more often in 'wetter' than in 'drier' phases.

12.1.3 Heathland management

Edwards *et al.* (1995) have argued for a possible relationship between fire and heathland at a number of sites in the Outer Hebrides, and argue that there may be evidence that burning was used to make heathland more productive. There is no clear evidence at any of the sites in this study that fire was used deliberately to create heathland, but charcoal values and *Calluna vulgaris* frequencies are particularly high at Loch Olabhat during the Neolithic and over the last 2000 years, suggesting that burning may have been used to sustain it. The same may be the case at Loch Airigh na h-Achlais, where *Calluna* and charcoal values are high from *c.* 3200 cal BP (3420 cal BP).

12.2 Settlement patterns and the pollen record

A series of distribution maps has been created in order to obtain an impression of the changing settlement patterns on the islands. In particular, there appears to have been a shift in land use and settlement, from the inland areas during the Neolithic, to coastal areas by the Iron Age. The reasons for this may be a deterioration in climate and progressive spread of blanket bog on the islands, which made inland areas unsuitable for agriculture (Barber and Brooks, n.d.). The pollen record indicates that there was indeed an increase in blanket bog and heathland communities between the Neolithic and Iron Age, supporting the notion that inland areas were becoming increasingly infertile. There may also be evidence in the pollen record of expansion into eastern South Uist during the Bronze Age and Iron Age. However, a shift to machair areas could not be traced in these profiles as none of the sites were actually located in or adjacent to the machair. In any case, human impact on the western side of South Uist is difficult to detect, because woodland had already declined to a great extent during the Mesolithic. There is no evidence that the central part of the island was abandoned, but anthropogenic indicators are not prominent during this period, and agricultural activity in the area may have been largely limited to grazing.

12.3 The Future

It is probably now beyond the powers of palynological reconstruction to achieve a full understanding of land use history in the Outer Hebrides - agricultural systems in the crofting period are not necessarily similar to those of more distant time and the availability of appropriate modern analogues is questionable. However, the quantative analysis of pollen-vegetation relationships for cleared areas (cf. Gaillard et al., 1992), especially if conducted in localities targeted for their potential in improving our understanding of taphonomy, may supply vital clues to unlocking the significance of the pollen record.

It is difficult to make any advances in assessing the fire record on the basis of modern studies in the Outer Hebrides. The scale of management of heathland by fire today may be far less than was practised in prehistoric and historical times, and climatic and certainly vegetational conditions in the first half of the Holocene at least, differed from those of today. Even more than pollen evidence, there is a serious lack of fossil microscopic charcoal data from the area, and more information would be very helpful in evaluating vegetation-fire relationships, particularly in connection with heathland management.

There is also a need for more pollen sites in small lochs located in areas with good archaeological evidence, as well as pollen records from archaeological sites themselves. The former may provide sensitive records of catchment area impacts, both natural and human, while the latter may provide valuable information on agricultural activity.

Although this study has contributed to our knowledge of the vegetation history of the Outer Hebrides (placing it, where appropriate, in a settlement context), and it has provided data which can inform research debates, the total data set available to researchers is still rather limited. Further studies, both archaeological and palaeoecological, are needed to resolve issues such as Mesolithic human impact, the causes of woodland decline, and the relationship between settlement patterns and the pollen record. Despite the contemporaneous research on archaeology and palaeoecology in the Outer Hebrides (cf. Armit, 1990c; Branigan and Foster, 1995; Gilbertson et al., 1996), and allowing for a few exceptions (e.g. Crone, 1993; Mills et al., 1994), there is a marked lack of integration between these fields. This may stem from a lack of suitable deposits on archaeological sites, but it probably also reflects a lack of will (see discussion in Edwards and Ralston, 1997). The present study barely remedies this situation, but it does serve to emphasize a perceived void that the writer hopes can be filled in the future.

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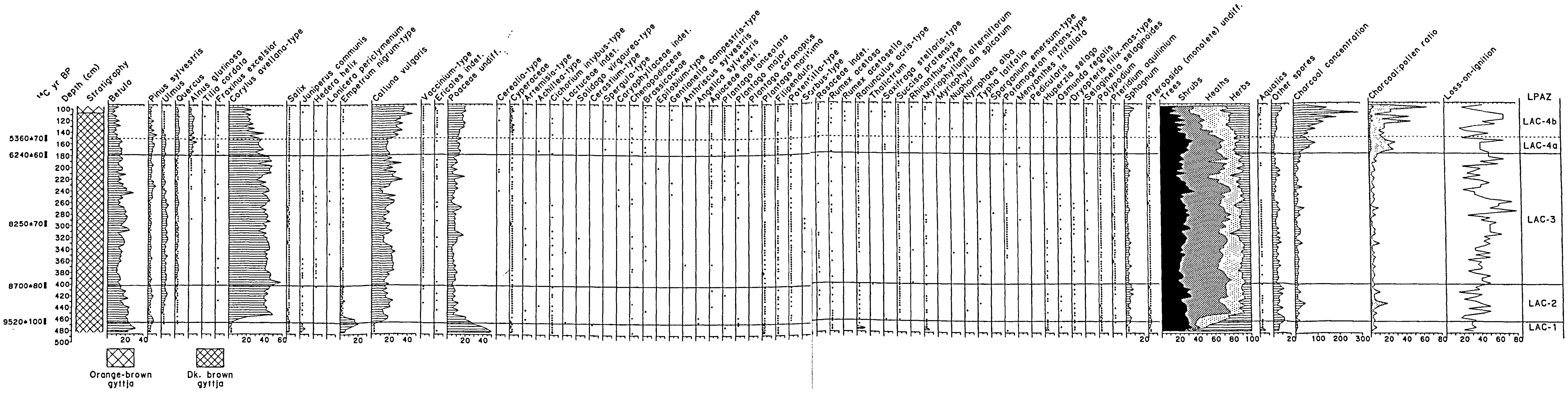

Fig. 6.3 Pollen and spore percentage diagram from Loch a' Chabhain (+ = <2%). Shaded curves are exaggerated x10.

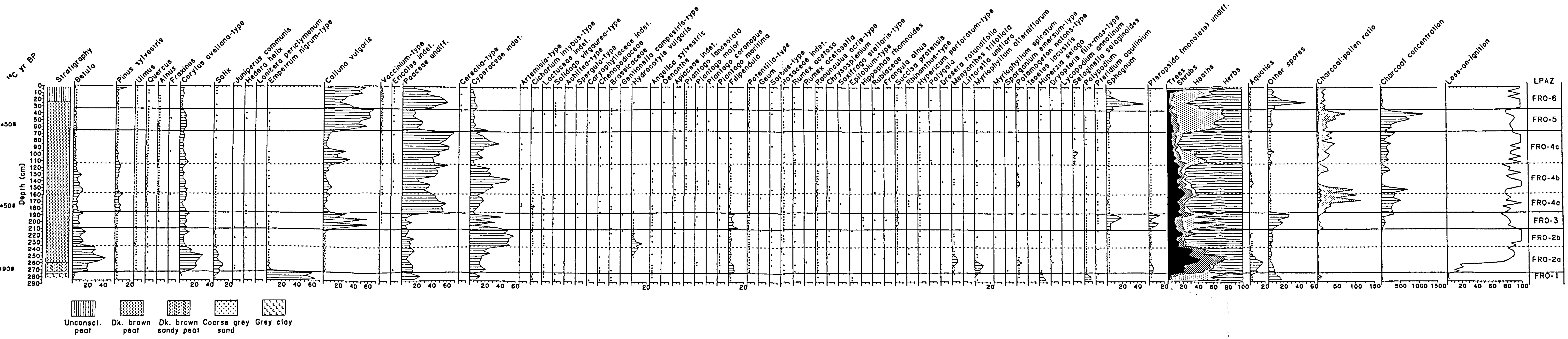

Fig. 7.3 Pollen and spore percentage diagram from Frobost (+ = <2%). Shaded curves are exaggerated x10.

Fig. 9.4 Pollen and spore percentage diagram from Loch Olabhat (+ = <2%). Shaded curves are exaggerated x10.

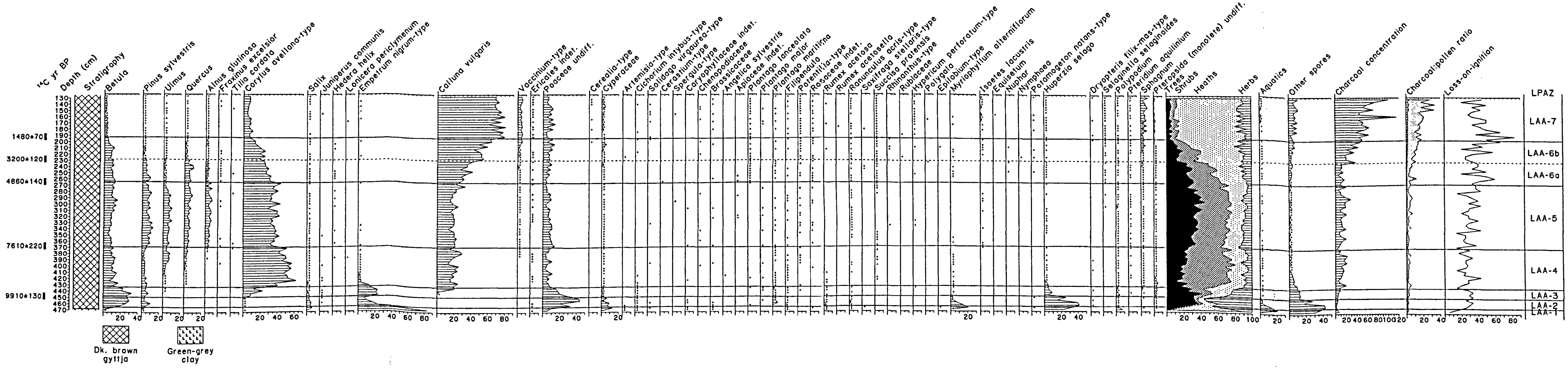

Fig. 8.3 Pollen and spore percentage diagram from Loch Airigh na h-Achlais (+ = <2%). Shaded curves are exaggerated x10.

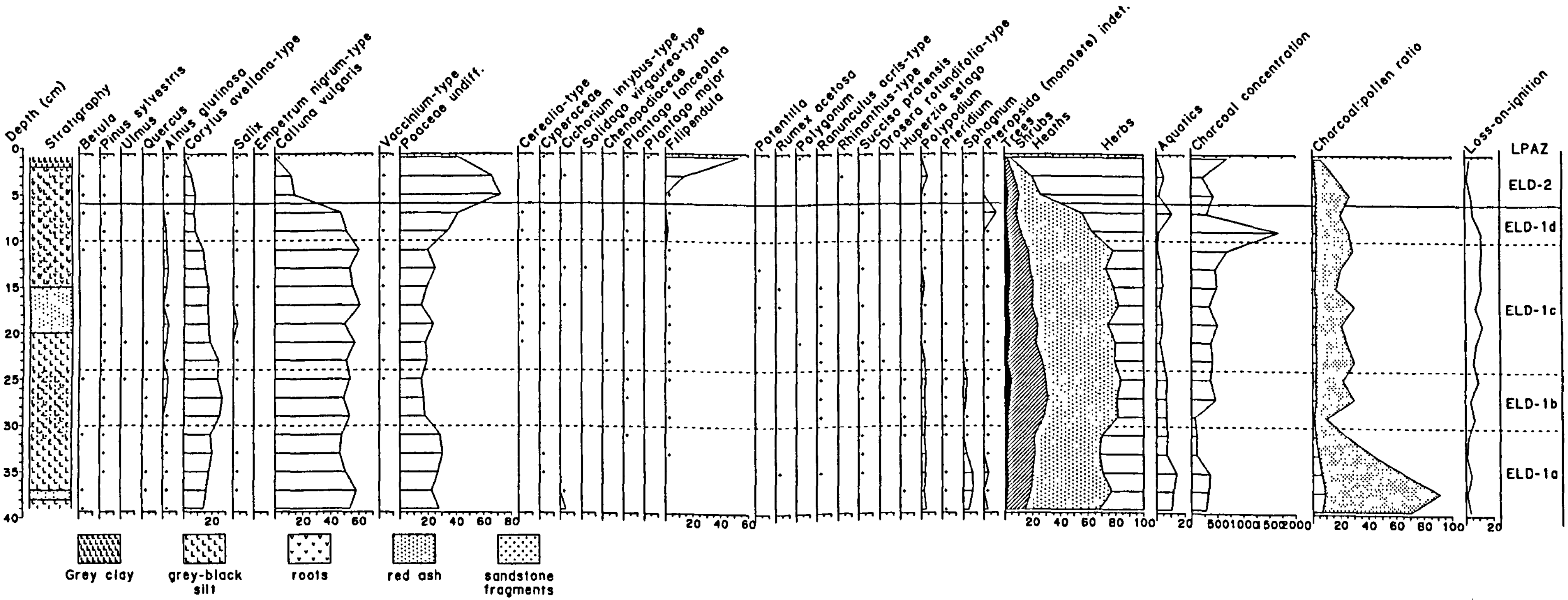

Fig. 10.3 Pollen and spore percentage diagram from Eilean Domhnuill (+ = <2%). Shaded curves are exaggerated x10.