Abstract

This thesis investigates concepts of marginality and the response of human populations to changing environmental conditions in prehistoric Orkney. Archaeological remains from the Orcadian Bronze Age are less visible than those from the Neolithic and Iron Age, leading to suggestions that the Neolithic-Bronze Age transition represents a cultural and/or economic 'decline'. This 'decline' has often been attributed to environmental deterioration, although there is little published evidence for post-Neolithic environmental conditions in the islands and that which does exist comes from areas that are considered agriculturally marginal today.

Palaeoecological records from three small wetland basins situated within landscapes with differing degrees of marginality are presented here. Radiocarbon chronologies for these sequences show that events previously assumed to be synchronous across Orkney, such as woodland decline, are in fact highly variable. High-resolution analysis has been carried out between *c*. 3000 cal. BC and *c*. 600 cal. AD (late Neolithic to Iron Age), and records compared with the distribution of archaeological sites in order to reconstruct changes in land-use, farming practices and settlement patterns across this time period. The new records have been synthesised with existing palaeoecological and archaeological data in order to review the evidence for the hypothesised 'Bronze Age decline' in Orkney.

These data indicate that during the Bronze Age a pastoral specialism developed in the more marginal parts of Orkney while elsewhere arable cultivation intensified. This seems to have occurred in response to the fragmentation of society and population which is argued to have begun during the late Neolithic. There are indications of a slight climatic deterioration and of the spread of heathland at some sites in the late Bronze Age, and it seems that farming practices were adapted in order to cope with changing environmental conditions.

Although there are distinct cultural differences between the Neolithic and Bronze Age, there is now no reason to suggest that Orkney underwent a 'decline' shaped by environmental deterioration during the latter period. The changes seen in the archaeological record at this time are likely to result from a combination of environmental, social and cultural factors.

Acknowledgements

Last but not least, I would like to thank my friends and family. I am grateful to all my friends, both in Hull and further afield, for their encouragement and support over the last four years. I am especially grateful for the patience, understanding and support of my family throughout the completion of this research. Particular mention must go to my sister Katie, who insists that she wants to read this thesis.

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Chapter 1: Introduction

This thesis is concerned with concepts of marginality and the response of human populations to changing environmental conditions. In this chapter some background to these ideas is provided and the geographical area that will be investigated in this project is introduced. The wider research context, aims and objectives of the study are then stated before the structure of this thesis is outlined and the physical background to the study area is described. Finally, some of the common terms used and conventions adopted throughout this thesis are defined.

1.1 Background

Environmental change in the form of climatic deterioration has frequently been invoked to explain the apparent abandonment of 'marginal' upland regions of Britain at various times throughout both the prehistoric and historic periods (e.g. Parry 1978; Burgess 1985; Barber 1998). Three overlapping definitions of marginality tend to be used in archaeology, which Coles and Mills (1998) summarise as environmental, economic and social/political marginality. With *environmental marginality*, marginal situations may arise because a critical environmental resource is absent or in short supply, limiting population growth. Marginality may also occur because a critical environmental variable changes, triggering the collapse of societies which are already operating at the limits of their particular environment (Coles and Mills 1998).

Economic marginality associates the term 'marginal' with the viability of a landscape for a particular form of subsistence activity. This type of marginality may be created or ameliorated by changes in the subsistence base, technology, and/or by the organisation of the economy itself (Coles and Mills 1998). *Social and political marginality* is associated with the political and cultural isolation of communities living on the edge of larger social groupings. This isolation may occur due to geographic remoteness, religious, ethnic or linguistic differences, or the status of the group concerned within society, which may result in them having either restricted access to resources, or access only to land considered to be marginal by other communities (Coles and Mills 1998).

Parry (1978) has argued that in Britain, climatic deterioration at various times in the past would have directly impacted on the ability to grow a subsistence crop, and that repeated crop failures would have forced the abandonment of more environmentally

marginal areas. Based on average temperatures Parry (1978) identified several upland regions of Britain that can be considered as either 'climatically marginal' or 'climatically sub-marginal' for arable cultivation. In several of these regions, including Bodmin Moor (Brown 1977), Dartmoor (Caseldine 1999; Fleming 2008), and parts of northern Scotland (Burgess 1985) there have been suggestions of widespread land abandonment during the later Bronze Age, and this has generally been linked to climatic change. In Ireland, alternating phases of prolific metalwork production and apparent recessions occur throughout the middle to late Bronze Age. These phases of 'recession' have been interpreted as times of socio-political stress, often attributed to environmental deterioration (e.g. Baillie 1989; Raftery 1994).

There have been numerous suggestions that the eruption of the Icelandic volcano Hekla in 1159 cal. BC caused severe climatic deterioration (Burgess 1989; Grattan 1998), resulting in crop failure and widespread settlement abandonment across north and west Britain (Grattan and Gilbertson 2000). However the eruption of Mount Agung in Bali in 1963, which had a similar sulphur output to Hekla 3, caused a maximum temperature decrease of 0.02-0.5 $^{\circ}$C (Hansen *et al*. 1978), which is indistinguishable from normal background fluctuations (Self *et al*. 1981; Kelly and Sear 1984; Grattan 1998). It has therefore been argued that climatic anomalies following the Hekla 3 eruption are unlikely to have caused severe environmental degradation or settlement abandonment (Dodgshon *et al*. 2000; Grattan and Gilbertson 2000).

It has since been proposed that acid volatiles from Hekla 3 were deposited in quantities far exceeding the annual critical loads of many habitats in northern Scotland. Communities that were already living in marginal environments may have been unable to cope with the added pressures of volcanically induced crop damage and soil acidification, resulting in them being forced to abandon their settlements (Grattan and Gilbertson 2000). It is thought unlikely that the effects of the Hekla 3 eruption alone would have caused widespread settlement abandonment in northern Britain in the 2nd millennium BC. However the eruption may have played a role in intensifying an ongoing subsistence crisis originally caused by other factors, such as a run of poor harvests caused by an already deteriorating climate, or perhaps social conditions were responsible (Dodgshon *et al*. 2000). It is argued that only if societies occupying marginal areas were already vulnerable would the deposition of acid volatiles be enough to induce settlement abandonment (Grattan 1998).

Whilst there is little direct evidence for sudden climate change as a result of Icelandic volcanic eruptions (Buckland *et al.* 1997), several studies have provided support for a longer-term increase in climatic wetness in the later Bronze Age. Several palaeoclimate records from north-west Europe indicate a period of increased wetness between *c*. 1000 and 500 cal. BC (Barber *et al*. 2003; 2004).   The exact timing of this change is uncertain, since many of the sites reviewed by Barber *et al*. (2003; 2004) have poor chronological control, and Baillie (1991) has warned against the dangers of relating loosely dated environmental and archaeological information and linking them together as cause and effect.

The three overlapping definitions of marginality considered at the beginning of this chapter illustrate the development of ideas about the concept, with a move away from simple determinism to more complex explanations of cultural change. While some studies have shown the potential importance of environmental change as triggers for the collapse of societies already operating at the limits of growth, others have stressed that the perception of land as marginal is influenced more by social and economic factors than by any inherent environmental marginality (Coles and Mills 1998).

More recent palaeoecological research on Bodmin Moor (Gearey *et al*. 2000) and Dartmoor (Amesbury *et al*. 2008) has shown that, while there is some evidence for climatic deterioration coinciding with apparent shifts in settlement pattern in these areas, this is an overly simplistic explanation for these changes. Gearey *et al*. (2000) presented evidence for continuing pastoral activity on Bodmin Moor following the demise of Bronze Age settlement there, implying that the climatic deterioration was not so severe as to cause a total abandonment of the area. On Dartmoor pollen and fungal spore data suggest that, following a period of intensive pastoralism in the middle Bronze Age, there was a shift to low intensity land-use in the late Bronze Age and Iron Age (Fyfe *et al*. 2008). In both regions it is suggested that a complex combination of both environmental and socio-economic factors is responsible for the change in emphasis of activity from upland to lowland regions (Gearey *et al*. 2000; Amesbury *et al*. 2008).

Plunkett (2009) has examined the apparent phases of economic expansion and recession in Ireland during the mid-late Bronze Age in relation to palaeoecological evidence for land-use at this time. It seems that periods of prolific metalworking correspond to times

when there is widespread evidence in pollen records for human activity, suggesting that the industry was supported by a productive subsistence economy. The times of 'recession' appear to be characterised by evidence from both the archaeological and palaeoecological records for the centralisation of settlement and subsistence production in some areas. Plunkett (2009) argues that there is no reason to suggest that cultural changes were brought about as a result of a collapse in the subsistence economy following environmental deterioration, and instead suggests that the impetus for these changes is more likely to have been disparate socio-economic and political factors.

In a recent review of palaeoecological sequences from Scotland, Tipping (2002) concluded that there is no clear evidence that upland landscapes were abandoned during the late Bronze Age and that no regional response to climate change can be detected. At most of the sites covered by this review, it seems that land was used only for livestock grazing. Tipping (2002) suggests that this does not necessarily represent agricultural specialisation since cereal pollen is produced in small quantities and is not widely dispersed (Edwards and McIntosh 1988), and therefore the absence of cereal pollen at a particular site cannot be taken as firm evidence that arable cultivation was not practiced. There is evidence for Bronze Age cereal cultivation at Lairg in Sutherland, north-east Scotland, but the settlement and associated cultivated plots here seem to have been abandoned in the late Bronze Age at *c*. 1000 cal. BC. The palaeoecological record from this site indicates that the area was still used as pasture until *c*. 200 cal. BC. The late Bronze Age abandonment of this site is interpreted as the result of long-term soil deterioration (Tipping and McCullagh 1998).

Young (2000) and Tipping (2002) have suggested that environmental deterioration in marginal upland areas may have encouraged the modification of existing agricultural systems rather than leading to abandonment. This seems to have been the case at Lairg, with evidence for the continuation of pastoralism long after the abandonment of upland settlement and cultivation (Tipping and McCullagh 1998). It is felt unlikely that people would have settled in this area out of choice, since the available evidence suggests that conditions here would always have made agriculture difficult, and it is possible that the area was settled due to a need to expand away from core localities. However, Tipping and McCullagh (1998) stress that the apparently marginal nature of the site is based on a value judgement, and the values by which Bronze Age communities judged landscapes are not understood. Attachment to place has been identified elsewhere as being

important during the Bronze Age, and is believed to have influenced the evaluation of potential strategies for action during times of environmental stress (Young and Simmonds 1997; Brück 2000).

People living in upland communities may not have viewed themselves as particularly vulnerable to change, and it has been suggested that their resilience might have been enhanced by some form of economic independence (Tipping and McCullagh 1998; Tipping 2002). Trade in produce between communities has been identified as an important coping mechanism during times of crisis (Dodgshon *et al*. 2000), but Tipping (2002) proposes that later prehistoric upland communities may have turned to diversification of resources and land-use in order to survive at these times. This is supported by the palaeoecological evidence from Scotland, which implies a diverse range of upland land-uses rather than specialisation. Since climatic changes have occurred in the past at intervals of several hundred years, these coping strategies must have either been maintained when they were not needed, or remembered in times of stress. Tipping (2002: 22) invokes 'social memory' (McIntosh *et al*. 2000) as a process to explain the durability of agriculture in the uplands, and suggests that rather than being 'flawed, inherently vulnerable and frail', the communities inhabiting these regions were 'resilient, ingenious and resourceful'.

Dark (2006) points out that the discussion of potential links between climate change and land-use at this time has been limited to sites where there are signs of abandonment, ignoring sites where changes in climate seem to have had no effect. In a review of the palaeoecological evidence for climatic deterioration and land-use change in the late Bronze Age across the whole of Britain, Dark (2006) concluded that the overall picture is of continuity of land-use, and in some cases intensification of agricultural activity. However there is some regional variation, with a possible greater tendency towards land abandonment in Wales and central southern England.

Despite the evidence for changes in land-use, settlement patterns and society during the later Bronze Age in Britain, the tendency towards environmentally deterministic explanations for these changes is beginning to be redressed, with many authors adopting a more possibilistic approach to the influence of the environment on human populations. Possibilism sees the physical environment as a series of possibilities for human development, rather than as a limiting factor which people are unable to overcome

(Simmons 1996). Recent research has tended to conclude that a combination of environmental, economic, social and cultural factors were responsible for the changes seen in upland regions of Britain during the later Bronze Age.

1.2 Study Area

Orkney, a group of islands situated off the northern coast of Scotland (Fig. 1.1), provides an excellent opportunity to study the possible influence of environmental conditions on prehistoric human activity within a geographically defined area with a rich archaeological record.
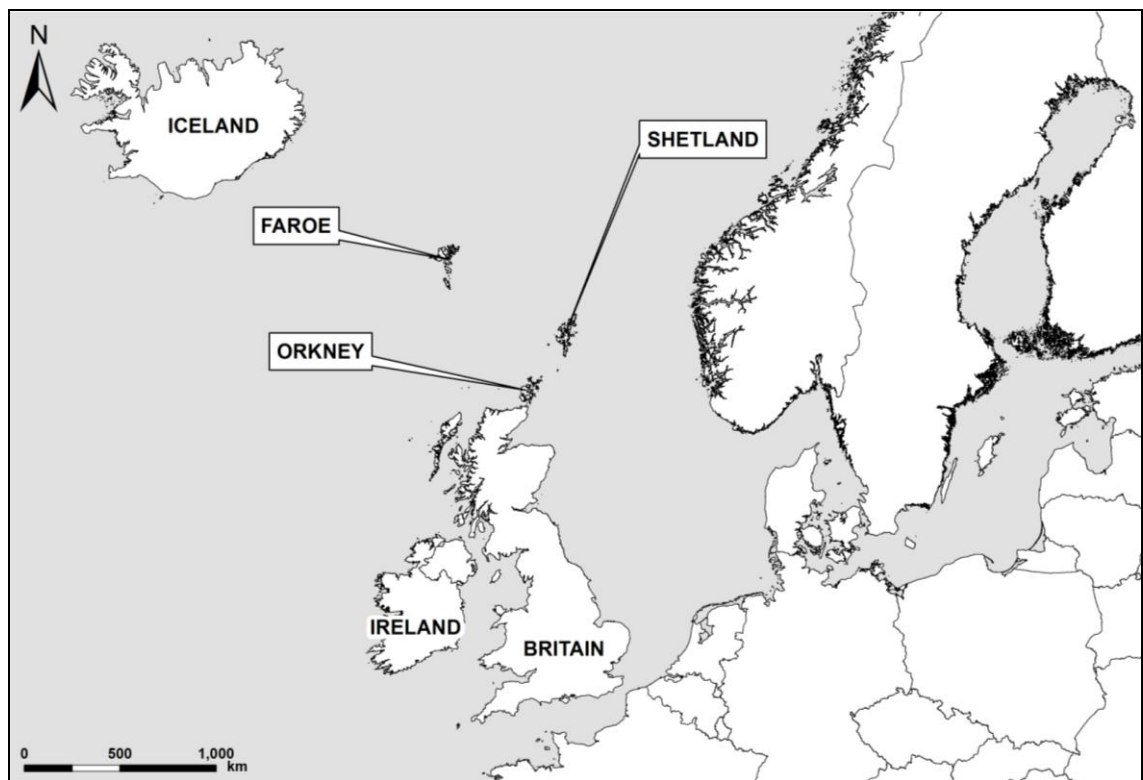
Figure 1.1 The location of Orkney in relation to Europe

1.2.1 Bronze Age 'Decline' in Orkney

Archaeological remains from the Orcadian Bronze Age are less visible than those from the Neolithic and Iron Age, leading to numerous suggestions that the Neolithic-Bronze Age transition in Orkney represents a decline in the standard of living in the islands. In *Prehistoric Orkney*, a book aimed at a general audience, the Bronze Age chapter is entitled '*A prehistoric recession?*' (Ritchie 1995: 86) and begins with a statement that 'Orcadians seem to have gone into a period of economic recession towards the middle

of the third millennium BC'. The chapter concludes 'Compared with the architectural achievements of the fourth and earlier third millennium and those that were to follow in the first millennium, Orkney's Bronze Age seems a dull time and certainly has not left many monuments at which to marvel' (Ritchie 1995: 95).

Similarly, in *The Prehistory of Orkney* (Renfrew 1985), Øvrevik comments that Bronze Age Orcadians produced 'little in the way of a surplus to enable the development of a leisured class' (Øvrevik 1985: 131), although the idea that there was a 'leisured class' in Orkney during the preceding Neolithic is now no longer widely accepted (e.g. Richards 1998; 2005), and is not supported by the skeletal evidence from the chambered tombs (e.g. Hedges 1983a). Øvrevik (1985: 137) also argues that the material culture of Bronze Age Orkney 'perhaps indicates a growing insularity, suggesting that 'Orkney failed to establish itself within the mainstream of developments at this time' (Øvrevik 1985:141). This apparent 'cultural decline' is usually attributed to environmental factors such as climatic deterioration, overuse of the soil in the late Neolithic, effects of the eruption of the Icelandic volcano Hekla in *c*. 1159 cal. BC, and/or the spread of blanket peat (e.g. Øvrevik 1985; Ritchie 1995).

Although Orkney arguably represents one of the best preserved and most intensively studied archaeological landscapes in the world, much of the attention has been focused on the highly visible Neolithic and Iron Age structures, with the result that the Bronze Age has, until recently, been largely neglected. Downes (2005) notes that the apparent scarcity of Bronze Age settlement evidence in Orkney is probably the result of failure to identify it, rather than a real lack of occupation at this time. The gap in settlement evidence for this period is now beginning to be addressed, with a wider range of Bronze Age settlement types now being recognised from the islands (Downes 2005). In addition, evidence from archaeological sites such as Crossiecrown (Downes and Richards 1998) and Tofts Ness (Dockrill *et al*. 2007) has demonstrated continuity of settlement across the Neolithic-Bronze Age transition. The archaeological record of Orkney is described in more detail in Chapter 2.

Despite the relatively intensive study of Orcadian archaeological remains, there have been few attempts to reconstruct the environmental context in which this record developed, and those that have been undertaken tend to be poorly dated (e.g. Moar 1969; Keatinge and Dickson 1979; Bunting 1994). As with the archaeological record,

evidence for environmental conditions during the Bronze Age in Orkney is particularly fragmentary as most palaeoecological investigations have tended to focus on the earlier part of the Holocene and questions such as the status of woodland in the islands.

The Bronze Age is covered by just one securely radiocarbon dated record from west Mainland (Glims Moss: Keatinge and Dickson 1979), one radiocarbon dated sequence from Rousay (Loch of Knitchen: Bunting 1996) and possibly by a short, undated record from a Bronze Age archaeological site on South Ronaldsay (Liddle: Bartlett 1983). A sequence from Scapa Bay on Mainland (de la Vega-Leinert *et al*. 2007) is also thought to cover the Bronze Age, although this is unconfirmed by radiocarbon dating. A record from Lesliedale Moss on Mainland has radiocarbon dates indicating that it begins in the late Neolithic, and it is thought to continue until the end of the Iron Age, although there is no secure dating evidence to confirm this interpretation (Davidson *et al.* 1976). Other putatively Bronze Age records are either poorly dated or are single context samples from archaeological sites, which provide a localised picture of environmental conditions, often only at one particular point in time (e.g. Jones 1975; 1977), and these sequences are therefore not particularly useful for reconstructing past vegetation changes at a regional scale. There is a clear need for more radiocarbon dated pollen sequences covering this period, especially from sites outside west Mainland. The existing palaeoecological record from Orkney will be evaluated in more detail in Chapter 3.

1.2.2 Bronze Age 'Decline' Hypotheses

There are three hypotheses for the apparent 'cultural decline' in Bronze Age Orkney, all of which should be detectable in the palaeoecological record:

(1) Population collapse

A failure to respond adequately to changes in the situation of a particular social group may result in social fragmentation, famine, death and large scale emigration (Coles and Mills 1998). If this occurred in Orkney during the Bronze Age, it would be expected that the palaeoecological record would show an overall decrease in the level of human activity, and perhaps a retreat away from the more marginal parts of the landscape since the needs of a smaller population would not require the exploitation of these areas.

(2) Change in farming practices forced by environmental change

The apparent Bronze Age 'decline' is often attributed to environmental factors such as climatic deterioration, overuse of the soil in the late Neolithic, effects of the eruption of the Icelandic volcano Hekla in *c*. 1159 cal. BC, and/or the spread of blanket peat.

- If the climate became wetter and/or colder, it would be expected that there would be indications of increasing surface wetness at the sites studied. There might also be evidence for a change in the proportion of heathland and pasture in the wider landscape, since with climatic deterioration the competitive balance would shift in favour of heathland.
- If soil deterioration is responsible for a change in farming practices, it would be expected that heathland would spread into marginal pastures, perhaps resulting in increased grazing pressure on better land.
- If the volcanic eruption hypothesis is true, then evidence of this in the form of tephra might be found, and a simultaneous 'crisis' would be seen at all sites.

If any of these situations did occur in Orkney, there would perhaps be increased pressure on more fertile land, or a change in emphasis from arable cultivation to pastoralism. The adoption of new technologies and subsistence methods may also occur in Orkney in response to increasing environmental marginality, as has been observed at Tofts Ness on Sanday. At this site there is evidence that fertilisation practices changed in response to deteriorating soil conditions over the lifespan of the settlement, allowing sustained arable cultivation in what would have been an extremely marginal landscape for agriculture (Simpson *et al.* 1998; Simpson *et al.* 2007).

(3) Cultural change

The changes observed in the archaeological record may simply be the result of cultural changes. Across Scotland and the rest of Europe during the Bronze Age cultural practices seem to reflect greater significance being given to individuals, as opposed to priority being given to belonging to a larger community (e.g. Ashmore 1996; Harding 2000). This may have resulted in social fragmentation, which is evidenced by the division of the landscape into territories which seems to have taken place throughout Britain during the Bronze Age (e.g. Fleming 2008). Parker Pearson (2005: 96) states that during the Bronze Age 'from an archaeological point of view, the landscape of the dead was replaced by a landscape of the living', with communal burial monuments

falling out of use and the landscape being divided up for agricultural purposes. The remains of the dead were no longer at the centre of life, and personal identities became less defined by lineage and more by territory, with control over land being as important as control over people (Parker Pearson 1999).

If the changes seen in Orkney are solely the result of cultural processes, then it would be expected that there would be no evidence for a change in faming type. However there would perhaps be a change in the distribution of agriculture, since a more dispersed population may require more land for grazing than a population clustered in village settlements and sharing common grazing land. There may also be evidence for some specialisation of agriculture, since a pastoral specialisation is argued to have developed in some upland regions of Scotland at the time of the Bronze Age-Iron Age transition (e.g. Tipping *et al.* 2008a).

1.3 Wider Research Context

The need for better understanding of prehistoric environmental conditions in Orkney is recognised in the *Heart of Neolithic Orkney World Heritage Site Research Agenda*, in which 'formation and utilisation of the landscape' is identified as one of two broad research themes framing future work in the area (Downes *et al.* 2005: 87). Within this theme, several priorities are listed including investigation of the development of extensive arable cultivation and the management of grazing animals; the impacts of Holocene climate change on human populations; and evaluation of hypotheses for various phases of agricultural intensification and resource specialisation seen in Orkney (e.g. Bond 1998; Barrett *et al.* 2000; Hunter 2000; Simpson 1997; 1998) which include population pressure, a response to marginality or environmental change and structural and/or economic changes within the social fabric. It is hoped that many of these will be at least partially addressed by this project.

1.4 Aims and Objectives

The main aim of this research is to investigate the possible Bronze Age 'decline' in the islands and assess the evidence for each of the three hypotheses outlined above in order to determine the most likely explanation for the changes seen in the Orcadian archaeological record at this time, and to set the Bronze Age environment into its longer-term context by considering environmental change from the Mesolithic through to the end of the Viking period. A secondary aim is to determine whether patterns of

human activity and environmental impact in Orkney were distinctly different from the rest of Scotland during the Bronze Age. These aims will be achieved by:

(1) Obtaining sedimentary sequences from small (*c*. 100-500 m diameter) basins within landscapes with differing degrees of marginality. Dark (2006) points out that discussion of evidence for land-use change at the time of the Bronze Age-Iron Age transition in Britain has been limited to sites where there are indications of abandonment, ignoring the potential significance of sites where climate change seems to have had no impact. It is therefore important to consider evidence from a range of sites from both 'marginal' and 'optimal' environments within a wide geographical area (Dark 2006).

(2) Establishing chronologies for these sequences using both radiocarbon dating and tephrochronology in order to allow high-resolution analysis across the period of interest for this study (*c*. 3000 cal. BC to *c*. 600 cal. AD; late Neolithic to Iron Age), and so that the palaeoecological and archaeological records from each site can be linked.

(3) Producing high-resolution (at least one sample for every 50 years from *c*. 3000 cal. BC to *c*. 600 cal. AD) palaeoecological records from these sequences, principally using pollen analysis. A range of other techniques including non-pollen palynomorph, microscopic charcoal and plant microstructure analyses as well as lithostratigraphy and loss-on-ignition will also be employed.

(4) Assessing the archaeological evidence for changes in settlement patterns across the study period by mapping the age and distribution of archaeological sites in the vicinity of each coring location using data from the RCAHMS Canmore database.

(5) Synthesising the palaeoecological and archaeological data in order to reconstruct changes in land-use, farming practices and settlement patterns from the late Neolithic to the Iron Age, and investigate the reasons for any changes seen:
   a) At the level of the individual sites studied here.
   a) At the intersite level in order to consider differences between 'marginal' and 'optimal' areas of Orkney.
   b) Across the whole island group, incorporating both new and existing data.
   c) At a regional level, comparing the Orcadian evidence with that from north-east mainland Scotland and Shetland.

1.5 Thesis Structure

In the remainder of this chapter, an introduction to the study area of Orkney is given and the geology, climate and present-day vegetation of the region are described. This is followed by a section defining some of the common terms used, and conventions adopted, throughout the thesis.

Chapters 2 and 3 provide background information for the study. Chapter 2 introduces the archaeological record of Orkney and discusses the evidence for changes in settlement, burial, ritual, economy, material culture and society throughout Orcadian prehistory. Chapter 3 describes published palaeoecological sequences from the islands and discusses these in the wider geographical context of north-east mainland Scotland and other Atlantic islands, including Shetland and Faroe.

The methodology adopted to answer the research aims outlined above is described in Chapter 4. Field and laboratory methods are detailed and the analysis and presentation of data is explained.

Results from each of the areas chosen for study in this project are presented in Chapters 5, 6 and 7, along with a discussion of prehistoric environmental change, land-use and farming practices in the landscape surrounding each site. Chapter 5 presents results from the 'marginal' case study, Chapter 6 details the 'semi-marginal' case study, and the 'optimal' case study is presented in Chapter 7.

Chapter 8 summarises and correlates the results from the three study areas, and these results are then combined with other available palaeoenvironmental data for Orkney in order to provide a new synthesis of Orcadian environmental history. Evidence for environmental and land-use change in the islands during prehistory is discussed in the wider geographic context of Shetland and mainland Scotland, and the 'Bronze Age decline' hypotheses outlined above are then reviewed in the light of all the available evidence. The investigation is summarised in Chapter 9, and gaps in current understanding of prehistoric Orcadian environmental change are highlighted and discussed in terms of implications for future research.

1.6 Introduction to Orkney

Orkney lies off the north-eastern coast of Scotland (see Fig. 1.1) and is separated from the mainland by the Pentland Firth, which is only 10 km wide at its narrowest point. The islands lie at approximately the same latitude as Leningrad and the southern tip of Greenland, and Kirkwall, the main town, is closer to Oslo and the Arctic Circle than it is to London. The county comprises about 70 islands, of which 16 were inhabited at the 1991 census (Berry 2000). A detailed map of Orkney showing island names and the locations of main towns is shown in Fig. 1.2.
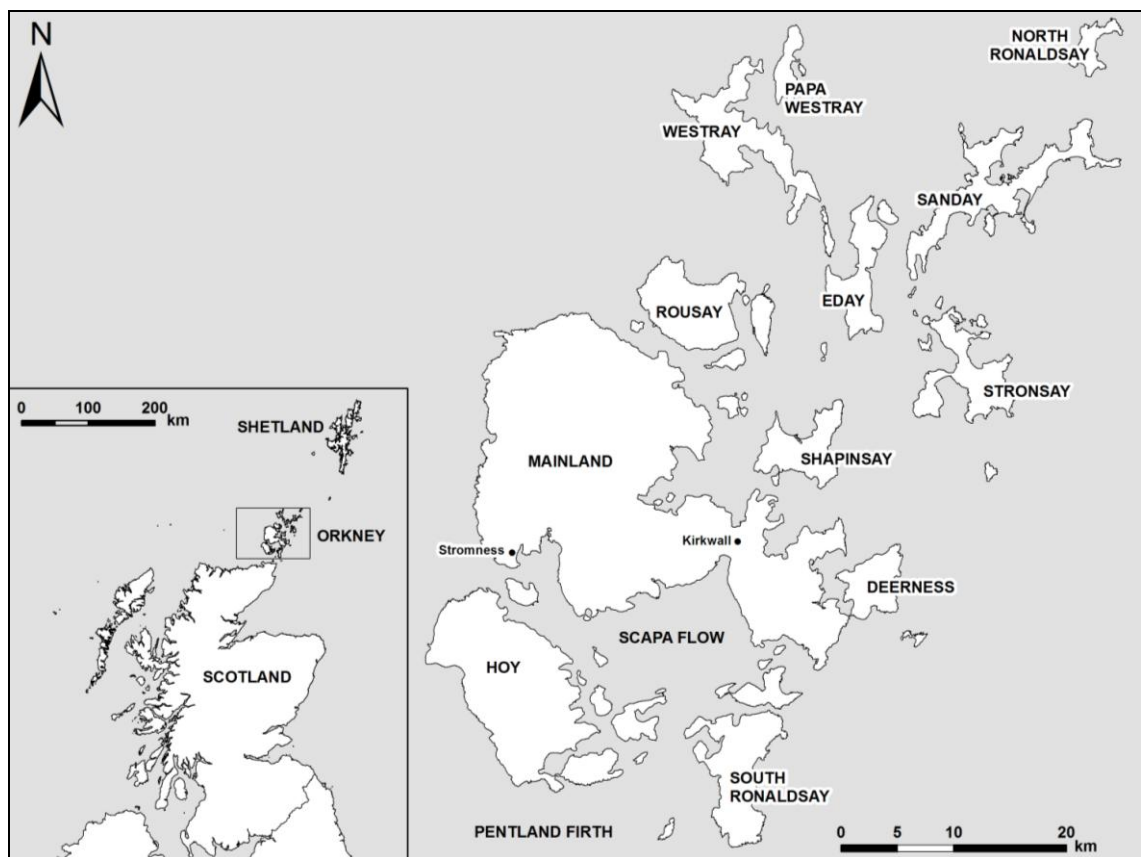
Figure 1.2 Detailed map of Orkney, showing island names and the locations of main towns

1.6.1 Geology

Orkney consists almost entirely of sedimentary rocks, the majority of which are flagstones forming thin regular beds. Fig. 1.3 shows the distribution of the major rock types, and a simplified stratigraphic diagram of Orkney's geology is given in Fig. 1.4.

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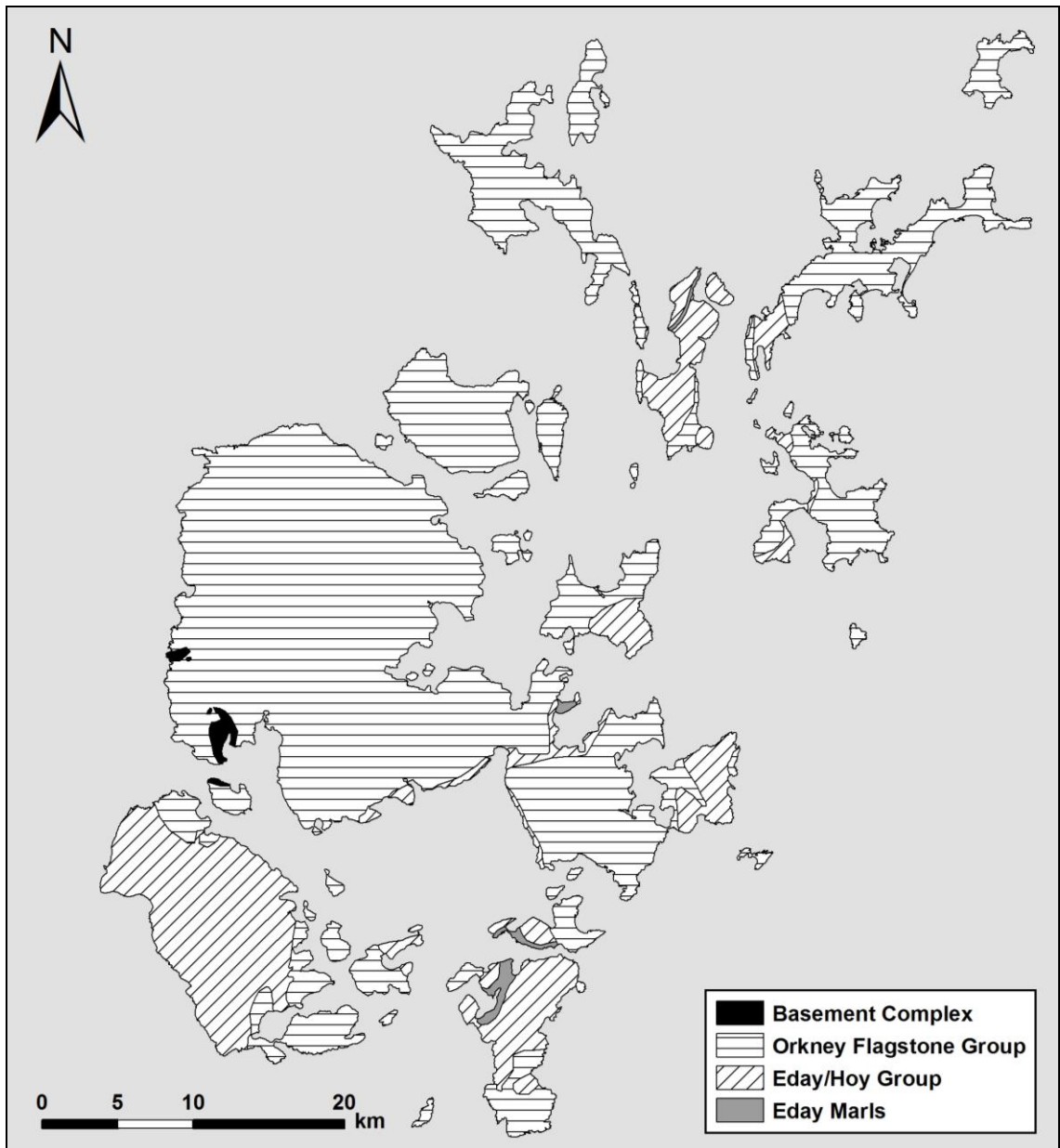
Figure 1.3 Simplified geological map of Orkney (after Marshall *et al*. 1996)
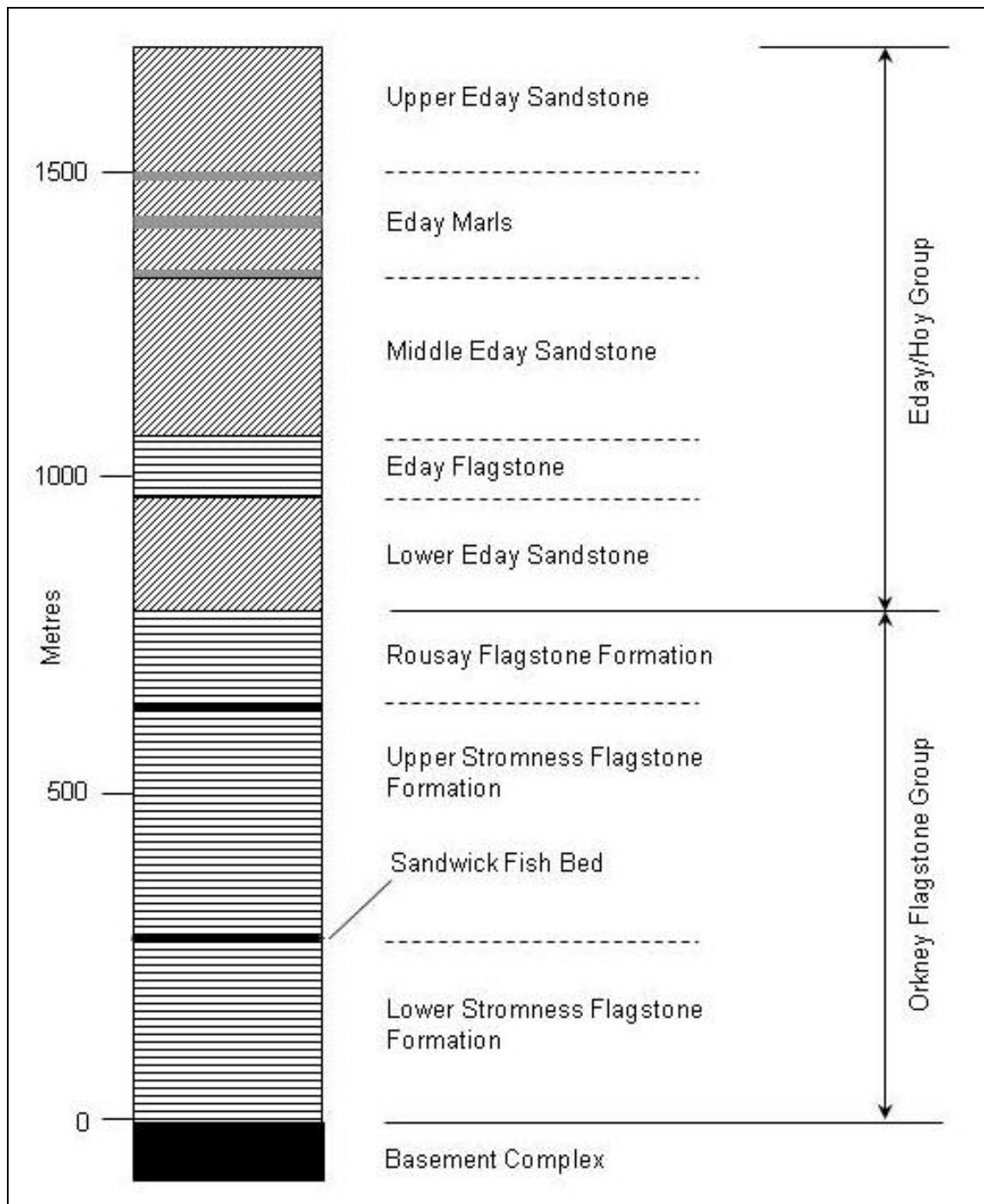
Figure 1.4 Simplified stratigraphic diagram of Orkney's geology (after Brown 2000)

The geological structure of Orkney has affected the present-day landscape of the islands. In west Mainland, Rousay and Westray hills reach 170-275 m in height and have small escarpments or weakly defined terrace features, reflecting the alternation of hard and soft layers in the Old Red Sandstone that forms most of the archipelago (Mykura 1976). Substantial parts of Eday, Sanday, South Ronaldsay, and some of eastern Mainland are underlain by thick beds of sandstone, giving rise to well developed ridges and escarpments. The topography of western Hoy is markedly different to that of

the rest of Orkney as it consists of massive sandstones forming rounded, steep-sided hills up to 477 m in height and sea cliffs reaching 335 m on the west coast of the island (Mykura 1976).

Stratigraphy

Precambrian Basement Complex

The basement rocks of Orkney are dominated by a granite-gneiss complex (Brown 2000) and are exposed as a number of small inliers at Graemsay, Stromness and Yesnaby (Black 1978).

Lower Devonian Sediments

This unit has a restricted outcrop on Orkney, one example being the Yesnaby Sandstone formation. Here, dune sands are overlain by reworked fluvial sands and Middle Devonian lake sediments (Brown 2000). Siltstones, sandstones and breccias thought to be of similar age have been encountered in a borehole at Warebeth, west of Stromness, although these are not exposed at the surface (Mykura 1976; Black 1978).

Lower Middle Devonian Sediments

The Orkney Flagstone group comprises thinly bedded grey and black flagstones which were deposited in a lacustrine environment of variable salinity, and can be divided into three major types. The Lower Stromness Flagstone Formation comprises a basal breccia beach deposit which passes upwards into lake cycle flagstones. The Sandwick Fish Bed, which contains vast numbers of fossil fish, marks the top of this formation. The Upper Stromness Flagstone Formation comprises lake cycle deposits with increased amounts of fluvial river sand and sheet flood deposits. These are overlain by the lake cycle deposits of the Rousay Flagstone Formation (Brown 2000).

Upper Middle to Upper Devonian Sediments

A series of transition beds marks the passage from the mainly lacustrine Rousay Flagstone Formation to the fluviatile Eday Group. These are overlain by three thick sequences of yellow and red sandstone known as the Lower, Middle and Upper Eday Sandstones, which are separated by two fine, silty formations known as the Eday Flagstones and the Eday Marl (Black 1978). A few thin basaltic lava flows and tuffs are present locally within the Eday Flagstones and the Lower Eday (Hoy) Sandstone (Mykura 1976; Brown 2000).

Post-Devonian Rocks

No sedimentary rocks younger than Devonian have been definitely identified in Orkney, although geochemical analysis of organic carbon in the Devonian rocks indicates that they were once covered by at least 2000 m of younger rock (Brown 2000). It is thought that tectonic inversion early in the Permian uplifted the Orkney basin to its present level, leading to erosion of the younger sediments. A swarm of minor igneous intrusions in the islands were formed during the late Permian (Brown 2000).

Quaternary Glaciation

There is little evidence of pre-Late Devensian glaciation in Orkney as most of it was removed by the last major ice advance 30,000 years ago. The Late Devensian ice sheet reached its maximum extent approximately 24,000 years ago. The main ice retreat began around 15,000 years ago and Orkney was largely deglaciated by about 13,000 years ago. Small end moraines on Hoy provide evidence for a final phase of local glaciation around 11,000 years ago, during the Loch Lomond stadial (Brown 2000).

Quaternary glaciation in Orkney seems to have smoothed out the pre-existing topography, although in some places, such as on the island of Rousay, the passage of the ice appears to have scoured out the debris between escarpments, emphasising the terracing. The ice also over-deepened some of the channels between the islands and scoured out many shallow basins which are currently occupied by inland lakes (Mykura 1976). In north-west Hoy, which is the only part of Orkney that supported local glaciers, a variety of glacial features including corries, terminal and lateral moraines, U-shaped valleys, hanging valleys and truncated spurs can be seen (Brown 2000).

Compared with Shetland and the Western Isles, Orkney has relatively few burns and lochs because it has much less topographic variation as a consequence of the smoothing action of the Quaternary ice sheets. The lochs that do occur are shallow in comparison with those on mainland Scotland as they are underlain by flat sedimentary rock and glacial drift deposits (Berry 2000).

Superficial Deposits

Superficial deposits cover about 85% of Orkney (Davidson and Jones 1985), and their distribution is shown in Fig. 1.5. When the Devensian ice melted, a layer of boulder clay was deposited in most of the low-lying areas of Orkney (Brown 2000). Blown

sand deposits, consisting of fine shell fragments and blown inland from beaches by on-shore gales, occur on west Mainland and in Deerness, and also cover considerable areas of Sanday, Westray, Eday and North Ronaldsay (Mykura 1976). It is thought that in the Bay of Skaill area of west Mainland blown sand began to accumulate at *c*. 4950 cal. BC (de la Vega Leinert *et al*. 2000). Peat covers large areas of west Mainland, Rousay and Hoy and also occurs on several of the smaller islands (Davidson and Jones 1985).
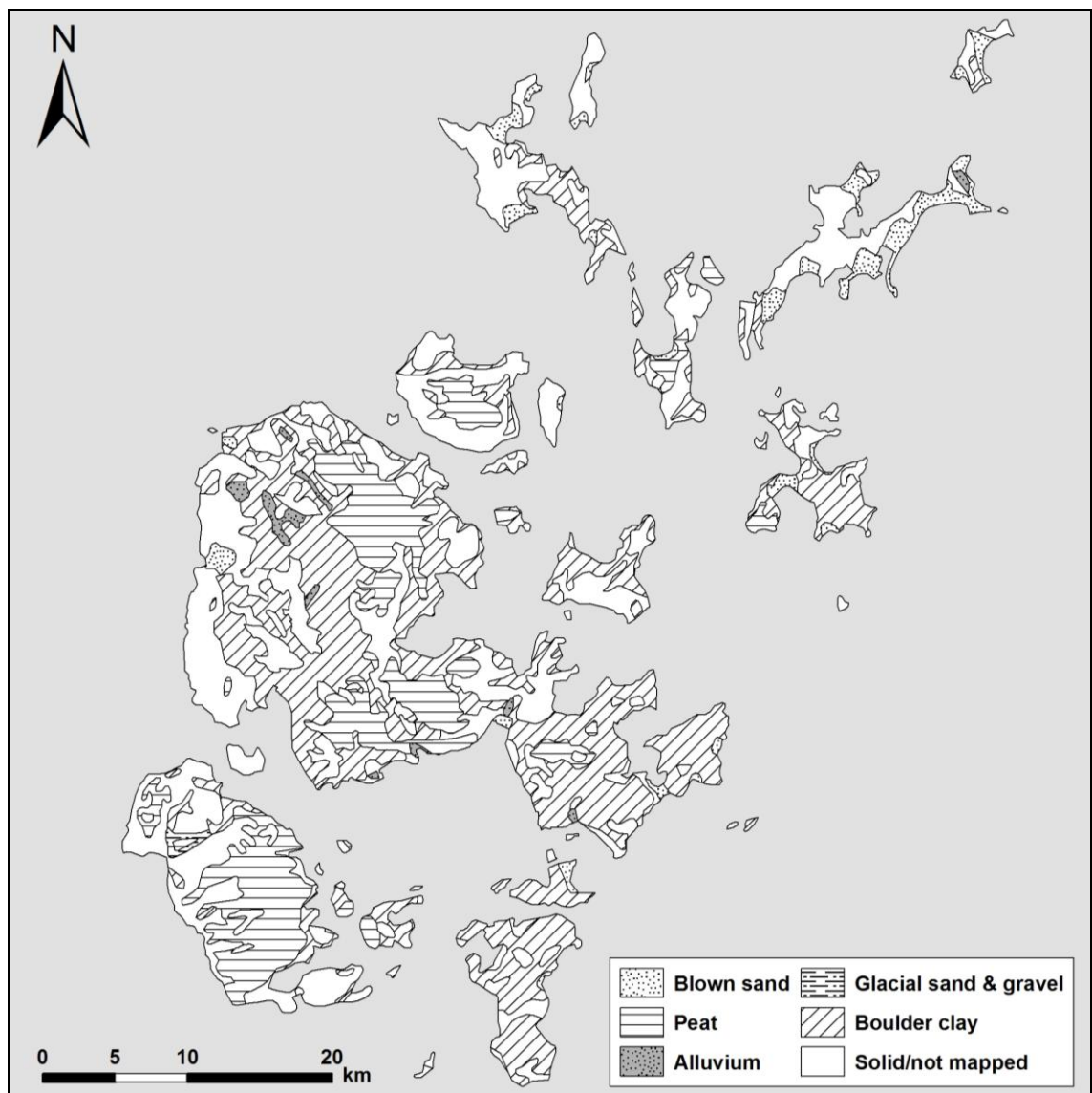
Figure 1.5 Distribution of superficial deposits in Orkney (© Crown Copyright/database right 2009. A British Geological Survey/EDINA supplied service).

Soils

Orcadian soil formation is linked to the superficial deposits (mainly boulder clay), the hyperoceanic climate, the gentle topography and the influence of human activity (Davidson and Jones 1985). Eight major soil groups and sub-groups have been identified within Orkney, including podsols, peaty podsols, non-calcareous gleys, peaty gleys, brown calcareous soils, oroarctic podsols, calcareous gleys and saline gleys (Macaulay Institute for Soil Research 1978). Davidson and Jones (1985) summarised the hydrologic sequence as being from peat on hill summits, through peaty podsols and peaty gleys on upper and middle slopes to freely and imperfectly drained podsols in the best drained localities. Non-calcareous gleys and peats are the dominant soil type on footslopes and in hollows. This spatial patterning occurs throughout much of Orkney, although there are differences in areas of high relief such as Hoy and areas where blown sand is extensive (Davidson and Jones 1985).

Holocene Sea Level Change

Holocene sea level change in Orkney is only beginning to be understood. There is evidence in some areas that relative sea levels have been different in the past, for example on Hoy there are beach gravels of interstadial or interglacial age resting above present day sea level (Sutherland 1996), while areas of submerged peat occur on several islands in the archipelago over a range of altitudes (Smith *et al*. 1996). It would therefore appear that there have been both isostatic and eustatic controls on relative sea level in the region. Until recently, inferences about relative sea level change in Orkney during the Holocene have been drawn from evidence from mainland Scotland (e.g. Dawson and Smith 1997), although current work is beginning to address this. Relative sea levels around Orkney were lower for much of the Neolithic, with sea level rise at Echna Loch on Burray being radiocarbon dated to *c*. 2460 cal. BC and marine ingression into the Loch of Stenness on Mainland occurring at *c*. 1360 cal. BC. The time lag between the two sites is interpreted as the result of the sheltered nature of the sampled site at Stenness behind a shallow rock lip, which may have allowed freshwater conditions to prevail for longer at the north-western edge of the loch (Wickham-Jones *et al*. 2008).

1.6.2 Climate

Orkney's climate is categorised as hyperoceanic and is typified by high winds and a small annual temperature range (Berry 2000). The climate is mild in comparison with

other regions at the same latitude, and this can be attributed to the warming influence of the westerly Gulf Stream (Ross 1966). The annual temperature range is small, with the difference between the mean daily maximum in January and in July being 9.7 $^{\circ}$C (Berry 2000). The cool summers result in a growing season of five to six months, compared with seven to eight months in lowland England, and therefore the Orcadian climate is marginal for arable farming at the present day (Berry 2000).

Average annual rainfall in the islands ranges from about 800 mm in the southern and eastern areas to over 1000 mm on the uplands of Rousay, Hoy and west Mainland (Davidson and Jones 1985). Rainfall is distributed fairly evenly throughout the year, occurring on a mean of 241 days (Berry 2000), and generally the western areas of the island group are wetter than the east (Bailey 1971). Snow or sleet falls on an average of 64 days a year, but does not often lie for long, with an average figure of 15 days per year (Berry 2000).

1.6.3 Present-Day Vegetation and Land-Use

Over half of the present day landscape in Orkney is used for some kind of agriculture, principally for livestock farming, although oats, barley and root crops are also grown. The remaining vegetation can be grouped into three main categories: grass heath, tall herb and wetland communities within the agricultural zone; coastal plant communities such as salt marsh and machair; and upland vegetation in areas that are not suitable for agriculture, for example heath, blanket bog and mire (Davidson and Jones 1985).

Grass heath, dominated by grasses, sedges and ericaceous species, is found on steep slopes in the agricultural zone, and tall herb and fen vegetation occurs in the upper parts of valleys (Davidson and Jones 1985). Many of the former wetlands of Orkney have been drained over the centuries to improve the land for agriculture, but extensive areas of bog and marsh still remain in some areas. Peat has been extensively dug as a domestic fuel on the raised bogs, and as a result Orcadian wetland basins are typically mosaics of marsh and bog (Crawford 2000).

Coastal habitats include widespread areas of dune pasture or machair, normally termed 'links' in Orkney and supporting diverse herbaceous plant communities (Crawford 2000). Salt marsh occurs in sheltered locations along the coastline, and high rainfall and the constant influx of freshwater from terrestrial communities provide favourable

conditions for a wide range of species, including many freshwater plants as well as typical halophilic species (Crawford 2000).

Maritime heath occurs in western areas of the islands, which are exposed to gales and frequently subjected to salt spray. This community is characterised by a mosaic of cliff-top species such as *Plantago maritima* and heath species including *Calluna vulgaris*, *Erica cinerea*, *Empetrum nigrum* and various sedges (Crawford 2000).

Blanket bogs occur on all types of terrain, irrespective of topography, and their vegetation is similar to that of heather moorland and raised bogs but with a higher frequency of rushes and sedges. Considerable areas of blanket bog are found in north Hoy, Rousay and parts of west Mainland, but elsewhere much of this community has been removed in recent years to improve the land for agriculture (Crawford 2000).

The exposed conditions of the north Hoy hills coupled with cool oceanic summers results in a tundra-like, or fell-field, vegetation in the highest areas. Strong winds produce stepped terraces interspersed with areas of bare ground, and the vegetation community is a combination of hardy Arctic and alpine species (Prentice and Prentice 1975).

No semi-natural woodland is currently found in the agricultural zone, although trial plantations of exotic trees in north Hoy by the Forestry Commission provide evidence that Orkney does not lie beyond the physiological limits to tree growth (MacDonald 1967). The only area of natural woodland that occurs in Orkney today is found at Berriedale on the island of Hoy, and it has been suggested that in the absence of grazing this woodland may spread into other parts of the islands (Chapman and Crawford 1981). The dominant tree species at Berriedale is *Betula pubescens* and the woodland supports a rich ground flora of tall-herbs and ferns (Prentice and Prentice 1975).

1.7 Conventions and Definitions

This section defines some of the common terms and conventions used throughout this thesis. Dates are expressed as calibrated years BC/AD, since this investigation focuses on answering archaeological questions. The 'present' is taken as 1950 AD, and where calibrated dates were given in original publications these are cited in the thesis. Where uncalibrated radiocarbon dates were presented in the original publications these were

calibrated using CALIB 5.1 (Stuiver and Reimer 1993). The original uncalibrated radiocarbon dates as published are presented in Appendix 1. Calibrated radiocarbon dates are approximated as the mid-point of their ±2σ age range (95% confidence limits), and then rounded to the nearest 10 years.

The term 'Holocene' is used to refer to the present interglacial period (i.e. from around 9000 cal. BC to the present), and the period of transition from full glacial to fully temperate conditions (*c*. 13,000-9000 cal. BC) is referred to as the 'lateglacial'. Place names follow current Ordnance Survey map nomenclature. Vascular plant nomenclature follows Stace (1997), and pollen taxonomy is based upon Bennett *et al*. (1994) and Bennett (1995).

Since this thesis aims to answer archaeological questions, discussion is framed around broadly defined archaeological periods. The Late Upper Palaeolithic is taken as the starting point for discussion, as recent research has shown that humans were first present in Orkney some time towards the end of this period (Pitts 2007). The Late Upper Palaeolithic is taken here as spanning the same time period as the lateglacial, *c*. 13,000-9000 cal. BC. The dates for the Mesolithic (*c*. 9000-4000 cal. BC), Neolithic (*c*. 4000-2000 cal. BC) and Bronze Age (*c*. 2000-800 cal. BC) are drawn from Edwards and Ralston (2003) and Card (2005). The transition from earlier to later Neolithic in Orkney is usually taken as *c*. 3000 cal. BC (Card 2005), and in Scotland the Neolithic period does not tend to be further subdivided due to a relative lack of radiocarbon determinations, meaning that only broad chronologies based on monument types and pottery styles are available (Noble 2006a).

The Iron Age is defined here as beginning at *c*. 800 cal. BC and continuing until *c*. 600 cal. AD, when Orkney became part of the Pictish kingdom (Ritchie 1985). The Pictish period in the islands lasted until *c*. 800 cal. AD, when Viking settlers arrived in the coastal regions of northern and western Scotland (Grieve and Gibson 2005). The end of the Viking period in Orkney is usually defined by the death of Earl Thorfinn the Mighty in 1065 (Crawford 1987), and therefore the Viking period is defined here as *c*. 800-1065 cal. AD. The Orkney Viking period is considered to be proto-historic, as there are some documentary records for this period but none of any great detail and none from Orkney itself (Grieve and Gibson 2005), and is taken here as marking the end of the prehistoric period in the islands and so the cut-off point for discussion.

Chapter 2: The Archaeological Record of Orkney

This chapter describes the archaeological record of Orkney as it is currently understood. Broadly defined archaeological periods from the Late Upper Palaeolithic onwards (since recent research has shown that the islands may have been occupied at this time) are used to structure a review of the evidence for changes in settlement, burial, ritual, economy, material culture and society throughout Orcadian prehistory. Here prehistory is taken to include the Pictish and Viking periods, since there is little written evidence for these periods in the islands, and none from Orkney itself.

2.1 Late Upper Palaeolithic (*c*. 13,000 – *c*. 9000 cal. BC)

The timing of the initial human occupation of northern Scotland following deglaciation has been the subject of considerable debate. Following the rejection of the idea that Scotland could have been inhabited during the lateglacial period (Lacaille 1946), it has generally been assumed that the first human occupation of the region occurred at some time during the Mesolithic period, between about 9000 and 4000 cal. BC. However, recent research has challenged this. Scattered finds of "tanged points", a distinctive type of arrowhead, have suggested that small groups of hunters were present in Scotland prior to this. A recent review concluded that only two of these artefacts, one from Tiree and one from Shieldaig in Wester Ross, can confidently be identified as genuine Scottish tanged points (Ballin and Saville 2003). The arrowheads are typologically similar to those of the Ahrensburgian culture of northern Germany, which are thought to have been in use during the Upper Palaeolithic (Edwards and Mithen 1995).

Two tanged points from Orkney were described by Livens (1956), one from the Ness of Brodgar on Mainland, and one from Millfield on Stronsay, but these have since been lost and are therefore unavailable for re-examination (Ballin and Saville 2003). They were dismissed by Livens (1956: 443) as representing '…the survival of a lingering, Upper Palaeolithic tradition of flint-working in the remoter areas of Scotland, long after such a tradition had been supplanted or absorbed elsewhere in the British Isles.' However, the recent discovery of two tanged points during fieldwalking at Links House on Stronsay, confirmed as being similar to Ahrensburgian points, has again raised the possibility that Orkney was initially colonised towards the end of the Upper Palaeolithic (Woodward 2007). Fig. 2.1 shows all locations from which artefacts of apparent Upper Palaeolithic age have been recovered in Orkney.
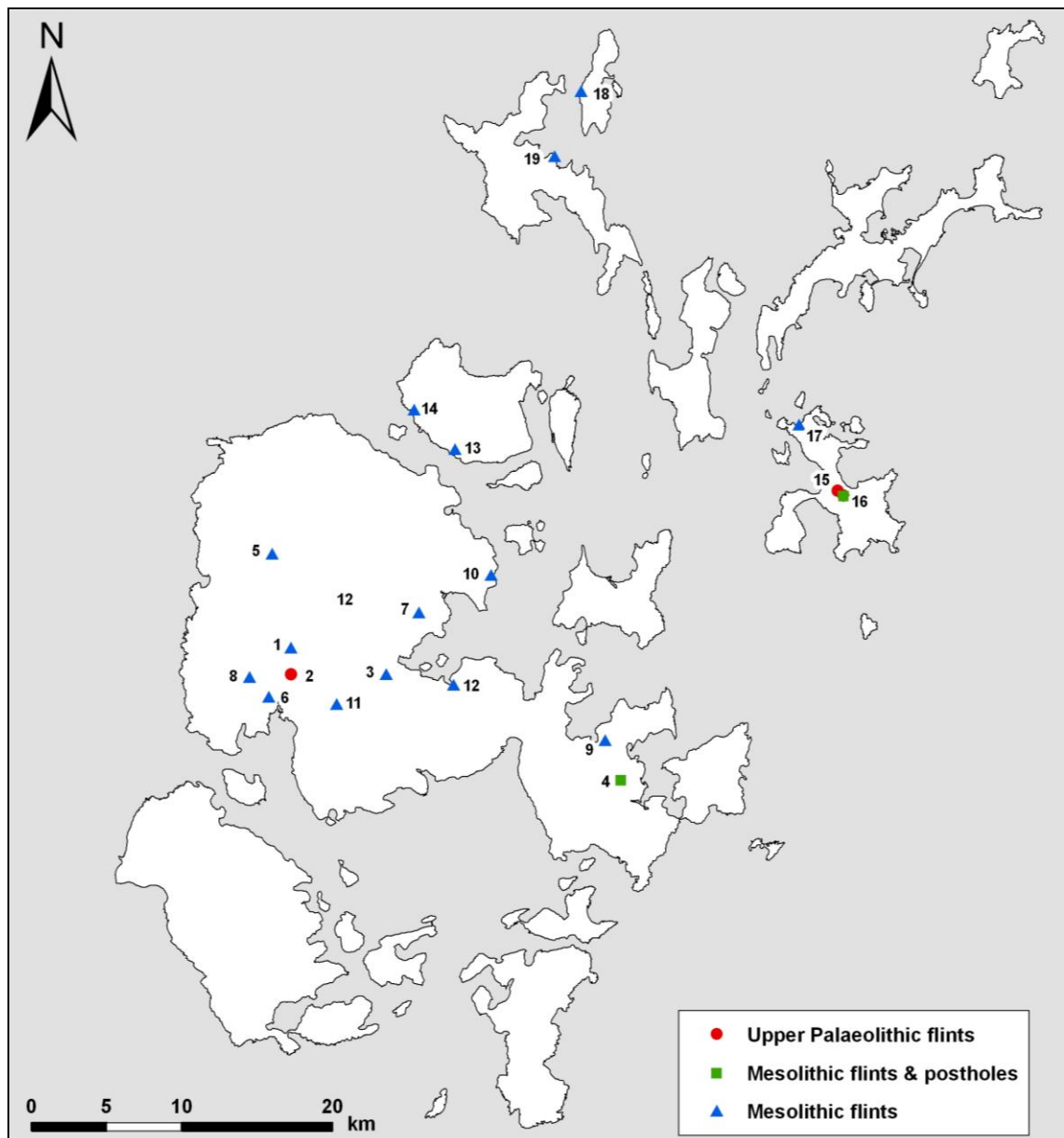
Figure 2.1 Location of Palaeolithic and Mesolithic sites in Orkney: 1. Bookan; 2. Brodgar; 3. Heddle Hill; 4. Long Howe; 5. Quinni Moan; 6. Ragashore; 7. Redland; 8. Seatter Farm; 9. Slap O'Valdigar; 10. South Aittit; 11. Stenness; 12. Wideford Hill; 13. Hullion; 14. Midhowe; 15. Links House; 16. Millfield; 17. Sands of Odie; 18. Knap of Howar; 19. Point of Cott (coordinates from the RCAHMS Canmore database)

2.2 Mesolithic (*c*. 9000 – *c*. 4000 cal. BC)

As with the preceding Palaeolithic period, the question of whether Mesolithic people were present in Orkney has been the subject of considerable debate. It was initially argued that there was no Mesolithic occupation of the islands, and finds of flint tools with characteristically Mesolithic form were dismissed as representing the continued use of this technology in the Neolithic and Bronze Age (e.g. Lacaille 1935; 1954). The extraordinary quality of Neolithic and later remains in Orkney has, until recently, led to

a general lack of interest in research targeted at searching for Mesolithic evidence (Wickham-Jones 2006).

Mesolithic people are known to have been present in Caithness and Sutherland (Wickham-Jones 1994; Saville 1996) and Orkney is clearly visible from the Scottish mainland. Furthermore, boats suitable for crossing the Pentland Firth were certainly available to Mesolithic people (Johnstone 1980). The necessary woodland and coastal resources for human survival were present on Orkney (Ritchie 1995; Edwards 1996), and the raw material for stone tool production was also abundant (Saville 1996). As there is increasing evidence for early settlement of coastal areas at high latitudes, such as Norway, Tierra del Fuego and Alaska, all areas that would provide a similar range of resources as Orkney, there is no practical reason why Orkney should not have been settled during the Mesolithic (Wickham-Jones 2006).

Mesolithic structures would have been of a more temporary nature than the stone-built settlements of the Neolithic (Mithen 1999), and this has restricted investigations of the Orcadian Mesolithic as it has been assumed that there would not have been enough timber in the islands for building work. However, recent work has shown that timber was available, both as driftwood (Dickson 1992) and as local scrub woodland (e.g. Bunting 1994). The recent discovery of the remains of two timber buildings dated to the early Neolithic at Wideford Hill on Mainland (Towrie 2003) has shown that timber buildings were built in Orkney, and that their traces still survive today. In the past excavation strategies have been focused upon the investigation of stone structures, and it is possible that this may have biased the evidence by inhibiting the recovery of timber structures (Wickham-Jones 2006).

There is some palaeoecological evidence for a Mesolithic presence in Orkney. At Keith's Peat Bank on the island of Hoy, a decline in woodland at *c.* 5350 cal. BC linked with evidence of burning and increased grazing pressure supports a hypothesis of clearance by humans (Blackford *et al.* 1996). At Quoyloo Meadow in west Mainland, a woodland decline associated with a charcoal peak at *c.* 5450 cal. BC has also been linked with Mesolithic human activity (Bunting 1994). Mesolithic occupation of the Inner Hebrides has been well documented (e.g. Mellars 1987; Wickham-Jones 1990a; Mithen 2000), and Edwards (1996) believes that the palynological evidence from

Orkney is sufficiently similar to that from the Inner Hebrides to support a hypothesis of human presence in Mesolithic times.

Following a recent re-evaluation of Lacaille's Orkney flints, along with several others from the National Museums of Scotland collection, Saville (1996) concluded that there was certainly a Mesolithic presence on Rousay and west Mainland. Several other Mesolithic flint scatter sites have also been identified on Mainland, both from old collections and from recent fieldwalking (Wickham-Jones 1990b, 1994; Cantley 2005). The flint assemblage from beneath the chambered tomb at Point of Cott on Westray has recently been interpreted as Mesolithic (Findlay 1997), and implements from Stronsay and Papa Westray provide further indications that there may have been a Mesolithic community on the north isles (Wickham-Jones 1990b). The locations of sites where Mesolithic artefacts have been found are shown in Fig. 2.1.

Recent work has shown that Mesolithic remains other than flint tools do exist in Orkney. During the excavation of a Bronze Age barrow at Long Howe in Tankerness, a number of Mesolithic flints were discovered. A charred hazelnut shell found in soil below the mound has been radiocarbon dated to *c*. 6740 cal. BC (Wickham-Jones and Downes 2007), confirming that the islands were indeed occupied during the Mesolithic. Recent investigations at Millfield on Stronsay have revealed a number of post-holes along with several pieces of flint estimated to date from the early Mesolithic period (Towrie 2008a).

Despite this recent research, the picture of Mesolithic Orkney is far from complete. None of the characteristic coastal shell middens that occur in the Western Isles and along the west coast of Scotland (e.g. Mellars 1987; Wickham-Jones 1994) have yet been discovered. This may reflect a real absence of such sites, or it may be that sea level change during the Holocene has submerged many early coastal sites in the islands. At present there is no detailed information on the rates of sea level change that have affected Orkney but it is thought that relative sea level may have risen by as much as 30 m since the end of the last glacial period (Wickham-Jones 2006). A project investigating Holocene sea level change around Orkney is currently underway (Wickham-Jones *et al*. 2008), and completion of this project will highlight areas of likely Mesolithic settlement. This should allow for much more focused attempts to locate remains from this period (Wickham-Jones 2006).

The shift from the Mesolithic to the Neolithic in Orkney, and in Britain as a whole, was not necessarily a clear-cut transition (e.g. Jones 1996; Sturt 2005). Zvelebil and Rowley-Conwy (1986) have distinguished between an availability phase where knowledge of the Neolithic economy was available, and a later phase of wide-scale adoption of this economy by Mesolithic hunter-gatherers. This model argues that in order to progress from availability to adoption of the Neolithic economy, there must either be a perceived advantage to using cultivated resources or a crisis in the availability of wild ones (Zvelebil and Rowley-Conwy 1986). In Britain, the traditional view of Neolithic culture being introduced by continental European immigrants (e.g. Piggott 1954) is now challenged, and the consensus is now that the indigenous Mesolithic population became Neolithic by adopting new material culture, subsistence staples and belief systems (e.g. Whittle 1999; Thomas 2007). The idea of the indigenous Mesolithic population adopting Neolithic culture is also hypothesised for Orkney (e.g. Wickham-Jones 2006).

Studies of prehistoric diet based upon stable isotopes in human bones seem to show an abrupt change from diets with a dominant marine component to an almost exclusive reliance on protein from terrestrial sources at *c*. 4000 cal. BC (Schulting 1998; Richards and Hedges 1999; Richards 2003). This has been interpreted as evidence of a rapid change from a subsistence economy that made extensive use of marine resources to an agricultural economy based on cultivation and stock-keeping (Schulting 2000). The results come from the bones of both inland and coastal populations (Richards *et al*. 2003), and so in some cases ceasing to eat fish, marine mammals and shellfish would have involved a positive avoidance of foodstuffs that were readily available. Thomas (2007) therefore interprets this shift in diet as a conscious rejection of foods that were positively associated with the Mesolithic. In Orkney, the burial of whole red deer carcasses at the edge of the Neolithic settlement at the Links of Noltland on Westray may provide further evidence for the symbolic rejection of wild resources in favour of domesticated ones (Sharples 2000). Thomas (2007) suggests that this apparent practice of rejection of wild resources seems to indicate that 'being Neolithic' involved overtly *not* being Mesolithic.

It has been argued that in Britain 'the very sudden cultural change from Mesolithic to Neolithic appears to be superimposed upon a much more long-term shift from food gathering to food-production' (Thomas 1999: 16). Mesolithic activities are

thought to have continued into the early Neolithic in western Scotland (Finlayson and Edwards 2003), although in other parts of the country there is little evidence for continuity between Mesolithic and Neolithic lifestyles (Noble 2006a). As discussed in the following section, there is evidence that in Orkney hunting and fishing continued alongside farming activities, and it seems that many aspects of the hunter-gatherer lifestyle in the islands did not simply disappear with the coming of the Neolithic.

2.3 Neolithic (*c*. 4000 – *c*. 2000 cal. BC)

Orkney is arguably one of the best preserved and most intensively studied archaeological landscapes in the world, and this status is reflected by the designation of six discrete Neolithic sites in west Mainland as a UNESCO World Heritage Site. These monuments are described as 'outstanding testimony to the cultural achievements of the Neolithic peoples of northern Europe' (Historic Scotland 2008: 15).

The Orcadian Neolithic is usually divided into an early and a late phase, each of which is characterised by different pottery and architectural styles. There is some overlap between the two phases and the period of transition is thought to have occurred at around 3000 cal. BC (Card 2005). The pottery used during the earlier phase is known as Unstan Ware, and comprises shallow bowls with round bottoms, sometimes featuring incised decoration (Clouston 1885). The later pottery is called Grooved Ware and is often bucket-shaped, with flat bottoms and deeper sides, featuring applied decoration (Wickham-Jones 2006).

There has been some debate over whether these two pottery styles reflect culturally distinct groups of people who occupied the islands at the same time (e.g. Hedges 1983a) or whether the two groups were chronologically separate; until recently a lack of well-stratified and well-dated sequences has limited this discussion. Recent excavations at Pool on Sanday (Hunter *et al*. 2007) revealed a well-stratified Neolithic pottery sequence, the study of which has confirmed a chronological progression from Unstan to Grooved Ware. The earliest occupation deposits contained plain Unstan bowls, which were replaced in the second phase by flat-based vessels with incised decoration. Pottery from the third phase was mostly bucket-shaped with applied decoration being dominant, although incised decoration was still present (Hunter and MacSween 1991; MacSween 2007a). This sequence confirms the link between the two types of pottery and suggests that there was a degree of temporal overlap in their use.

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2.3.1 Settlements

The locations of all currently known Neolithic settlement sites in Orkney are shown in Fig. 2.2. At present the earliest radiocarbon dates for permanent human settlement on Orkney come from an early Neolithic farmstead at the Knap of Howar on Papa Westray. These indicate occupation of the site from around 3600 cal. BC to *c.* 3100 cal. BC (Ritchie 1983). The site consists of two stone-built structures linked by a passage and dug into an existing midden (Fig. 2.3). Midden material was also used as wall-core. Each structure is long, with rounded ends, and has its internal space divided by stone uprights (Fig. 2.4). The larger building is split into two roughly equal parts, and is interpreted as the living quarters. The smaller structure has been interpreted as a workshop and is divided into three sections. Both buildings contained stone furniture, and there is also evidence of wooden furnishings (Ritchie 1983).

Knap of Howar was thought to be typical of the settlements of early Neolithic Orkney for many years, although other types are now known from this period. For example, excavations at Pool on Sanday (Hunter *et al.* 2007) have revealed early settlement roughly contemporary with that at the Knap of Howar. However the set of structures discovered at Pool are complex and irregularly arranged, and all the enclosed areas are small and are interpreted as representing parts of complexes of chambers rather than self-contained units (Hunter *et al.* 2007). As at Knap of Howar, the early houses at Pool were built upon and surrounded by midden material.

Recent excavations at Stonehall in west Mainland have also uncovered the remains of a substantial early Neolithic settlement complex, so far dated only on the basis of material culture. Up to seven possible houses at this site have been discovered and two of the structures have been investigated in detail, yielding several items of early Neolithic material culture including round-based pottery and polished stone axes (Carruthers and Richards 2000). At the Braes of Ha'Breck on Wyre, recent excavations have identified several buildings associated with early Neolithic pottery and flint artefacts. Activity on the site is spread over an area covering several hundred square metres, making this one of the largest known early Neolithic settlement sites in Orkney (Thomas 2008).
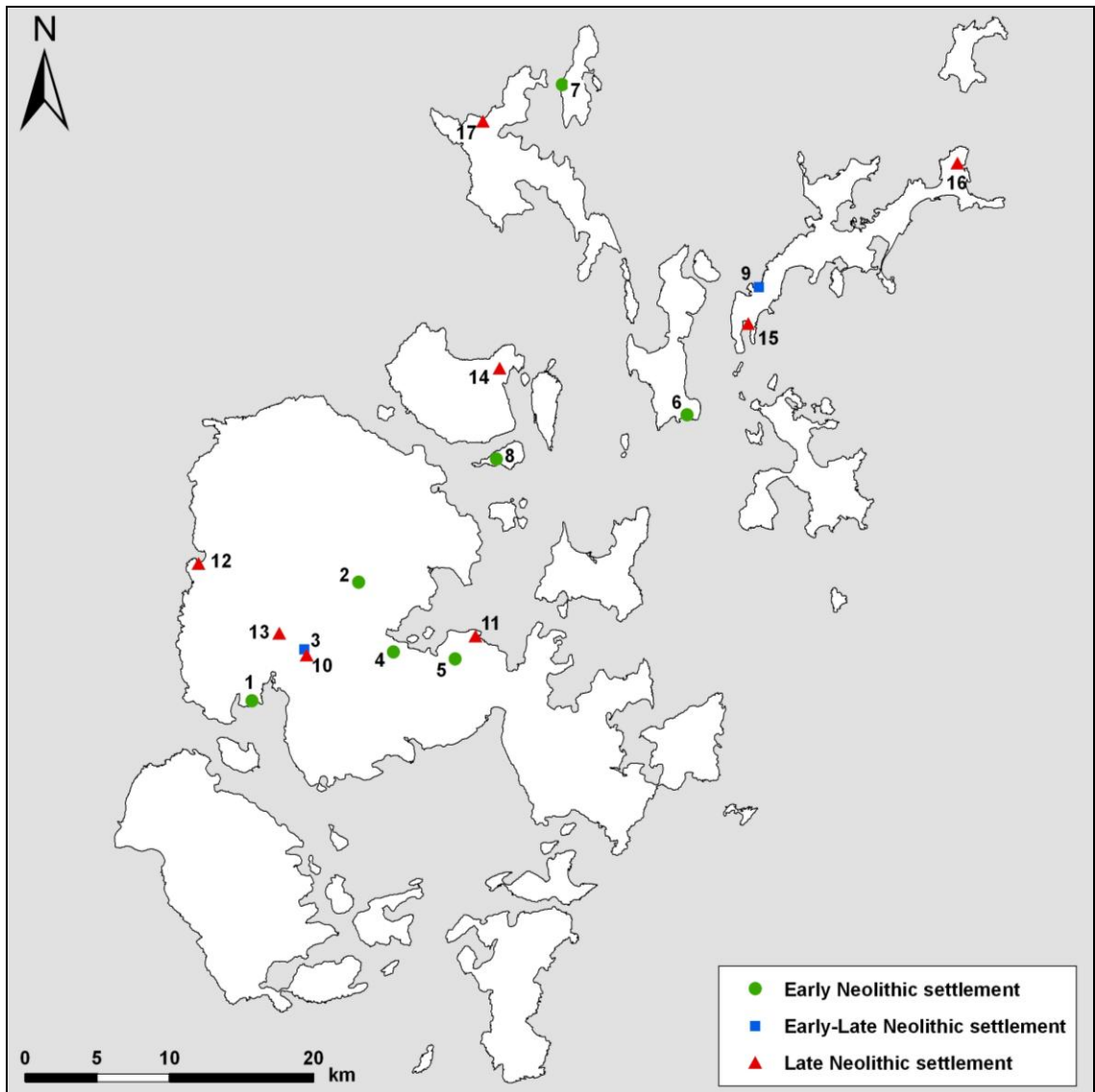
Figure 2.2 Location of Neolithic settlements in Orkney: 1. Garson; 2. Knowes of Trotty; 3. Ness of Brodgar; 4. Stonehall; 5. Wideford Hill; 6. Green; 7. Knap of Howar; 8. Braes of Ha'Breck; 9. Pool; 10. Barnhouse; 11. Crossiecrown; 12. Skara Brae; 13. Wasbister; 14. Rinyo; 15. Bay of Stove; 16. Tofts Ness; 17. Links of Noltland (coordinates from the RCAHMS Canmore database)

Figure 2.3 The early Neolithic settlement at Knap of Howar, Westray
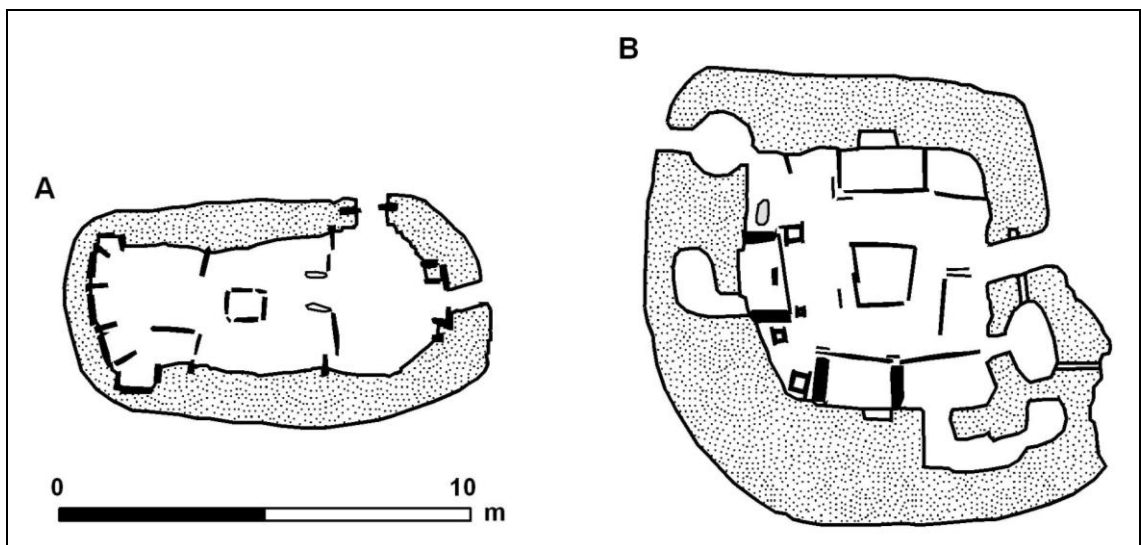
Figure 2.4 Plans of Neolithic houses: (A) Knap of Howar house 2 – early Neolithic; (B) Skara Brae house 1 – late Neolithic (after Ritchie 1995)

During excavations at the Bronze Age barrow cemetery of the Knowes of Trotty, a rectilinear structure was uncovered adjacent to a paved working area. Based on the similarity of this building to those at Knap of Howar and Stonehall this structure has been interpreted as an early Neolithic house (Card *et al*. 2006). In addition, the remains

of a number of circular wooden structures with central hearths, from which early Neolithic pottery was recovered, have been found at Wideford Hill and were perhaps occupied as early as 3900 cal. BC. The remains of a stone structure have also been uncovered at this site, and based on its similarities with the houses at Knap of Howar and Stonehall, as well as finds of Unstan Ware pottery, it is believed to date from around 3600 cal. BC (Towrie 2003).

Based on the evidence from Knap of Howar, it was believed for many years that early Neolithic settlement on Orkney was characterised by individual or dispersed households, which were thought to reflect units of a segmentary society. Later, nucleated settlements were thought to have developed as a response to the creation of a more centralised society during the late Neolithic (e.g. Renfrew 1979; Sharples 1985). However, the early Neolithic structures at Pool and elsewhere in the islands are clearly distinct from those at Knap of Howar in terms of both their size and their layout, demonstrating that early Neolithic settlement on Orkney was more complex than previously thought. As such, the distinction between early and late Neolithic settlement and society may not be quite so clear cut (Hunter *et al.* 2007). Rather than being characterised by individual farmsteads, it now seems more likely that the early Neolithic in Orkney was represented by 'dispersed' village settlements (Carruthers and Richards 2000).

Unlike the earlier Neolithic villages, houses at late Neolithic settlement sites in Orkney tend to cluster together. The houses tend to be linked by passages, and ancillary buildings lie adjacent to the central nucleus. This pattern is best illustrated by Skara Brae in west Mainland, where the second phase village consisted of at least six houses linked by passageways (Fig. 2.5). The houses are built into pits dug into a pre-existing midden heap, and the passages were constructed within channels created in the midden. Each house is very similar in terms of construction techniques, size and internal layout, consisting of a single room entered from the connecting passageway by a low, narrow doorway (Clarke and Sharples 1985). Each house has a large stone-lined hearth in the centre and a substantial 'dresser' on the wall opposite the doorway, with box beds along the side walls (Fig. 2.4; Fig. 2.6). There are a number of cells in the houses, and these have been variously interpreted as storage areas, safes and lavatories (Clarke and Sharples 1985; Ritchie 1995). One structure, shown in Fig. 2.7, is separate from the main cluster of houses and does not conform to the general pattern described above.

This building has been interpreted as a workshop on the basis of finds of tools and flint-working debris (Clarke and Sharples 1985).
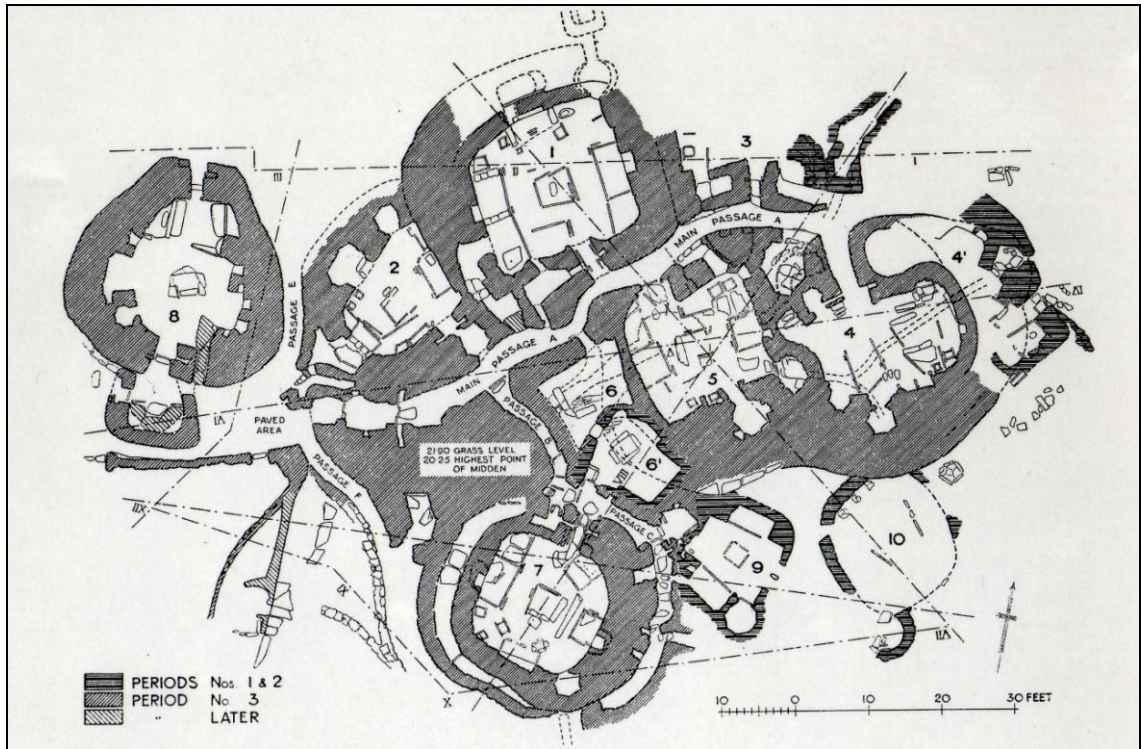
Figure 2.5 Ground plan of Skara Brae, west Mainland (Historic Scotland)

Figure 2.6 Interior of house 1 at Skara Brae, showing the central hearth, 'dresser' and box beds

Figure 2.7 Structure 8 at Skara Brae, which stands apart from the main settlement and has been interpreted as a workshop

Several other late Neolithic settlement sites have been discovered on Orkney, including Rinyo on Rousay (Childe and Grant 1938; 1948), Links of Noltland on Westray (Clarke *et al.* 1977; Clarke 1978; 1979; 1980; 1981), Pool on Sanday (Hunter *et al.* 2007), Tofts Ness, also on Sanday (Dockrill *et al.* 2007), and Barnhouse on Mainland (Richards 2005). In terms of architecture and material culture, Rinyo is very similar to Skara Brae, and the Neolithic building excavated at the Links of Noltland comprised two rooms joined by a passage and produced a similar artefact assemblage to that discovered at Skara Brae (Clarke 1980; 1981; Clarke and Sharples 1985). Midden was used in construction elsewhere in Orkney during the Neolithic, although nowhere to the same extent as at Skara Brae. At Rinyo, artificial terraces were created using midden material and horizontal stones in order to counteract the slope of the hillside and provide level terraces for building on (Ritchie 1995), and the excavated building at the Links of Noltland had been constructed in a pit dug into a sand dune and lined with midden (Clarke 1980; 1981; Clarke and Sharples 1985).

At Pool, late Neolithic settlement began somewhere around the mid fourth millennium BC and ended in the late third millennium BC (Hunter *et al.* 2007). The later Neolithic structures here are more elaborate than the earlier ones, exhibiting casing walls and more sophisticated construction techniques in terms of coursing and the use of orthostats. The later Neolithic buildings at Pool were free-standing and, as at other Orcadian Neolithic settlements, some have been interpreted as workshops on the basis of their artefact assemblages (Hunter *et al.* 2007). Overall, the layout of the settlement and internal configuration of the buildings are similar to those at other late Neolithic sites in Orkney (Hunter *et al.* 2007).

At Tofts Ness, the earliest radiocarbon dates suggest that settlement began at *c*. 3200 cal. BC, in the late Neolithic, and continued until *c*. 600 cal. BC in the early Iron Age. The earliest structural evidence is of a free-standing cellular building, although the function of this structure could not be determined due to the extensive stone robbing that had occurred at the site (Dockrill *et al*. 2007). The significance of this settlement lies in the fact that it is situated on land that would have been very marginal for agriculture, and in that there is continuity of settlement from the Neolithic into the Bronze Age, whereas other excavated sites appear to have been abandoned at the end of the Neolithic. Since the Tofts Ness peninsula is not a prime site for cultivation, it has been suggested that the settlement here may represent a secondary phase of Neolithic settlement or a daughter settlement in an increasingly populated landscape. Furthermore, the development of intensive infield land management strategies allowed continued occupation of an increasingly marginal site (Dockrill *et al.* 2007). The poorer status of Tofts Ness, especially when compared with Pool on the same island (Hunter *et al*. 2007), is also evidenced by the material culture and economic information recovered from the site (Dockrill *et al*. 2007).

Settlement at Barnhouse, which is located close to the Neolithic ceremonial monuments in the Stenness-Brodgar area, began at around 3100 cal. BC and had ended by *c*. 2900 cal. BC (Ashmore 2005). In contrast to the late Neolithic Orcadian settlements described above where the houses are strikingly similar in size and internal layout, Barnhouse appears to have a hierarchical spatial structure. Excavations revealed a settlement complex which began with a long period of occupation and ended with the construction of monumental structures (Richards 2005). Early settlement at the site is contemporary with the primary occupation of Skara Brae, and consists of at least six

houses surrounding a larger, more complex house structure. The surrounding houses are typical of the Skara Brae-Rinyo form, although at Barnhouse they are free-standing and do not incorporate midden material into their structure. The larger building, House 2, closely resembles the tombs at Quanterness and Quoyness, although it has been interpreted as a dwelling by Richards (2005).

Structure 8 at Barnhouse (Fig. 2.8) was built after habitation at the site had ceased, and is described as 'monumental' by Richards (2005). It is thought that there may be a relationship between it, the chambered tomb of Maeshowe, and the ritual monument of the Stones of Stenness, all of which are constructed in the immediate vicinity. The structure is centrally positioned within a surrounding circular yellow clay platform which is in turn enclosed by a substantial stone wall, and in this respect it is similar to Maeshowe where the main passage-grave is surrounded by a clay platform and enclosed by a ditch (Richards 2005). However, Maeshowe is a place of the dead and is situated away from the settlement, with its entrance passage aligned with the winter solstice. Structure 8 lies within the settlement and its entrance is orientated towards the summer solstice. The overall impression of Structure 8 is that of a large building drawing on certain elements of the typical Orcadian Neolithic house and transforming them into monumental proportions, incorporating elements of tombs and henges as well (Richards 2005).

Figure 2.8 'Monumental' Structure 8 at Barnhouse, west Mainland

2.3.2 Burials

The locations of all Neolithic burial sites referred to in the text are shown in Fig. 2.9. The earlier Orcadian tombs belong to the Orkney-Cromarty group of passage graves found throughout northern Scotland (Davidson and Henshall 1991). These comprise an entrance passage leading to a central chamber that may be tripartite or divided by stone uprights into a series of stalls (Fig. 2.10; Fig. 2.11). The chambers are covered by round or rectangular cairns depending on their length. In northern Caithness and Orkney, these tripartite and stalled tombs were apparently a development of the single-compartment or bipartite forms found in Ross-shire and the Western Isles (Davidson and Henshall 1991). Also forming part of the Orkney-Cromarty group are the Bookan cairns, a small group of tombs with compartments defined by orthostats arranged radially around a central space (Sharples 1985). Reilly (2003) states that there are at least 59 known Orkney-Cromarty type tombs in Orkney, although 64 are currently listed in the RCAHMS Canmore database, and it is the locations of these that are shown in Fig. 2.9. These tombs are mainly concentrated on Rousay and the adjacent coast of Mainland, Eday, Westray and South Ronaldsay (Henshall 1985).

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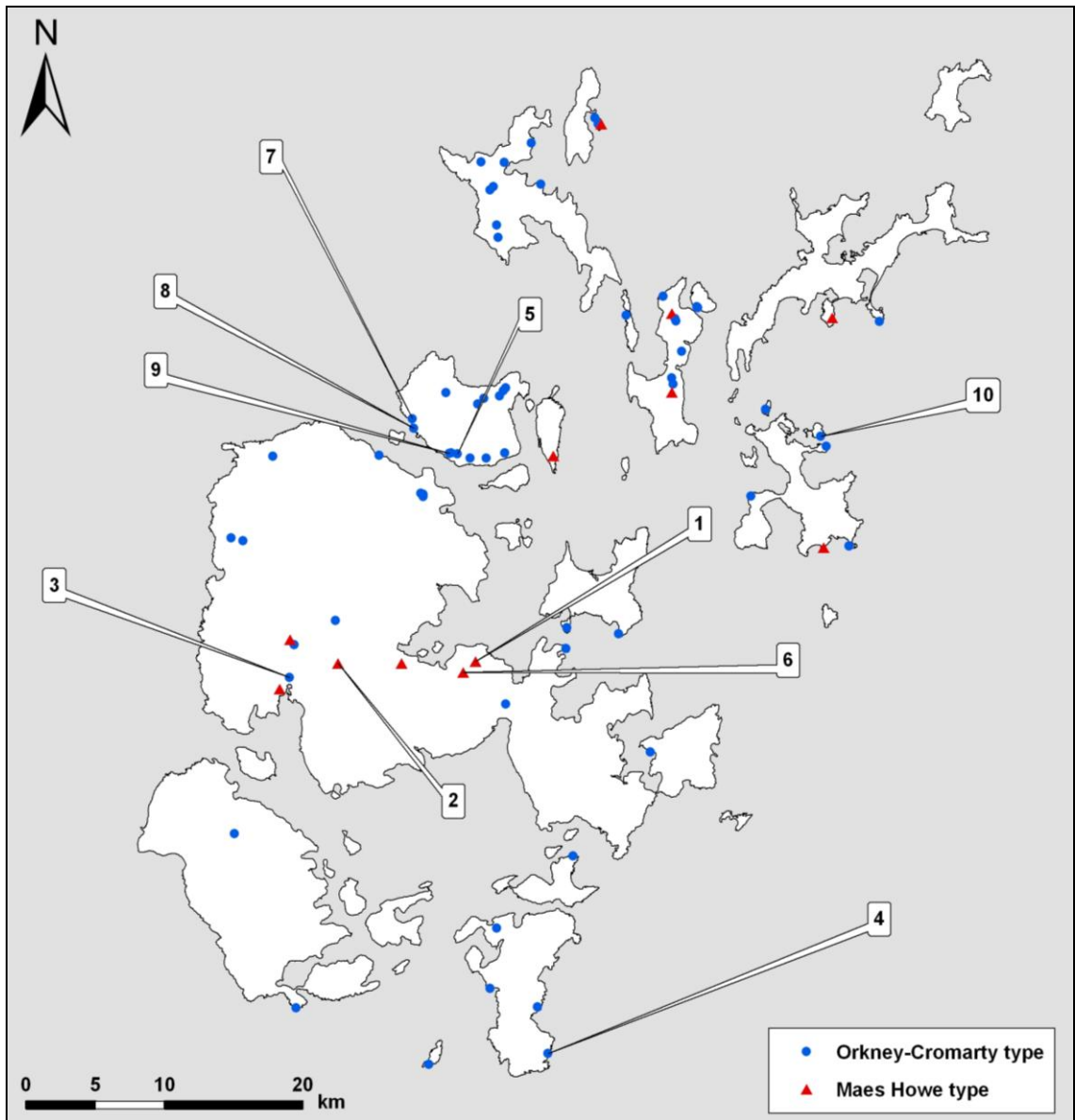
Figure 2.9 Location of Neolithic chambered cairns in Orkney (numbers represent sites discussed in the text): 1. Quanterness; 2. Maeshowe; 3. Unstan; 4. Isbister; 5. Knowe of Yarso; 6. Wideford; 7. Midhowe; 8. Knowe of Rowiegar; 9. Knowe of Lairo; 10. Earl's Knoll (coordinates from the RCAHMS Canmore database)

Figure 2.10 Interior of the early Neolithic stalled cairn at Midhowe, Rousay
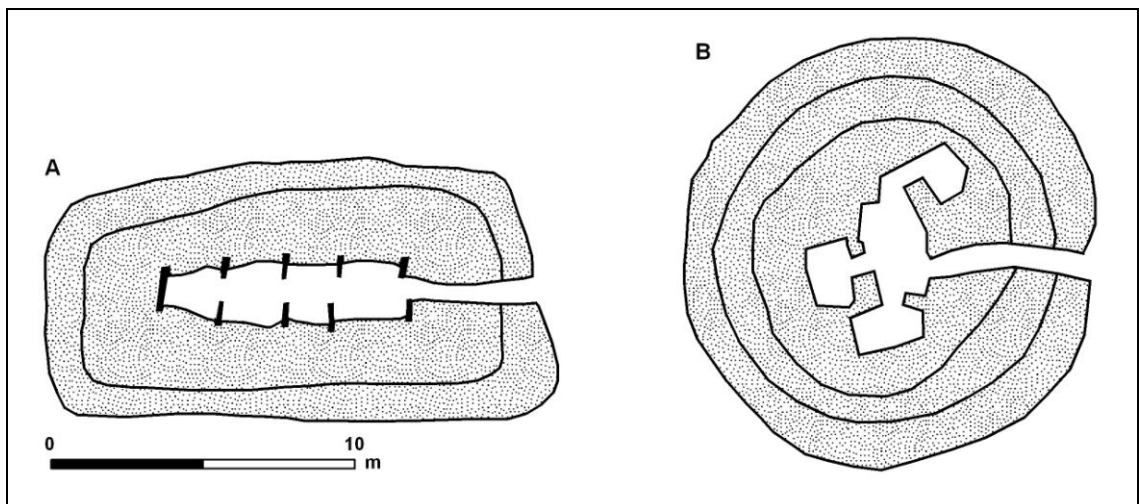
Figure 2.11 Plans of Neolithic chambered cairns: (A) the early Neolithic stalled cairn of Yarso; (B) the late Neolithic Maeshowe-type tomb of Wideford (after Ritchie 1995)

The other class of tomb found on Orkney dates to the late Neolithic and is known as the Maeshowe-type. Henshall (1985) states that only 10 cairns of this type are known, although the RCAHMS Canmore database lists 12 such sites and the locations of these are shown in Fig. 2.9. Maeshowe-type tombs tend to be concentrated on Mainland.

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The main feature shared by the tombs of this type is a long, low entrance passage leading to a large, high-roofed central chamber (Henshall 1985; Reilly 2003). The chambers are usually rectangular in plan and have side cells arranged symmetrically around the centre of the tomb (Fig. 2.11; Fig. 2.12; Fig. 2.13). The cells are usually irregular in shape, except at Quanterness and Maeshowe where they are rectangular and square respectively (Reilly 2003). The chambers and cells tend to be built of large slabs of precisely cut sandstone. The chamber walls begin to gently slope about a metre above the floor to produce a domed profile, and the chambers are roofed by flat transverse lintels (Henshall 1985; Davidson and Henshall 1989).

There are also hybrid tomb forms, for example the tombs at Unstan and Isbister contain both the side chambers of the Maeshowe-type and the stalls typical of the Orkney-Cromarty group. Renfrew (1979) suggested that these two tombs represent a link indicating the development of the Maeshowe-type from the Orkney-Cromarty type. However radiocarbon dates do not show a clear chronological succession between the two types, since those from Isbister indicate that it was roughly contemporary with its supposed typological successor at Quanterness (Sharples 1985).

There are direct architectural links between the tombs and domestic settlements of early and late Neolithic Orkney (Fig. 2.14). Early Neolithic houses tend to be rectangular with rounded corners and some are divided into rooms by pairs of upright slabs, mirroring the design of the Orkney-Cromarty tombs. Late Neolithic houses at Skara Brae (Childe 1931), Rinyo (Childe and Grant 1938) and Barnhouse (Richards 2005) show similarities with the Maeshowe group of tombs, being square inside and rounded outside with entrances to storage cells built into the thickness of the walls. These links between Neolithic houses and tombs have led to the suggestion that the tombs were constructed in order to function as 'houses for the dead' (Ritchie 1995).

Figure 2.12 The chambered cairn of Maeshowe, west Mainland

Figure 2.13 Interior of the Maeshowe-type chambered cairn at Cuween, west Mainland, showing two of the side cells
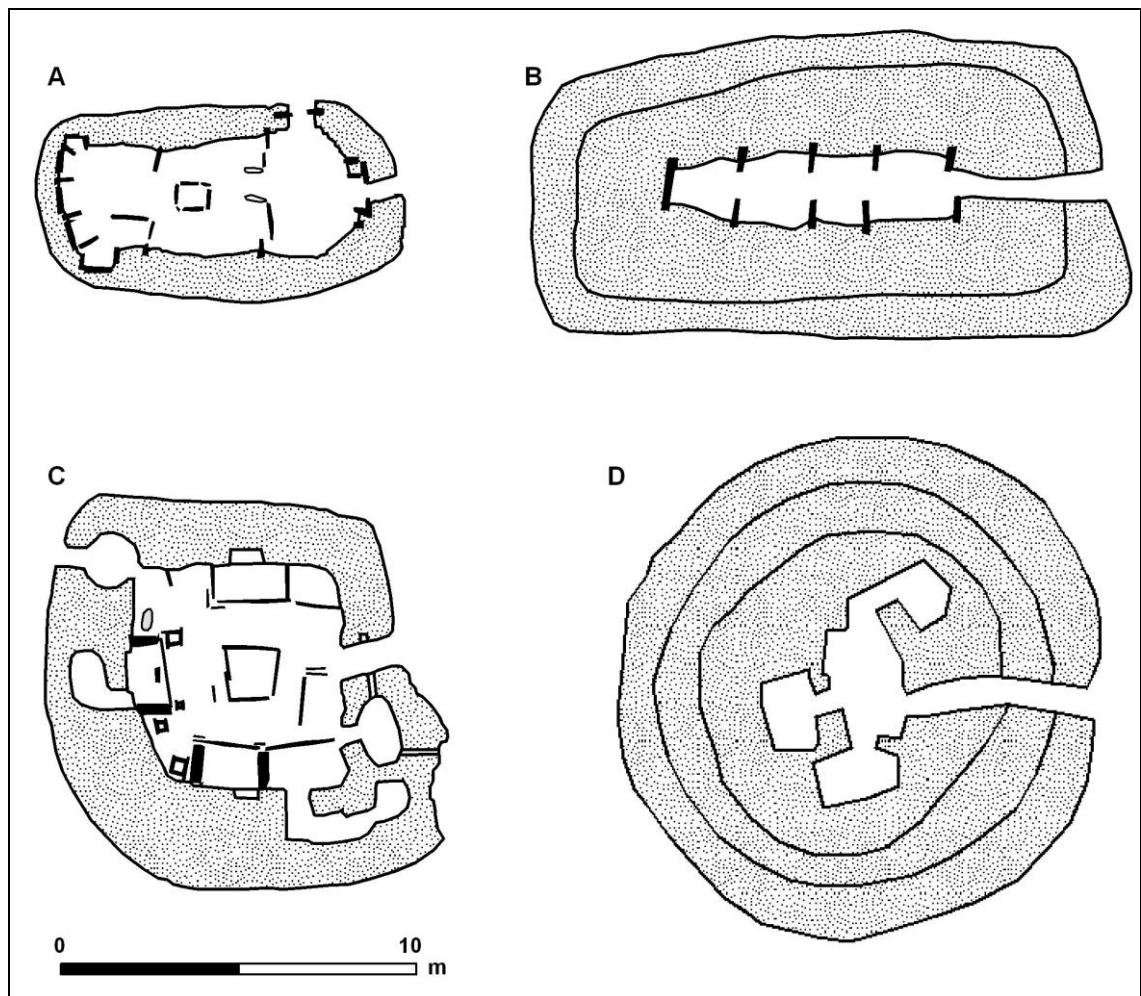
Figure 2.14 Early and late Neolithic houses and chambered cairns compared: (A) Knap of Howar house 2; (B) Yarso chambered cairn; (C) Skara Brae house 1; (D) Wideford chambered cairn (after Ritchie 1995)

A common feature of the two styles of cairn is that they were designed to be entered repeatedly, with radiocarbon dates from Isbister suggesting that the tomb was used for around 800 years, although the major period of activity at the site was between 3200 cal. BC and 3050 cal. BC (Renfrew *et al*. 1983). At Quanterness the radiocarbon dates indicate that the tomb may have been in use for a millennium, starting at around 3400 cal. BC, although again the period of intensive use is likely to have been much shorter, from *c*. 3000 cal. BC to *c*. 2430 cal. BC (Renfrew 1979). This implies that Orcadian cairns were used for between 150 and 550 years, which contrasts with recent studies of long barrows in southern England. Here, the results of Bayesian modelling of radiocarbon dates suggest that the primary use of the barrows for burial lasted for only two or three generations, and in some cases for only 10-30 years. Following these short periods of intensive use, sporadic reuse of these barrows continued for several generations (Bayliss *et al*. 2007; Meadows *et al*. 2007).

In terms of Neolithic burial rites, the evidence for excarnation is particularly strong from Isbister where there was no evidence that bodies were placed in the tomb while still articulated (Chesterman 1983). The skeletal remains were generally bleached and weathered, and only parts of skeletons were present. In the absence of any indication of burning, butchery or gnawing by animals such as dogs, Hedges (1983a) proposes that the dead were probably placed on specially constructed platforms, perhaps in the forecourt of the tomb, with excarnation being effected by decay, carrion-feeding birds, maggots, and the elements. 95% of the bird-remains found within the tomb at Isbister came from carrion-feeders, particularly the white-tailed eagle, and Hedges (1983a) suggests that the inclusion of these birds may have been totemic, particularly when their potential role in the process of excarnation is considered.

The selection of bones placed in the tomb at Isbister seems to have been quite unsystematic and was probably governed by what remained after the process of excarnation. It seems to have been a token representation of an individual, with little obvious effort to gather up every bone possible (Chesterman 1983). Several smaller bones, such as tarsals and carpals, were present at Isbister, and since the majority of the bones in the tomb were bleached and weathered this has been interpreted as the result of incomplete excarnation as opposed to bodies being placed in the tomb intact. Some of the bones recovered from Quanterness were in better condition than others (Chesterman 1979), leading Hedges (1983a) to suggest that excarnated remains were placed into the tombs during ceremonies which took place at specific times of year, regardless of the duration of exposure. This may also explain the presence of tarsals and carpals, since if remains were only placed into the tomb at certain times of year some bodies could still have been partially articulated when interred (Hedges 1983a).

Despite the convincing evidence for excarnation from Isbister, a recent reassessment of the evidence from other Orcadian tombs suggests that a burial rite involving a combination of both direct interment and excarnation was in use during the Neolithic. In most cases it seems that an articulated corpse was directly interred in a tomb and then, following decomposition, the bones were removed or rearranged until only the skull remained. According to Reilly (2003) this process may have occurred amongst several tombs during the earlier Neolithic, and during the later Neolithic the practice took place entirely within a single tomb.

The south coast of Rousay is characterised by a series of natural terraces, and set on these terraces are several stalled cairns dating from the early Neolithic. The tombs of Midhowe (Callander and Grant 1934) and Rowiegar (Davidson and Henshall 1989), situated on the lower terraces, contained fully articulated corpses placed on low stone benches along the side walls of the tombs. Following decomposition, the bones were placed in a distinct heap within the chamber. Specific bones, in particular the skull and long bones, were under-represented at Midhowe and Rowiegar and Reilly (2003) has suggested that these were removed to another nearby cairn, perhaps one on a higher terrace such as the Knowe of Lairo, which contained disarticulated skeletons (Grant and Wilson 1943). It has been suggested that certain bones, especially the skulls, were then transferred to tombs on the upper terraces, such as the Knowe of Yarso which contained a large number of skulls (Callander and Grant 1935). Reilly (2003) suggests that in this context, the movement of the bones is technically excarnation, and that the stalled cairns of Rousay form a cemetery in which both direct interment and excarnation were practiced during the early Neolithic.

This argument is also applicable to the evidence from other chambered cairns examined by Reilly (2003), for example at Isbister and Quanterness, which belong to the later group of Maeshowe-type tombs. Instead of excarnation taking place outside the tomb, most likely on the forecourt as suggested by Hedges (1983a), Reilly (2003) argues that the corpse was placed in the main chamber, and once it had decayed the bones, especially the skulls, were moved into the side cells. This would indicate that there was a continuation of a particular mortuary practice throughout the Neolithic of Orkney, and that the later Maeshowe-type tombs are effectively a microcosm of what occurred between the stalled cairns of southern Rousay (Reilly 2003).

There are clearly simpler and more economical means of disposing of the dead than the building of a chambered tomb, and Hedges (1983a) notes that the construction of these elaborate monuments implies that they were of considerable importance to the communities that built them. The fact that the tombs were designed to be re-entered on a regular basis is a clear indicator that as well as having a functional role in the disposal of the dead, they were also places for the living. Several features of the tombs suggest that not all members of a community had access to their interiors; for example entrance is often difficult and the chambers could only have held a few people (Wickham-Jones 2006). Several cairns had blocking stones at the entrances, and at Maeshowe this could

be put in position from inside the tomb, suggesting that those inside needed to restrict access and knowledge of what went on from the majority of the community. Some tombs also have 'sound boxes' designed to convey noise between the interior and exterior (Wickham-Jones 2006). These features have led Barber (2000) to suggest that the cairns were initially constructed as places of worship and were only used for burials later, drawing parallels with Christian churches.

Many of the Orcadian tombs have external forecourts that seem to have been set aside for a specific purpose, and where these areas have been excavated the evidence suggests that they were used for ceremonies involving larger groups of people than were allowed inside the tomb. It is suggested that these areas may have provided a way for the wider community to be part of the ceremonies that took place within the tombs, and that the tombs should actually be regarded more as temples than as burial places (Barber 2000).

Due to the remarkable preservation of the Orcadian chambered cairns and the considerable number that have been excavated, several investigations into the distribution and landscape setting of this particular class of monument have used Orkney as a case study. In an early study of the island of Rousay, Childe (1942) linked cairn distribution with that of modern farmsteads, and thereby proposed that each monument belonged to a single Neolithic household. It was also noted that the cairns were located on cultivated land, or on the border between farmland and heath, and Childe (1942) proposed that proximity to good agricultural land was important in the siting of the monuments.

Renfrew (1973) interpreted the monuments as territorial markers of segmentary societies. This argument was strengthened by plotting cairn location in relation to arable land on Rousay, using Thiessen polygons to suggest the likely areas of each territory. This territorial model has since been widely adopted (e.g. Fraser 1983; Hedges 1984; Sharples 1985). Fraser (1983) analysed various factors governing the site of the Orcadian tombs and concluded that a view over farmland was the most important consideration in their location, strengthening Renfrew's (1973) territorial hypothesis.

However, on Rousay the relationship between cairns and areas of agriculture is questionable, and Davidson *et al.* (1976) attempted to identify other environmental factors which might help to explain the distribution of cairns on the island. A modelling

approach was used to simulate the positions of a large number of cairns according to different weightings of factors, and then to determine which factors and weightings gave the closest pattern to the actual distribution of sites. The results indicated that agricultural land was not as important a factor as previously thought, and instead emphasised the importance of a prominent location and visibility of or from the sea (Davidson *et al.* 1976).

There are other problems with Renfrew's (1973) study, in that both cairn locations and number of cairns were wrongly plotted. If the distribution is corrected, the hypothetical territories drawn by Renfrew (1973) are reduced in size, and their interpretation as agricultural divisions becomes doubtful. The situation is further complicated by the subsequent identification of further possible chambered cairn sites on Rousay (Noble 2006b). Renfrew (1973) also attributed the lack of cairns on other islands to destruction by modern agriculture, although this is questionable considering the lack of intensive agriculture in recent years and comparison with early Bronze Age monuments, several of which are known to have been destroyed in the 19th century but which still have a more widespread distribution than the chambered cairns. There are also chronological problems with the territorial hypothesis, which assumes all the cairns were in contemporary use, despite the finds and typology of the cairns suggesting differences in use dates between them (Noble 2006b).

Hedges (1984) developed Renfrew's idea of territoriality further by estimating the number of person hours required to build each of the Orcadian tombs, and dividing the islands into territories based on tombs that took more than 10,000, more than 15,000, more than 20,000 and more than 25,000 person hours to build. At each stage of this analysis, the distribution of territories remained dispersed throughout the islands. Hedges (1984) concluded from this that there was a gradual coalescing of territories throughout the Neolithic period. He strengthened this argument by noting that not only did the smaller territories unite to make larger ones with roughly the same boundaries, but that the territories of Unstan Ware and Grooved Ware tombs, which Hedges (1983a) considered to have been contemporary, remained as discrete as was possible. Hedges (1984) postulated that, by the late Neolithic, Orkney was divided into two territories, with the Mainland and the South Isles being dominated by Maeshowe, and the North Isles by the Earl's Knoll on Papa Stronsay. However there are several problems with this hypothesis, not least that all the tombs cannot be confidently assigned to one or the

other subculture. Also, the evidence from Pool suggests that the Grooved Ware tradition developed from the Unstan Ware tradition (Hunter *et al*. 2007), and that the two pottery styles were for the most part chronologically separate.

In a GIS study of the distribution of Orcadian cairns, Woodman (2000) found that the majority of the monuments were situated on the coast overlooking large areas of seascape, lending additional weight to the findings of Davidson *et al.* (1976). Taking into account sea-level rise since the Neolithic, Phillips (2003) used these observations to suggest that the cairns were located to be viewed from the sea, often away from known settlement sites and occupying critical points along the coastline such as on promontories, offshore islands or overlooking bays. These positions have been linked with movement between different seascapes and the locations of critical marine passages (Phillips 2003). In a study of the chambered cairns of Caithness, which are typologically similar to the earlier tombs in Orkney, Phillips (2002) noted that they tended to be aligned along the local contours so that they are visible from likely areas of settlement. There appears to be a lack of concern with the sea in this region, leading to the suggestion that in both regions the monuments were located towards the edge of, and overlooking, the areas of routine activity, especially at topographically critical points (Phillips 2003). On the mainland everyday movement was across land, whilst on Orkney much of it was across the sea.

Cummings and Pannett (2005) noted that in southern Orkney chambered cairns are not evenly distributed but tend to cluster in certain areas. They argue that there are discrete patterns in their location which vary regionally, and suggest that this relates to differing priorities amongst different communities within the islands. These separate groupings are not necessarily found on separate islands but rather span islands, with a particular focus on the narrow sounds between islands. For example Rousay appears to be divided into two, with chambered cairns in the north seemingly located on the periphery of the domestic lowland landscape, and those in the south apparently sited in relation to Eynhallow sound, which separates Rousay from Mainland. Cummings and Pannett (2005) suggest that the northern cairns represent a separate group from those in the south of the island, which are part of a grouping with the cairns that cluster along the Eynhallow sound on northern Mainland. They further hypothesise that this represents a series of connections between islands, with water and water transport being highly significant aspects of daily life in the Neolithic.

Noble (2006b) further investigates the siting of the Orcadian monuments in relation to the sea, and considers that the concentration of chambered cairns on Rousay and Eday, two of the least fertile islands in the Orkney archipelago, may reflect the active selection of these islands for monument construction, as their barren nature may have provided active metaphors for the dead. Rather than being the chance survival of an original distribution, as described by Renfrew (1973), Noble (2006b) proposes that the number of cairns on Rousay and Eday can perhaps be better interpreted as cemeteries that served communities more widely dispersed throughout Orkney. For example, the group of chambered cairns arranged along the terraces on the south coast of Rousay has been interpreted as a megalithic cemetery due to the differing deposits of human and animal remains that have been recognised within the monuments on the different terraces (Jones 1998; Reilly 2003). The islands of Rousay and Eday form a natural link between the dispersed islands of the Orkney group, with most other islands able to be reached from them in a day (Noble 2006b). It is therefore suggested that these islands were seen as ideal meeting places for communities linked by the death of a member of their kinship group. Noble (2006b) proposes that during the early Neolithic Rousay and Eday may have been seen as 'islands of the dead', occupying a central place in the geography of Orkney at this time.

The later Neolithic monuments of Orkney tend to be concentrated on the Stenness and Brodgar peninsulas in the centre of Mainland, representing a shift in the focus of monumental construction to the southern part of the archipelago (Noble 2006b). While in Orkney the earlier Neolithic contacts seem to have been mainly inter-island in nature, the material culture of the late Neolithic indicates contact with a number of more geographically distant regions, suggesting that inter-regional links were growing during this period. The location of later Neolithic monuments adjacent to the Loch of Stenness would have enabled direct access to them from the Atlantic sea routes, and the placement of the complex here is thought to indicate an attempt to stress Orkney's central position amongst the growing regional contacts during this period (Noble 2006b).

2.3.3 Ceremonial Monuments

Ceremonial monuments generally associated with early Neolithic Britain, such as cursus monuments and causewayed enclosures, do not seem to be present in Orkney. However, the ceremonial heartland of late Neolithic Orkney appears to have been an

area of west Mainland concentrated around the two lochs of Stenness and Harray.
Several ritual monuments are located in the area (Fig. 2.15), including the henge
monuments and stone circles known as the Ring of Brodgar (Fig. 2.16) and the Stones
of Stenness (Fig. 2.17), the chambered tomb of Maeshowe, and several groups of
standing stones and later burial mounds.
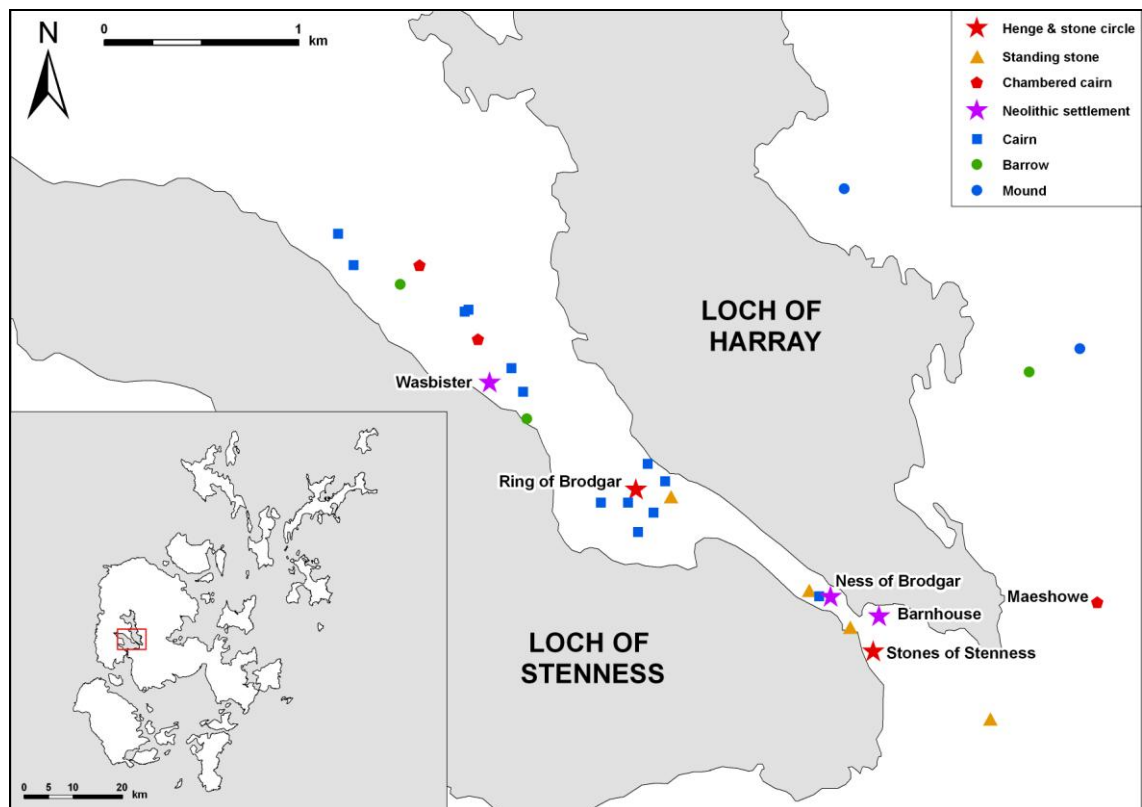
Figure 2.15 The Neolithic ceremonial area centred around the lochs of Stenness and Harray in west
Mainland (coordinates from the RCAHMS Canmore database)

The settlement at Barnhouse is believed to have acted as a focal point for the
construction of the surrounding ceremonial monuments (Richards 1996). At around
3000 cal. BC there is evidence for the construction of a ceremonial centre at Maeshowe
with similarities in design to the henge sites (Challands *et al.* 2005a). The building of
the tomb at around the middle of the third millennium BC represents a shift of focus
here as it became a burial place and the site of different ceremonies that may have
included fewer people (Wickham-Jones 2006). Radiocarbon dates on animal bone from
the bottom of the ditch at the Stones of Stenness indicate that this monument was also in
existence at around 3000 cal. BC (Ritchie 1976). Less is known about the construction
of the Ring of Brodgar, but it is likely to have started later, around 2500 cal. BC
(Renfrew 1979).

Figure 2.16 The Ring of Brodgar, west Mainland

Figure 2.17 The Stones of Stenness, west Mainland

Originally, the Stones of Stenness seem to have been a Class I henge with a rock-cut ditch surrounded by a substantial bank, and a central circle of 11 stones (Ritchie 1976). Small amounts of Grooved Ware pottery were recovered during excavations, providing a link between the people who used the monument and those living at the nearby late Neolithic settlements of Barnhouse and Skara Brae (Ritchie 1976; Richards 2005). At the Ring of Brodgar there were originally 60 stones in the circle, which is surrounded by a rock-cut ditch with entrance causeways in the north-west and south-east quadrants, forming a Class II henge (Renfrew 1979). It has been estimated that some 80,000 hours of work went into the construction of the ditch at the Ring of Brodgar (Renfrew 1979), and the figure for the ditch surrounding the Stones of Stenness is 50,000 hours (Ralston 1976). The ditches at both sites were found to be waterlogged upon excavation, suggesting that they contained water for long periods of time throughout the year (Ritchie 1976; Renfrew 1979).

The function of henge monuments and stone circles is unclear, although the existence of ditches and banks implies that symbolic boundaries were important and that the internal space could only be physically accessed by certain people. This practice of enclosing and formalising space by ordering the approach to, entrance into and movement around certain areas is part of a tradition that had begun with the early Neolithic causewayed enclosures of southern Britain (Whittle 1999). The orientation of these monuments and outward views to horizons and other natural features also seems to have been important. For example, the Stones of Stenness and the Ring of Brodgar have been interpreted as a representation of the local topography, with their water-filled ditches and external banks referencing the lochs and encircling hills. The standing stones at Stenness are again thought to imitate the local topography, dwarfing the internal features at the site while the surrounding hills overlooked the dwellings and lives of the Neolithic people (Richards 1996; Garrow *et al.* 2005).

There have been suggestions that many of the ceremonies that took place within henge monuments may have coincided with observations of particular stars or other features that marked the change from one season to the next (Thom 1971; Curtis 1976; MacKie 1977; Heggie 1981). The importance of the sun and the seasons to the people of Neolithic Orkney, who depended upon farming for their survival, is illustrated by the alignment of the entrance passage at Maeshowe with the winter solstice (MacKie 1997),

and of the entrance to Structure 8 at the Barnhouse settlement with the summer solstice (Richards 2005).

It has been suggested that although today we tend to focus on the upright stones and the sites as we see them, the actual acts of construction may well have been equally important to those who originally designed and used the area (Challands *et al.* 2005b). It seems that a complete stone circle was never accomplished at the Stones of Stenness, since the socket for stone 12 is not considered substantial enough to have ever held a standing stone, and unlike the sockets for other missing stones it does not contain any stone packing (Ritchie 1976). Based on this evidence Challands *et al.* (2005b) have hypothesised that each stone was sequentially erected over a long period of time, perhaps as part of ancestor rituals. It is suggested that the gradual addition of standing stones provided the main focus for ceremonies at the Stones of Stenness, as opposed to a fully-formed stone circle providing the context for these rituals. The use of the site does not seem to have been dependent on the presence of a completed stone circle, a point which is reinforced by the fact that the massive stone hearth at the centre of the monument cuts through ash deposits resulting from the use of an earlier hearth. No burnt material appears to cover the slots dug to contain the stones of this hearth, and it seems that it was no longer used following its 'monumentalisation' with massive stones (Challands *et al.* 2005b). The conclusion is that 'the Stones of Stenness was not built to be used, but on the contrary, it was used as it was being built' (Challands *et al.* 2005b: 225).

Whatever their function, the construction of the Stones of Stenness and the Ring of Brodgar implies the existence of an organised social system, and it has been suggested that the people who managed this system may have lived at the nearby settlement of Barnhouse. Similarities between pottery styles recovered from the Stones of Stenness and Barnhouse, which do not occur in any great quantity elsewhere in Orkney, provide a link between these two sites (Richards 2005). One of the structures at Barnhouse, House 2, is much larger than the rest and has six large recesses that have been interpreted as bed spaces. This structure remained standing throughout the lifetime of the settlement, while the surrounding houses were demolished and rebuilt several times, perhaps indicating that it held special significance for the inhabitants of the village. It has been interpreted as the home of people with a higher social status than those who lived in the majority of the houses at Barnhouse (Richards 2005).

With the discovery of the Neolithic settlement of Barnhouse adjacent to the Stones of Stenness it became clear that this area may not have been a purely ceremonial landscape, and recent geophysical survey and excavation on the southern tip of the Ness of Brodgar has found evidence of further late Neolithic settlement in the area. Excavation concentrating on a linear feature running along the peninsula and tentatively interpreted as a causeway or processional way (Card and Ovenden 2005) uncovered several structures containing stalls, drains, hearths and stone furniture, and at the northern end a monumental stone wall was excavated (Card *et al*. 2007). This wall has since been shown by further geophysical survey and excavation to extend right across the peninsula, separating the remains on the Ness of Brodgar from the Brodgar area to the northwest (Card 2007). Geophysical survey to the north of the Ring of Brodgar at Wasbister has indicated what may be another extensive late Neolithic settlement, around 6 ha in extent (Card *et al*. 2007). The boundary formed by the wall separating the settlement on the Ness of Brodgar from the stone circle has been shown by recent excavation to be replicated to the north of the circle, this time in the form of an earthen bank running across the Ness (Towrie 2004). Within these two boundaries, the land around the Ring of Brodgar is geophysically 'blank', perhaps indicating that it was set apart from domestic life (Card *et al*. 2007).

Several large 'monumental' buildings have been discovered on the Ness of Brodgar, including one that is even larger than Structure 8 at Barnhouse, and it has been suggested that they had more than a simple domestic function (Card *et al*. 2007). The largest structure on the Ness of Brodgar is known as Structure 10 and measures 25 m long by 20 m wide, with 5 m thick walls. The building is currently interpreted as a temple (Towrie 2009). An extremely diverse range of pottery types has been recovered during excavations at the settlement. When compared with the limited range of pottery recovered from other Neolithic settlements in Orkney it would seem that this site was a focus for several different communities, and may have been visited by people from all over the islands (Towrie 2008b). Vast quantities of cattle bone, thought to be the remains of ceremonial feasts at the site, have also been found. The pottery and cattle bone evidence has led Card *et al*. (2007) to draw parallels with recent excavations at the site of Durrington Walls in southern England. Here part of a settlement thought to have housed the builders of Stonehenge, and later the people who came to the area to participate in ceremonies, has been uncovered (Parker Pearson 2007).

2.3.4 Economy

Midden deposits from Neolithic settlement sites indicate that the economy was based on mixed farming and fishing. It seems that cattle and sheep were reared in roughly equal proportions, along with a few goats and pigs. Although the bones of sheep and goats are difficult to differentiate, attempts to distinguish between the two have been made at several Orcadian sites and the majority of the remains have been identified as sheep (e.g. Quanterness: Clutton-Brock 1979; Knap of Howar: Noddle 1983; Pool: Bond 2007a; Tofts Ness: Nicholson and Davies 2007).

Over 50% of the cattle bones recovered from Knap of Howar were from individuals that had died in the year they were born, and since they seemed to have a good standard of nutrition Noddle (1983) suggested that rather than being slaughtered early due to a lack of winter fodder (e.g. Barker 1983), they were actually killed for their hides. Finds of red deer bones at some sites have been interpreted as representing the farming of these animals (Clutton-Brock 1979), although this is debatable and could simply mean that some hunting was still taking place at this time (Sharples 2000).

Cereal crops including wheat and barley were grown (Dickson 1983a; Whittington 1983; Lynch 1983; Bond 2007b). Further evidence for arable cultivation in Neolithic times is provided by traces of plough furrows at Links of Noltland (Clarke 1980; 1981), and by evidence of manure being spread on the Neolithic soils of the Tofts Ness peninsula on Sanday. At Tofts Ness, the application of domestic midden material to land covered by calcareous wind blown sand deposits allowed arable cultivation in what would have been a very marginal farming environment (Simpson *et al.* 1998; Simpson *et al.* 2007). Despite the evidence for arable cultivation, the lack of evidence for storage pits and lack of suitable ceramic storage vessels (Jones 1999) would suggest that crops were not grown in sufficient quantities to provide food during the winter (Sturt 2005).

Elsewhere in Britain, it seems that wild plants continued to form a significant proportion of the Neolithic diet (e.g. Robinson 2000; Chamberlain and Witkin 2003), and there is little dental evidence in the form of caries to support cereal consumption (Wysocki and Whittle 2000). On this basis it has been suggested that cereals were rarely eaten during the Neolithic, except perhaps at public ceremonies (Thomas 2004). Cereals in Neolithic Orkney may therefore not have formed part of the everyday diet and may have held a ritual significance which led to their deposition in chambered

tombs such as Isbister (Hedges 1983a). However there is a paucity of archaeobotanical data from Neolithic settlements in Orkney, and so it cannot be determined with any certainty whether wild plants still formed a major part of the diet in the islands at this time.

The large fish bone assemblage from Knap of Howar was described by Wheeler (1983) and 67% of the species represented indicate deep sea fishing, with similar offshore fishing practices indicated by the fish remains recovered from Tofts Ness (Nicholson 1998). Sturt (2005) suggests that the hides of the young calves slaughtered at the Knap of Howar were used to make the boats from which these fish were caught. It is thought that marine resources played an important part in the Neolithic economy, due to the lack of evidence for storage of cereal crops and the fact that fishing can take place throughout the whole year (Sturt 2005). This contrasts with stable isotope studies of human bone from both coastal and inland locations in the rest of Britain, which show a rapid shift from a marine to a terrestrial based diet at the beginning of the Neolithic (Richards *et al.* 2003).

Large numbers of limpet shells and fish bones, along with bird bones and small fragments of birds' eggs, were recovered from the midden deposits at Knap of Howar (Ritchie 1983) and at Skara Brae (Ritchie 1995), indicating that wild resources were fully exploited to supplement the mixed agricultural economy at these sites. A similar mixed farming, fishing and hunting economy was also in existence at Pool on Sanday (Hunter *et al.* 2007). Although cattle and sheep were clearly an important source of food during the Neolithic, the overall picture is of an inclusive economy which exploited a wide range of areas and resources at different times of the year (Sturt 2005).

2.3.5 Material Culture

Stone tools recovered from Neolithic settlements include scrapers, knives, hammerstones, axes and quern stones (Ritchie 1995). The stone from which these tools are made tends to be local sandstone, which would have been collected as cobbles on local beaches (Wickham-Jones 1986). Flint for making tools was collected from glacial till deposits and from beaches where it was deposited following erosion (Wickham-Jones 1986). While most of the prehistoric population of Orkney were able to collect enough flint for their requirements, many tools at Skara Brae were made of

chert, an inferior stone that is available locally, suggesting that flint was not readily available in this area (Wickham-Jones 1977).

Certain buildings at both Knap of Howar and Skara Brae have been interpreted as workshops (Ritchie 1983; Clarke and Sharples 1985), indicating that everyday items were produced by the communities that used them. Pottery was also made in the villages, and this aspect of the material culture has been discussed above in the context of its role in dividing the Orcadian Neolithic into early and late periods.

Several bone tools used to make garments, including needles, have been discovered at Skara Brae and Knap of Howar, along with toggles and pins that would have been used as fastenings (Childe 1930; 1931; Ritchie 1983). However no weaving equipment has been discovered at Neolithic settlement sites in Orkney, suggesting either that clothing was made of hides and furs, or that textile production took place away from settlement sites, although there is currently no evidence for this. At Rinyo, little bone survived due to the acidic soil conditions, but the presence of several pieces of pumice with grooves worn by sharpening the points of bone pins and awls indicates that bone tools were also used to make clothing at this site (Childe and Grant 1938; 1948).

2.3.6 Population Structure and Social Organisation

The large quantity of human bone recovered during excavations at the chambered tombs of Quanterness (Renfrew 1979) and Isbister (Hedges 1983a) have allowed several inferences to be made about the size, structure and dynamics of the Neolithic population of Orkney. Roughly equal numbers of males and females were identified in the two tombs and all ages of the population were represented, from infancy to adulthood. This seems to indicate that burial within a chambered cairn was not reserved for an elite class of the population (Renfrew 1979; Hedges 1983a).

A comparison of measurements of the lengths of long bones from Isbister and those from a modern population has shown that the average height of the Neolithic Orcadians was around 170 cm for males and 160 cm for females (Chesterman 1983). The bones from Isbister also indicate that the people were muscular, probably as a result of environmental conditions. This applied to the whole group and supports the idea that there was no leisured class amongst this population (Hedges 1983a). In particular, evidence of hard muscular work with the ankles involved in a dorsi-flexed position has

been interpreted as the result of regularly climbing cliffs to collect seabirds and their eggs, and well-developed neck muscles and depressions in the front of the skull are thought to represent the carrying of heavy loads by a rope over the head (Hedges 1983a).

The skeletal remains from Isbister and Quanterness have also provided information on the health of the Neolithic population. Most of the teeth recovered from the two tombs were remarkably healthy with little sign of decay (Chesterman 1979; 1983). This suggests that although cereals were grown in Neolithic Orkney, they were not consumed in any large quantity since dental caries is indicative of a carbohydrate-rich diet. Several studies have shown a much higher incidence of caries in human remains following the introduction of agriculture to a region (e.g. Molnar and Molnar 1985; Larsen *et al*. 1991; Lubell *et al*. 1994). This lends additional weight to the suggestion that cereals did not form part of the everyday diet in Neolithic Britain (Thomas 2004) and perhaps implies that they held some ritual significance in Orkney at this time.

Degenerative disease of the spine in adults was a very common condition, with diseases such as osteoarthritis, osteophytosis and intervertebral disc lesions being prevalent amongst the population. Based on the bones from Isbister it seems that degenerative spinal diseases occurred amongst at least 47% of the population (Hedges 1983a). Accidents which involved trauma fracture of the bones seem to have been rare, and the overall impression gained from the human remains from Isbister is that the low life expectancy (around 20-25 years) was a result of harsh physical conditions (Hedges 1983a).

Given the number of individuals whose remains were recovered from Quanterness and the length of time that the tomb had been in use, and assuming all members of the community were buried there, Renfrew (1979) calculated that the community using the tomb had an average membership of 13-20 individuals. The remains from Isbister and the lifespan of this tomb suggest an average population size of 21 (Hedges 1984). The size of settlements such as Skara Brae supports the idea of small communities and taking all the evidence into account Hedges (1984) suggests that a figure of 25-50 people is a reasonable estimate of the size of the communities which used each of the chambered cairns. If the present distribution of Orcadian tombs is the same as the original, then the Neolithic population of Orkney must have been somewhere between

1600 and 3200. However, given the distribution of the known cairns, it seems likely that only half of the tombs have been located, and Hedges (1984) suggests the size of the Neolithic population was actually double this figure.

Using data on traditional Orcadian quarrying and drystone building practice, Renfrew (1979) calculated that Quanterness would have taken somewhere in the region of 10,000 hours to construct. On the basis of this figure Fraser (1983) has estimated that on average Orcadian tombs must have required an input of between 2000 and 10,000 hours each, which would seem to represent a considerable investment of labour from such small communities. However, Hedges (1984) has calculated that although only 40% of the population represented at Isbister would have been old enough to contribute to the skilled work involved in building the tomb, more than half of the work could have been carried out by unskilled members of the community, such as children. Each adult in the Isbister community would therefore have had to put in just 3-6 weeks work in order to complete the tomb, and Hedges (1984) believes that it would have been possible for each community to build their own tomb without outside help.

Largely on the basis of evidence from the chambered tombs and henge monuments, Renfrew (1973; 1979) argued that early Neolithic society in Orkney was segmentary, and that this social structure was modified at around 3000 cal. BC by centralising tendencies assuming the form of a common leadership controlling several groups. Sharples (1985) has used the changes in tomb design and use between the early and late Neolithic to suggest that in the later period, the relationship of individuals to their land was less important than their membership of a community, which ties in with Renfrew's suggestion of centralisation at this time. Renfrew (1979) suggested that the investment of the amount of time and labour required to construct monuments such as the Stones of Stenness and the Ring of Brodgar must have involved a hierarchical social system in the form of a chiefdom, although there is very little supporting evidence for this kind of political centralisation.

Richards (1998) points out that there is no evidence to support the gradual increase in scale of construction over time envisaged by Renfrew (1979), with monuments such as the tomb of Quanterness and the Stones of Stenness being in contemporary use and having little to separate their dates of construction. It is argued that instead of an increase in social complexity and the emergence of centralising tendencies, there was a

move away from communality towards individual family groups which continued into the second millennium BC (Richards 1998). The monumentality that is taken by Renfrew (1979) to have marked the emergence of a chiefdom towards the end of the Neolithic period is now believed to have occurred earlier, and it is now thought that social evolution in late Neolithic Orkney consisted of a gradual fragmentation and heterogeneity of culture. These changes began a period of social fragmentation and isolation which continued into the early Bronze Age and lasted for around one thousand years (Richards 1998).

More recently, Richards (2005) has argued that the power and authority required to mobilise the communal effort involved in the creation of monuments such as the Stones of Stenness and the Ring of Brodgar is much more likely to have derived from cosmological beliefs and the exploitation of kinship relationships extending beyond the level of the village unit. Additionally, Richards (2005) uses the evidence from Barnhouse to suggest that each village in later Neolithic Orkney may have had its own identity, rather than forming part of a homogeneous group identity. This is based on differences between the design of Grooved Ware pottery found at Skara Brae and at Barnhouse, with certain decorative motifs being present at one site and not at others (Richards 2005). It is also suggested that, rather than each chambered tomb belonging to and being used by a single community, most of the tombs are likely to have been used by a variety of communities on the basis of kin relations and alliance (Richards 2005). The idea that a centralised society developed in the later Neolithic in Orkney, and in Britain generally, is no longer widely accepted (e.g. Whittle 1999).

2.4 Bronze Age (*c*. 2000 – *c*. 800 cal. BC)

Archaeological remains from this period are less visible than those from the Neolithic and Iron Age, leading to numerous suggestions that the Neolithic-Bronze Age transition in Orkney represents a decrease in the standard of living in the islands. This apparent 'cultural decline' is often attributed to environmental factors such as climatic deterioration, overuse of the soil in the late Neolithic, effects of the eruption of the Icelandic volcano Hekla in *c*. 1159 cal. BC, and the spread of blanket peat (e.g. Øvrevik 1985; Ritchie 1995).

These environmental factors have also been invoked as the reason for abandonment of upland regions across Britain, including Dartmoor, Bodmin Moor, Derbyshire, the

North York Moors and large areas of western and central Scotland, which had all been extensively settled and used for agriculture prior to about 1200 cal. BC (e.g. Champion 1999; Parker Pearson 2005). The cause of this abandonment does not seem to have affected all areas of Britain, since in some areas that would have been most vulnerable to environmental changes, such as the Outer Hebrides, there is no archaeological evidence to suggest an interruption in continuity of settlement (Parker Pearson *et al*. 2004).

There is also an apparent 'decline' in Wessex in southern England in the middle Bronze Age, when it seems that the region became isolated from the continent. In the early Bronze Age there are several elaborate burials from this area with rich grave goods, the style of which indicates close contact with continental Europe. However in the middle Bronze Age trade with the continent seems to have ceased and areas of eastern England seem to have monopolised the supply of metalwork from the continent, resulting in a comparatively impoverished culture in Wessex (Parker Pearson 2005). It is clear therefore that the apparent 'decline' seen in Orkney during the Bronze Age is not unique to the islands.

2.4.1 Settlements

Over 210 Orcadian burnt mounds are listed in the RCAHMS Canmore database, making them the best recorded type of presumed Bronze Age domestic site in the islands. However, there is considerable debate over their actual date and function (e.g. Barber 1990). The burnt mounds appear to be evenly distributed throughout Mainland and most of the islands (Anthony 2003), as illustrated by Fig. 2.18.

Until recently it was assumed that Orcadian burnt mounds were almost exclusively in use during the Bronze Age (e.g. Ritchie 1995), despite the fact that in other areas of Britain they occur in contexts from the late Neolithic through to the medieval period. In Orkney, the burnt mound at Liddle has been radiocarbon dated to the middle Bronze Age (Hedges 1975), and a series of thermoluminescence dates for a group of seven Orcadian burnt mounds on Mainland and South Ronaldsay (see Fig. 2.18) suggested that they were in use from the middle to late Bronze Age (Huxtable *et al*. 1976). However recent research has shown that seven burnt mounds on the island of Eday range in date from the early Neolithic through to the Iron Age, although a peak in burnt

mound activity on the island does appear to occur during the Bronze Age (Anthony 2003).
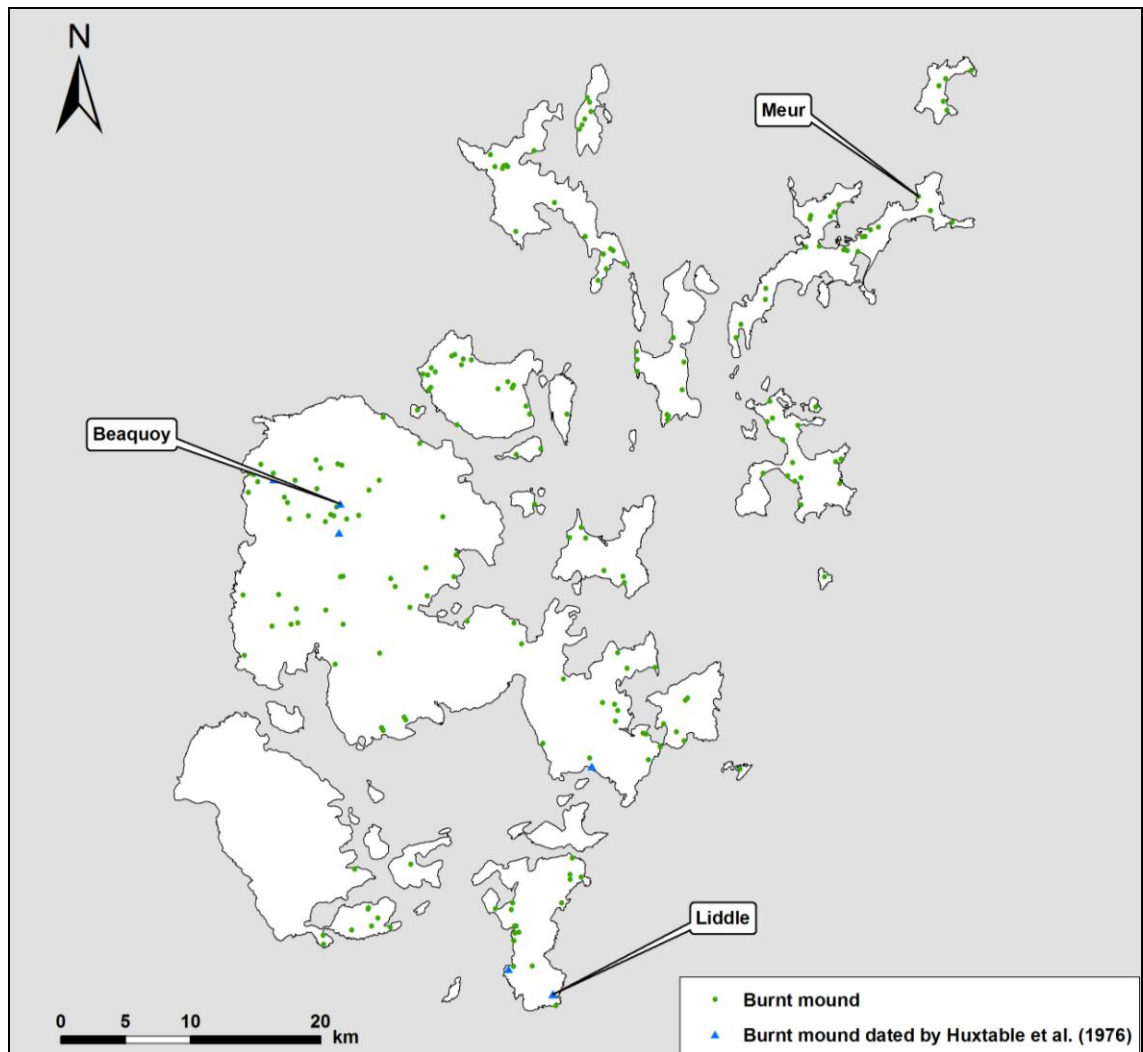
Figure 2.18 Distribution of Orcadian burnt mounds as recorded by the RCAHMS Canmore database (sites discussed in the text are labelled)

A typical burnt mound consists of a large heap of burnt stone and dark soil containing charcoal and ash, often associated with a stone slab-lined trough and situated close to a source of freshwater (Hedges 1975; Huxtable *et al*. 1976; Ritchie 1995). Traditionally the burnt stones have been interpreted as the waste products of a cooking technique which involved heating stones in a hearth and dropping them into a tank of water to heat it (O'Kelly 1954; Ritchie 1995). One problem with this interpretation is the lack of cooking debris at burnt mound sites, which is usually attributed to poor bone preservation in acidic soils (e.g. Hedges 1975; Huxtable *et al*. 1976; O'Drisceoil 1988).

However not all burnt mound sites have low soil pH, and at a site in Clydesdale bone was recovered from a wide variety of sites in the vicinity of two burnt mounds, yet not from the mounds themselves (Banks 1999). No bone was found at a burnt mound site in the West Midlands either, despite total sieving of large amounts of material, neutral soil pH, and finds of bone in pre-mound levels (Barfield and Hodder 1987). It therefore seems that the lack of cooking debris at these sites is real.

Apart from cooking, there have been many other suggestions as to the function of burnt mounds. The most notable of these is that they represent the sites of prehistoric saunas (Barfield and Hodder 1987; Armit and Braby 2002). Rather than stones being heated and placed into water to boil it, water would be placed on the heated stones in order to produce steam. Barfield and Hodder (1987) suggest that the absence of domestic debris at burnt mound sites and the small floor area of associated structures supports their interpretation as saunas. However O'Drisceoil (1988) has argued that the presence of a trough, usually surrounded by burnt mound material implying that stones were thrown straight out from the trough on three sides, and the absence of roofed structures at the sites, present major problems regarding this hypothesis.

Other suggestions for burnt mound function include industrial processes such as salt production, brewing, and textile processing (Barfield 1991; Jeffery 1991; Ripper 2003; Dockrill *et al.* 2007). However, as with the cooking and sauna hypotheses, there is a lack of positive evidence for any of these functions. It is also recognised that all burnt mounds did not necessarily share the same function (Barber 1990), or indeed that any one mound was limited to one function (O'Drisceoil 1988).

Following thermoluminescence dating of seven Orcadian burnt mounds (Fig. 2.18), Huxtable *et al.* (1976) suggested that they functioned primarily as permanent settlements, based on the wide range of dates obtained from individual sites which were assumed to represent prolonged occupation. Anthony (2003) also found that burnt mounds on Eday were in use over long periods of time, on the order of 1000 years. Following excavations at Liddle on South Ronaldsay, the discovery of a stone structure containing a hearth and a large central tank (see Fig. 2.19), interpreted as a house, in close proximity to the burnt mound led to the conclusion that the site was permanently occupied (Hedges 1975). Excavation of a burnt mound at Beaquoy, Harray revealed a similar stone structure, complete with hearth and clay-lined trough (Hedges 1975).

However Øvrevik (1985) believes that the small floor space of the structures means that they cannot have been permanently occupied, and it is possible that the wall at Liddle was little more than a revetment against the mound of stones (Ritchie 1995). Additionally, little domestic refuse was found associated with the structure at Liddle, and it is situated on boggy ground not ideal for settlement (Anthony 2003; Dockrill *et al*. 2007). In addition to Liddle and Beaquoy, the RCAHMS Canmore database records 11 other burnt mounds as having associated buildings of some sort.

In Britain, burnt mounds are usually found in marginal locations, but in Orkney they tend to be situated on the best agricultural land (Hedges 1975). This does not necessarily indicate a direct link between burnt mounds and settlement since the current distribution of burnt mounds may simply be due to factors of discovery and survival (Øvrevik 1985), although Hunter and Dockrill (1990) note that on Fair Isle in Shetland the distribution of burnt mounds has survived major agricultural changes, suggesting that here at least they can be used as indicators of early settlement locations. Dockrill *et al.* (1998) have demonstrated that in Shetland, although the location of burnt mounds may coincide with good land when examined at a large scale, at a more local scale many of them are sited in places that seem unsuitable for occupation. This may also hold true for Orkney.

Figure 2.19 Structure associated with the burnt mound at Liddle, South Ronaldsay, showing the large central tank

An alternative to the theory that burnt mounds represent permanent settlements is that they were situated on the periphery of settlements, rather than being the focus of them. Dockrill *et al.* (1998) have argued that structures associated with burnt mounds mainly represent buildings for the specialised use of hot stone technology, rather than being domestic houses, and Hunter and Dockrill (1990) have suggested that major burnt mounds may have had a specialised function within their contemporary landscapes. For example at Tangwick on Shetland, the presence of serving vessels within the pottery assemblage and the seemingly restricted nature of movement within the associated structure led to interpretation as a highly specialised site, perhaps at which seasonal feasting took place (Moore and Wilson 1999).

Communal feasting has also been suggested as the function of the burnt mound at Meur on Sanday (Toolis 2007). Here the apparent separation of the site within the contemporary settled landscape and the sophisticated nature of the structure associated with the burnt mound, which appears to have had a formal organisation of space around the central trough, led to the interpretation that this was a site where communal feasts were prepared in order to optimise the limited resources of the island's land holdings and help maintain social cohesion (Toolis 2007).

Very few Bronze Age hut circle and field system complexes have been identified in Orkney. Evidence for Bronze Age settlement in Scotland as a whole is patchy (Cowie and Shepherd 2003), and as Downes (2005) notes, the apparent scarcity of Bronze Age settlement evidence in Orkney is probably the result of a failure to identify it, rather than a real lack of occupation at this time. The Bronze Age settlements that are recorded by the RCAHMS Canmore database are shown on Fig. 2.20. All sites referred to in the text are labelled. Excavations at Spurdagrove revealed two hut circles, probably of Bronze Age date and forming part of a larger complex of circular structures, field walls and ditches (Hedges 1978a). At Whaness Burn on Hoy are the remains of two enclosed settlements containing several prehistoric houses and a series of sub-peat dykes. Enough structures have been detected in this valley to suggest that 150 ha of land was once in agricultural use, and the existence of sub-peat dykes implies that this was during the Bronze Age (Lamb 1996). Several other possible Bronze Age settlements have been identified on Hoy and South Walls (Lamb 1989; see Fig. 2.20), and survey work by Nayling (1983) led to the discovery of probable Bronze Age sub-peat dykes in many other locations, particularly on Eday. Fig. 2.20 also shows the

locations of currently recorded sub-peat dykes as they are generally thought to represent Bronze Age field systems (Lamb 1983). A recently discovered site at Old Head on South Ronaldsay may also date to the Bronze Age, based on comparison with similar sites in Shetland. The settlement at Old Head consists of several houses, field systems and clearance cairns (J.W. Hedges pers. comm.).
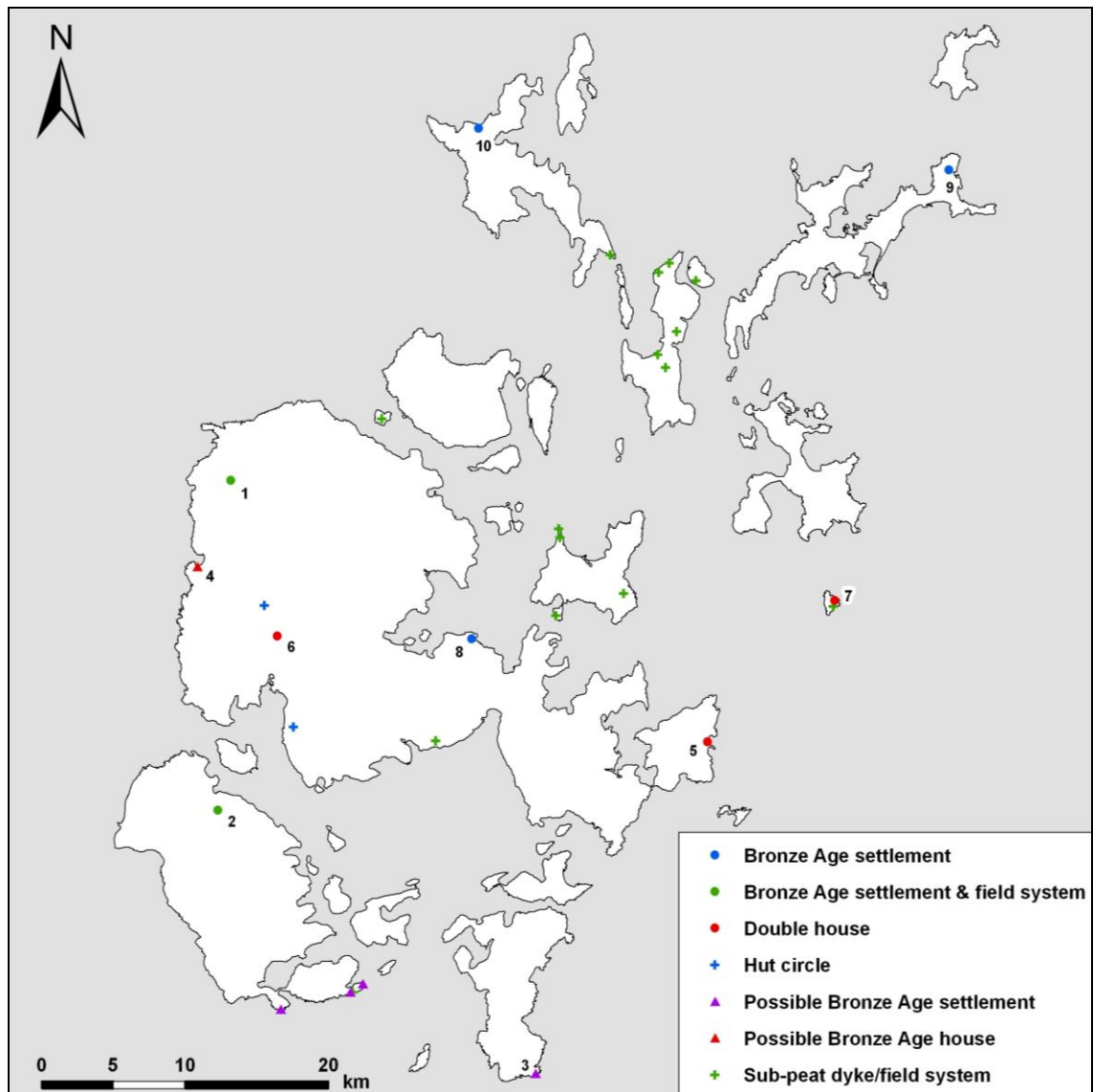
Figure 2.20 Location of Bronze Age settlements and field systems in Orkney (places discussed in the text are numbered): 1. Spurdagrove; 2. Whaness Burn; 3. Old Head; 4. Skara Brae house 8; 5. Skaill; 6. Wasbister; 7. Auskerry; 8. Crossiecrown; 9. Tofts Ness; 10. Links of Noltland

In a recent re-evaluation of presumed Neolithic houses in Shetland, Downes and Lamb (2000) have suggested that most are in fact Bronze Age, following a radiocarbon date of *c.* 2000 cal. BC from charred grain found under the wall of the structure at Ness of

Gruting. This house is similar to four others in Shetland, being oval in form with rounded cellular recesses set into the walls, and it is thought that they date from a similar period (Downes and Lamb 2000). Downes (2005) suggests that House 8 at Skara Brae, which has traditionally been interpreted as a workshop (Clarke and Sharples 1985), may in fact be a Bronze Age house on the basis of its similarities to those identified in Shetland.

Excavations at Sumburgh in Shetland revealed a 'double house' that was inhabited throughout the Bronze Age (Downes and Lamb 2000), and in recent years 'double houses' similar to this have been discovered in Orkney (see Fig. 2.20 for locations). At Skaill in Deerness, the initial structure was sub-oval with a south-east facing entrance, next to which a smaller house with a north facing entrance was built. Later the two buildings were linked by an adjoining south-west facing entrance. The settlement is thought to date from the middle to late Bronze Age (Buteux 1997). At Wasbister, geophysical survey has revealed a double house with a hearth in the centre of the larger house, surrounded by several other structures, field systems and enclosures (Card *et al*. 2005a; Card *et al*. 2007). Another double house has been identified on the island of Auskerry, along with the remains of other Bronze Age houses and prehistoric field dykes (Downes 2005).

The Neolithic-Bronze Age transition in Orkney is generally characterised by the abandonment of Neolithic settlements such as Pool (Hunter *et al*. 2007), Skara Brae (Childe 1931), Rinyo (Childe and Grant 1938) and Barnhouse (Richards 2005). However, as a result of recent research this view is now changing. A link between late Neolithic and Bronze Age settlement is provided by evidence from Crossiecrown on Mainland, where excavations revealed one large house of typical later Neolithic layout with a square central hearth, stone furniture and recesses in the walls, which was later replaced by another very similar house in a slightly different position (Card and Downes 2000). Associated midden deposits indicated a late Neolithic/early Bronze Age date for these structures, and the earlier house has since been radiocarbon dated to *c*. 2380 cal. BC, and the later to *c*. 1850 cal. BC (Downes and Richards 1998; Downes 2005). The settlement spans the transition from Neolithic to Bronze Age and the house has a similar plan to those in the late Neolithic 'village' settlements such as Skara Brae and Rinyo, but is situated in isolation (Downes 2005).

At Tofts Ness on Sanday further evidence for continuity of settlement over the Neolithic-Bronze Age transition is provided by a small, nucleated long-term settlement, apparently occupied continuously from the late fourth millennium to the mid second millennium BC. During the late Bronze Age at Tofts Ness, domestic settlement is represented by a roundhouse containing a central hearth and with radial divisions interpreted as defining sleeping and eating areas (Dockrill *et al*. 2007). Similarly, recent excavations at the Links of Noltland on Westray have revealed that following abandonment of the late Neolithic settlement at the site, occupation continued nearby. Three Bronze Age buildings were excavated adjacent to the Neolithic settlement, one of which has been interpreted as a domestic building that may also have provided shelter for animals. The second is thought to have been used as a byre or storehouse, but the third was too poorly preserved for its function to be ascertained (Moore and Wilson 2007).

It is clear from this review that more evidence for the Bronze Age settlement of Orkney is gradually beginning to emerge, undermining the popular opinion that Orcadian society became impoverished at this time (e.g. Øvrevik 1985; Ritchie 1995). The situation is summarised well by Downes (2005: 23), who states that 'It is quite clear that it is our approach to the Orcadian Bronze Age that is 'dull', and not that the Bronze Age society was uninspired.'

2.4.2 Burials

During the early Bronze Age in Orkney, chambered tombs continued to be used for burial (e.g. Henshall 1974). However in common with the rest of Britain at this time, communal burial in chambered tombs was gradually superseded by individual burial. In Orkney bodies were usually buried in a cist, and cremation was the dominant funerary rite. However this view has been shown to be over simplistic, since many Bronze Age burials contain the remains of multiple individuals either through a single interment of more than one person or through later additions to the burial site (Downes 2005).

Cists are stone boxes, which in Orkney were constructed from sandstone flags. The term 'short cist' is used to describe later prehistoric cists that were built to contain a crouched burial, as opposed to the long cists used from the late Iron Age onwards to house extended inhumations (Downes 2005). The term therefore describes a very broad class of monuments dating from the Neolithic through to the early Iron Age.

Around 100 short cists have been recorded in Orkney (Øvrevik 1985), and these can be classified into two types. The term 'unobtrusive cist' is used by Downes (2005) to describe cists which are set into the ground and do not appear to have been covered by a mound, and this terminology is adopted here. The other type of short cist occurs within barrows. A field survey carried out as part of the Orkney Barrows Project recorded a total of 565 barrows in 260 burial mound sites throughout the islands (Downes 1999; Downes 2005). The locations of all Orcadian short cists and barrows recorded by the RCAHMS Canmore database are illustrated in Fig. 2.21. All sites discussed in the text are labelled.
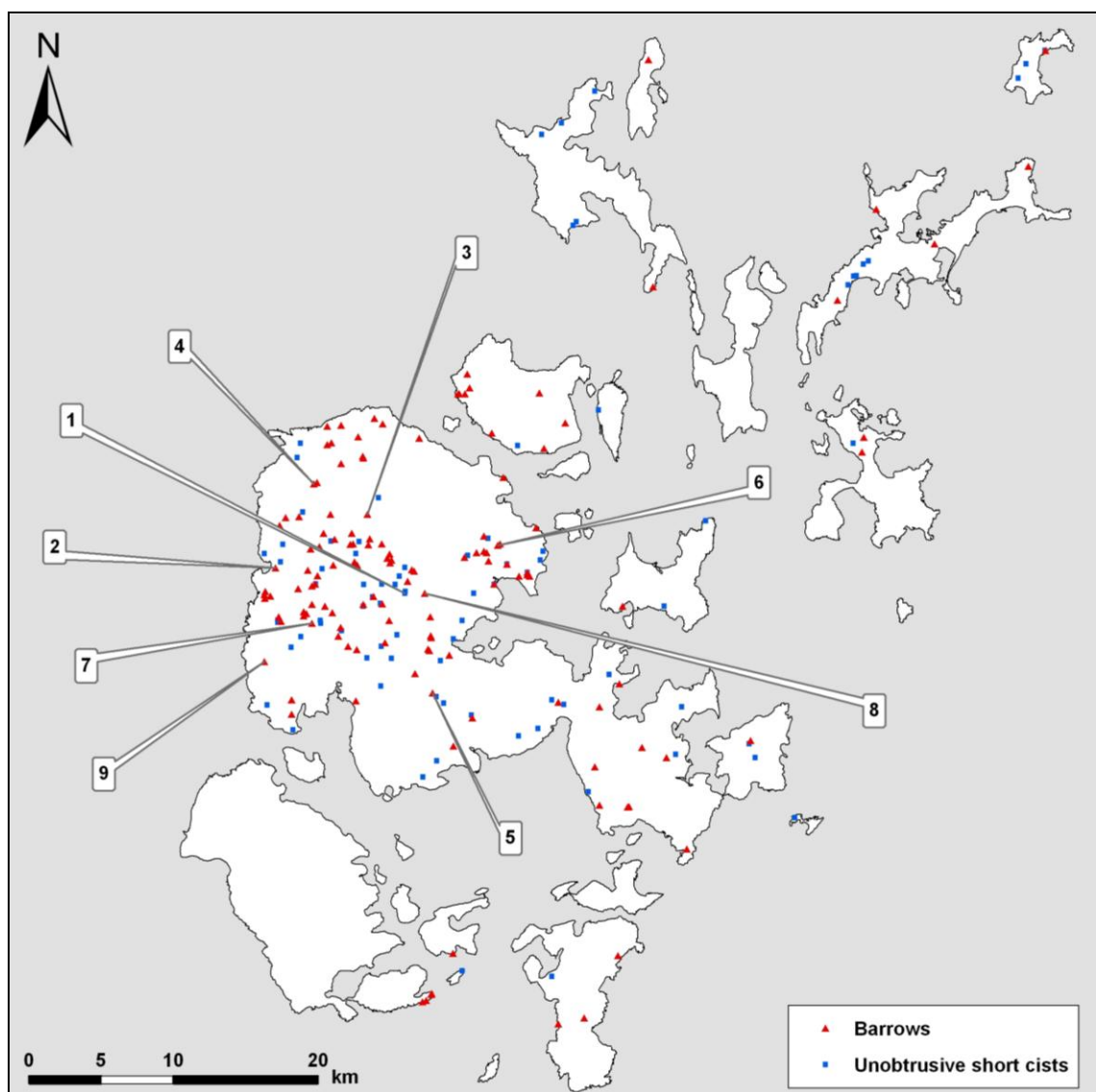
Figure 2.21 Distribution of Orcadian short cists and barrows as recorded by the RCAHMS Canmore database (sites discussed in the text are numbered): 1. Howe; 2. Sandfiold; 3. Knowes of Quoyscottie; 4. Queenafjold; 5. Summersdale; 6. Gitterpitten; 7. Linga Fiold; 8. Knowes of Trotty; 9. Mousland

Despite the apparent existence of two different types of short cist (unobtrusive and barrow), very few of these monuments have been fully excavated and it is unclear whether they might all have originally been covered by mounds and therefore represent a single type of Bronze Age burial. There are several similarities between unobtrusive cists and barrow cists, suggesting that they may indeed represent a single burial tradition.

In general, unobtrusive cist burials are earlier in date than barrow burials and seem to have been designed to be re-entered and re-used in terms of having further burials placed in them, in a similar manner to the Neolithic chambered tombs (Downes 2005). An inhumation burial within an unobtrusive cist at Howe in Harray has been radiocarbon dated to *c*. 2830 cal. BC (Downes 2005), and the cist at Sandfiold in Sandwick is thought to have been constructed and first used between 2900 and 2500 cal. BC (Dalland 1999). It seems that unobtrusive cists were not constructed after the early Bronze Age, although some continued to be used throughout the entire Bronze Age (Downes 2005). For example a second inhumation burial was inserted into the cist at Sandfiold between 2200 and 1700 cal. BC, and the last use of this cist is believed to have been some time between 1000 and 800 cal. BC, when cremated human bone was placed into it (Dalland 1999).

During the first half of the second millennium BC burials were more commonly placed in barrow cemeteries and cremation became the dominant burial rite, although unobtrusive cist burials and inhumation did still occur (Downes 2005). An example of a barrow cemetery is provided by the Knowes of Quoyscottie in west Mainland. This is a group of ten mounds, of which four were excavated and three were found to contain cremated bone (Hedges 1977). Slightly to the north of this barrow cemetery lie the Knowes of Cuean, a group of seven largely destroyed mounds thought to have originally been part of the Quoyscottie cemetery (Hedges 1977).

In the second half of the second millennium BC burials appear more sporadic and most commonly took the form of cremations placed in pits at barrow cemeteries such as Knowes of Quoyscottie, where several of these pits cluster around just one of the barrows (Hedges 1977). It is possible that these flat cremation cemeteries also occur elsewhere, since at other excavated barrow cemeteries such as Queenafjold (Ritchie and Ritchie 1974) and Summersdale (Ashmore 1974) only one mound was excavated,

leaving the evidence inconclusive (Hedges 1977). Occasional inhumation burials thought to date from this period have also been found (Downes 2005). During the late Bronze Age, burial practices do not appear to change, with cremations either being added to unobtrusive cists (e.g. Sandfiold: Dalland 1999) or placed in pits at barrow cemeteries (e.g. Quoyscottie: Hedges 1977; Gitterpitten: Downes 2005).

It can therefore be seen that the two types of Bronze Age burial, i.e. unobtrusive cists and barrow burials, occur throughout the entire period, although both are more prevalent in the early Bronze Age. Other similarities are that both cremation and inhumation burials occur in both types of monument, and that both types of burial can occur either singly or in groups (Hedges 1980; Downes 2005).

Despite these similarities, there are also many differences between the unobtrusive cists and the barrows. In terms of setting, barrows are often situated close to areas of settlement, whereas unobtrusive cists tend to have been placed in more 'natural' places, for example knolls, rocky crevices, or close to the sea (Downes 2005). The two types are also architecturally distinct, as unobtrusive cists are negative, underground features whereas cists within barrows are usually constructed on the ground surface. Unlike the unobtrusive cists, cists within or around barrows were not designed to be re-entered and secondary burials were always placed above or around the primary burial rather than within it (Downes 2005).

There are also differences in terms of the items of material culture that are discovered within the two types of burial. Food vessels have been found in unobtrusive cists, whereas in barrow cemeteries steatite urns usually containing cremations occur. The few finds of metalwork that have been recovered from Bronze Age burials were all from barrow cists rather than unobtrusive cists. Additionally, stone implements relating to cultivation are commonly found within barrow burials but very rarely occur in unobtrusive cists (Downes 2005).

Based on these differences, Downes (2005) considers that unobtrusive cists are typologically distinct from barrow burials, and therefore that there were two architecturally distinct types of burial tradition running in parallel throughout the Bronze Age. The view that unobtrusive cists and barrow cists were typologically distinct was also proposed by Hedges (1980) in his review of excavated short cists in

Orkney. However not all burials in short cists are necessarily Bronze Age, since some Scottish short cists have been found to contain grave goods that date from the early Iron Age. Hedges (1980) points out that there is very little evidence for Iron Age burial practices in Orkney, and is possible that some short cists actually date to this period rather than to the Bronze Age.

Previous studies of the location of barrows in Orkney have focused on the position of the monuments in relation to cultivable land, leading to the conclusion that they were deliberately constructed on marginal land and may have marked territorial boundaries (e.g. Parry 1977; Øvrevik 1985). However this may simply be due to factors of preservation, because land-use since the Bronze Age means that the current distribution of barrows is probably as much a result of destruction of sites by cultivation as anything else. It is apparent from the results of the Orkney Barrows Project that Orcadian burial mounds are predominantly sited in prominent positions on hill summits or ridges, and most are visible from several directions from a distance of 2-5 km (Downes 2005). It may be that visibility was a more important factor in the positioning of these mounds than land-use.

Several sites were excavated as part of the Orkney Barrows Project, including Linga Fiold and the Knowes of Trotty. At Linga Fiold nine of the fifteen mounds were investigated and several features, all associated with different stages of cremation, were revealed. These included pyre sites, spreads of pyre debris, around 100 cists and pits, and a mortuary building (Downes 2005). Palynological investigation of samples from Linga Fiold indicated that *Plantago lanceolata*, a plant that is strongly associated with pasture land (Sagar and Harper 1964; Behre 1981), was deliberately deposited in some of the cists (Bunting *et al*. 2001). High values of *P. lanceolata* pollen were also reported from the burial at Mousland in Stromness (Downes 1994). At several other Bronze Age sites in Scotland (e.g. Tipping 1994a; Clarke 1999) high values of *Filipendula* pollen have been interpreted as reflecting floral offerings included with the burial. This plant has an attractive flower and scent and it has been suggested that it had a symbolic significance in the Bronze Age (Clarke 1999). Since *Plantago lanceolata* does not have a particularly distinctive or attractive flower it is suggested that it may have had a ritual rather than a decorative significance which led to its inclusion in Bronze Age Orcadian burials (Bunting *et al*. 2001).

The cemetery at the Knowes of Trotty consists of 16 barrows arranged in a double row which extends over a distance of 375 m. A rare find of rich grave goods associated with a Bronze Age burial in Orkney occurred during excavations at the site in the 1850s, which recovered four gold discs and several amber beads and spacer plates from a cist in one of the mounds (Petrie 1860). More recent excavations have uncovered evidence of the pyres used for cremation and of several cists and pits, and work is still ongoing (Downes 2005).

Recent investigation of barrow cemeteries through geophysics and excavation has shown that there is huge variety and complexity in these monuments and has revealed several associated features. These include clusters of pits and cists containing cremated remains in flat cemeteries close to barrows at Linga Fiold, Gitterpitten and the Knowes of Trotty. Pyre sites have been excavated at Linga Fiold and the Knowes of Trotty, with redeposited pyre material and mortuary buildings providing evidence for all stages of the cremation process (Downes 2005).

2.4.3 Ceremonial Monuments

Bronze Age ceremonial activity appears to have been focused around the same sites that were used in the preceding Neolithic period. Many sites appear to have been added to and adapted at this time (e.g. Ritchie 1976), and many of the single standing stones in the islands may have been erected during the Bronze Age (Wickham-Jones 2006).

The late Neolithic ceremonial monuments of the Ring of Brodgar, the Stones of Stenness, Maeshowe and the Ring of Bookan seem to have acted as a focus for Bronze Age burial mounds (see Fig. 2.15). The positioning of these mounds respects the earlier monuments, emphasising their continued importance during this period. The significance of the Ness of Brodgar at this time is attested to not only by the number of barrows erected in the area, but also by the range of different barrow types present and the scale of some of the mounds (Card 2005).

In 1934 a total of nine burial mounds were present in the vicinity of Maeshowe, although only one still survives. Around the Stones of Stenness six mounds were recorded in the 19th century, none of which can be seen today. Around the Ring of Brodgar, four large barrows and nine smaller barrows still survive (Card 2005; Wickham-Jones 2006). To the north of the henge on the shore of the Loch of Stenness

is a disc barrow, a type which is rare in Orkney (Card 2005). Eleven barrows have been recorded around the Ring of Bookan, although seven of these have since been destroyed by cultivation. In addition to the barrows clustered along the Ness of Brodgar numerous unmarked cist burials have also been uncovered (Card 2005), and there are indications that there may also have been unmarked cremation burials in pits in the area (Wickham-Jones 2006).

Potential evidence for another aspect of ceremonial activity is provided by the recent discovery of a late Bronze Age socketed axehead during peat cutting at Hobbister in Orphir (Cowie and O'Connor 2006), leading to suggestions that the axe was deposited as a ritual act (Towrie 2006). Throughout northern and western Europe, ritual deposits of precious metalwork and other items were made in rivers and marshes during the Bronze and Iron Ages (Bradley 1990; Coles and Coles 1995), perhaps in response to environmental changes that were taking place (e.g. Pryor 2001).

Bronze Age metalwork (particularly that of the late Bronze Age) found in peat has been reported throughout Scotland, although these are rarely interpreted as votive deposits (Coles 1959; 1963; 1969). It is however possible that these were ritually deposited in the peat bogs in which they were found as a response to the expansion of blanket peat into agriculturally valued landscapes that occurred as a result of the widespread northwest European climatic change at *c*. 850 cal. BC (e.g. van Geel *et al*. 1996; Mauquoy *et al*. 2004; Blundell and Barber 2005; Swindles *et al*. 2007). In Orkney, Bronze Age objects have been discovered during peat cutting in the past (e.g. Cursiter 1887; 1908; Stevenson 1958; O'Connor and Cowie 1995), although the provenance of these objects is not well recorded and unfortunately it is not possible to determine whether they were casual losses or intentional deposits; some authors suggest that they were votive deposits (e.g. Øvrevik 1985; Wickham-Jones 2006).

2.4.4 Economy

Much of the current economic evidence for the Orcadian Bronze Age comes from the site of Tofts Ness on Sanday, which suggests a mixed subsistence economy based on animal husbandry and arable cultivation of six row barley (Dockrill *et al*. 2007). Sheep and cattle were reared at Tofts Ness, along with a small number of pigs, and there seems to have been a general shift in favour of sheep over cattle over time at the settlement (Nicholson and Davis 2007). There is also an increase in the mortality rate of calves

over time, perhaps implying a shift in strategy towards the exploitation of milk products and dairying (Nicholson and Davis 2007; Serjeantson and Bond 2007a).

Red deer were occasionally exploited, and the presence of both juvenile and adult bones in the Tofts Ness assemblage are interpreted as evidence that a stable breeding herd was present on Sanday throughout the Bronze Age. It also appears from the quantity of bone fragments present that marine mammals were a minor resource at Tofts Ness, although the small number of bones recovered from the site may simply reflect the butchering of the carcasses at the beach rather than at the settlement (Nicholson and Davis 2007). Analysis of the fish bones recovered from the site indicates inshore fishing from boats as well as line fishing from rocks, and that fish from the littoral zone and rock pools may have been an important resource during the Bronze Age (Nicholson 2007a).

The calcareous sands of the Bronze Age Tofts Ness landscape would have been extremely marginal for arable activity due to a lack of available water in summer and a high risk of erosion when cultivated (Simpson *et al*. 2007). However, soil thin section analysis of samples from Tofts Ness indicates that moderately intensive cultivation took place during the Bronze Age (Simpson *et al*. 1998). A combination of soil analyses undertaken on these samples has shown that domestic waste midden including faecal material (primarily human, perhaps implying that animal manure was valued as a fuel source), grassy turf material and ash was added to the soil throughout the Bronze Age (Simpson *et al*. 1998; Bull *et al*. 1999; Simpson *et al*. 2007). This intensive manuring made sustained arable production viable in this landscape by providing additional nutrients and enhancing soil stability (Simpson *et al*. 2007). Preliminary surveys of the Hacks Ness and Spurness peninsulas, also on Sanday, have revealed extensive evidence of anthropogenic soils around prehistoric structures, indicating that these intensive manuring practices were also in use elsewhere (Simpson *et al*. 1998).

The importance of cultivation in the Bronze Age is attested to by the common occurrence of stone ard shares and other agricultural implements in funerary contexts (Hedges 1977; Øvrevik 1985; Clarke 2007a). Further evidence for arable farming during the Bronze Age is provided by the wooden yoke found at White Moss, Shapinsay, which has been radiocarbon dated to *c*. 1380 cal. BC (Hedges *et al*. 1993).

Indications in the form of sub-peat dykes (e.g. Lamb 1983; Nayling 1983) also suggest that considerable land enclosure took place at this time.

2.4.5 Material Culture

Bronze Age pottery finds mainly comprise simple urn forms from funerary contexts. The pottery largely appears to be locally manufactured (e.g. Williams 1977) and the style seems to have developed in response to imported funerary rituals, displaying little of the variety of styles seen in the rest of Britain (Øvrevik 1985). Domestic pottery from the early Bronze Age found at Tofts Ness, Sanday, is similar to that of the late Neolithic, with a high incidence of incised decoration, whilst that of the late Bronze Age is barrel-shaped, flat-rimmed and undecorated (MacSween 2007b). The stone and bone tool assemblages recovered from Bronze Age contexts at Tofts Ness are similar to those from Neolithic contexts both at this site and elsewhere in Orkney, indicating a degree of continuity (Dockrill *et al.* 2007).

Steatite vessels occur in several cists and barrows, and radiocarbon dating of cremated bone found with these vessels has shown that most date from the early Bronze Age (Sheridan 2003). Recent excavations at Skaill, Deerness and Tofts Ness have now demonstrated that steatite vessels also occur in domestic contexts (Buteux 1997; Smith 2007a). Since the nearest source of steatite is Shetland, this implies trade links between the two groups of islands at this time (Øvrevik 1985; Smith 2007a). A clay incense cup from a barrow in South Ronaldsay is unique in Orkney and may represent a link between Ireland and Orkney in the early Bronze Age (Øvrevik 1985).

There have been less than twenty finds of Bronze Age metalwork from Orkney and many of these are unprovenanced (Øvrevik 1985). While copper ore occurs in several places on Orkney, there is no evidence to suggest that it was exploited in prehistoric times (Ritchie 1995; Wickham-Jones 2006) and therefore those bronze artefacts that have been found were almost certainly imported. Early Bronze Age metal artefacts include two or three flat axes, a dagger, and the four gold discs from the Knowes of Trotty. From the middle Bronze Age a flanged axe, a spearhead, a sandstone mould for a flanged axe, and a razor have been found. The presence of a mould implies knowledge of the process of metalworking, and although it seems that this did not take place in the islands, it perhaps suggests that metalworking may have held some symbolic significance. Late Bronze Age artefacts consist of socketed axes, socketed

knives, spearheads and razors (Øvrevik 1985; Buteux 1997). A particularly interesting late Bronze Age find is a wooden leaf-shaped sword made from yew, discovered during peat cutting in east Mainland (Stevenson 1958).

The small number of bronze objects in Orkney from the early Bronze Age is characteristic of the north of Scotland in general (Coles 1969). The relative lack of middle Bronze Age artefacts from Orkney, however, is often interpreted as implying that the islands underwent some degree of regional insularity and failed to keep up with the developments that were occurring in the rest of Britain at this time (e.g. Øvrevik 1985; Ritchie 1995). It may be that this apparent scarcity of metalwork reflects biasing of the record, since as discussed earlier several metal objects from this period have been recovered during peat cutting and it may be that many more remain to be discovered. However peat in the islands has been cut for fuel fairly intensively in the recent past (Berry 2000), and it is likely that the lack of Bronze Age metalwork in the islands is real. It seems that metal artefacts were more commonly used in Orkney by the late Bronze Age (Øvrevik 1985), which correlates with the increase in their production which occurred in Scotland at this time (Coles 1964).

In general, the metal artefacts and pottery from Orkney seem to suggest a lack of regular contact with the rest of Britain, except for Shetland, during the Bronze Age. The steatite vessels suggest steady trade with Shetland, although the metal artefacts, particularly those from the early and middle Bronze Age, are believed to represent periodic imports rather than trade (Øvrevik 1985). It is possible that the widespread northwest European climatic change at *c*. 850 cal. BC (e.g. van Geel *et al*. 1996; Mauquoy *et al*. 2004; Blundell and Barber 2005; Swindles *et al*. 2007) disrupted Atlantic trade routes. This could account for the apparent isolation of Orkney during the middle Bronze Age (Øvrevik 1985), at a time when a decline in trade with continental Europe is also argued to have resulted in an 'impoverished' culture in Wessex in southern England (Parker Pearson 2005).

2.4.6 Social Organisation

Social organisation in Orkney during the Bronze Age appears to have developed along locally autonomous lines, continuing the process of social fragmentation and isolation which is now hypothesised to have begun towards the end of the Neolithic period (e.g. Richards 1998). The settlement evidence and the barrow cemeteries indicate a scattered

settlement pattern, and support for the existence of a largely autonomous society during the Bronze Age is also provided by the massive linear earthworks that run for long distances across Orkney, known as 'treb dykes' (Lamb 1983). These features appear to define territories, and due to their size they are believed to relate to a political or administrative system rather than to private ownership. The treb dykes do not conform to any known historical administrative divisions, such as *tunships* or the medieval *urislands* (McKerral 1951; Lamb 1983), and Lamb (1983) suggests that they are the remains of a land-allotment system that broke down at the end of the Bronze Age.

This process of social fragmentation and division of the landscape into territories seems to have taken place throughout Britain during the Bronze Age. Several upland regions in south-west England, including Dartmoor (Fleming 2008), Bodmin Moor (Brisbane and Clews 1979) and Penwith (Herring 2008), were divided into field systems at this time, and regions of sandy soils such as the New Forest and the Weald also began to be occupied (Parker Pearson 2005). In northern England, field systems have been identified in parts of the Peak District, North Yorkshire and upper Teesdale (Fleming 2008). The limestone areas of the White Peak in Derbyshire had been settled since *c*. 2500 cal. BC, but the less fertile soils on the millstone grit of the Dark Peak were largely colonised only after *c*. 1800 cal. BC (Parker Pearson 2005).

The remnants of the system of Bronze Age land division on Dartmoor can be seen today in the form of 'reaves', which are low, collapsed stone walls covered by turf and heath. These walls divide the moors into five main territories, each of which is subdivided into large strips formed by parallel reaves. Some of these strips were further divided into smaller fields (Fleming 2008). It seems that considerable planning went into the division of land in this area, and Fleming (2008) suggests that the Bronze Age field systems of Dartmoor represent the management of land held collectively by a sizeable community, perhaps within a stratified, hierarchical society. However Johnston (2005) has recently argued that the reaves merely represent a formalisation of pre-existing boundaries with a long and complex history, and that this emerged within particular traditions of land tenure and use and did not require the presence of an elite controlling authority or the structuring influence of a commonly conceived plan. In the medieval period, organised field systems are known to have been associated with both autonomous and hierarchical societies (Baker and Butlin 1973; Williamson 1988), and it is unclear on the basis of the current evidence which of these types of society was

responsible for the changes in settlement pattern and land organisation seen in the Orcadian Bronze Age.

It has been suggested that the effects of the northwest European climatic deterioration at *c*. 850 cal. BC (e.g. van Geel *et al*. 1996; Mauquoy *et al*. 2004; Blundell and Barber 2005; Swindles *et al*. 2007) resulted in the abandonment of more marginal, upland areas of Britain, leading to increased competition for land in the more fertile lowlands (e.g. Champion 1999; Parker Pearson 2005). In Orkney, it has been hypothesised that this climatic deterioration led to the demise of the land-allotment system defined by the treb dykes (Lamb 1983; Wickham-Jones 2006). In addition, it has been argued that distal effects of the eruption of Hekla in *c*. 1159 cal. BC may have caused widespread settlement abandonment across northern Scotland during the late Bronze Age (e.g. Burgess 1989; Grattan 1998; Grattan and Gilbertson 2000), and this may also have been a contributing factor in Orkney (e.g. Ritchie 1995).

This increased competition for land would have meant that it became more important for individuals to demonstrate social dominance, and across Scotland and the rest of Europe during the Bronze Age cultural emphasis seems to have shifted towards a rise in the significance of individuals, as opposed to the significance of communities and ancestors seen in the Neolithic evidence (e.g. Ashmore 1996; Harding 2000). This trend is also seen to some extent in Orkney, where certain individuals were able to amass personal wealth at this time, such as the person buried at the Knowes of Trotty with four gold discs and several amber beads (Coles 1969).

Parker Pearson (2005: 96) states that during the Bronze Age 'from an archaeological point of view, the landscape of the dead was replaced by a landscape of the living', with the communal burial monuments such as the chambered tombs of Orkney falling out of use and the landscape being divided up for agricultural purposes. The remains of the dead were no longer at the centre of life, and personal identities became less defined by lineage and more by territory, with control over land being as important as control over people (Parker Pearson 1999).

2.5 Iron Age (*c*. 800 cal. BC – *c*. 600 cal. AD)

In the north of Scotland the Iron Age is generally subdivided into early (up to *c*. 200 cal. BC), middle (*c*. 200 cal. BC – *c*. 300 cal. AD) and late (*c*. 300 – *c*. 800 cal. AD)

(Foster 1990). The term Pictish is usually applied in Orkney to material dating from around 600 cal. AD (Card 2005).

2.5.1 Settlement

The locations of all Orcadian roundhouses, brochs and other types of Iron Age settlement recorded by the RCAHMS Canmore database are shown in Fig. 2.22. Sites discussed in the text are labelled. During the early Iron Age, between *c.* 800-400 cal. BC, substantial drystone roundhouses were constructed in Orkney, with examples known from Bu, Quanterness, Tofts Ness and Pierowall. These are all isolated single farmhouses and are termed simple Atlantic roundhouses (Armit 1991). Some sort of social change is indicated by the decision to build these distinctive and substantial structures, and it has been hypothesised that the earliest, simple roundhouses were occupied by elite members of society. It is thought that part of their function was to demonstrate the power and territorial control of their inhabitants on a local scale (Armit and Ralston 2003). It is possible that these changes are linked with climatic deterioration (e.g. van Geel *et al*. 1996; Mauquoy *et al*. 2004; Blundell and Barber 2005; Swindles *et al*. 2007) and agricultural intensification (e.g. Keatinge and Dickson 1979), resulting in greater competition for land and a more aggressive society (Hedges 1987; Ritchie 1995; Armit 2003).

Hingley (1992) has argued that the construction of the roundhouses represents a new application of the concept of monumentality, as they mark a significant departure from the cellular, semi-subterranean house forms of the Neolithic and Bronze Age. The Orcadian evidence has been interpreted as indicating that the occupants of the roundhouses were using the status of their ancestors and past monumental construction to enhance their own status, with many roundhouses being built on the site of chambered tombs, for example Pierowall (Sharples 1984), Quanterness (Renfrew 1979) and Howe (Ballin Smith 1994). There is also evidence for the reuse of old house sites and reconstruction of disused house structures at Howe (Ballin Smith 1994) and at Pool, Sanday (Hunter *et al*. 2007), adding further weight to the argument that the people who inhabited the roundhouses were drawing on the status of their predecessors (Hingley 1992).
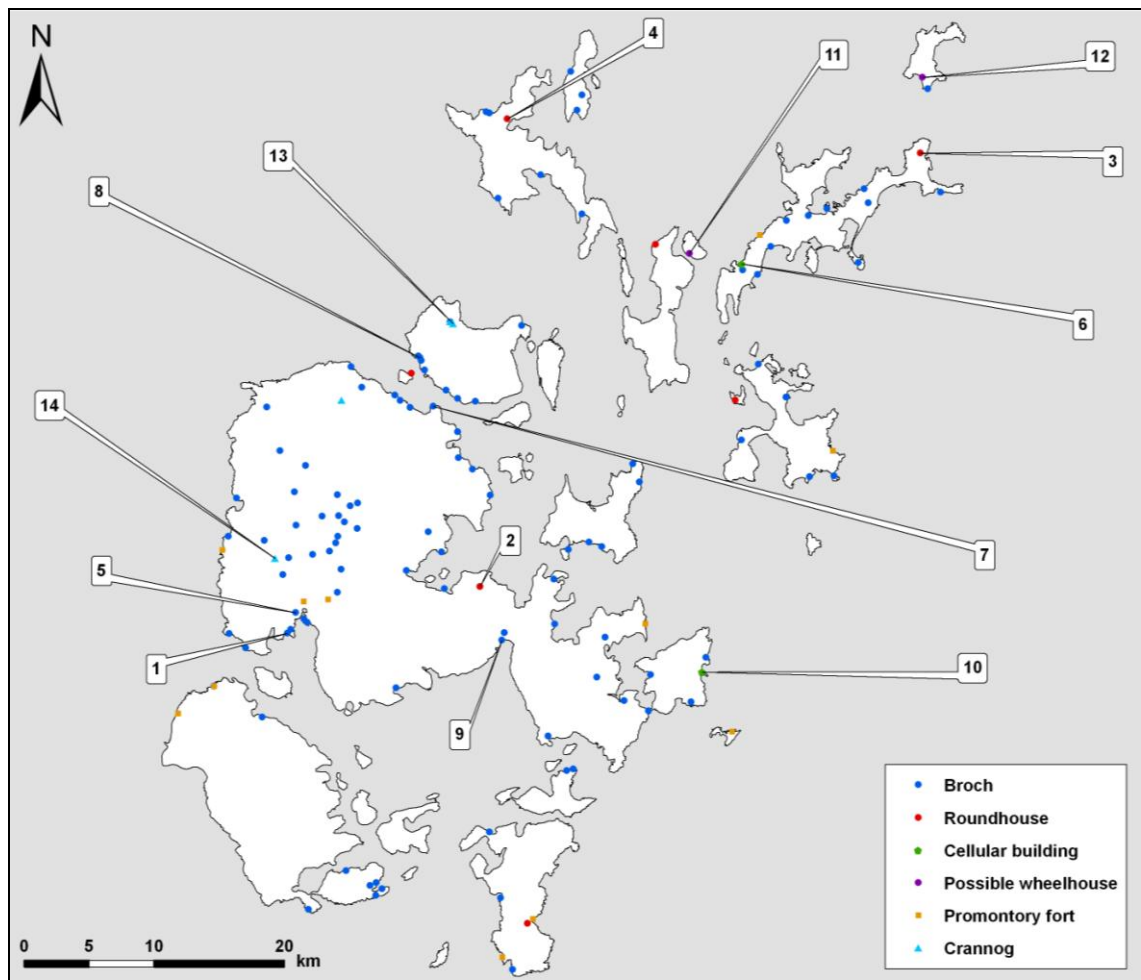
Figure 2.22 Distribution of Orcadian roundhouses, brochs and other types of presumed Iron Age settlement, as recorded by the RCAHMS Canmore database (sites discussed in the text are numbered: 1. Bu; 2. Quanterness; 3. Tofts Ness; 4. Pierowall; 5. Howe; 6. Pool; 7. Gurness; 8. Midhowe; 9. Lingro; 10. Skaill; 11. Calf of Eday; 12. Howmae; 13. Bretta Ness; 14. Voy

From *c*. 400 cal. BC radiocarbon dates indicate that the simple roundhouses had been abandoned and were beginning to be replaced by more architecturally complex roundhouses (Armit 1991), such as that at Howe, Stromness, which was occupied from *c*. 600 cal. BC (Ballin Smith 1994). These complex roundhouses incorporated some features of broch architecture, although they were not built on the same scale as the broch towers (Armit and Ralston 2003).

This architectural tradition culminated in the construction of the 'true' broch towers during the second and third centuries BC (Armit 1991). These are tall, drystone round towers (Fig. 2.23), which taper in diameter with height. The structures are hollow-walled with intra-mural staircases and galleries and they usually have a single entrance, often reached via a passageway (Hedges 1985; Armit 2003). Another characteristic feature is the scarcement ledge, which projects from the inner wall to form

a circuit around the interior of the broch, at an average height of around 2.4 m (Armit 2003). Brochs have no windows, although they frequently contain vertical rows of window-like holes known as 'wall voids' in the inner wall face. The entrances of brochs appear to be highly defended by having recessed doorways, often with small chambers usually referred to as 'guard cells' partway along the entrance passages (Hedges 1985; Armit 1991). It is believed that the broch towers would originally have been roofed, although how this would have been achieved is a matter of considerable debate (Armit 2003).

Figure 2.23 The Broch of Gurness, west Mainland. The outer 'defences' can be seen in the foreground.

Brochs were originally interpreted as defensive structures (e.g. Graham 1947), although this hypothesis is no longer generally accepted since in most brochs access to the wall-head is limited and they are not always sited in the most tactical locations for defence, often with no access to a water source (Harding 2006). Although some features of broch architecture such as height, 'guard cells' by the entrances and lack of windows do seem to indicate a defensive function, it has been argued that these features may reflect seasonal raiding or localised short-term, perhaps ritualised, conflict rather

than large-scale warfare, since the brochs do not seem to have been designed to protect resources such as cattle or crops (Hingley 1992).

An as yet unpublished architectural study of brochs by John Hope led to the suggestion that many features of their design may have contributed to the weather-proofing of the buildings. The intra-mural galleries would have prevented the penetration of rainwater through the inner wall, keeping the inside of the structure dry. The wall voids would have allowed warm air from inside the building to circulate within the intra-mural space, and the combination of galleries and voids may therefore have been designed to keep the inside of the brochs warm and dry (Armit 2003). One explanation for the function of the scarcement ledge is that it acted as the support for a floor, upon which was the main domestic space of the broch, the ground floor being used to shelter stock which would have generated heat that passed up through the floor above into the living space (Armit 2003). The basic principles by which broch architecture may have contributed to the weather-proofing of the structures are illustrated in Fig. 2.24.

A distinctive feature of the Orcadian Iron Age is the occurrence of nucleated settlements clustered around some of the brochs, for example at Gurness (Fig. 2.25), Midhowe, Howe and Lingro (Armit 2003). These settlements are often situated within substantial enclosures or located on defended coastal promontories, and it is clear that they supported large communities. As discussed earlier the brochs in these settlements are no longer generally thought of as defensive structures, since the internal space is clearly not large enough to protect people from the entire settlement as well as resources such as cattle and crops (Hingley 1992). The brochs in these settlements have been interpreted as the homes of elite members of society, who drew surplus agricultural produce and labour services from dependent, subsidiary households in the settlements (Hingley 1992).
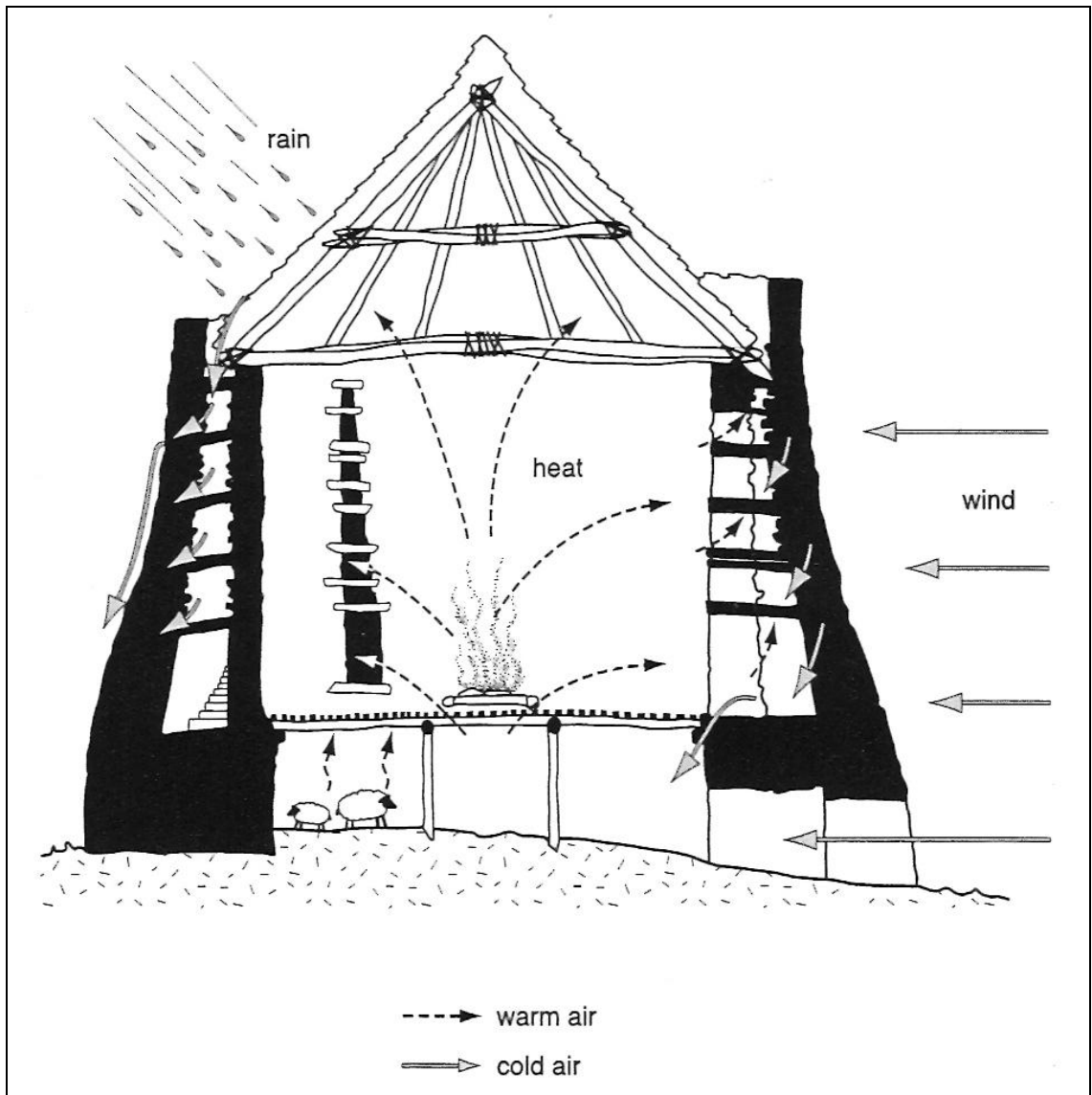
Figure 2.24 Illustration of the basic principles by which broch architecture may have contributed to the weather-proofing of the buildings (Armit 2003)

Figure 2.25 Nucleated village settlement at the Broch of Gurness, west Mainland

Several brochs incorporate underground chambers (Hedges 1985), generally interpreted either as wells or as cellars used for storage (Ritchie 1995). Underground cellars or souterrains, usually entered via a passage, are also found independently of brochs and around 40 of these sites have been recorded in Orkney (Fig. 2.26). They are generally interpreted as Iron Age on the basis of evidence from mainland Scotland, although one in Shetland at Jarlshof is thought to be of late Bronze Age date on the basis of material culture (Hamilton 1956), but this has not been confirmed by radiocarbon dating. According to recent research, Orcadian examples are usually late Bronze Age or Iron Age in date (M. Carruthers pers. comm.).
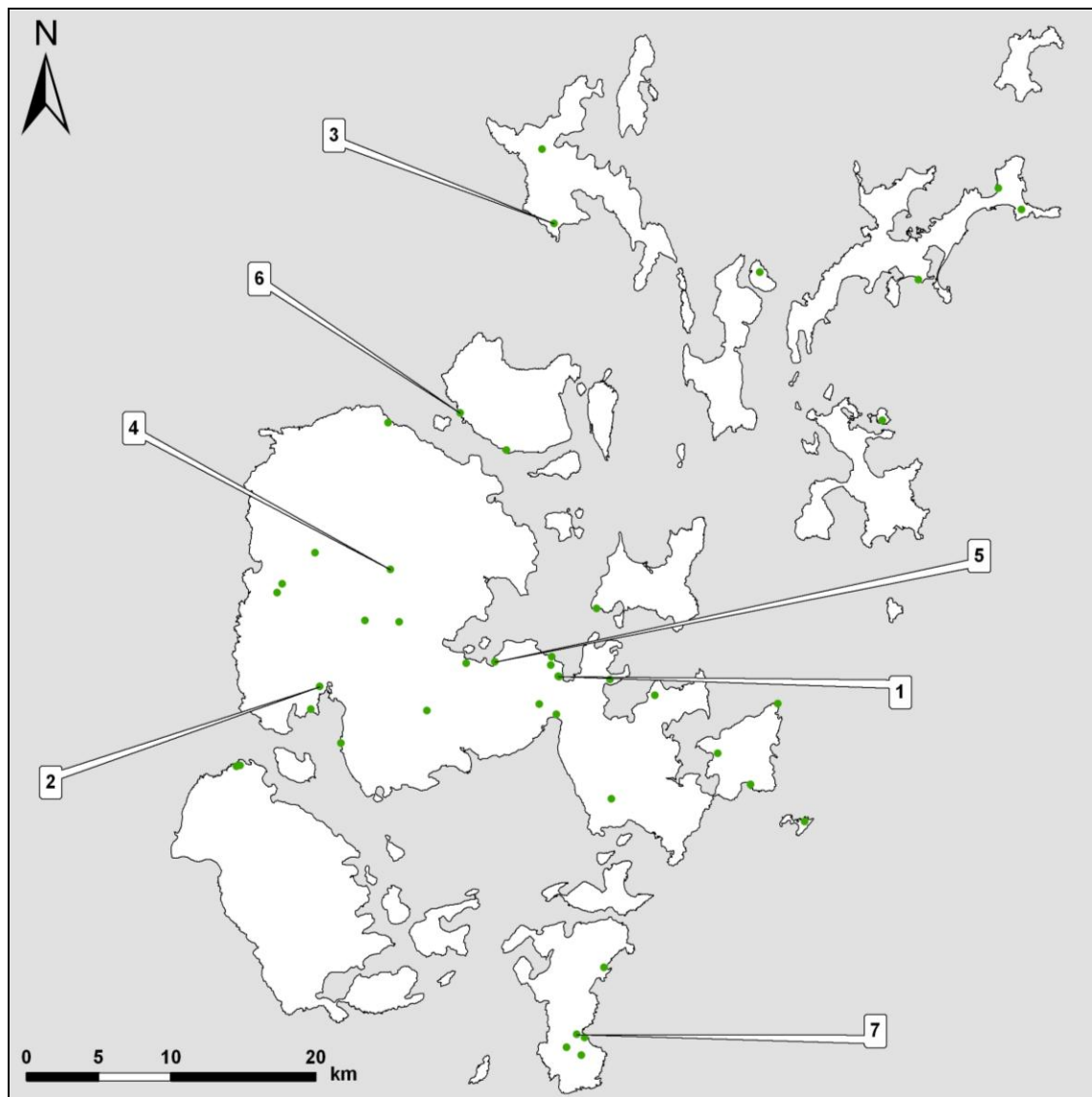
Figure 2.26 Distribution of Orcadian souterrains as recorded by the RCAHMS Canmore database (numbers represent sites discussed in the text): 1. Grainbank; 2. Howe; 3. Langskaill; 4. Nessbreck; 5. Rennibister; 6. Rowiegar; 7. Windwick

Following excavation of the souterrain at Grainbank near Kirkwall in 1857, it was discovered that the land surface above the structure contained extensive evidence of contemporary domestic settlement, although this is undated (Ritchie 1995). During later excavations of a small area adjacent to the existing souterrain, another souterrain was found, again with traces of surface settlement which has been dated to the Iron Age on typological grounds (Haigh and Smith 1982; Haigh 1983). At Howe, Stromness, the souterrain was constructed within an earlier chambered tomb and evidence for a contemporary early Iron Age roundhouse was found (Ballin Smith 1994). At Windwick, South Ronaldsay, recent excavations have revealed a souterrain in the centre of a massive roundhouse structure (Carruthers 2007), and at Langskaill on Westray a

souterrain and associated roundhouse have recently been excavated (Moore and Wilson 2005a). These two structures are tentatively dated to the Iron Age on the basis of typology and material culture.

Souterrains have traditionally been interpreted as the cellars of ground-level domestic settlements, perhaps used for the storage of grain or dairy products (e.g. Hamilton 1956; Bradley 1978). Palynological analysis of samples from a souterrain at Nessbreck in west Mainland showed that cereal-type pollen was present within the structure, perhaps indicating local storage of the plant material. However no firm conclusions could be drawn from the analysis of these samples due to problems of poor pollen preservation and indications of post-depositional biasing of the assemblages (Bunting 2009). Recent research in Orkney has also suggested a possible ritual purpose for the souterrains (M. Carruthers pers. comm.), which will be discussed later.

Recent excavations such as those at Pool on Sanday (Hunter *et al*. 2007) have demonstrated the potential range of non-broch associated Iron Age settlement in Orkney (Fig. 2.22). No broch is associated with the settlement here, which developed from two buildings, one of probable roundhouse type and the other interpreted as an animal shelter, occupied in the later Iron Age. This evolved into a complex of interconnecting cells and chambers in the Pictish period (Hunter *et al*. 2007). The excavations here have provided an important link between earlier roundhouse type structures and later Pictish cellular buildings such as those at Buckquoy, Birsay (Ritchie 1977). The settlement at Skaill, Deerness also represents the continuation of a traditional cellular form of house construction into the broch period (Buteux 1997). Potential wheelhouses, a type of settlement thought to have been common in Scotland during the first few centuries AD, have also been identified in the islands, for example on the Calf of Eday and at Howmae on North Ronaldsay. However these do not conform to typical wheelhouse plan-forms so their classification is uncertain (Crawford 2002).

Promontory forts are also known from Orkney (Fig. 2.22), and have been the subject of an extensive survey by Lamb (1980). They are usually considered to date to more recent periods than the Iron Age (Wickham-Jones 2006), although the dating of the promontory fort at Crosskirk in Caithness (Fairhurst 1984) may indicate a similar Iron Age date for some of these sites in Orkney (Card 2005).

A type of Iron Age site that is common throughout Scotland (Armit and Ralston 2003) but potentially under-recognised in Orkney is the crannog. These are lake settlements sited on either natural islands or artificially constructed platforms. They are sometimes interpreted as defensive structures although they may also have been sited in this way in order to maximise the area of agricultural land available (Wickham-Jones 2006). Studies of aerial photographs indicate that several potential crannog sites exist in Orkney (Card 2005), although only four are currently recorded by the RCAHMS Canmore database (see Fig. 2.22). One site at Bretta Ness on Rousay has been shown to have been occupied during the Iron Age (Marwick 1984), and another at Voy in the Loch of Stenness also seems likely to have been in use during this time (Dixon and Forbes 2004).

2.5.2 Burials

The locations of sites discussed in the text are illustrated in Fig. 2.27. Until recently there was very little evidence for Iron Age burials in Orkney, in common with the rest of Scotland (Hingley 1992). From around 1000 cal. BC to *c.* 400 cal. AD the remains of formal burials seem to be absent from the islands, although later Iron Age burials are present (Ashmore 2003). However as discussed earlier, not all Scottish burials in short cists are Bronze Age, since some have been found to contain grave goods that date from the early Iron Age. It is therefore possible that some of the undated Orcadian cist burials thought to be of Bronze Age date are actually Iron Age (Hedges 1980).

Two recent excavations are providing new insights into Iron Age burial practices in the islands. Locations of the burial and ceremonial sites discussed in the text are illustrated in Fig. 2.27. The Knowe of Skea on Westray, an isolated skerry well away from any settlement remains, is believed to have been a funerary complex with a cemetery dating to the first half of the first millennium AD and a large central structure thought to have been used as a mortuary building. A smaller building was found to contain a hearth, metalworking waste and a pin mould, suggesting it may have been used for metal casting. To date more than 100 burials have been excavated at the site, about 60% of which are children and newborn babies (Moore and Wilson 2005b).
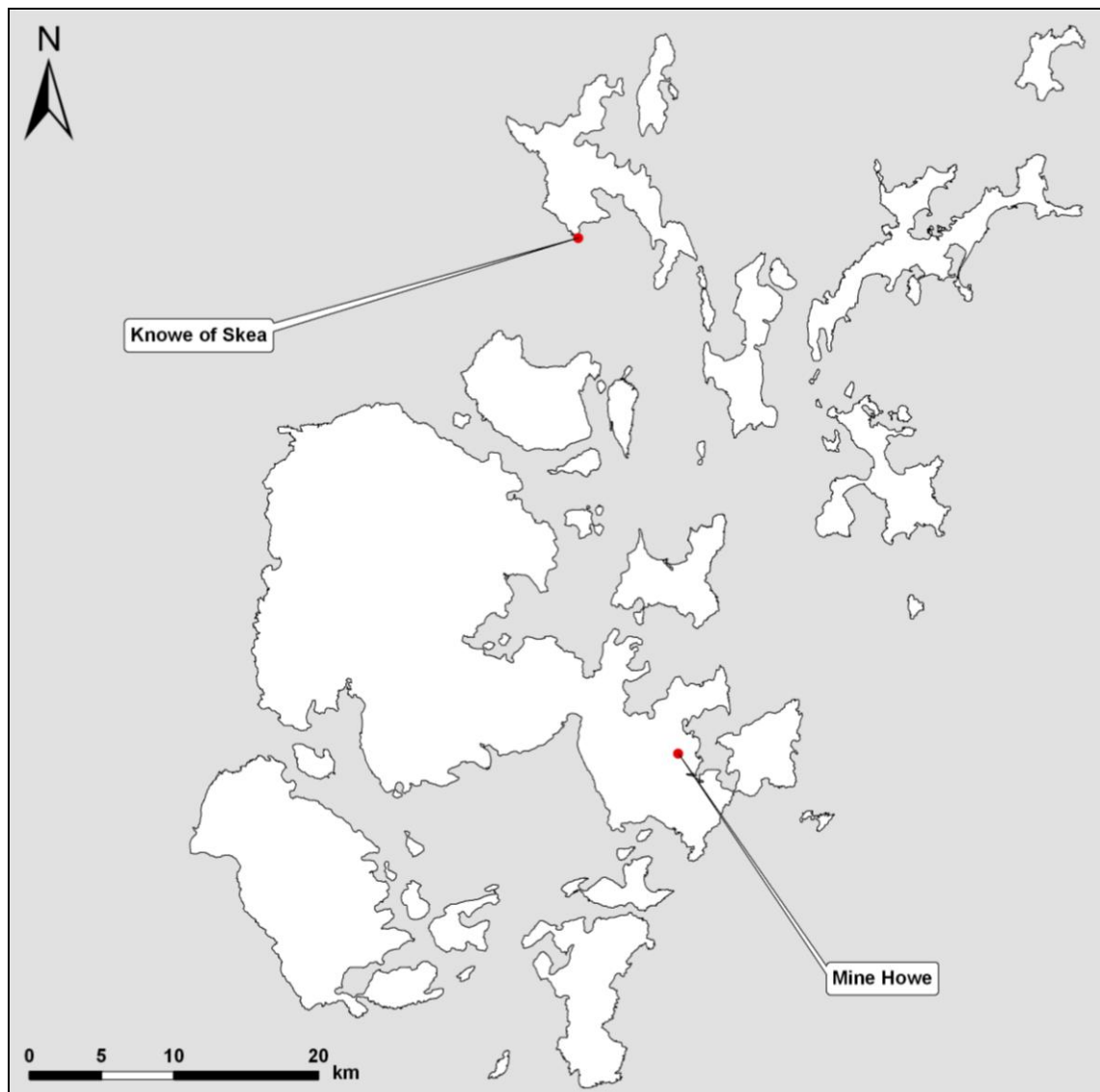
Figure 2.27 Location of Orcadian Iron Age burial/ceremonial sites discussed in the text (coordinates from RCAHMS Canmore database)

Mine Howe is an underground structure entered through the top of a large sub-circular glacial moraine, which is surrounded by a substantial man-made ditch. From the entrance a flight of stone steps descend *c.* 2.5 m to a half-landing where they turn back on themselves and descend a further *c.* 3 m to the floor of the main chamber (Card and Downes 2003). There is no evidence for there ever having been a structure on top of the mound, but outside the ditch lie the remains of a cellular structure with associated midden deposits which were found to contain evidence of metalworking including a hearth, anvils, crucibles, moulds, a small amount of ore and waste consisting of slag and hammer scale. Samples from the central hearth of this structure have been archaeomagnetically dated to the middle Iron Age (Card and Downes 2003; Harrison 2005). An iron-smelting furnace has also been uncovered on the side of the mound

(Harrison 2005). To date two burials have been found at the site, one under the floor of the cellular structure and another in a shallow pit dug into the midden immediately outside this building. It is thought that there may well be other burials around Mine Howe, perhaps even a cemetery similar to the one at the Knowe of Skea (Harrison 2005). The association of metalworking with burials at the two sites is particularly striking, and together they have provided some evidence for early Iron Age burial practices in Orkney.

2.5.3 Ceremonial Monuments

The Iron Age, prior to the introduction of Christianity, is often viewed as a time when people were more concerned with the 'mundane' aspects of life (Card and Downes 2003). This idea has been supported by the general lack of evidence for Iron Age burials and structures to which a ritual function could be assigned across Scotland as a whole (Hingley 1992). However, recent research into settlements from this period is demonstrating that everyday life may have been structured by belief systems which seem to be apparent in the orientation of buildings, organisation of domestic space, and structured deposits found both within pits and around settlements (Hill 1995; Armit 2003).

The reuse of Neolithic chambered tombs during the early Iron Age in Atlantic Scotland is indicated by finds of pottery and other domestic items within the burial chambers and by the building of domestic structures over the earlier monuments (Hingley 1996). Four chambered tombs in Orkney are known to have contained Iron Age pottery and the rebuilding and reuse of Neolithic tombs as houses occurred at Pierowall, Quanterness and Howe (Hingley 1996), as well as at Pool (Hunter *et al*. 2007). There is some evidence for a continued interest in the Stones of Stenness in the form of Iron Age pottery and wood radiocarbon dated to the late Iron Age (Ritchie 1976), although there is no evidence that the site was still a major focus for ceremonies (Wickham-Jones 2006). The reuse of earlier monuments by the Iron Age Orcadians implies a long memory of the tombs and their function, and has been interpreted as a desire to enhance their status by drawing on that of their ancestors and past monumental construction (Bradley 1991; Hingley 1992; 1996).

Card and Downes (2003) note that the underground well-like structure at Mine Howe is strikingly similar to the structures that are often termed 'wells' in brochs and suggest

that they too may have a had a ritual function, emphasising the potential of domestic buildings to contain ritual structures. This fits well with recent research that indicates souterrains may have been constructed for ritual purposes (M. Carruthers pers. comm.). The entrance passage of these structures often curves around and into the chamber, and it is usually possible to stand almost upright in the chamber whereas the approach along the passage may involve crouching, in a similar manner to the entrance passages of the chambered cairns. At Rennibister, Firth (Fig. 2.26), disarticulated human remains representing men, women and children of various ages were found on the floor of the chamber (Marwick 1927), suggesting some sort of ritual use of the structure. Furthermore, Downes (2005) notes that the construction of some souterrains within earlier chambered cairns, for example at Howe in Stromness and at Rowiegar on Rousay (Fig. 2.26), may provide further evidence that these structures had a ritual function.

At Mine Howe, as at the Knowe of Skea on Westray (Moore and Wilson 2005b), evidence for metalworking has been found close to human remains. In the past metalworking has been viewed as a powerful, dangerous process involving transformation and the elements, and the people who carried out this process may well have held a particular status in Iron Age Orkney (Card and Downes 2003). It is thought that while the site was in use it would have been almost completely surrounded by wet, boggy ground (Harrison 2005). The association of Iron Age metalworking with wetland areas is also known from Yorkshire, in the Foulness Valley (Halkon 2008). Here metalworking took place away from areas of settlement, possibly due to its ritual connotations, and it is possible that more metalworking sites may be discovered in Orkney if areas away from known settlements are investigated.

Hills, wells, underground and watery places are all believed to have had religious significance in the Iron Age (e.g. Bradley 2000), and Mine Howe combines all of these features. The topographic situation of the site, along with the symbolic significance attached to the process of metalworking, the human burials associated with the area where metalworking took place, and the lack of any domestic structures are all taken as evidence that Mine Howe was a purely ritual site (Card *et al*. 2005b).

2.5.4 Economy

Recent research indicates that the Iron Age was a period of agricultural development and intensification in the Northern Isles. During the early Iron Age the main cereal crop grown was barley (Bond 2003). There seems to have been an increase in arable cultivation during the later Iron Age (e.g. Keatinge and Dickson 1979), which may coincide with the introduction of new crop species such as oats and flax at some time between the Iron Age and the Norse period (Bond 1998). At Pool on Sanday, oats seem to have been introduced some time in the late third to fourth centuries AD (Bond 2003).

At Tofts Ness, also on Sanday, a change from the use of domestic midden material to animal manure as fertiliser occurred as part of this expansion in arable farming (Simpson *et al*. 2007). Evidence of plaggen-type manuring, in which turves removed from another part of the landscape were placed on the arable area along with midden material in order to create a more fertile soil within an area of sand deposits, was also found at this site (Simpson *et al*. 2007).

The use of animal manure as fertiliser during the Iron Age would have required that the animals be stabled or folded, implying that there may also have been intensification in animal husbandry at this time. There is evidence for an increase in dairying at Pool during the late Iron Age, provided by the remains of higher numbers of calves that were slaughtered before they were six months old (Bond 2003). Also at this site pigs comprise about 15-20% of the animal bone assemblage, a higher proportion than at any Orcadian site in the preceding Bronze Age and Neolithic, perhaps indicating a rise in meat consumption (Bond 2002).

Wild resources such as red deer were still utilised during the Iron Age, although with the intensification in agriculture that occurred at this time it is presumed that less importance was placed on them (Card 2005). Birds were exploited and the carcasses of whales and seals were used, and onshore and offshore fishing continued to play a role in the Iron Age economy (Ritchie 1995).

There is evidence for metalworking having taken place at Howe (Ballin Smith 1994), Mine Howe (Card and Downes 2003) and the Knowe of Skea (Moore and Wilson 2005b), although it is thought that the raw materials for this process must have been imported as there is no evidence for the extraction of local iron ore during prehistoric

times (Wickham-Jones 2006). However, some iron ore deposits outcrop in certain places on the shore of northern Hoy (Mykura 1976), and it is known that impure iron deposits can develop in wetlands by the chemical or biochemical oxidation of iron carried in solution (Allaby 2008). It is therefore possible that the raw materials for ironworking in Orkney were gathered from deposits such as these.

2.5.5 Material Culture

Items of Iron Age material culture recovered from Orcadian sites include stone tools such as spindle-whorls, loom-weights, whetstones and querns (Hedges 1987; Ritchie 1995; Clarke 2007b), iron objects including knives, needles, nails and buckles (McDonnell 2007), and bone combs, pins, and needles (Hedges 1987; Smith 2007b). Bronze jewellery and imported items of Roman origin including pottery and a bronze ladle were recovered from Midhowe, implying that the inhabitants of the broch were wealthy and of high status (Ritchie 1995).

Evidence from pottery recovered from Orcadian Iron Age sites indicates trade between Orkney and Shetland, as well as with southern Britain (Hingley 1992). Similarities between the pottery of the Atlantic Scottish Iron Age and that from southern Britain and western Europe indicates a complex network of intercommunication between southern Britain, northern Britain, Ireland and north-western Atlantic Europe. This network could have brought communities in northern Britain into contact with external cultural influences, not just via southern Britain but through direct maritime exchange across the North Sea and Western Seaways (Harding 2006). Orkney lay on the axis of several trade routes at this time, which may have been responsible for the apparent recovery from the proposed Bronze Age 'decline'.

The Roman occupation of Scotland did not extend as far as Orkney, but the existence of the islands was recognised and there are hints of a link between Orkney and the south of England at the time of Roman occupation. Two sherds of a distinctive Roman amphora were found at the broch of Gurness, more than 600 miles north of other British examples. However the exact find-spot is unknown so it cannot be certain that the amphora was in Orkney within the period in which it was manufactured (Ritchie 1995). Other evidence is provided by the Roman finds from Midhowe and a glass cup from a cist on Westray, although the volume of imported Roman goods was never very high. However some locally made objects are direct imitations of Roman goods, such as a

sandstone lamp carved in the shape of a Roman lamp from the broch of Oxtro in Birsay and a copy of a bronze ladle like that from Midhowe, but made from steatite, found at Gurness. This seems to reflect knowledge of and a desire to copy the Roman lifestyle (Ritchie 1995).

2.5.6 Social Organisation

Some sort of social change is indicated by the decision to build the distinctive and substantial roundhouses and brochs of the Orcadian Iron Age. It is possible that the changes seen are linked with climatic deterioration (e.g. van Geel *et al*. 1996; Mauquoy *et al*. 2004; Blundell and Barber 2005; Swindles *et al*. 2007) and agricultural intensification (e.g. Keatinge and Dickson 1979; Bond 2002; 2003), resulting in greater competition for land and a more aggressive society (Hedges 1987; Ritchie 1995; Armit 2003).

Evidence for increased pressure on agricultural land during the Iron Age is provided by the development of intensive plaggen manuring at Tofts Ness on Sanday. This settlement is interpreted as a secondary 'daughter' settlement of the more high-status site of Pool on the same island (Dockrill *et al.* 2007; Hunter *et al.* 2007). It is also thought that population expansion may have forced the maintenance of earlier, secondary settlements despite increases in their marginality (Simpson *et al*. 2007).

It is believed that the Atlantic roundhouses represent a largely autonomous segmentary society, and the occurrence of contemporary villages around brochs such as those at Gurness and Midhowe has often been taken to indicate the emergence of a more centralised hierarchical society in the mid to late Iron Age (e.g. Armit 2003). The brochs in these settlements have been interpreted as the homes of the elite who drew surplus agricultural produce and labour services from dependent, subsidiary households in the village settlements (Hingley 1992; Dockrill 2002). However, it may simply be that increased pressure on agricultural land forced people into more compact settlement patterns at this time (Card 2005). This process of settlement aggregation had begun during the late Bronze Age in many areas of lowland Britain (Haselgrove 1999).

2.6 The Pictish Period (*c*. 600 – *c*. 800 cal. AD)

The Pictish period in Scotland begins with the first mention of the name *Picti* in the surviving historical record in 297 cal. AD, and it ends with the union of the Picts and

the Scots under the Scottish king Kenneth mac Alpin, about 843 cal. AD (Ritchie and Ritchie 1981). By the sixth century AD Orkney was part of the Pictish kingdom, and the Picts that inhabited the islands are believed to be the descendants of the people who had occupied the nucleated broch villages and the independent farmsteads such as those at Pool and Tofts Ness on Sanday (Ritchie 1985). The adoption of the Pictish culture in Orkney therefore reflects the migration of ideas rather than the influx of a new population. See Fig. 2.28 for the locations of all Pictish sites referred to in the text.

2.6.1 Settlement

Pictish Orcadians lived in dispersed stone-built farmsteads divided into several cellular rooms (Wickham-Jones 2006). The Birsay area of west Mainland seems to have been an important focus for Pictish settlement in Orkney, with settlements known on the Brough of Birsay and at Buckquoy, although this may be a biased view influenced by the intensive archaeological activity that has taken place in this area. On the Brough of Birsay traces of earlier domestic settlement underlie the Viking period buildings. Radiocarbon dates falling in the eighth century AD have been obtained from these pre-Viking occupation levels. However the extent of the settlement and its function, whether monastic or secular, are unknown (Ritchie 1985).

The remains of a farmstead occupied during both the Pictish and Viking periods have been excavated at Buckquoy (Ritchie 1977). The Pictish phases at this site covered the seventh and early eighth centuries AD. Structures dating to this period consist of a simple house with a series of sub-rectangular cells, which was later replaced by a trefoil-shaped building (Ritchie 1977). The last Pictish house to be built at Buckquoy was larger than its predecessors but is representative of a related type of plan-form, the figure-of-eight house. The structure basically consists of a large oval living area with a central hearth and a smaller circular chamber opening off one end. There was a rectilinear room at the opposite end beyond which was a small entrance vestibule. The whole structure formed a linear unit of interconnecting rooms and was almost 14 m in length (Ritchie 1977).
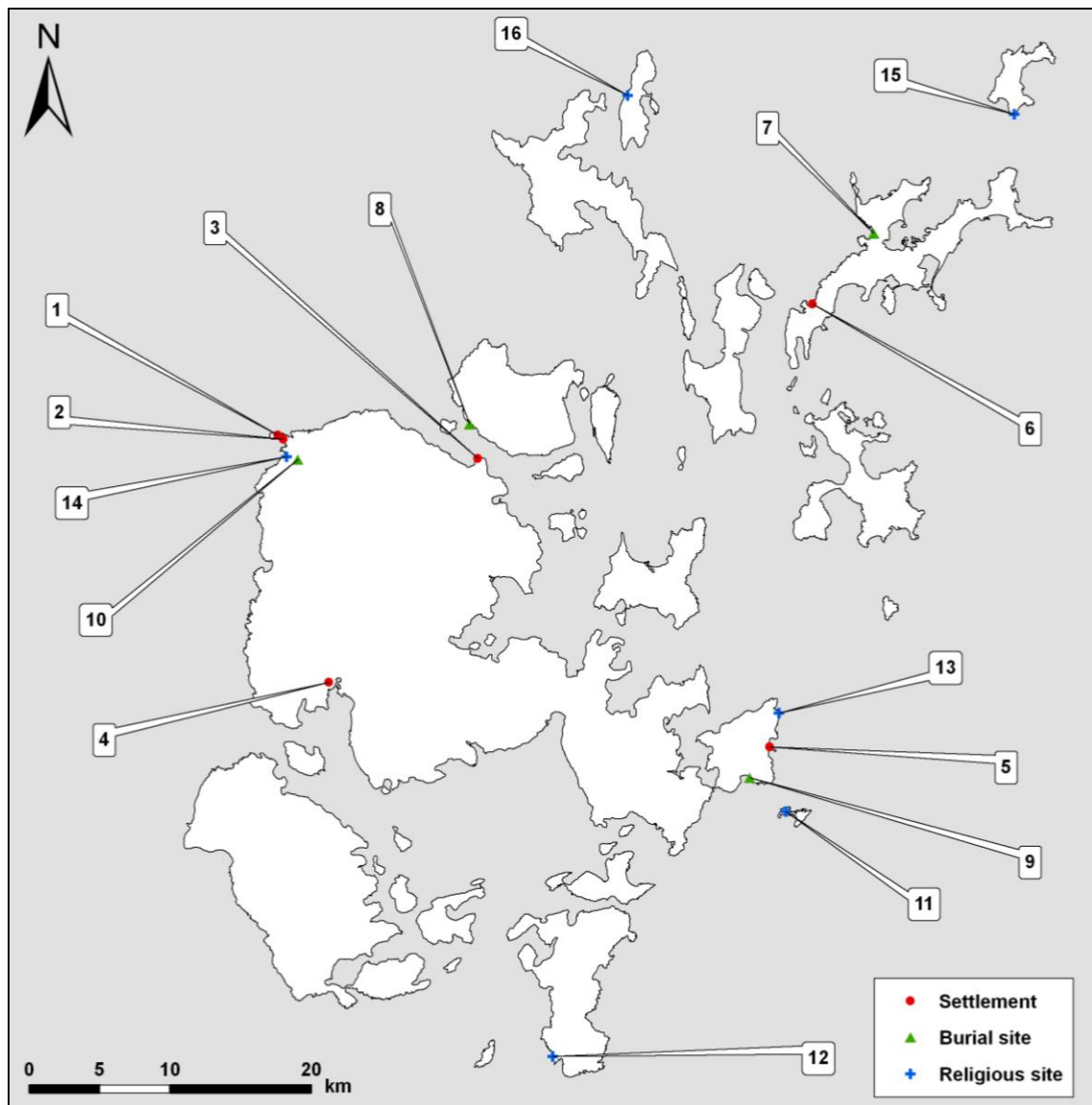
Figure 2.28 Location of Pictish sites discussed in the text (coordinates from the RCAHMS Canmore database): 1. Brough of Birsay; 2. Buckquoy; 3. Gurness; 4. Howe; 5. Skaill; 6. Pool; 7. Hermisgarth; 8. Westness; 9. Newark; 10. Oxtro; 11. Corn Holm; 12. Castle of Burwick; 13. Brough of Deerness; 14. Saevar Howe; 15. Broch of Burrian; 16. St Boniface

A wide range of Pictish house designs are present in Orkney, particularly in post-broch settlements where old buildings were continuously modified and reused. Building types from this period include both curvilinear and rectilinear plans, indicating that there are no 'blueprints' by which Pictish structures can be recognised (Brundle *et al*. 2003). At the Broch of Gurness evidence of Pictish occupation has been found overlying the earlier village settlement that surrounded the broch. This consists of two buildings, one rectangular and the other cellular (Fig. 2.29).

Figure 2.29 Cellular Pictish building at the Broch of Gurness, west Mainland

The cellular structure at Gurness is very similar to the earlier Pictish houses at Buckquoy (Ritchie 1985). At Howe, Stromness, a series of Pictish farmsteads, the latest of which is described as a figure-of-eight house, overlie a broch and associated settlement (Neil 1985; Ballin Smith 1994). Other evidence that the Picts used and refurbished earlier buildings in preference to building new structures has been found at Skaill in Deerness, where an *ad hoc* arrangement of structures built across a flagged surface overlies a circular Iron Age structure (Gelling 1985; Buteux 1997). At Pool on Sanday, the late Iron Age settlement developed from two buildings, one of probable roundhouse type and the other interpreted as an animal shelter, into a complex of interconnecting cells and chambers in the Pictish period (Hunter *et al*. 2007).

2.6.2 Burials

Few Pictish burials have been identified in Orkney, but there is nevertheless some evidence for burial practices during this period. Following the apparent lack of formal burials in the early and mid Iron Age, inhumations again occur from the fifth century AD onwards. In total, 42 Orcadian burials have been radiocarbon dated to some time between the fifth century and the end of the first millennium AD. These come from

four locations, Birsay in west Mainland, Hermisgarth on Sanday, Westness on Rousay and Newark in Deerness (Ashmore 2003).

It is possible that burial in short cists was undertaken earlier in the Pictish period, since Pictish symbol stones have been reused as cover slabs for such cists, for example in the cemetery at Oxtro, Birsay (Ritchie 1985). A flat cist cemetery dating to the Pictish period is also present at Westness on Rousay (Kaland 1993).

Excavations at Hermisgarth on Sanday (Downes 1997) have demonstrated that inhumation in cists and cremation were both practised in the Pictish period. With the arrival of Christianity some time between the late 6th and early 8th centuries AD, long cists became the normal burial mode in Orkney (Close-Brooks 1984), although the Hermisgarth excavations have also shown that burial in long cists does not necessarily imply the adoption of Christianity (Downes 1997). An extended inhumation in a long cist also occurs close to the Pictish farmstead at Buckquoy, and may belong to the same period (Ritchie 1977).

A distinctively Pictish type of burial monument has been identified in which a long cist is set beneath a low circular or rectilinear cairn with a slab-built kerb (Ashmore 1980). Examples occur in Shetland, Orkney, Caithness and Sutherland, and the distribution of this type of burial is therefore essentially northern. Radiocarbon dates indicate that the rectilinear form remained in use later than the circular form, and it was then adopted by the Norse settlers (Ritchie and Ritchie 1981). Only the circular form has been found in Orkney, at Buckquoy, implying that the burials here are Pictish (Ritchie 1985). This has since been confirmed by radiocarbon dating of the remains from these cairns (Brundle *et al*. 2003).

2.6.3 Ritual and Religion

Little is known about the pagan religion of the Picts, although it is widely believed that there must have been some continuity of Celtic ideas and practices. For example, Adomnan recorded a story in which Columba blesses a well sacred to the Picts, indicating that water held a similar ritual significance for the Picts as it had for earlier people (Anderson and Anderson 1961; Bradley 2000). The possible ritual function of the 'wells' within Orcadian brochs has already been discussed, and the association of a symbol stone with the well at the Knowe of Burrian suggests that this may have

continued into Pictish times (Ritchie 2003). In addition, Ritchie (2003) has suggested that several small circular or oval structures that occur within settlements in Orkney may have been Pictish shrines, indicating that ritual was part of everyday life rather than separate from it. Orcadian examples have been found near to the Pictish settlements at Skaill, Deerness (Buteux 1997) and Gurness (Hedges 1987).

By far the single most influential development in Orkney during Pictish times was the introduction of Christianity. Conversion was a gradual process, thought to have begun in the sixth century and being completed in the eighth (Ritchie 2003). Little is known about early Christian churches in Orkney due to a lack of excavation of these sites. Apart from one early Christian site on the Brough of Birsay, no church or monastery can be definitely dated to before the Norse period (Ritchie 1985; Laing and Laing 1993). Some sites, such as Corn Holm in Deerness and Castle of Burwick on South Ronaldsay, have been interpreted as eremitic monasteries and may date from the eighth century through to the tenth and eleventh centuries AD (Lamb 1973). There is no evidence for a pre-Norse monastery on the Brough of Deerness and the buildings surrounding the chapel at this site are thought to be secular and domestic rather than ecclesiastical (Morris and Emery 1986). Recent excavations at the site have revealed the presence of deeply stratified archaeology, suggesting that pre-Norse occupation of the site may yet be discovered, although it is still felt that the presence of a monastery is unlikely (Barrett and Slater 2009).

Although there is little structural evidence for early Christianity in Orkney, there are traces of it in the archaeological record in the form of sculptures and artefacts from at least the seventh century AD onwards (Ritchie 1985). Small iron bells recovered from Saevar Howe in west Mainland and the Broch of Burrian on North Ronaldsay probably date from the eighth or ninth centuries AD (Bourke 1980). Crosses have been found carved on slabs at the church of St Boniface on Papa Westray and at the Broch of Burrian, and they are likely to date from the seventh and eighth centuries respectively (Ritchie 1985). The carved front panel of a stone altar has also been discovered on the island of Flotta and has been dated to the late eighth century AD (Thomas 1971). Overall it seems that the Christian church was fairly well established in Orkney by the eighth century AD, and there is evidence to suggest that there may have been a resident bishop at St Boniface on Papa Westray at this time (Wickham-Jones 2006).

2.6.4 Economy

Documentary sources record that cereal crops were more commonly grown in later medieval times than today, especially barley and oats, and the fact that traces of both of these crops were found at Birsay perhaps suggests that arable farming was also important in pre-Viking times (Donaldson *et al*. 1981). Oats were grown at Pool on Sanday during the middle Iron Age (Bond 2007b), and at Howe, Stromness they were introduced during the seventh century AD, in Pictish times. Flax was also introduced at Howe (Dickson 1994) and Warebeth (Bell and Dickson 1989), both in Stromness, during the late Iron Age/Pictish period.

Animal bones recovered from Buckquoy comprised about 50% cattle, 30% sheep, and 20% pig (Noddle 1977), indicating that pigs became more important to the economy in the Pictish period. This increase in the proportion of pig bone recorded also occurs at Pool, where bones from this species comprise about 15-20% of the animal bone assemblage. This has been interpreted as a rise in meat consumption, since pigs are usually bred for their meat (Bond 2002). At Howe (Ballin Smith 1994) and Pool (Serjeantson and Bond 2007b) there were increases in the number of calves slaughtered when under six months old during late Iron Age/Pictish times, which is thought to indicate an increase in dairying at this time (Bond 2002; Serjeantson and Bond 2007b).

In general there seems to have been a greater emphasis on domesticated animals in the Pictish period, with a decline in reliance on wild animals such as red deer (Ritchie 1985; Ballin Smith 1994). Red deer were still consumed in small quantities during late Iron Age/Pictish times, particularly at Pool (Bond 2007b). Interestingly though they do not seem to have formed a part of the diet at the nearby early Iron Age settlement of Tofts Ness, and it may be that the larger, higher status settlement at Pool controlled access to the red deer herds on the island (Bond 2002).

Barrett *et al*. (1999) synthesised all the available data for fishing practices during Pictish and Norse times in northern Scotland, and hypothesised a transition to a fishing strategy that specifically targeted larger members of the cod family from around the Pictish-Norse transition, followed by intensification of fishing activity in the Late Norse period. At Pool, there seems to have been an increase in fishing and an increased emphasis on large cod, saithe and ling species from Pictish times onwards (Nicholson 2007b). A recent stable isotope study of Pictish, Viking and Late Norse human remains from

Newark Bay in east Mainland found evidence for a high level of marine protein in the diet during these periods, which is unusual for post-Mesolithic societies in Britain (Richards *et al*. 2006) and supports the idea of an intensification of fishing strategies at this time.

2.6.5 Material Culture

Few artefacts can be described specifically as Pictish, rather than as belonging to a common cultural tradition that was present throughout northern and western Britain at this time (Ritchie 1985). Items recovered from the Pictish phases of Orcadian sites include stone tools such as spindle-whorls, loom-weights, whetstones and querns (Ritchie 1977; Clarke 2007b), and bone items including pins, needles, spindle-whorls, bobbins, combs and spoons (Ritchie 1977; 1985; Smith 2007b). At Pool, several bone objects carved with Pictish symbols were found, and some of these have been interpreted as playing pieces or as pendants. Bone dice were also present at this site (Smith 2007b). Some of the Pictish artefacts recovered from Buckquoy indicate connections with communities in both the North Sea and Atlantic regions (Brundle *et al*. 2003). Late Iron Age/Pictish pottery assemblages comprise both shouldered and open-necked vessels, which are rarely decorated but often have burnished surfaces (Ballin Smith 1994; Buteux 1997; MacSween 2007a).

At the Brough of Birsay an assemblage of metalworking material was recovered, which includes clay moulds used in the manufacture of Pictish penannular brooches. These brooches date from the eighth century and examples have been found at Pierowall on Westray and Stromness on Mainland (Ritchie 1985). Copper brooches and pins were recovered from Pictish occupation levels at Pool (Smith 2007c), along with iron objects including knives, needles, nails and buckles (McDonnell 2007).

The most frequently occurring Pictish objects are the carved symbol stones, of which around 250 survive throughout Scotland (Ritchie and Ritchie 1981). Some symbols depict everyday objects, such as mirrors and combs, some represent animals and fish, and others are purely abstract designs. The meaning of the symbols is unknown, although it has been suggested that stones with a single animal symbol may define the boundaries of territorial groups (Ritchie and Ritchie 1981). Twelve symbol stones have been found in Orkney, although few of these are reliably provenanced (Card 2005). The recent discovery of a symbol stone in a secure stratigraphical context at Pool (Hunter *et*

al. 2007) has provided support for the assumption that most of the Orcadian examples date from around the seventh century AD (e.g. Ritchie 1985).

Ogham inscriptions occur on various objects from Orkney. Ogham is a form of writing in which around twenty letters or sounds are represented by groups of vertical or diagonal lines, which was in use from the 3rd to the 9th centuries AD throughout northern and western Britain. Problems with the interpretation of the Orcadian ogham inscriptions derive from the fact that they are written in the Pictish language rather than in Gaelic like their Scottish counterparts (Ritchie 1985). Forsyth (1995) has recently re-examined an ogham-inscribed spindle-whorl from Buckquoy and argues that rather than being written in non-Celtic Pictish, the text seems to be in Old Irish. This object therefore provides evidence for Irish influence in Orkney during the pre-Norse period.

2.6.6 Social and Political Organisation

Pictish territory effectively included all of Scotland north of the Forth and Clyde rivers, and written references to the Picts suggest a highly stratified society (Wickham-Jones 2006). It is believed that from the sixth century onwards Pictland was ruled by a single king, although it seems that Orkney may have had its own regional leader who paid service to a higher authority with a centralised power base further south (Ritchie and Ritchie 1981; Wickham-Jones 2006). The widespread distribution of broadly similar Pictish symbols from the Western Isles, Orkney and Shetland down the east coast to Fife is thought to emphasise the political and cultural cohesion of an organised and complex society, as well as indicating that the kingdom was ruled over by a single authority (Ritchie and Ritchie 1981).

Apart from at the Brough of Birsay, Orcadian settlement evidence indicates that the population of Orkney was decreasing towards the end of the Pictish period. Howe and Skaill both went into decline in the 7th and 8th centuries, and the single farmsteads at Gurness and Buckquoy were abandoned before being reoccupied by the Norse (Ritchie 2003). The only site where real structural continuity from the Pictish into the Viking period can be shown is at Pool, and even here the scale of immediately pre-Viking occupation seems to be limited (Hunter *et al*. 2007).

There are documentary references to the 'destruction' of Orkney by the Pictish high king Bridei in 681 cal. AD (Anderson 1973), and dendrochonological evidence from

Ireland indicates a period of climatic decline from 648-720 cal. AD, with historical records of plague between 664 and 668 cal. AD (Baillie 1998). The attack by Bridei can perhaps therefore be set within a context of climatic deterioration and famine, and the apparently limited nature of Pictish settlement immediately prior to Viking occupation may indicate that the islands failed to fully recover from these events (Ritchie 2003).

2.7 The Viking Period (*c*. 800 – 1065 cal. AD)

In Orkney the Viking period is generally accepted to have begun at the close of the 8th century AD, when Norse settlers arrived in the coastal regions of northern and western Scotland (Grieve and Gibson 2005). The Norse earldom of Orkney, which later included Shetland and Caithness and at times other areas of mainland Scotland, the Western Isles and Ireland, was established by 900 cal. AD (Taylor 1938). The end of the Viking period in Orkney is usually regarded as being signified by the death of Earl Thorfinn the Mighty in 1065 (Crawford 1987). The Orkney Viking period is considered to be proto-historic, as there are some documentary records for this period but none of any great detail and none from Orkney itself. Most of the evidence for this period has been provided by archaeological investigations, supported by place-name evidence and later documentary sources such as the *Orkneyinga Saga*, which details the history of the earls of Orkney and was written at around 1200 cal. AD by an unknown author in Iceland (Grieve and Gibson 2005).

2.7.1 Settlement

The main Viking period settlements that have so far been excavated in Orkney are at the Brough of Birsay (Hunter and Morris 1981), Buckquoy (Ritchie 1977), Brough Road (Morris 1993), Saevar Howe (Hedges 1983b), all in the Birsay Bay area, Skaill in Deerness (Buteux 1997), Pool in Sanday (Hunter *et al*. 2007) and Quoygrew in Westray (Barrett *et al*. 2005). The locations of all Viking and Late Norse sites referred to in this discussion are illustrated in Fig. 2.30. At the Brough of Birsay, Saevar Howe, Buckquoy and Skaill there is clear evidence of Pictish settlements being replaced by Viking buildings (Morris 1985). The Viking buildings at these sites were longhouses, roughly rectangular with a central hearth and a byre at one end. There were also smaller buildings associated with the houses at each site (Grieve and Gibson 2005).
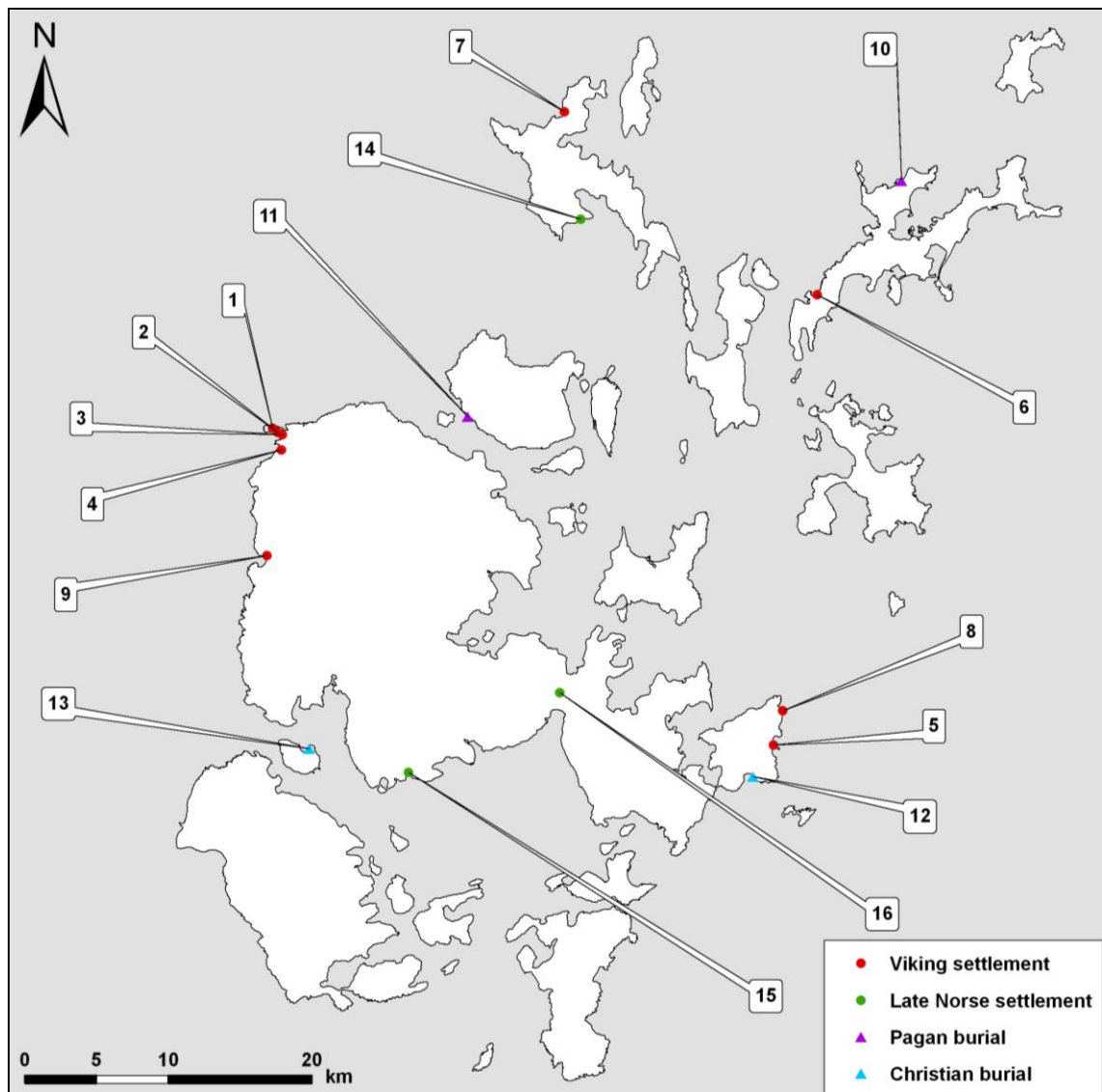
Figure 2.30 Location of Viking and Late Norse sites referred to in the text (coordinates from the RCAHMS Canmore database): 1. Brough of Birsay; 2. Buckquoy; 3. Brough Road; 4. Saevar Howe; 5. Skaill; 6. Pool; 7. Quoygrew; 8. Brough of Deerness; 9. Castle of Snusgar; 10. Scar; 11. Westness; 12. Newark; 13. Sandside; 14. Tuquoy; 15. Earl's Bu; 16. Bishops' Palace

On the Brough of Deerness in east Mainland is a stone church, underneath which are the remains of an earlier timber chapel. This chapel predates a layer that was found to contain an Anglo-Saxon coin minted between 959 and 975 cal. AD, providing the earliest known evidence for Viking Age Christianity in the North Atlantic region. Associated with the church are the remains of approximately 30 other buildings, and the site has been interpreted as a Viking stronghold with a private chapel (Morris and Emery 1986). Current excavations on the Brough are aimed at investigating the nature of these associated buildings, but to date only Late Norse layers have been excavated and the function of the site is still unclear (Barrett and Slater 2009).

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It is thought that the Bay of Skaill in west Mainland may also have been an important focus for Viking settlement, as the place-name 'Skaill' is derived from the Norse name *skali* which refers to a feasting hall (Thomson 2001). A hint of Viking settlement in the area was provided by the discovery of the largest Viking hoard yet to be discovered in Scotland, which was found in a large mound known as the Castle of Snusgar at the north end of the Bay of Skaill (Grieve and Gibson 2005). Recent excavations at the site have confirmed the presence of a Viking farmstead (Griffiths 2007; Towrie 2007).

The *udal* system of land-tenure was introduced to Orkney by the Viking settlers. Under this system land was held in absolute ownership, gained by holding the land over a number of generations, normally originally by settlement. This land was held in freehold, with no obligation except a duty to pay tax to the king. The main residence was inherited by the eldest son and the rest of the property was shared amongst his siblings. This resulted in an extreme fragmentation of land ownership and the aggregates of farms growing out in this way from the original settlement, which would often hold arable and grazing land in common, became known as *tunships* and form nucleated settlements (Morris 1985).

2.7.2 Burials

A range of burial practices were used by the pagan Vikings of Orkney, and Orkney has the most pagan graves of any region within Scandinavian Scotland (Grieve and Gibson 2005). There are boat burials such as that at Scar on Sanday (Owen and Dalland 1999), large numbers of inhumations within cemeteries such as Westness on Rousay (Kaland 1993), and cremations in short cists (Ashmore 2003). In some cases burials took place within existing mounds, under new mounds or stone cairns, in flat oval and rectangular stone-lined graves and in unlined pits (Morris 1985; Wickham-Jones 2006).

Grave goods were common, for example at Buckquoy in west Mainland a man was buried with several objects including a spear, knife and whetstone, a bronze-ringed pin, an iron buckle and an Anglo-Saxon coin, dating the burial to the middle of the tenth century (Graham-Campbell and Batey 1998), and the boat burial at Scar contained several household objects as well as weapons and jewellery (Owen and Dalland 1999). Analysis of grave goods associated with pagan Viking burials has given an estimated date range from the middle of the ninth century AD to the middle of the tenth century AD (Graham-Campbell and Batey 1998). The male burial at Buckquoy described

above is thought to be amongst the latest of these graves and it is likely that the practice of pagan burial with grave goods was probably abandoned at different times by communities in different parts of the islands (Graham-Campbell and Batey 1998).

Christian Viking burials in Orkney are difficult to recognise, given the absence of grave-goods. However one cist grave that contained no grave goods at Sandside, Graemsay has been radiocarbon dated to *c.* 1150 cal. AD (Hedges 1978b), and it is thought that the cemetery at Saevar Howe dates to the tenth century on the basis that the graves are superimposed on houses radiocarbon dated to the earlier part of the Viking period (Hedges 1983b). Another Norse Christian cemetery is situated at Newark in Deerness (Graham-Campbell and Batey 1998).

2.7.3 Religion

Despite the introduction of Christianity to Orkney in the Pictish period, there is no evidence that the religion continued to be practised following settlement by the pagan Vikings (Wickham-Jones 2006). This is supported by the number of pagan burials from Viking times, with Orkney having more pagan graves from this period than any other part of Scotland (Grieve and Gibson 2005).

According to saga evidence, the Vikings in Orkney were forced to adopt Christianity in 995 cal. AD by the Norwegian King Olaf Tryggvason, and this date is taken to be the official conversion of the Orcadian Vikings to Christianity (Ritchie 1993). This date is supported by archaeological evidence that two small chapels in the islands were in use by the middle of the tenth century AD, one at Newark in Deerness and one on the Brough of Deerness (Grieve and Gibson 2005). The chapel at Deerness is currently interpreted as a private chapel belonging to a Viking/Late Norse period settlement (Morris and Emery 1986; Barrett and Slater 2009).

It seems likely that by the end of the tenth century AD there were several Christian foundations within Orkney (Grieve and Gibson 2005), and in 1065 the Bishopric of Orkney was established at Birsay (Taylor 1938). Following this the places of worship and burial in the islands were brought into ecclesiastical order with priests being assigned to groups of parishes (Graham-Campbell and Batey 1998).

2.7.4 Economy

A mixed economy existed during the Orcadian Viking period, which combined pastoral and arable farming with the exploitation of wild resources including fish, shellfish and birds. Barley, oats and flax (used for making linen) were all grown (Donaldson *et al*. 1981; Dickson 1983b; Bond 2007b) and it is believed that at Pool on Sanday the development of an infield system took place at this time to accommodate the flax crop, with oats being grown in the less fertile outfield (Bond 2007b). Further evidence for intensive cultivation at this time comes from the site of Quoygrew on Westray (Barrett *et al*. 2005). The discovery of small querns at several sites suggests that flour production occurred on site, although the horizontal mill at the Earl's Bu in Orphir suggests that larger scale milling also occurred in the Viking period (Graham-Campbell and Batey 1998).

There is clear evidence that animal husbandry was fundamental to the Viking economy. At Saevar Howe, Buckquoy and Pool cattle, sheep and pig bones were all found in significant numbers (Morris 1985; Bond 2007a). Although at Pool there do not seem to be any substantial changes in the faunal data between the Pictish and Viking phases, the numbers of calves that were slaughtered at a young age are thought to represent a continued increase in dairying that had begun in Pictish times (Serjeantson and Bond 2007b).

Evidence for the development of a more intensive fishing strategy that specifically targeted larger members of the cod family around the time of the Pictish-Norse transition in northern Scotland has been reviewed by Barrett *et al*. (1999). This was followed by a further intensification of fishing in the Late Norse period, and it is suggested that the produce was being exported to Scandinavia at this time (Barrett *et al*. 1999). At Quoygrew on Westray, fishing seems to have become much more important to the local economy during the 11th century AD, and this continued into the 14th century AD (Barrett *et al*. 2005). Analysis of molluscs (predominantly limpets which may have been used as fish bait) from Viking and Late Norse middens at the site has provided further evidence for intensification of fishing activity during the 11th-12th centuries AD, as the harvesting of limpets for fish bait had a measurable impact on the structure of the local limpet population (Milner *et al*. 2007). In addition, stable isotope evidence for a significant proportion of marine protein in the diet during the Viking and Late Norse period at Newark Bay in east Mainland has recently been presented by

Richards *et al*. (2006), perhaps implying that a large proportion of the catch was being consumed in Orkney rather than exported as suggested by Barrett *et al*. (1999).

The success of the Viking economy in Orkney is attested to by the evidence of hoard material, which reflects both the political importance of the islands and the considerable wealth of particular individuals. Hoards from Burray and Skaill weighed 1.9 kg and 8 kg respectively. In both cases less than 0.5% consisted of silver coins, and the rest was silver objects and hack-silver. The hoards seem to contain both ready units of measure and material yet to be cut to specific units, suggesting they were not acquired by raiding but rather by economic activity (Morris 1985). The presence of certain coins dates both of these hoards to the tenth century AD (A. Ritchie 1993). Viking hoards in Orkney are usually thought to have been deposited during periods of warfare or local unrest, rather than for ritual purposes, since none are known from the period of pagan Viking burial in the islands (Graham-Campbell and Batey 1998). Alternatively, the deposition of these hoards may reflect attempts by certain individuals to control the economy by taking this material out of circulation.

2.7.5 Material Culture

The basic material culture of the Viking period is broadly similar to that of the Pictish period. It comprises stone tools such as spindle-whorls, loom-weights, whetstones and querns (Ritchie 1977; Clarke 2007b), and bone items including pins, needles, combs, pendants and toggles (Smith 2007b). Items found in pagan graves at Westness on Rousay include brooches, beads, a belt, a comb, items of domestic equipment including a bronze bowl, iron shears and an iron sickle, and an elaborately decorated sword (Ritchie 1993).

Although steatite vessels were in use at the nearby settlement of Tofts Ness during the Bronze Age (Smith 2007a), their first appearance at Pool occurs with the Viking occupation of the site. Many of the earlier Viking vessels in the Pool assemblage are typically Norwegian in form, with Shetland steatite being introduced in the second half of the tenth century AD (Smith and Forster 2007). At Pool, the use of steatite seems to gradually increase at the expense of pottery during Norse occupation of the site, although the use of ceramic vessels never completely ceases. Pottery was not manufactured by the Norse in their homeland, and it is suggested that the continued presence at Pool of the native population provided a means for ceramic production. The

adoption of local pottery by the Norse in Orkney does not seem to have been as extensive as it was in the Western Isles, perhaps reflecting the closer location of a source of steatite to Orkney (Smith and Forster 2007).

2.7.6 Social and Political Organisation

The Pictish settlement at Buckquoy in Birsay was replaced by a rectangular building, interpreted as a Viking farmstead, towards the end of the first millennium AD. There were distinct differences between the Pictish and Viking house types, and since the associated artefacts gave little indication of cultural change it is the difference in building form that is used to date the later structure as Viking (Ritchie 1977). It has been suggested that this evidence indicates a degree of social integration between the Picts and the Viking settlers, and Ritchie (1974) has postulated that the Norse occupation of Orkney was predominantly peaceful, contrasting with the traditional view of a violent transition to Viking rule in the Northern and Western Isles of Scotland (e.g. Crawford 1981).

However recent research has reopened the debate on relations between the Vikings and the indigenous Pictish population in the Northern Isles. Few pre-Norse place-names still exist in Orkney, indicating that a new administrative system was soon established, and Smith (2003) has argued that the transition to Viking rule in Orkney completely destroyed the native culture and was more aggressive than has previously been assumed. However Brundle *et al*. (2003) have recently suggested that the presence of native artefacts on Viking sites in Orkney may be the result of taxation, a process which is known to have occurred in northern Norway where the indigenous Sami payed taxes to the Vikings in the form of skins and whalebone artefacts (Page 1995). If this was also the case in Orkney, it is possible that Pictish artefacts would have decreased in value as the Pictish culture declined, and these objects would eventually have been discarded in early Viking contexts. Brundle *et al*. (2003) therefore hypothesise that the indigenous Pictish population of Orkney were able to exist alongside the incoming Vikings by paying taxes, and it is argued that the eventual success of the Norse Orkney earldom would have ensured the gradual loss of Pictish placenames in the islands. It is suggested that there would in fact have been very little need for physical conflict (Brundle *et al*. 2003).

Orkney was at the centre of a complex political structure during Viking times (Crawford 1987), which included the earldoms of Orkney and Caithness as well as the Norwegian and Scottish kingdoms, and allegiances with other political figures such as that with the king of Leinster which led to the presence of Orcadians at the Battle of Clontarf in Ireland in 1014 (Wickham-Jones 2006).

2.8 Later Developments

The end of Viking Orkney marks the end of the prehistoric period in the islands. During the Late Norse period (1065-1231 cal. AD), the Orkney earldom continued to grow as a significant power in the north, and urbanisation and centralisation in the islands began to take place during the 12th century AD. This is particularly illustrated by the growth and development of the town of Kirkwall (Grieve and Gibson 2005). Excavations at Skaill, Deerness (Buteux 1997) and Tuquoy on Westray (Owen 1993) have revealed high-status sites with large hall-type dwellings dating from the 12th century AD, interpreted as rich farm estates with associated churches. Other-high status Late Norse settlements occur at the Earl's Bu in Orphir, the Bishops' Palace in Kirkwall, and at Westness on Rousay (Kaland 1993; Grieve and Gibson 2005).

Officially, Orkney remained part of the Norse kingdom until AD 1468, when it came under Scottish rule (Mooney 1966). However the Scottish crown had begun to have an increasing influence on the islands following the death of the last Norse earl in AD 1231, after which a succession of Scottish earls ruled Orkney (Morris 1985). Even after the islands officially came under Scottish rule, Norse influence continued in the form of Norn, the Norse dialect which was spoken in Orkney into the 18th century (Lamb 2003) and is still evidenced in the majority of Orcadian place-names (Waugh 2003).

Chapter 3: The Palaeoecological Record of Orkney

This chapter will outline previous palaeoenvironmental research in Orkney and discuss it in the context of a wider area of northern Scotland including Shetland and Caithness. Firstly a short history of palaeoecological investigation in Orkney is given and gaps in the record are highlighted. This thesis is concerned with human interactions with the prehistoric Orcadian environment, so pre-Holocene vegetation and environments are not discussed in detail. However the lateglacial environment is briefly described, as recent research has shown that humans were first present in Orkney some time towards the end of the Upper Palaeolithic (Pitts 2007). The archaeological periods defined in Chapter 1 are then used to organise a description of Holocene vegetation dynamics in the islands until the end of the Late Norse period. This broad pattern is then compared to a wider region including north-east mainland Scotland and other Atlantic islands, including Shetland and Faroe, in order to assess differences and similarities within this region. Finally, this is set into a wider context with a brief discussion of prehistoric environmental change across Scotland as a whole.

3.1 Previous Palaeoecological Research

Although the archaeological record of Orkney is well preserved and relatively well studied, few investigations have attempted to reconstruct the environmental context in which this record developed. Early studies of the vegetational history include work by Traill (1868), who records numerous occurrences of submerged forests on the islands. The trees encountered were birch, hazel and pine, and the presence of 'some kind of fir' in a submerged forest at the Bay of Skaill was also recorded by Watt (1820: 101). More recently, a buried peat deposit at Otterswick, Sanday, has been found to contain wood identified as *Salix* that has been radiocarbon dated to 4500 cal. BC (Rennie 2006). Erdtman (1924) studied pollen from seven sites in Orkney, mostly on Mainland, and found varying percentages of arboreal pollen, mainly *Betula*, leading to the suggestion that trees had once been more widespread in Orkney.

Fig. 3.1 shows the distribution of more recent palynological studies in Orkney, and it can be seen that there is a concentration of sites in west Mainland. Only one record from the North Isles is available, from Rousay. There are no sites north of the Westray Firth and there are few sites on the South Isles such as Hoy and South Ronaldsay. So far long cores have only been obtained from three islands (Mainland, Rousay and Hoy),

and investigation of these has tended to focus on the early and mid Holocene, resulting in a relative lack of evidence for post-Neolithic environments (see Fig. 3.2).

Only one well-dated record, from a large mire, definitely covers the last 5000 years (Glims Moss, west Mainland: Keatinge and Dickson 1979). There are two other radiocarbon dated sequences that cover at least the earlier part of this period, although the latter parts of the records are undated so it is not clear whether the entire 5000 years is represented (Loch of Knitchen, Rousay: Bunting 1996; Scapa Bay, Mainland: de la Vega-Leinert *et al*. 2007). Four sites in west Mainland (The Loons: Moar 1969; Loch of Skaill: Keatinge and Dickson 1979; Crudale Meadow and Quoyloo Meadow: Bunting 1994) are also believed to cover this period, but this is uncertain due to poor dating of these sequences. A currently ongoing re-analysis of the Crudale Meadow sequence has in fact indicated that there may be a hiatus in the mid-Holocene (K.J. Edwards pers. comm.), and this may also be the case at Quoyloo Meadow (O'Connor and Bunting 2009).

Radiocarbon dates from Orcadian sediments are often affected by the 'hard water effect' (e.g. Keatinge and Dickson 1979), and reliable biostratigraphic markers in this area do not exist – for example woodland decline is generally attributed to clearance for Neolithic agriculture at *c*. 3500 cal. BC (Davidson and Jones 1985), but a closer inspection of radiocarbon dated sequences from the published literature shows that in fact the decline occurs over a period of *c*. 2500-3500 years (Fig. 3.3). At some sites there are two distinct woodland declines, complicating the story still further.
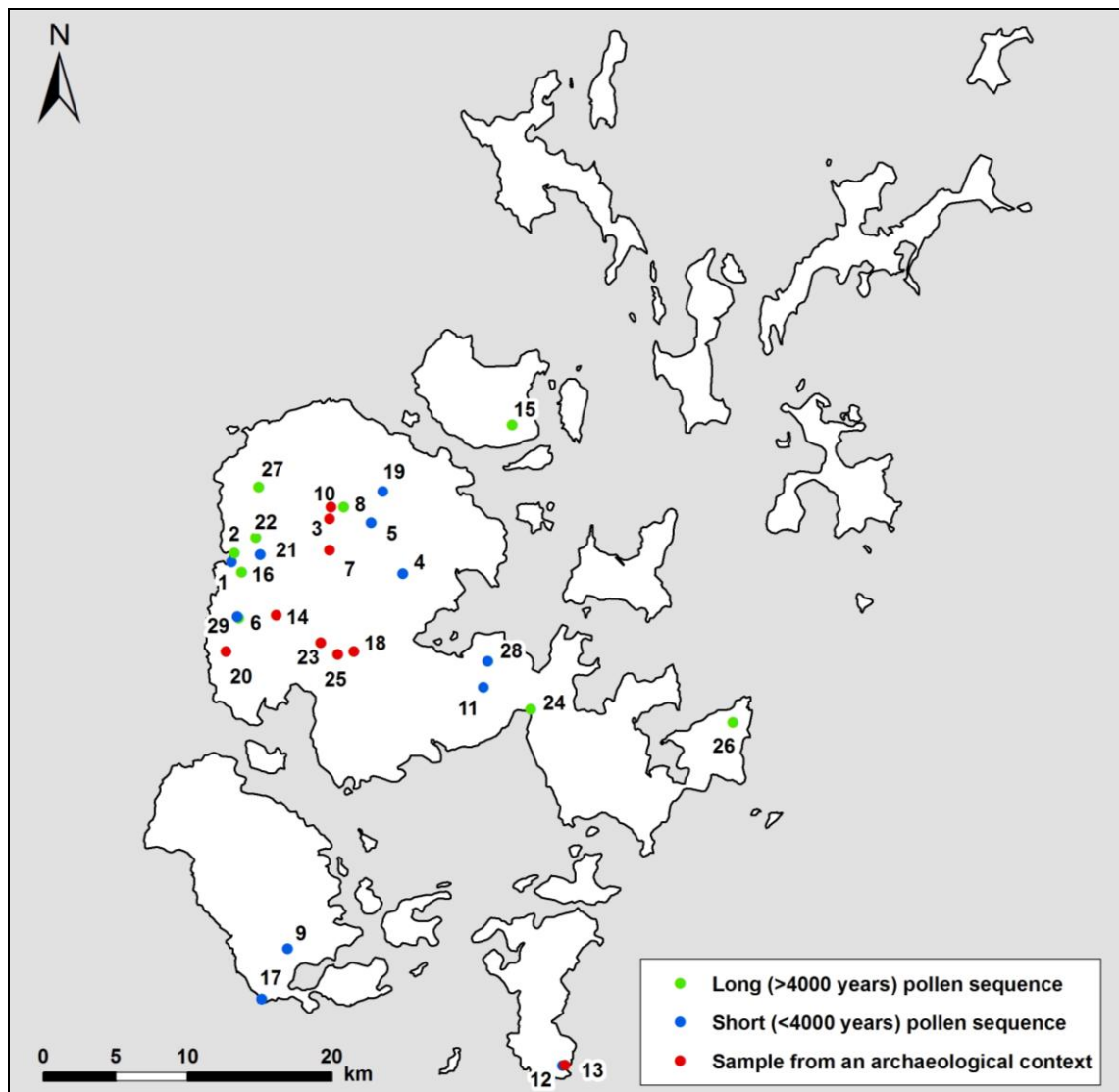
Figure 3.1 Location of previous palynological investigations in Orkney: 1. Bay of Skaill I (Keatinge and Dickson 1979); 2. Bay of Skaill II (de la Vega *et al.* 1996; de la Vega-Leinert *et al.* 2000); 3. Beaquoy II (Jones 1975); 4. Braes of Aglath (Keatinge and Dickson 1979); 5. Burn of Rusht (Keatinge and Dickson 1979); 6. Crudale Meadow (Bunting 1994); 7. Fan Knowe (Jones 1975); 8. Glims Moss (Keating and Dickson 1979); 9. Keith's Peat Bank (Blackford *et al.* 1996); 10. Knowes of Quoyscottie (Jones 1977); 11. Lesliedale Moss (Davidson *et al.* 1976; Jones, 1979); 12. Liddle Bog (Bartlett 1983); 13. Liddle I (Jones 1975); 14. Linga Fiold (Bunting *et al.* 2001); 15. Loch of Knitchen (Bunting 1996); 16. Loch of Skaill (Keatinge and Dickson 1979); 17. Loch of Torness (Bunting 1996); 18. Maeshowe (Godwin 1956; Davidson *et al.* 1976; Jones 1979); 19. Mid Hill (Keatinge and Dickson 1979); 20. Mousland (Downes 1994); 21. Pow (Keatinge and Dickson 1979); 22. Quoyloo Meadow (Bunting 1994); 23. Ring of Brodgar (Jones 1979); 24. Scapa Bay (de la Vega-Leinert *et al.* 2007); 25. Stones of Stenness (Caseldine and Whittington 1976); 26. Stove (Donaldson 1986); 27. The Loons (Moar 1969); 28. Wideford Hill (Jones 1979); 29. Yesnaby (Moar 1969)

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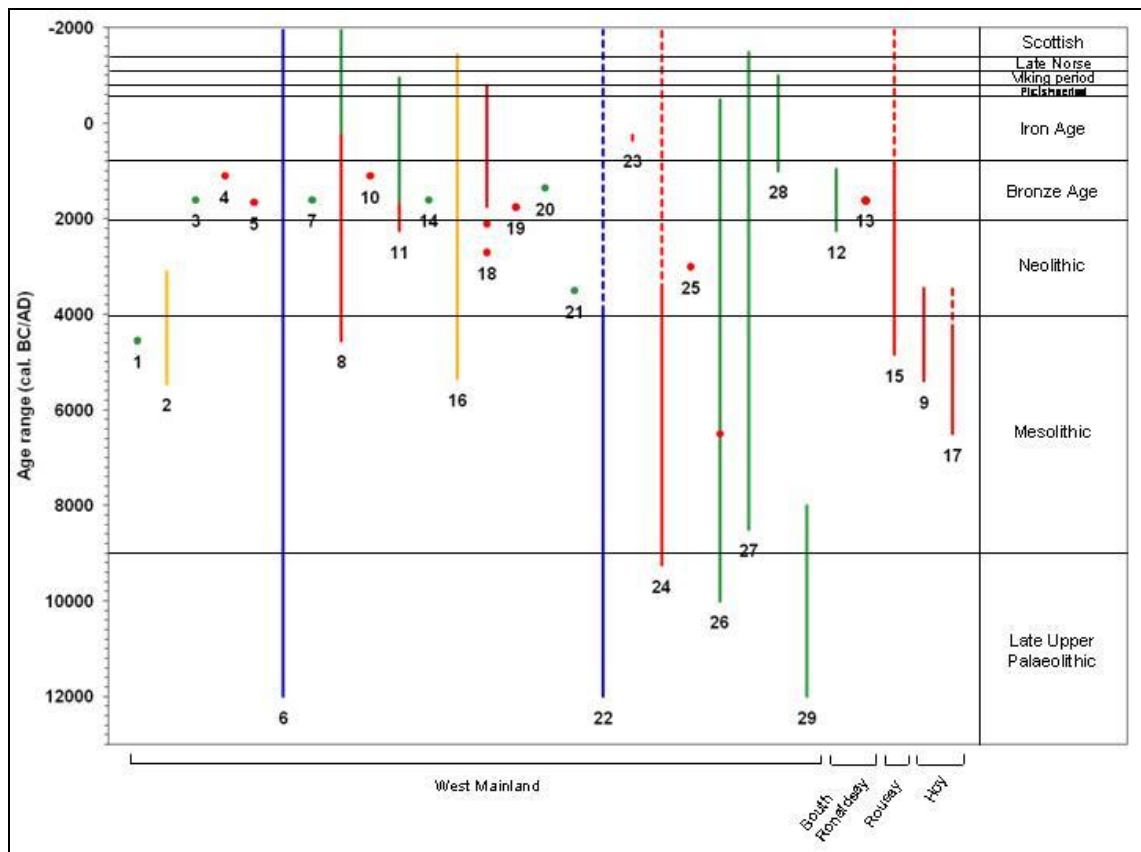
Figure 3.2 Age range of previous published palynological investigations in Orkney. Numbers correspond to the sites in Figure 1. Key: red – radiocarbon dated sequences; orange – radiocarbon dated sequences where dates are uncertain due to the 'hard water effect'; green – sequences dated using biostratigraphy; blue – sequences dated using biostratigraphy and tephrochronology; dashed lines indicate where dates have been extrapolated and are therefore uncertain; dots indicate single context samples.

Several investigations associated with archaeological sites have provided a localised picture of environmental conditions, often only at one particular point in time (e.g. Godwin 1956; Caseldine & Whittington 1976), and these sequences are therefore not particularly useful for reconstructing past vegetation changes at a regional scale. There is a clear need for more radiocarbon dated pollen sequences covering the past 5000 years, especially from sites outside west Mainland.

Evidence for environmental conditions during the Bronze Age in Orkney is particularly fragmentary. It is covered by just one securely radiocarbon dated record from west Mainland (Glims Moss: Keatinge and Dickson 1979), one radiocarbon dated sequence from Rousay (Loch of Knitchen: Bunting 1996) and possibly by a short, undated record from a Bronze Age archaeological site on South Ronaldsay (Liddle: Bartlett 1983). A sequence from Scapa Bay on Mainland (de la Vega-Leinert *et al*. 2007) is also thought to cover the Bronze Age, although this is unconfirmed by radiocarbon dating. The
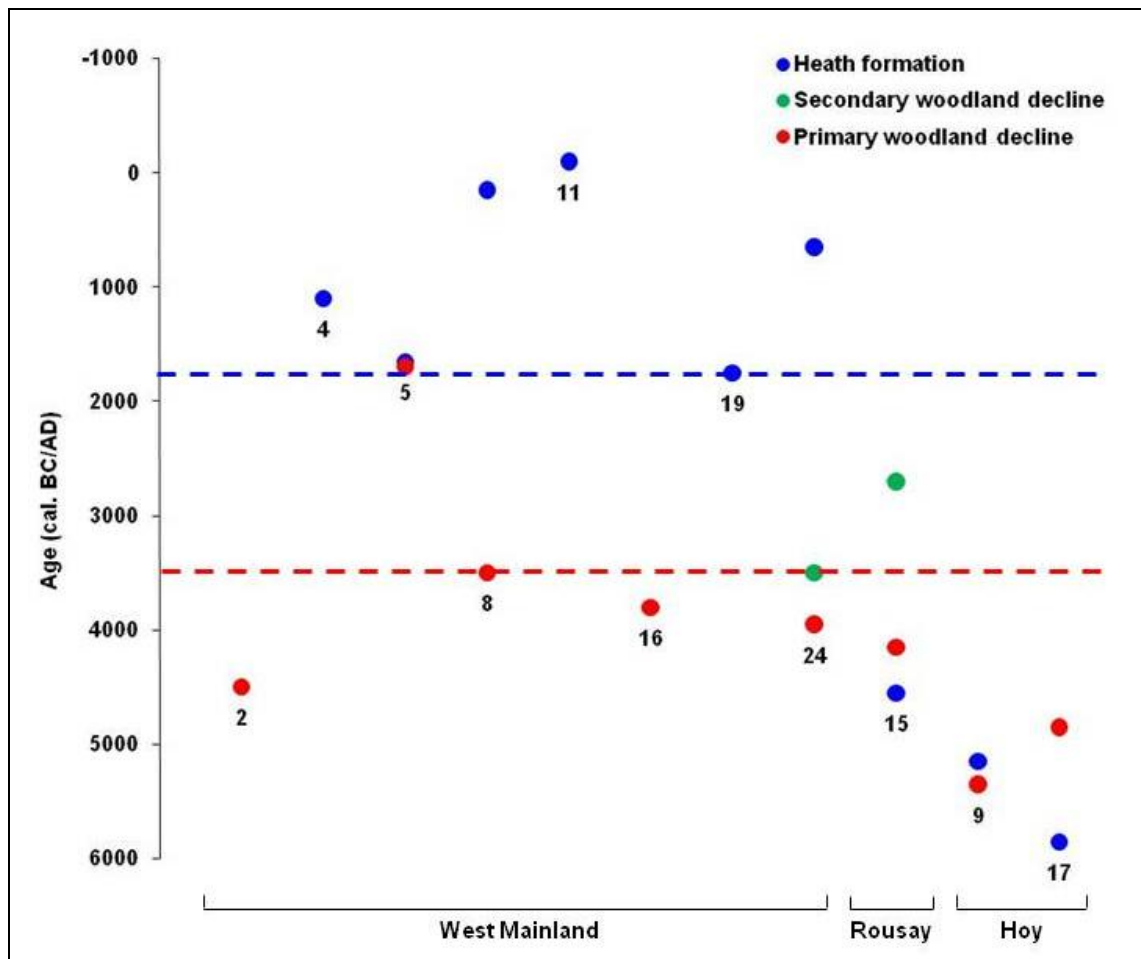
Figure 3.3 Woodland decline and heath formation dates from previously published radiocarbon dated pollen sequences from Orkney. Numbers correspond to the sites in Figure 1, and dashed lines represent the generally assumed dates for woodland decline and heath formation in the islands (e.g. Davidson and Jones 1985).

record from Lesliedale Moss on Mainland has radiocarbon dates indicating that it begins in the late Neolithic, and it is thought to continue until the end of the Iron Age, although there is no secure dating evidence to confirm this interpretation (Davidson *et al.* 1976). Other putatively Bronze Age records are either poorly dated or are single context samples from archaeological sites (see Fig. 3.2).

Figs. 3.4-3.7 show the areas of Orkney where vegetation change is most effectively recorded (the relevant source area of pollen or RSAP) by existing Orcadian sequences covering the Mesolithic to Iron Age periods. RSAP is defined by Sugita (1994) as the distance beyond which the relationship between vegetation composition and the pollen assemblage does not improve, and it is a function of both site size and landscape patterning (Sugita 1994; Bunting *et al*. 2004). Estimates of the RSAPs shown in these figures are based on the values for different sized basins given in Sugita (1994).

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Table 3.1 shows the size of each previously investigated site along with their estimated RSAPs. It is clear that only west Mainland is well represented throughout the whole of this timespan. More records from other islands are needed for the time period of interest for this thesis (*c*. 3000 cal. BC - 600 cal. AD) to allow a detailed assessment of the 'Bronze Age decline' hypotheses outlined in Chapter 1.

Site number (from Fig. 3.1)	Site name	Island	Site size	Estimated RSAP (m)
1	Bay of Skaill I	Mainland	Peat marginal to 'large' loch	2000-5000
2	Bay of Skaill II	Mainland	Peat marginal to 'large' loch	2000-5000
3	Beaquoy II	Mainland	Archaeological sample	50-100
4	Braes of Aglath	Mainland	Blanket peat	50-100
5	Burn of Rusht	Mainland	Blanket peat	50-100
6	Crudale Meadow	Mainland	400 x 250 m	300-400
7	Fan Knowe	Mainland	Archaeological sample	50-100
8	Glims Moss	Mainland	1750 x 900 m	2000-5000
9	Keith's Peat Bank	Hoy	Blanket peat	600-800
10	Knowes of Quoyscottie	Mainland	Archaeological sample	50-100
11	Lesliedale Moss	Mainland	1000 x 500 m	600-800
12	Liddle Bog	South Ronaldsay	250 x 250 m	300-400
13	Liddle I	South Ronaldsay	Archaeological sample	50-100
14	Linga Fiold	Mainland	Archaeological samples	50-100
15	Loch of Knitchen	Rousay	150 x 75 m	300-400
16	Loch of Skaill	Mainland	1200 x 700 m	2000-5000
17	Loch of Torness	Hoy	125 x 50 m	300-400
18	Maeshowe	Mainland	Archaeological sample	50-100
19	Mid Hill	Mainland	Blanket peat	50-100
20	Mousland	Mainland	Archaeological sample	50-100
21	Pow	Mainland	750 x 200 m	300-400
22	Quoyloo Meadow	Mainland	500 x 250 m	300-400
23	Ring of Brodgar	Mainland	Archaeological sample	50-100
24	Scapa Bay	Mainland	1000 x 500	2000-5000
25	Stones of Stenness	Mainland	Archaeological sample	50-100
26	Stove	Mainland	500 x 350 m	300-400
27	The Loons	Mainland	1000 x 1000 m	2000-5000
28	Wideford Hill	Mainland	Blanket peat	600-800
29	Yesnaby	Mainland	400 x 250 m	300-400

Table 3.1 Size and estimated RSAPs of previously investigated palaeoecological sites in Orkney. Estimated RSAPs are based on the values for different sized basins given in Sugita (1994).

3.1.1 Late Upper Palaeolithic (*c*. 13,000 – *c*. 9000 cal. BC)

Environmental records covering this period come from just two sites in west Mainland (Yesnaby/Crudale Meadow: Moar 1969/Bunting 1994 and Quoyloo Meadow: Bunting 1994). At around 12,000 cal. BC a sparse vegetation of dwarf-shrub heath and

arctic-alpine communities developed at both Crudale Meadow and Quoyloo Meadow as the catchments stabilised following deglaciation (Bunting 1994). This vegetation cover became sparser still and more herb-dominated at *c*. 10,950 cal. BC, and taxa such as *Artemisia*-type were present, suggesting disturbance of the environment was taking place. Heathland vegetation became re-established at *c*. 10,350 cal. BC (Bunting 1994). As the climate warmed and interglacial conditions became established, the heathland was replaced by tall-herb grassland, and by *c*. 9550 cal. BC this community was dominant at Mainland sites (Bunting 1994; de la Vega-Leinert *et al*. 2007). *Salix* fen was also present around the fringes of the sampling site at Scapa Bay at this time (de la Vega-Leinert *et al*. 2007).

3.1.2 Mesolithic (*c*. 9000 – *c*. 4000 cal. BC)

Fig. 3.4 shows the areas of Orkney falling within the RSAP of one or more existing pollen records covering the Mesolithic period. These areas are superimposed on maps showing altitude and drift geology in order to compare the distribution of sites on marginal and non-marginal land. Lamb (1989) proposes that the approximate upper limit of prehistoric settlement in Orkney is 60 m above sea level, and this value has been used as the boundary between lowland and upland areas on the altitude map. Recent research has shown that relative sea levels were lower than at present during the early Holocene (Wickham-Jones *et al*. 2008), and therefore the altitude map may be slightly inaccurate. West Mainland is relatively well covered, but existing sites in east Mainland and on Hoy only record the past vegetation cover of a very small area of that island and there are no records at all covering South Ronaldsay or the North Isles. The sites mainly cover fertile, low-lying parts of the archipelago, with the more marginal areas being under-represented.

Figure 3.4a Areas of Orkney for which existing palaeoecological records covering the Mesolithic period are available, overlain on a map of superficial deposits

Figure 3.4b Areas of Orkney for which existing palaeoecological records covering the Mesolithic period are available, overlain on a map showing altitude

Several sites in west Mainland (The Loons: Moar 1969; Crudale Meadow and Quoyloo Meadow: Bunting 1994) indicate that extensive birch-hazel scrub woodland with a fern-rich understorey was present in the region by *c*. 6950 cal. BC. Grassland was succeeded by this type of woodland slightly earlier around Scapa Bay, at *c*. 7450 cal. BC (de la Vega-Leinert *et al*. 2007). From *c*. 5850 cal. BC, *Alnus glutinosa* became part of the fen community immediately surrounding the sampled wetland at this site, where its presence increased at the expense of *Salix* (de la Vega-Leinert *et al*. 2007). A sequence from Deerness (east Mainland) suggests that fen conditions were succeeded by fairly dense birch-hazel scrub woodland at about 6500 cal. BC (Donaldson 1986), which is relatively late and does not support the argument that woodland development may have occurred earlier in the east of Orkney. However,

radiocarbon dating of this sequence is problematic, probably due to *in situ* contamination (Donaldson 1986), and woodland establishment in the area may well have occurred earlier. There is also evidence for the presence of birch-hazel scrub woodland during the later Mesolithic on southern Hoy in pollen assemblages from Loch of Torness (*c*. 5850 cal. BC: Bunting 1996) and Keith's Peat Bank (*c*. 5400 cal. BC: Blackford *et al.* 1996), and on Rousay from Loch of Knitchen at *c*. 4850 cal. BC (Bunting 1996). The sequences from Keith's Peat Bank and Loch of Knitchen begin post-woodland establishment, so the timing of woodland development on Hoy and Rousay is unclear.

Two episodes of woodland disturbance, at Quoyloo Meadow, west Mainland at *c*. 5450 cal. BC, and Keith's Peat Bank, Hoy at *c*. 5350 cal. BC, have been attributed to Mesolithic human activity (Bunting 1994; Blackford *et al.* 1996). At Quoyloo Meadow the woodland subsequently recovered, with increased species diversity and a less dense canopy which may have included *Pinus sylvestris* and *Quercus*. During the period of low arboreal pollen percentages at Keith's Peat Bank, charcoal concentrations were relatively high and *Melampyrum*, a species often associated with burnt ground and forest clearance, was present along with fungal spores indicative of the presence of grazing animals. This is interpreted as possible anthropogenic clearance about 1800 years before the first Neolithic settlement of Orkney, leading Blackford *et al.* (1996) to suggest that humans were present on Hoy during the Mesolithic period.

Although there is no doubt about the local presence of *Betula* and *Corylus avellana* on Orkney during the Mesolithic, there is some argument as to the origin of pollen from other arboreal species. At Quoyloo Meadow, similarities in the pollen curves for *Quercus* and *Pinus sylvestris* to those of *Corylus avellana* and *Betula* led Bunting (1994) to suggest that they were locally present, in contrast with other studies (e.g. Moar 1969; Keatinge and Dickson 1979), where the conclusion has been that *Quercus* and *Pinus sylvestris* pollen must have originated on the Scottish mainland. By analogy with Shetland (Bennett and Sharp 1993) and the Western Isles (Fossitt 1996), it seems likely that the woodland was more diverse in the more sheltered eastern areas of Orkney, which could have acted as a source from which taxa such as *Pinus sylvestris* and *Quercus* were able to colonise the brief opening of the woodland canopy which occurred at Quoyloo Meadow at *c*. 5450 cal. BC (Bunting 1994). Evidence for the local presence of *Quercus* further to the east in Orkney is provided by the Scapa Bay

sequence, where de la Vega-Leinert *et al*. (2007) inferred that this species grew in sheltered areas on the valley sides and formed part of a mixed deciduous woodland community from *c*. 5850 cal. BC. Small amounts of *Quercus* pollen also occur in the sequence from Deerness, although these are interpreted as representing long distance transport from the Scottish mainland (Donaldson 1986).

A radiocarbon dated sequence from the Loch of Torness on Hoy indicates that heathland began to form on exposed areas from *c*. 5850 cal. BC (Bunting 1996). No charcoal or anthropogenic indicator species are recorded from Loch of Torness, suggesting that no significant human impact occurred within the catchment. Instead the cause of heathland development at this site is attributed by Bunting (1996) to climatic and autogenic processes. A sequence from Loch of Knitchen on Rousay indicates that heath began to spread near the site at around 4550 cal. BC (Bunting 1996). The first decline in tree pollen proportions at this site occurs at around 4150 cal. BC, together with a further increase in heathland taxa. *Plantago* species and cereal pollen are present from this point onwards, and there is also a peak in microscopic charcoal just after the transition. Although heathland development had begun well before any clear human impact signal is seen, Bunting (1996) suggests that human activity may have had a significant effect on the later development of peat at this site.

Phragmites peat has been discovered in the intertidal zone at the Bay of Skaill, leading to the suggestion that it was once a freshwater loch with the coastline lying further to the west (Keatinge and Dickson 1979). This hypothesis is supported by the mollusc and diatom assemblages in samples from the opposite side of the bay (de la Vega *et al*. 1996). Today, the bay lies in a structural depression that was probably deepened by glacial action during the Devensian. Basal pollen assemblages indicate that from *c*. 5450 cal. BC an extensive freshwater marsh developed in this coastal depression (de la Vega-Leinert *et al*. 2000). Machair formation occurred around the site between *c*. 5250 and *c*. 3550 cal. BC, when aeolian blow-outs caused the redistribution of sand from a coastal dune ridge inland into machair landforms (de la Vega-Leinert *et al*. 2000).

3.1.3 Neolithic (*c*. 4000 – *c*. 2000 cal. BC)

Fig. 3.5 shows the parts of Orkney that fall within the RSAP of one or more existing pollen records covering the Neolithic period. While west Mainland is well represented,

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existing sites on Hoy and Rousay only record environmental changes within a very small area of those islands, and there are no records at all from South Ronaldsay or any islands north or east of Rousay. Again, the sites mainly cover fertile, low-lying parts of the archipelago, with few records from the more marginal areas.

Figure 3.5a Areas of Orkney for which existing palaeoecological records covering the Neolithic period are available, overlain on a map of superficial deposits

Figure 3.5b Areas of Orkney for which existing palaeoecological records covering the Neolithic period are available, overlain on a map showing altitude

At Quoyloo Meadow in west Mainland, it appears that following regeneration of woodland after the Mesolithic disturbance it declined again at *c*. 3950 cal. BC and was replaced by a more herbaceous-dominated vegetation (Bunting 1994). A pollen assemblage from Glims Moss, also in west Mainland, suggests that the birch-hazel scrub woodland which was initially present in the area declined at *c*. 3500 cal. BC (Keatinge and Dickson 1979) to be replaced by more open, herbaceous vegetation with high values of Poaceae and *Plantago lanceolata* pollen. This transition is also seen in sequences from the Loch of Skaill and Pow and is believed to date to roughly the same time as at Glims Moss, although Pow is undated and dating of the Loch of Skaill sequence is problematic due to the 'hard-water effect' (Keatinge and Dickson 1979). At another west Mainland site, Crudale Meadow, a woodland decline occurred at around

3450 cal. BC, slightly later than the second decline at Quoyloo Meadow (Bunting 1994).

Dating of these sequences is problematic. Age estimates for Bunting's (1994) sites were obtained by correlation with other, radiocarbon dated pollen diagrams from the region and by early Holocene tephras. Possible inaccuracies in radiocarbon dates from the Loch of Skaill led Keatinge and Dickson (1979) to use the position of the elm decline at *c.* 3000 cal. BC to infer dates for the changes seen in the pollen assemblage at this site. However, a review of Scottish woodland history by Tipping (1994b) highlights the fact that the timing of the elm decline was far from synchronous across the country, and a range of about a millennium in the timing of this event has been suggested for the British Isles (Bonsall *et al.* 1989; Kenney 1993). Despite these uncertainties, the general implication is that west Mainland was largely treeless by the mid-Neolithic. Evidence that this woodland decline was widespread across Mainland is provided by the sequence from Scapa Bay, where a decrease in woodland cover surrounding the site occurs at *c.* 3950 cal. BC (de la Vega-Leinert *et al.* 2007). A decline in arboreal pollen is also seen in the sequence from Deerness in east Mainland and by correlation with other pollen diagrams is assumed to occur at around 3700 cal. BC (Donaldson 1986).

At most Mainland sites the woodland loss took place over a few hundred years and coincided with the first solid records of the origin of pasture vegetation, leading to the suggestion that the primary cause of woodland decline was clearance by humans to make way for pastoral farming. At Quoyloo Meadow, for example, the decline in arboreal vegetation is accompanied by many signs of human activity, including increased charcoal abundance and the presence of cereal pollen and disturbance indicators such as *Plantago lanceolata* and *Artemisia* (Bunting 1994). There is a sedimentary change at this point in the core from lake sediments to herbaceous-dominated organic detrital sediments, and a sharp increase in magnetic susceptibility indicates allochthonous input to the basin. The sedimentary changes described are supported by the mollusc assemblage from this site, and are consistent with Neolithic human activity in the form of removal of tree cover and destabilisation of land surfaces by grazing animals (O'Connor and Bunting 2009).

At Scapa Bay, the woodland decline is associated with increases in pollen from species such as *Plantago lanceolata* and *Rumex acetosa*, both of which are indicative of grazing

activity, perhaps indicating an anthropogenic cause for the decline (de la Vega-Leinert *et al*. 2007). Following woodland loss at Deerness grassland became dominant in the area and this is thought to be due at least in part to human activity, indicated by the presence of pollen from *Plantago lanceolata* and other indicators of pastoral farming (Donaldson 1986). However, at Crudale Meadow the decline took place much more slowly over a period of about a thousand years, and is interpreted as being due to autogenic processes as much as to direct anthropogenic influence (Bunting 1994).

Keatinge and Dickson (1979) have also suggested that climatic changes may have been at least partly responsible for woodland decline. Blown sand deposits from coastal dunes at the Bay of Skaill stretch inland along the Loch of Skaill, and sand-blow events appear to have been occurring in the area since about 4950 cal. BC, with machair formation occurring since then until *c.* 3550 cal. BC (de la Vega-Leinert *et al.* 2000). Keatinge and Dickson (1979) suggest that the increase in wind speed indicated by these deposits may have contributed to the woodland decline either by causing physical damage to the woodland species, or indirectly via salt spray and sand abrasion.

The decline in woodland in west Mainland has been widely attributed to the onset of pastoral farming by Neolithic people in the area, due to increased charcoal abundance indicating woodland clearance and the presence of disturbance indicators such as *Plantago lanceolata* and *Artemisia*-type suggesting an increase in grazing pressure (Bunting 1994). Further evidence for both pastoral and arable farming during the Neolithic in west Mainland is provided by pollen assemblages from Maeshowe (Jones 1979) and the Stones of Stenness (Caseldine and Whittington 1976).

3.1.4 Bronze Age (*c*. 2000 – *c*. 800 cal. BC)

Fig. 3.6 shows the areas of Orkney falling within the RSAP of one or more existing pollen records covering the Bronze Age. Again, while west Mainland is relatively well covered, existing sites on other islands such as Hoy, South Ronaldsay and Rousay only reflect a small proportion of those islands. There are no records covering the Bronze Age from north or east of Rousay. Unlike the preceding Mesolithic and Neolithic periods, the records covering the Bronze Age come from both lowland sites on fertile boulder clay and from more marginal upland sites.
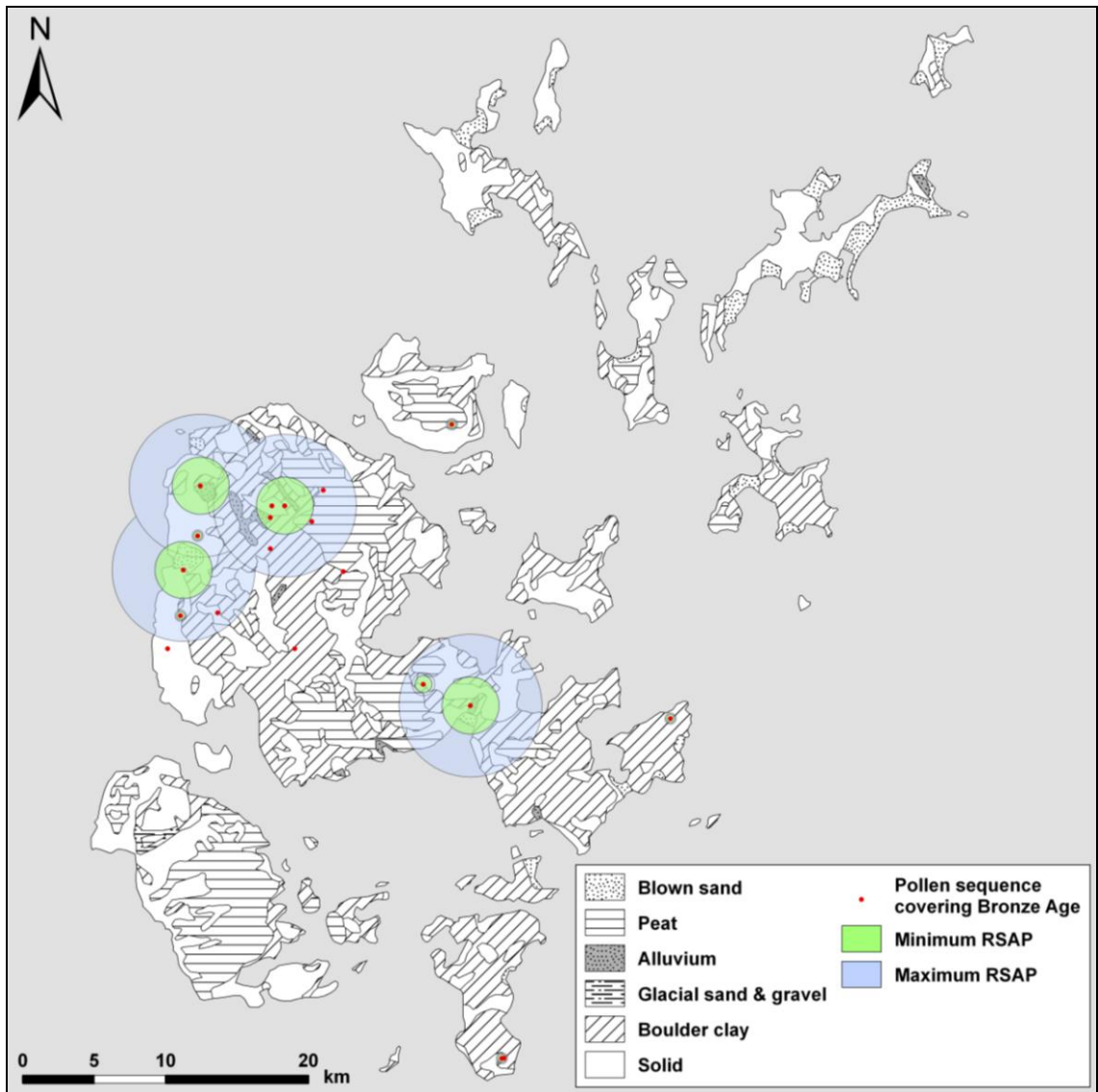
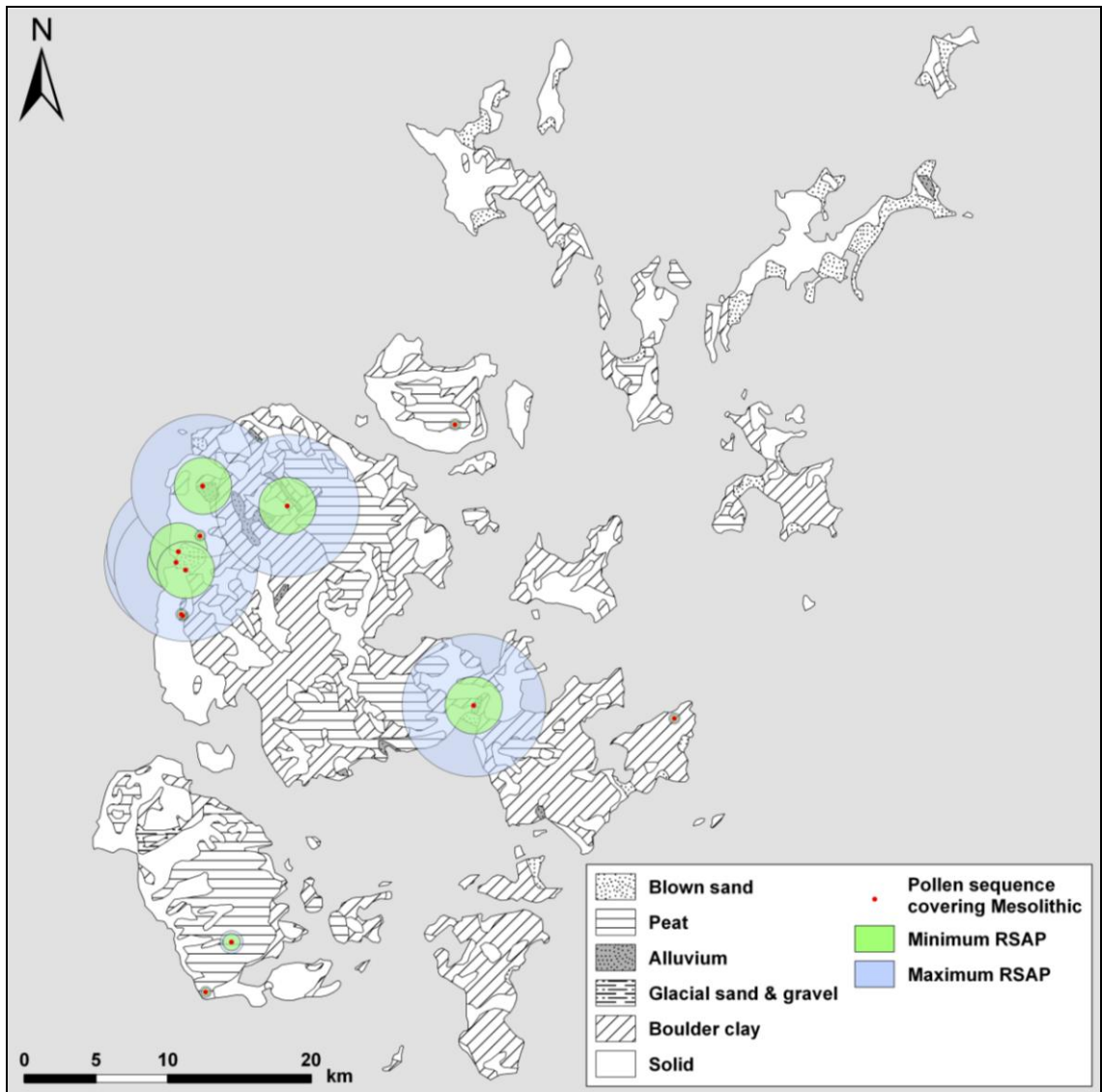**Figure 3.6a** Areas of Orkney for which existing palaeoecological records covering the Bronze Age are available, overlain on a map of superficial deposits
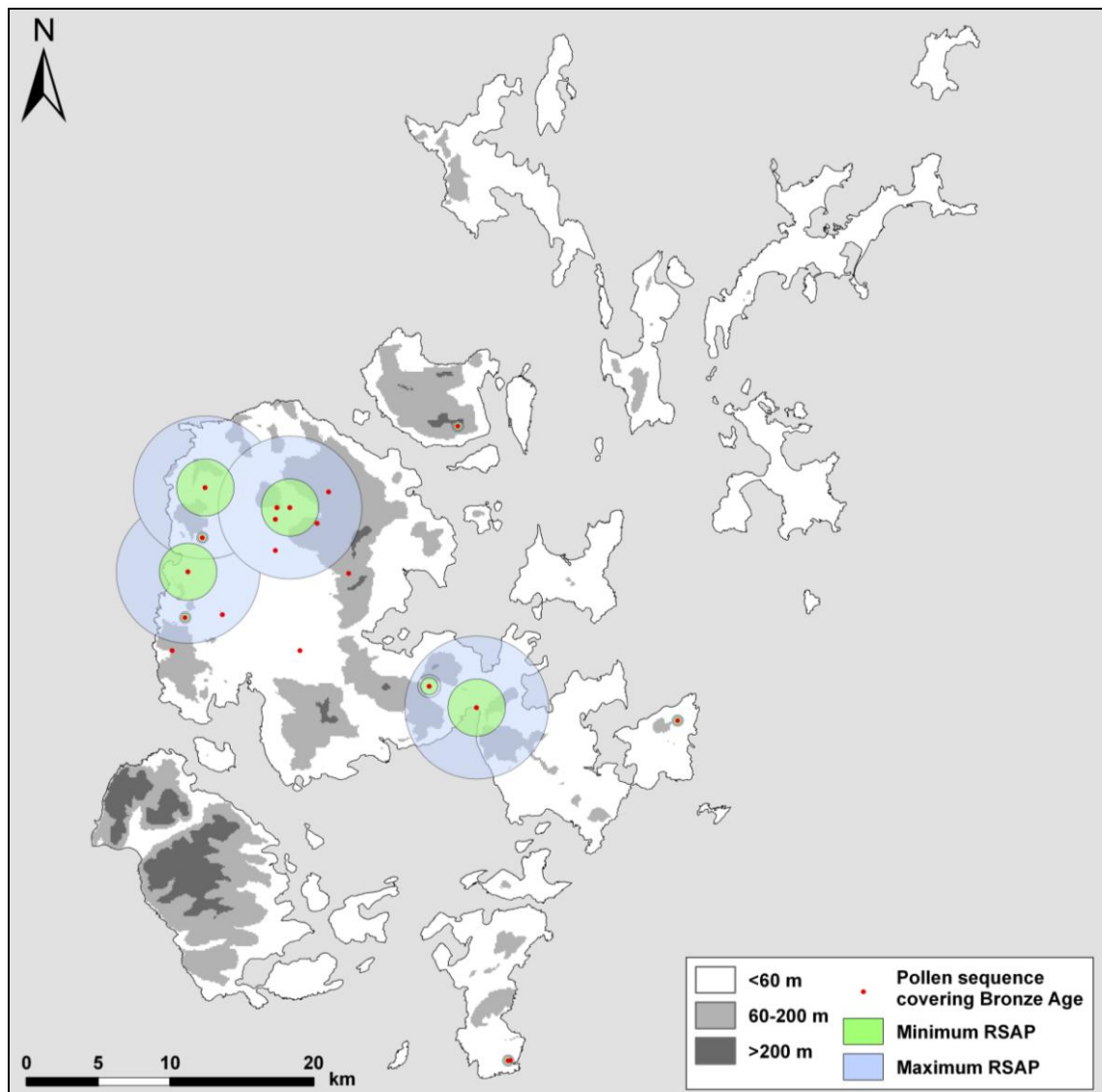
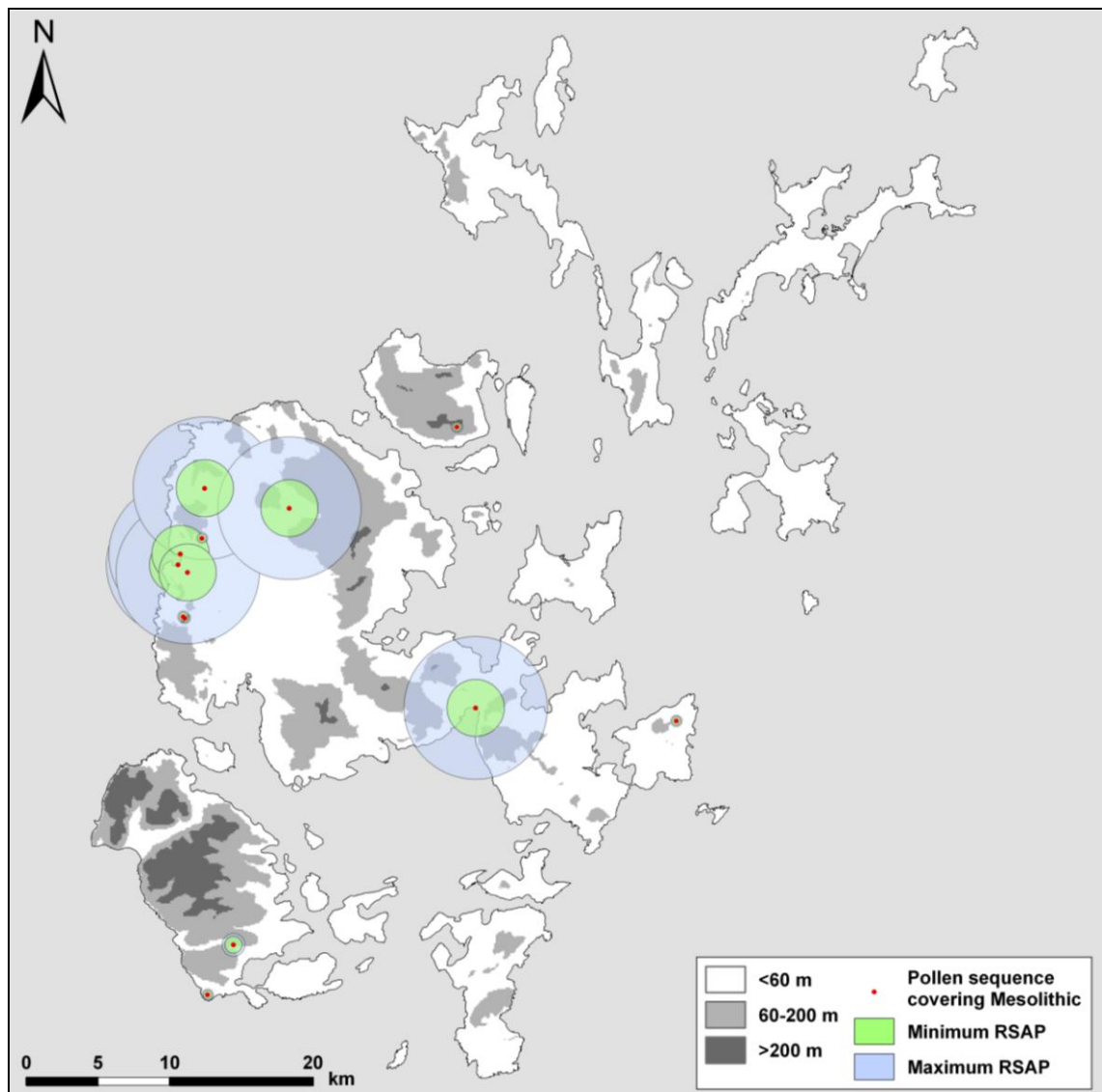**Figure 3.6b** Areas of Orkney for which existing palaeoecological records covering the Bronze Age are available, overlain on a map showing altitude

Evidence from Glims Moss in west Mainland indicates an open, largely treeless landscape during this period (Keatinge and Dickson 1979) and this is supported by shorter sequences from blanket peats in west Mainland, at Lesliedale Moss and Wideford Hill (Jones 1979). Despite this overall picture of an open environment there is evidence that small, relict stands of birch-hazel scrub persisted during the Bronze Age, for example near Burn of Rusht in west Mainland (Keatinge and Dickson 1979) and Liddle Bog on South Ronaldsay (Bartlett 1983), though the latter sequence is not radiocarbon dated. Whilst heathland development on the outer isles such as Hoy and Rousay had begun much earlier than the Bronze Age (Bunting 1996), radiocarbon dates from the bases of three peat cores from the west Mainland hills indicate that peat formation began in this area between *c.* 1750 cal. BC and *c.* 1100 cal. BC. Keatinge

and Dickson (1979) suggest that this may be linked to the well-documented northwest European climatic change that occurred at *c*. 850 cal. BC (e.g. van Geel *et al*. 1996; Mauquoy *et al*. 2004; Blundell and Barber 2005; Swindles *et al*. 2007), coupled with human pressure on the environment.

Evidence for Bronze Age agricultural activity comes from sites on both fertile and marginal land (see Fig. 3.6a). Of those records from areas of fertile boulder clay, evidence from organic deposits associated with Bronze Age archaeological sites in west Mainland and South Ronaldsay implies that there was a period prior to construction of the sites in the middle to late Bronze Age when the landscape was affected by low intensity human activity including mixed farming practices (Jones 1975; 1977; Downes 1994). Evidence from more marginal areas of upland peat includes pollen assemblages from three sites in the west Mainland hills which indicate that there was also quite intensive pastoral activity in the uplands during the Bronze Age (Keatinge and Dickson 1979). However, at other marginal sites such as Lesliedale Moss (Jones 1979) and Glims Moss (Keatinge and Dickson 1979) it is inferred that there was little agricultural activity during the Bronze Age, with evidence for some tree and shrub regeneration at Lesliedale Moss (Jones 1979).

The fact that fairly intensive pastoral activity was taking place in at least some upland areas in west Mainland during the Bronze Age (Keatinge and Dickson 1979) suggests that farming had expanded into more environmentally marginal areas, perhaps in response to a rise in population that resulted in increased pressure on more fertile soils and the need for more grazing land. However, there is little securely dated evidence of agricultural intensification from the more fertile areas in Orkney to support this argument.

Although dating of most Orcadian pollen sequences is poor, it does appear that there was a decline in anthropogenic activity in the more marginal areas towards the end of the Bronze Age (Jones 1979; Keatinge and Dickson 1979). The existing evidence from areas that are in agricultural use today show continued agricultural activity throughout the Bronze Age, with arable cultivation at Loch of Skaill (Keatinge and Dickson 1979) and indications of continuing pastoral activity from the Neolithic until the present day around Scapa Bay (de la Vega-Leinert *et al*. 2007). Although the proposed climatic change that occurred *c*. 850 cal. BC (e.g. van Geel *et al*. 1996; Mauquoy *et al*. 2004;

Blundell and Barber 2005; Swindles *et al*. 2007) would probably not have been enough to cause widespread agricultural abandonment in Orkney, it may have meant that exploitation of the more marginal areas was no longer economically viable.

Palaeoecological evidence for the Orcadian Bronze Age is fragmented and contradictory. This is due to the poor dating of long sequences and a large number of shorter pollen assemblages, including those from samples taken from archaeological sites. These archaeological samples provide a localised view of the environment from one particular point in time (see Fig. 3.2). There is a clear need for well-dated, high-resolution records of Bronze Age vegetation change from sites with differing degrees of marginality in order to fully understand the nature of human activity and land-use at this time. These records will allow investigation into possible reasons for the hypothesised 'decline' in culture and/or population seen in the Bronze Age archaeological record.

3.1.5 Iron Age (*c*. 800 cal. BC – *c*. 600 cal. AD)

Fig. 3.7 shows the parts of Orkney that fall within the RSAP of one of more existing pollen records covering this period. West Mainland is well represented, but of the other islands only Rousay has palaeoecological evidence covering the Iron Age, and the record of vegetation change from this site only covers a small area of the island. As for the Bronze Age, the evidence for Iron Age environments is drawn from a range of sites with differing degrees of marginality.

From *c*. 650 cal. BC, heathland began to develop on the slopes surrounding Scapa Bay on Mainland. Anthropogenic indicator species are well represented in the pollen record at this time, and it is suggested that while human activity probably contributed to heath spread around the site, pedological factors operating alongside the northwest European climatic deterioration at *c*. 850 cal. BC probably played a more significant role in this development (de la Vega-Leinert *et al*. 2007).
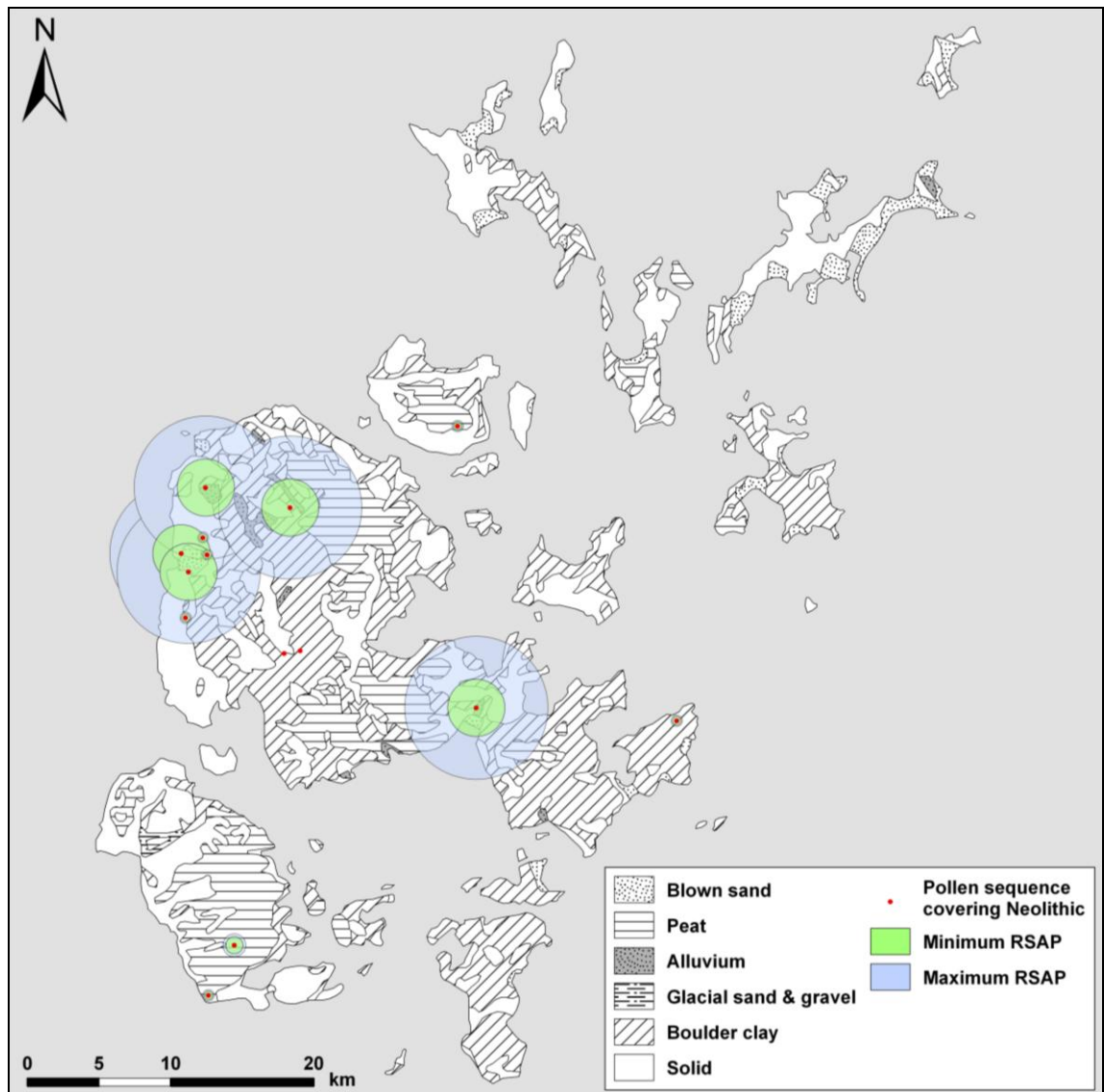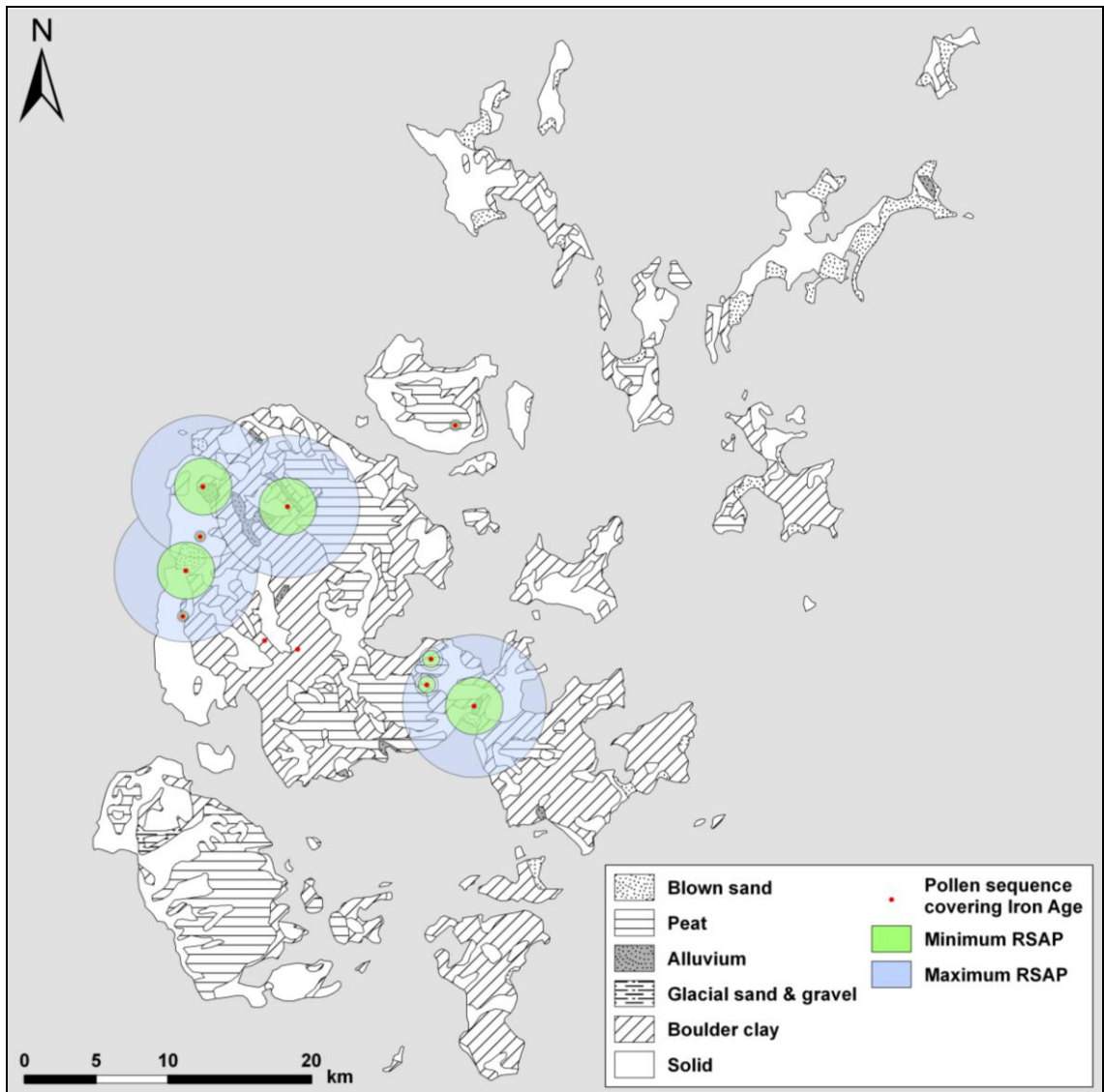
Figure 3.7a Areas of Orkney for which existing palaeoecological records covering the Iron Age are available, overlain on a map of superficial deposits
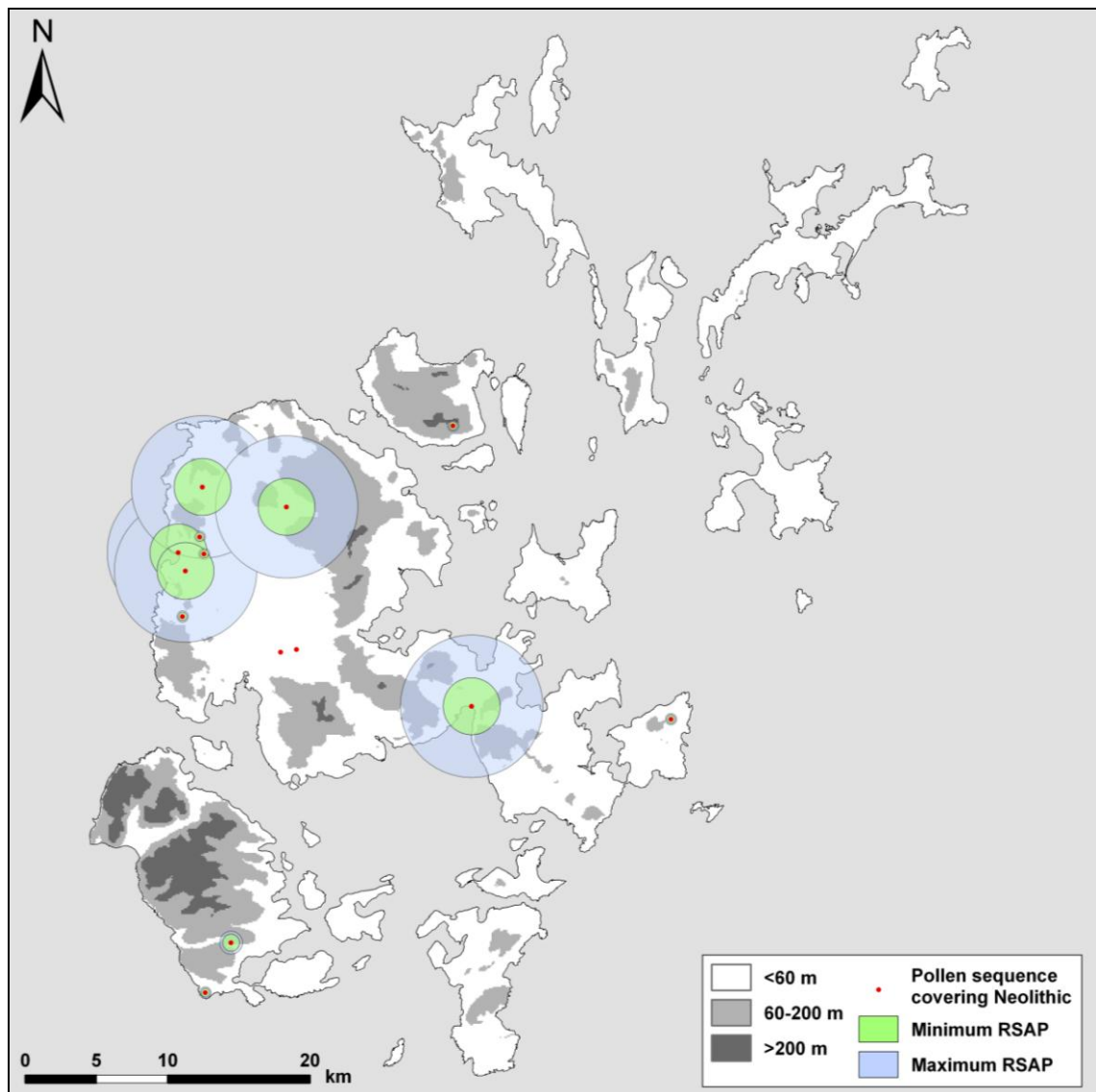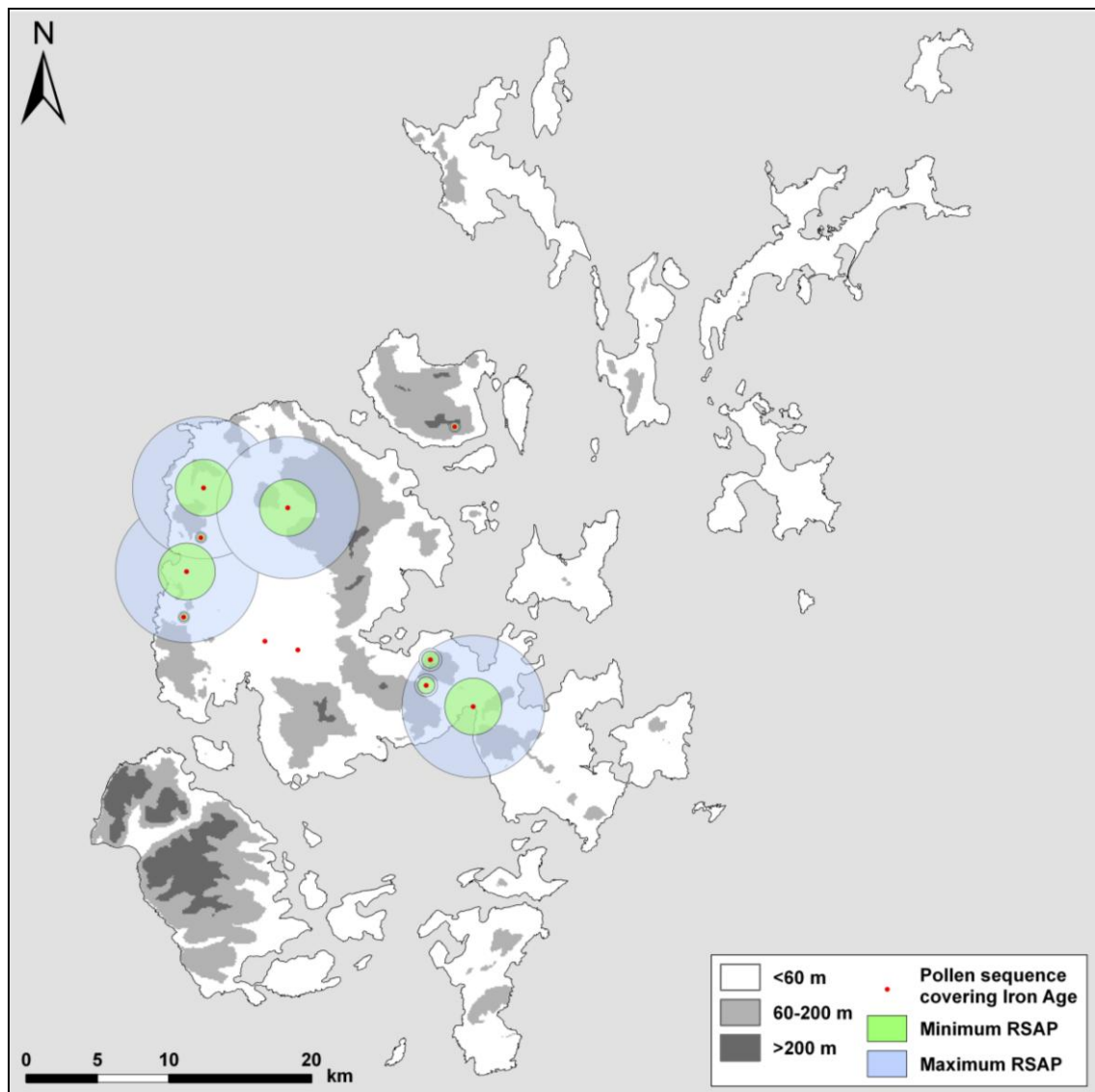
Figure 3.7b Areas of Orkney for which existing palaeoecological records covering the Iron Age are available, overlain on a map showing altitude

The sequence from Lesliedale Moss in west Mainland suggests that at around 100 cal. AD widespread heath formation occurred and heath and ruderal communities became dominant in the surrounding landscape (Jones 1979). It has been suggested that intensive agrarian practices during the Iron Age resulted in soil degradation and subsequent heath formation around this site, and this is supported by evidence from Wideford Hill (west Mainland: Jones 1979), Glims Moss (west Mainland: Keatinge and Dickson 1979) and Loch of Knitchen (Rousay: Bunting 1996). Peaks in pollen of disturbance indicators such as *Plantago lanceolata* and *Artemisia*-type at *c.* 100 cal. AD at Glims Moss have also been tentatively linked with increasing Iron Age agricultural activity by Keatinge and Dickson (1979). Further evidence for human activity during the Iron Age is provided by an increase in charcoal content and *Calluna* percentages at

Loch of Knitchen on Rousay at approximately 250 cal. AD, suggesting an increase in local fire frequency, perhaps as part of heathland management for grazing animals (Bunting 1996).

Excluding the sequence from Scapa Bay (de la Vega-Leinert *et al.* 2007), and with the possible exception of the record from Loch of Skaill (Keatinge and Dickson 1979) which shows continuity of arable activity and perhaps a slight decline in pastoral farming from the Bronze Age into the Iron Age, all the evidence comes from sites on marginal peatland and there is no clear Iron Age record from the more fertile areas of the archipelago (see Fig. 3.7a). The picture of widespread heath formation at this time may therefore be a biased view reflecting the dominance of evidence from more marginal sites. Additionally, the poor dating of the pollen sequences covering the Iron Age also makes it difficult to accurately infer patterns of Iron Age land-use in Orkney.

Localised evidence for vegetational change during the Iron Age is provided by a short radiocarbon dated sequence from Maeshowe, which demonstrates an expansion of heathland and renewed agricultural activity from about 400 until at least 800 cal. AD. Jones (1979) suggests that this is representative of Iron Age and subsequent cultural activity in the area. However, similar patterns are not seen in a profile from the nearby Ring of Brodgar, and it is possible that the special significance of the site led to the surrounding land being protected from intensive agricultural use, with the result that environmental degradation and heath formation occurred later than elsewhere (Jones 1979).

3.1.6 The Pictish, Viking and Late Norse Periods (*c*. 600 – *c*. 1400 cal. AD)

There is little securely dated palynological evidence for environmental conditions post-Iron Age, although it is likely that few significant changes occurred between the end of the Iron Age and the 20th century. Palaeoecological evidence for the west Mainland environments inhabited by Pictish and Viking societies is provided by grain and charcoal recovered during excavations of pre-Viking and Viking settlements on the Brough of Birsay (Donaldson *et al.* 1981). The grain mainly comprised bere and oats, and willow or poplar, birch, hazel, pine and oak have all been identified amongst the charcoal. Only small amounts of pine and oak were present, and there is some doubt about whether these species were native to Orkney at that point in time. It is therefore argued that they were most likely to have been imported or collected as driftwood.

Substantial amounts of the other species implies local material was being used, and may therefore indicate that some scrub woodland was present in the area at least up until the Viking period (Donaldson *et al.* 1981). However an undated mollusc assemblage from a midden deposit in the vicinity of the Pictish and Viking farmsteads at Buckquoy in west Mainland, which is assumed to be contemporaneous with the settlement, is characterised by species that indicate an absence of woody vegetation (Evans and Spencer 1975).

It appears from the evidence described above that the landscape during Pictish and Norse times was largely open, possibly with small relict stands of woodland in some areas. It also appears that relatively intensive arable cultivation was taking place, although in general environmental evidence for this period is scarce.

3.1.7 Summary of Main Palaeoecological Changes

Table 3.2 summarises the main environmental changes that have occurred in Orkney from the final few thousand years of the Upper Palaeolithic through to the end of the Norse period. The table highlights differences in the records from different parts of the archipelago, and shows that there are significant gaps in palaeoecological coverage.

Archaeological period	West Mainland fertile lowlands	West Mainland marginal uplands	Hoy	Rousay	South Ronaldsay
Viking/Late Norse	Landscape largely open, some small relict stands of woodland. Intensive arable cultivation.				
Pictish	Landscape largely open, some small relict stands of woodland. Intensive arable cultivation.				
Iron Age	Heathland development due to climatic & anthropogenic factors. Increased grazing & arable indicators.	Largely open, treeless landscape. Heathland development due to climatic & anthropogenic factors.		Increased charcoal & *Calluna* percentages; possible heathland management *c.* 250 cal. AD.	
Bronze Age	Largely open, treeless landscape with some small relict woodland patches. Low intensity mixed agriculture.	Largely open, treeless landscape with some small relict woodland patches. Peat formation due to climatic & anthropogenic factors. Fairly intensive pastoral activity.			Largely open, treeless landscape with some small relict woodland patches. Fairly intensive mixed agriculture.
Neolithic	Birch-hazel scrub woodland declined *c.* 3500 cal. BC. Replaced by more open, herbaceous vegetation. Increase in grazing indicators. Some arable cultivation.	Birch-hazel scrub woodland declined *c.* 3500 cal. BC. Replaced by more open, herbaceous vegetation.		Heathland development began *c.* 4550 cal. BC. Woodland decline and further heath development *c.* 4150 cal. BC, possibly linked with human activity.	
Mesolithic	Heathland vegetation replaced by tall-herb grassland *c.* 9550 cal. BC. Tall-herb grassland replaced by birch-hazel scrub *c.* 6950 cal. BC. Brief woodland disturbance attributed to human activity.		Birch-hazel scrub woodland present. Brief woodland disturbance attributed to human activity. Heathland development occurred from *c.* 5850 cal. BC. Woodland decline and further heath development *c.* 4850 cal. BC.	Birch-hazel scrub woodland present.	
Upper Palaeolithic	Sparse vegetation of dwarf-shrub heath and arctic-alpine communities present from *c.* 12,000 cal. BC				

Table 3.2 Summary of major palaeoecological changes in Orkney from the end of the Upper Palaeolithic through to the end of the Late Norse period

3.2 Wider Geographical Context

3.2.1 Holocene Environments in North-East Mainland Scotland

Caithness is the nearest part of mainland Scotland to Orkney. The two counties are geologically comparable, with Old Red Sandstone bedrock giving rise to gentle topography, an abundance of easily worked stone for building, and relatively fertile soils. The two areas also have very similar Neolithic archaeology, with 78 chambered cairns recorded in Caithness and 76 in Orkney, most of which belong to the Orkney-Cromarty group of passage graves found throughout northern Scotland (Davidson and Henshall 1991). There are many similarities between the two areas, so it is worth comparing the palaeoecological records of Orkney and Caithness and the rest of north-east mainland Scotland to assess whether the vegetational history of the islands differs from that of the mainland.

Like Orkney, north-east mainland Scotland has been neglected palaeoecologically and very few radiocarbon dated pollen sequences currently exist from the area. The two most complete sequences, one from Loch of Winless (Peglar 1979) and one from Cross Lochs on the Sutherland-Caithness border (Charman 1994), provide evidence of environmental conditions throughout the Holocene (see Fig. 3.8 for locations of sites mentioned in the text). Although both records are radiocarbon dated, dating of the core from Loch of Winless is problematic due to the presence of calcareous sediments (Peglar 1979).

During the early Holocene at Cross Lochs, open birch-juniper woodland with *Empetrum* and *Calluna* became established. Continued warmer conditions led to the arrival of *Corylus* shortly afterwards, with a change to more closed birch-hazel woodland at *c.* 8150 cal. BC (Charman 1994). Similar percentage tree pollen values (*c.* 50%) also occur at Loch of Winless at *c.* 8750 cal. BC, indicating the presence of this woodland further to the east as well (Peglar 1979). The apparent earlier establishment of woodland at Loch of Winless may not be accurate due to poor dating of this sequence (Peglar 1979). Open deciduous woodland comprising birch, willow, hazel, rowan and juniper was present around Loch Farlary further to the south at around 6550 cal. BC, although the timing of actual woodland establishment at this site is unknown since the record begins after this event (Tipping *et al*. 2008b).
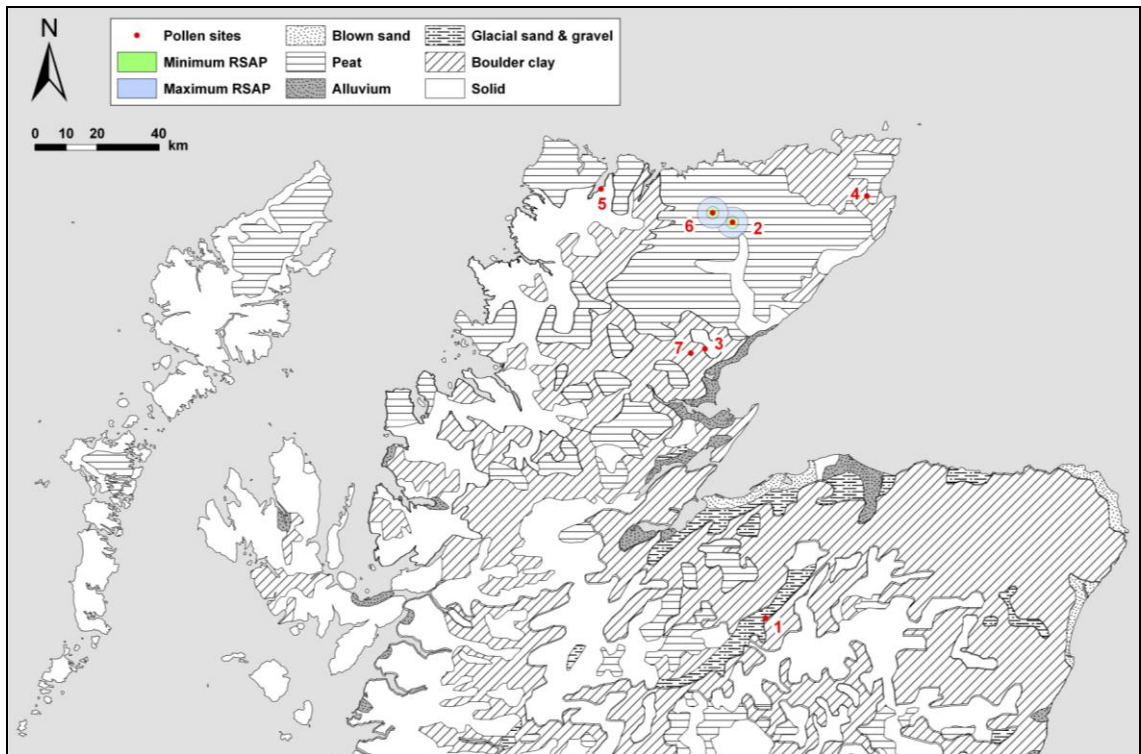
Figure 3.8a Map of northern Scotland showing the location of palaeoecological sites mentioned in the text, with RSAPs overlain on a map of superficial deposits: 1. Abernethy Forest (Birks 1970); 2. Cross Lochs (Charman 1994); 3. Loch Farlary (Tipping *et al.* 2008a; 2008b); 4. Loch of Winless (Peglar 1979); 5. Lochan an Druim (Birks 1993); 6. Lochstrathy (Gear and Huntley 1991); 7. Reidchalmai (Tipping *et al.* 2008a)
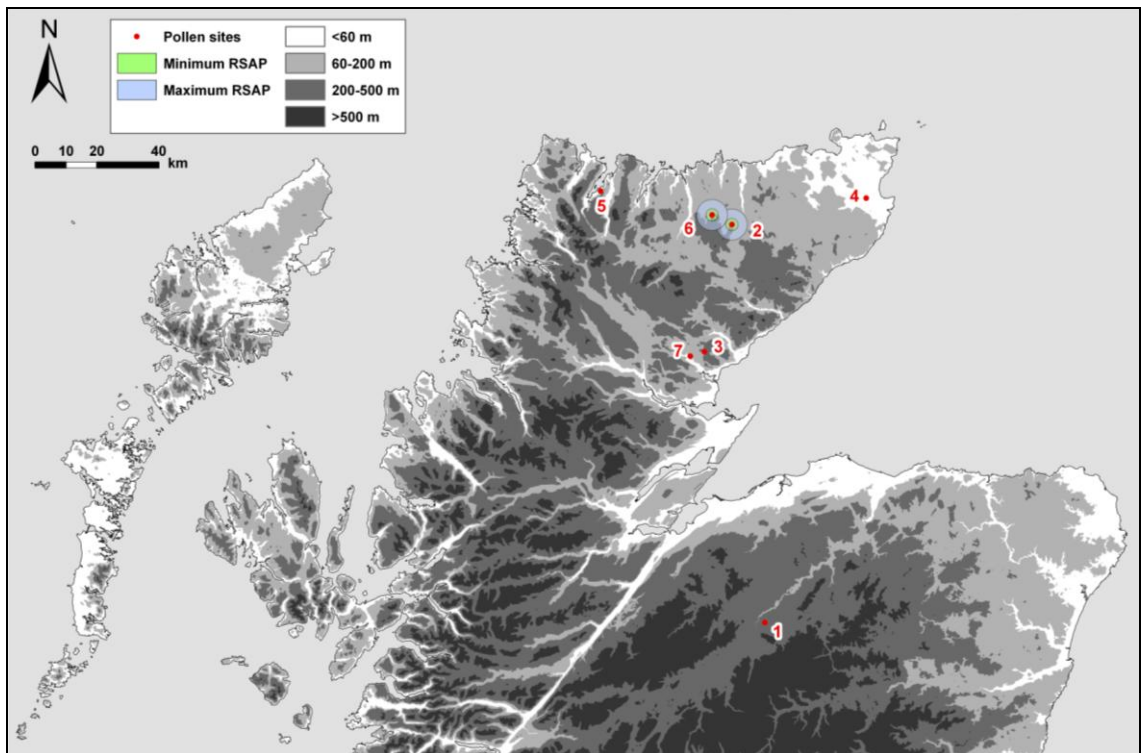
Figure 3.8b Map of northern Scotland showing the location of palaeoecological sites mentioned in the text, with RSAPs overlain on a map showing altitude: 1. Abernethy Forest (Birks 1970); 2. Cross Lochs (Charman 1994); 3. Loch Farlary (Tipping *et al.* 2008a; 2008b); 4. Loch of Winless (Peglar 1979); 5. Lochan an Druim (Birks 1993); 6. Lochstrathy (Gear and Huntley 1991); 7. Reidchalmai (Tipping *et al.* 2008a)

Work on detecting small stands of woodland in modern pollen assemblages from north-west Scotland (Bunting 2002) has shown that arboreal pollen values as low as 15-20% can indicate the presence of quite extensive local woodland. The values of *c.* 50% arboreal pollen from Cross Lochs and Loch of Winless therefore indicate that there was probably relatively extensive woodland near to these sites during the early Holocene, although cover does not seem to have been as dense as it was around sites to the north-west (Lochan an Druim: Birks 1993) and to the south (Abernethy Forest: Birks 1970) where higher percentage arboreal pollen values have been recorded (*c.* 80% and *c.* 70% respectively).

As in Orkney, the composition of early Holocene woodland in north-east mainland Scotland is ambiguous. Birch-hazel scrub woodland was almost certainly present at this time, but the local presence of other species such as pine, oak and elm is less certain. Small quantities of oak and elm pollen in the assemblage from Cross Lochs are interpreted as representing the establishment of mixed woodland further south (Charman 1994). The presence of *Pinus sylvestris* pollen is also attributed to long distance transport from the south and west (Peglar 1979; Charman 1994), as the growth of pine is thought to have been limited to the southern Highlands until around 3400 cal. BC (Gear and Huntley 1991). However Tipping *et al.* (2008b) have demonstrated the local growth of *Pinus sylvestris* at Loch Farlary between *c.* 5650 cal. BC and *c.* 4050 cal. BC, when *Pinus* woodland seems to have declined in the area in response to climatic changes.

An increase in aridity at around 5050 cal. BC seems to have caused fragmentation of the deciduous woodland at Loch Farlary. Fire frequency and/or intensity also increased as a result of this, which facilitated the expansion of heathland around the site (Tipping *et al.* 2008b). From around 4300 cal. BC at Cross Lochs, arboreal pollen declines to *c.* 10% and a generally open landscape is depicted. This open phase lasts until *c.* 2850 cal. BC and may reflect human impact at the start of the Neolithic period, for which there is abundant archaeological evidence in the area (Charman 1994). However, the period over which woodland loss occurs is quite long, similar to that at Crudale Meadow on Orkney, where the decline was attributed mainly to autogenic processes, possibly with some anthropogenic influence (Bunting 1994).

From *c.* 3250 cal. BC, *Pinus sylvestris* became established again at Loch Farlary, perhaps colonising areas where deciduous woodland cover had been disturbed by Neolithic human activity (Tipping *et al*. 2008b). The mixed woodland decline at Cross Lochs is followed by a pine expansion at around 2850 cal. BC, at around the same time as the range of pine in Scotland is hypothesised to have expanded northwards in response to the drying out of blanket mire surfaces caused by changes in atmospheric circulation (Gear and Huntley 1991). This pine expansion at Cross Lochs indicates the short-lived local presence of open pine forest which ceased around 2400 cal. BC in response to increases in mire surface wetness (Charman 1994), at around the same time as the widespread pine decline to the south and south-west of the site (Pennington *et al*. 1972; Birks 1975; Gear and Huntley 1991). This pine decline is also recorded at Loch Farlary at around 2050 cal. BC, although at this site it is attributed to low density grazing pressure rather than climatic change (Tipping *et al*. 2008b).

The occurrence of local pine in a pollen diagram is unusual for the far north-east of Scotland, despite widespread occurrences of macrofossils in peat deposits in the region (Birks 1975; Gear and Huntley 1991). It has been shown that at Lochstrathy in Sutherland pine pollen values sufficient to indicate the local presence of trees (>30% of the terrestrial pollen sum) were restricted to only 68 mm of peat which covered 325 ±85 years (Gear and Huntley 1991), and it is therefore possible that a short-lived period of local pine growth elsewhere in the far north-east of Scotland has remained undetected by those palynological studies with wider sampling intervals (Gear and Huntley 1991; Charman 1994).

Following the pine decline at Cross Lochs at 2400 cal. BC open habitats, probably mostly blanket mire, became established (Charman 1994). Extensive blanket peat was present from around 2600 cal. BC onwards around Loch Farlary to the south of Cross Lochs, and *Calluna* heath is increasingly represented at Reidchalmai from *c.* 2050 cal. BC (Tipping *et al.* 2008a). Following this widespread heath formation north-east Scotland remained almost treeless, with pollen diagrams dominated by *Calluna*, Poaceae and Cyperaceae (Peglar 1979; Robinson 1987; Charman 1994). At Cross Lochs there are no apparent major changes in the nature of the landscape from this time onwards (Charman 1994), although there may have been some intensification of human activity at the Loch of Winless at *c.* 700 cal. BC, with a sharp increase in pastoral weeds and Poaceae (Peglar 1979). If this date is correct, it corresponds with

the early Iron Age, when agricultural intensification is also suggested for Orkney (e.g. Keatinge and Dickson 1979), although dating of the Loch of Winless sequence is uncertain due to the presence of calcareous sediments in parts of the core (Peglar 1979).

Contrasts between lowland and upland land-uses in north-east Scotland are inferred from pollen sequences from two sites in the Garbh Allt catchment. Woodland decline around these two sites occurred from around 2350 cal. BC onwards, with the implication being that trees were cleared to make way for farming at Reidchalmai, a lowland site, at this time. At Loch Farlary, which is an upland site in the same catchment, anthropogenic indicator species appear later at *c.* 1550 cal. BC. While human response to woodland decline around Reidchalmai seems to have been immediate, in the uplands around Loch Farlary it was around 800 years before full use was made of the increasingly open landscape around this site (Tipping *et al.* 2008a), perhaps indicating that population expansion in the late Neolithic or early Bronze Age had resulted in increased pressure on the better agricultural land and was forcing the cultivation and exploitation of more marginal upland areas by the mid Bronze Age.

During the later Bronze Age, both landscapes seem to have supported similar agricultural practices, with arable cultivation as well as grazing of grassland and grassy heath (Tipping *et al.* 2008a). Following the widely recorded northwest European climatic deterioration at *c.* 850 cal. BC (e.g. van Geel *et al.* 1996; Mauquoy *et al.* 2004; Blundell and Barber 2005; Swindles *et al.* 2007), around the same time as a shift to wetter surface conditions occurred at Loch Farlary, arable cultivation appears to have ceased around this upland site, although the land continued to be grazed. In contrast, around the lowland site of Reidchalmai it appears that arable farming intensified following the shift to wetter conditions. Tipping *et al.* (2008a) suggest that the climate change at *c.* 850 cal. BC resulted in these changes in land-use as populations adapted to the new environmental conditions, with arable cultivation becoming dominant in the lowlands and a pastoral specialism developing in more marginal upland regions. Similar processes of adaptation and response to changing environmental conditions may explain the apparent agricultural intensification seen in the early Iron Age of Orkney (e.g. Keatinge and Dickson 1979).

3.2.2 Holocene Environments in Shetland and Faroe

Shetland has been the subject of more thorough palaeoecological investigation than either Orkney or north-east Scotland, although there are still large parts of the archipelago that have not been studied (see Fig. 3.9).   A comparison of the palaeoecological evidence from Shetland, Faroe and Orkney is necessary as the vegetation of the three island groups may have developed in a similar way due to their extreme northerly, maritime location.   However, since Orkney is much closer to mainland Scotland than Shetland or Faroe, palaeoecologically it may have more in common with north-east Scotland than with other Atlantic islands.

Four sites from Shetland have produced records covering the entire Holocene – two in the east, at Dallican Water (Bennett *et al.* 1992) and Lang Lochs Mire (Hulme and Shirriffs 1994), and two in the west at Murraster (Jóhansen 1975) and Gunnister (Bennett *et al.* 1993).   With the exception of Murraster, all these sequences are well dated with each having at least six reliable radiocarbon dates.   In addition, five other sequences from Shetland cover part of the Holocene.   These include Loch of Brunatwatt (Edwards and Moss 1993; Edwards and Whittington 1998), Troni Shun (Edwards and Whittington 1998), Clettnadal (Whittington *et al.* 2003), Clickimin (Edwards *et al.* 2005) and Scord of Brouster (Keith-Lucas 1986).   All these sequences are reliably radiocarbon dated, with the exception of that from Troni Shun which although undated correlates very well with the record from Loch of Brunatwatt (Edwards and Whittington 1998).   There are also two short sequences of unknown Holocene age from Papa Stour (Biggings Field and Loch of Biggings: Whittington and Edwards 1993). Fig. 3.9 shows the location of all Shetland sites mentioned in the text. It seems that Shetland represents the northernmost limit of extensive woodland during the early Holocene, since sites further north in the Faroe Islands have produced no evidence that woodland was ever abundant in these islands. Woodland in Faroe was probably limited to a few scattered stands of shrubby woodland including *Betula nana*, *Salix* and *Juniperus* in more sheltered parts of the archipelago during the early Holocene (e.g. Jóhansen 1975; Hannon *et al.* 2003; Hannon *et al.* 2005; Lawson *et al.* 2005; Lawson *et al.* 2008).
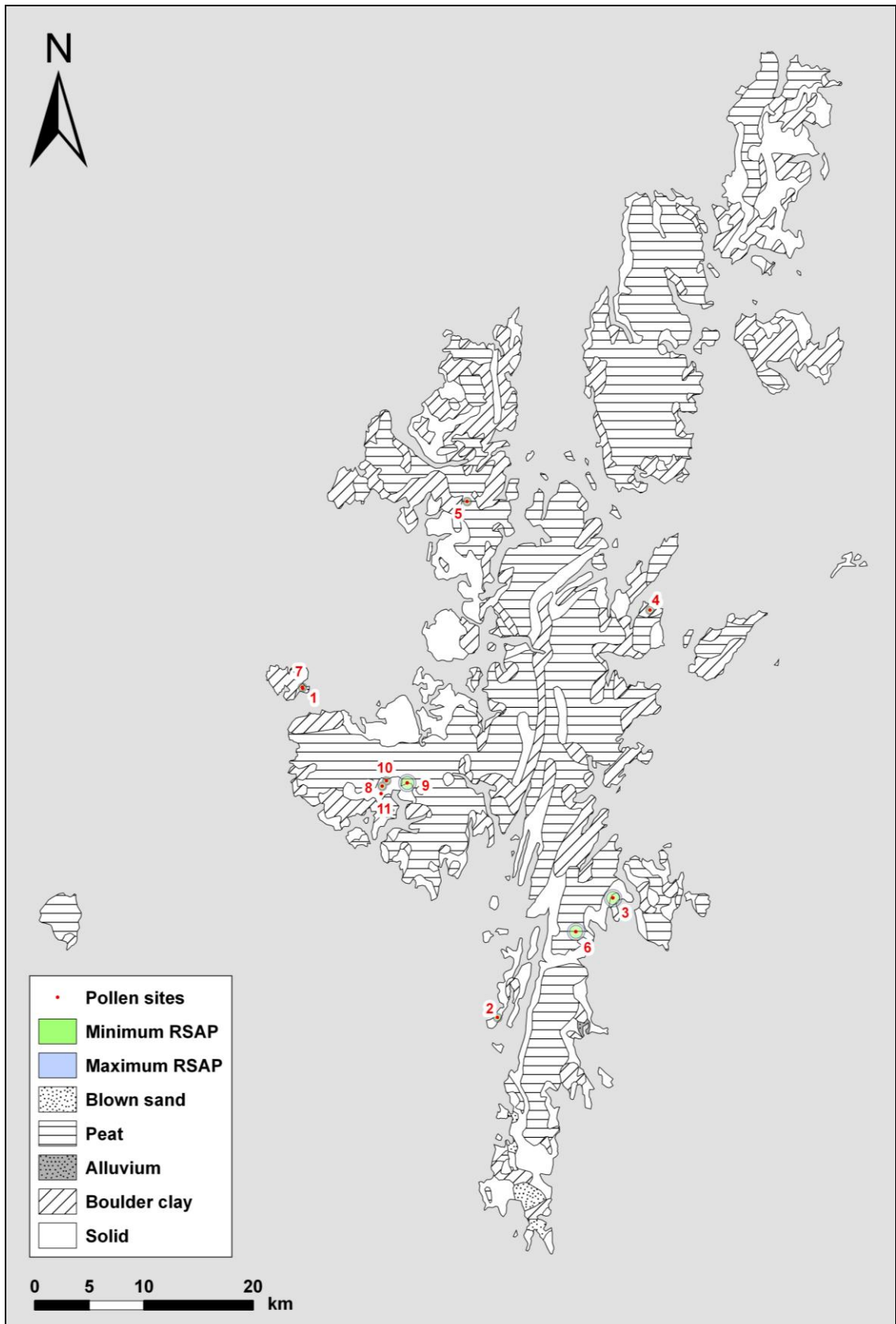
Figure 3.9a Map of Shetland showing the location of palaeoecological sites mentioned in the text, with RSAPs overlain on a map of superficial deposits: 1. Biggings Field (Whittington and Edwards 1993); 2. Clettnadal (Whittington *et al.* 2003); 3. Clickimin (Edwards *et al.* 2005); 4. Dallican Water (Bennett *et al.* 1992); 5. Gunnister (Bennett *et al.* 1993); 6. Lang Lochs Mire (Hulme and Shirriffs 1994); 7. Loch of Biggings (Whittington and Edwards 1993); 8. Loch of Brunatwatt (Edwards and Moss 1993; Edwards and Whittington 1998); 9. Murraster (Jóhansen 1975); 10. Scord of Brouster (Keith-Lucas 1986); 11. Troni Shun (Edwards and Whittington 1998)

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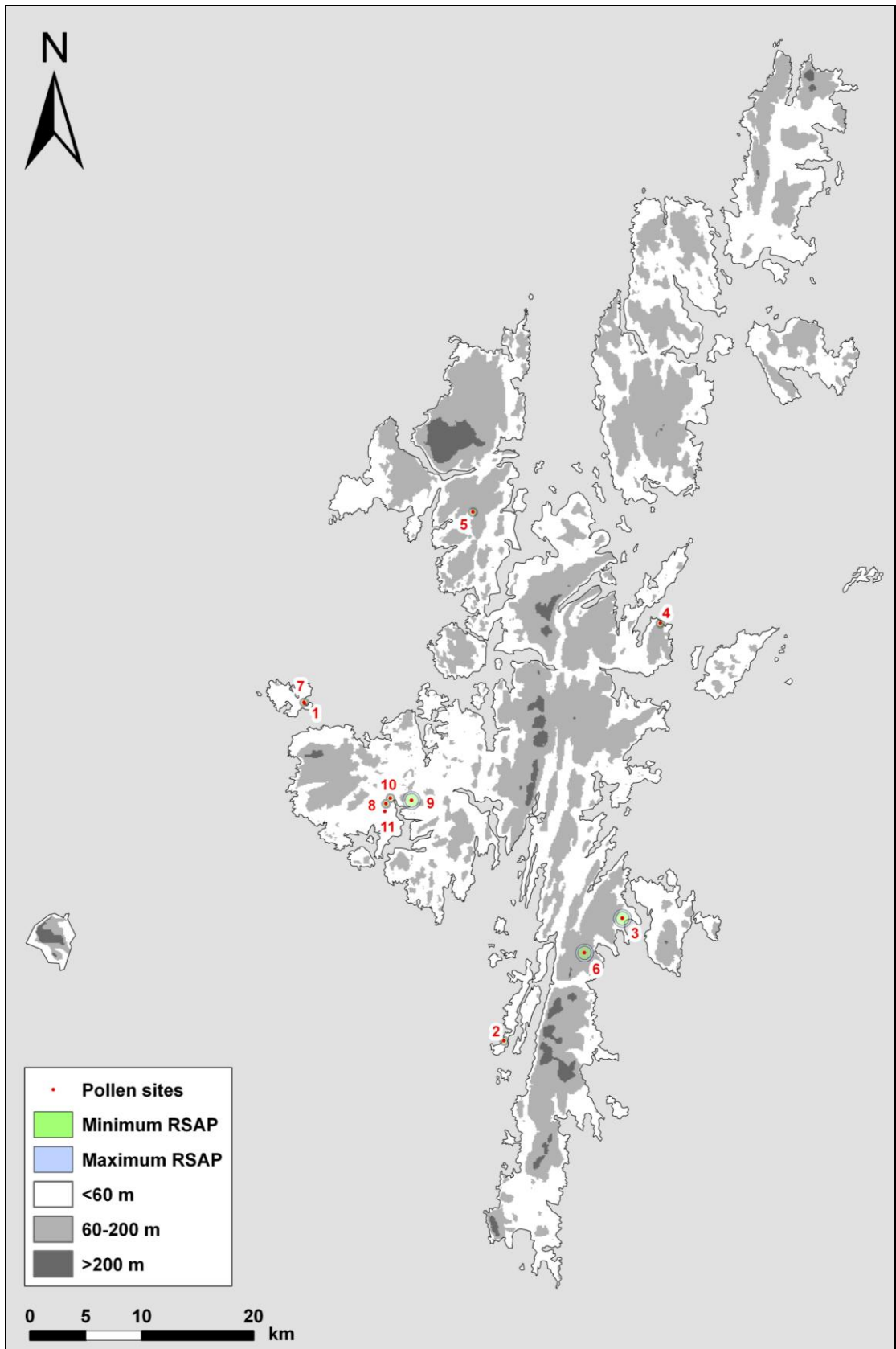
Figure 3.9b Map of Shetland showing the location of palaeoecological sites mentioned in the text, with RSAPs overlain on a map showing altitude: 1. Biggings Field (Whittington and Edwards 1993); 2. Clettnadal (Whittington *et al.* 2003); 3. Clickimin (Edwards *et al.* 2005); 4. Dallican Water (Bennett *et al.* 1992); 5. Gunnister (Bennett *et al.* 1993; 6. Lang Lochs Mire (Hulme and Shirriffs 1994); 7. Loch of Biggings (Whittington and Edwards 1993); 8. Loch of Brunatwatt (Edwards and Moss 1993; Edwards and Whittington 1998); 9. Murraster (Jóhansen 1975); 10. Scord of Brouster (Keith-Lucas 1986); 11. Troni Shun (Edwards and Whittington 1998)

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In the east of Shetland, woodland seems to have reached its full extent by around 8700 cal. BC (Bennett *et al*. 1992). The apparent relative lateness of woodland development in the west Mainland of Orkney at *c.* 6950 cal. BC may reflect the high degree of exposure of the sites sampled (Bunting 1994), and it is possible that in eastern Orkney woodland expansion occurred at a similar time to that in Shetland. This is supported by recent evidence from Scapa Bay further to the east on Mainland Orkney, where woodland became established at around 7450 cal. BC (de la Vega-Leinert *et al*. 2007).

Early woodland in Shetland has been shown to have consisted mainly of *Betula* and *Corylus avellana* and appears to have been similar to that which occurred in Orkney. However the record from Dallican Water indicates that, at least in eastern Shetland, more diverse woodland developed at *c.* 6750 cal. BC with *Alnus glutinosa*, *Quercus* and possibly *Ulmus* and *Fraxinus excelsior* being present (Bennett *et al.* 1992). Macrofossils of *Betula*, *Corylus avellana*, *Salix*, and *Alnus glutinosa* have been found in Shetland, confirming the presence of these taxa (Bennett and Sharp 1993). Bennett *et al*. (1992) argue that if *Alnus glutinosa* was present, then it is probable that *Quercus*, which has similar pollen productivity and dispersal but occurs in higher frequencies in the pollen record from Dallican Water, was also present. The diversity seen at Dallican Water suggests that a reassessment of the presence of oak and elm in Orkney is needed, as they may have been present in more sheltered eastern areas.

Following the establishment of woodland in Shetland, the vegetation of the islands developed differently according to locality. For example, *Corylus avellana* persisted until *c.* 6700 cal. BC at Lang Lochs Mire and Dallican Water, *c.* 3400 cal. BC at Murraster, *c.* 3000 cal. BC at Loch of Brunatwatt, and until *c.* 880 cal. BC at Gunnister, but it was only briefly present at Clettnadal at around 8400 cal. BC. Similarly, while *Betula* survived until *c.* 1700 cal. BC at Dallican Water, it had almost disappeared from Clettnadal by *c.* 8000 cal. BC. At Clettnadal, it is suggested that the extreme westerly and exposed coastal situation of the site may be responsible for the early replacement of woodland by maritime grassland (Whittington *et al.* 2003). This is similar to the situation in the Faroe Islands, where it is hypothesised that the early loss of woody vegetation at around 8400 cal. BC occurred in response to climatic change (Hannon *et al*. 2003). At Biggings Field and Loch of Biggings on Papa Stour, also at the western

edge of the archipelago, maritime heath and grassland were the dominant community types throughout much of the Holocene (Whittington and Edwards 1993).

At most sites on Shetland woodland clearance is inferred from pollen records from Neolithic times onwards (e.g. Jóhansen 1978; Keith-Lucas 1986; Bennett *et al*. 1992; Hulme and Shirriffs 1994; Edwards and Whittington 1998). However, with the exception of the records from Loch of Brunatwatt and Troni Shun (Edwards and Whittington 1998), where a marked reduction in arboreal pollen coincided with increases in pollen of anthropogenic indicator species at *c*. 3870 cal. BC (early Neolithic), the major period of environmental change associated with anthropogenic activity in the form of agricultural intensification seems to have taken place between around 2000 and 500 cal. BC (Bronze/Iron Age). At Dallican Water, woodland was almost completely cleared from the area within 150 years at about 1650 cal. BC. This clearance is associated with a charcoal peak and was probably the result of a deliberate act by humans to extend rough grazing (Bennett *et al.* 1992). An abrupt woodland decline is seen in the Gunnister profile at *c*. 880 cal. BC, again associated with increased charcoal (Bennett *et al*. 1993). At Clickimin, a major woodland decline took place at *c*. 1200 cal. BC and coincides with increases in cereal-type pollen (Edwards *et al.* 2005). It therefore seems that in Shetland the main period of human impact on the environment did not occur until *c*. 2000-500 cal. BC, rather than at the time of occupation by the first agricultural people at about 3900 cal. BC (Turner 1993). This is in contrast with Orkney, where major landscape change is associated with the arrival of the first Neolithic settlers at *c*. 4000 cal. BC. It also implies a possible Bronze Age population expansion in Shetland, again contrasting with Orkney where population and cultural decline is often suggested at this time (e.g. Ritchie 1995). Perhaps there was migration of people from Orkney to Shetland during the Bronze Age, or alternatively there could have been a shift in Shetland from an economy based mainly on fishing and marine resources to one in which farming became more important.

Blanket peat development was underway at Gunnister from *c*. 7750 cal. BC (Bennett *et al.* 1993), from around 6150 cal. BC at Lang Lochs Mire (Hulme and Shirriffs 1994), from *c*. 4890 cal. BC at Clickimin (Edwards *et al*. 2005) and from *c*. 3870 cal. BC at Loch of Brunatwatt (Edwards and Whittington 1998). At Dallican Water, the extent of peatland greatly increased at *c*. 3600 cal. BC, probably in response to natural soil leaching and acidification (Bennett *et al.* 1992). The spread of blanket peat around the

Neolithic settlement at the Scord of Brouster occurred from *c.* 1760 cal. BC and did not begin to cover former agricultural land until *c.* 300 cal. BC, long after occupation of the site had ceased (Keith-Lucas 1986). At sites further north in the Faroe Islands, peat accumulation began long before the first arrival of human settlers (e.g. Jóhansen 1975; Hannon *et al.* 2005; Lawson *et al.* 2005; Lawson *et al.* 2007), and it is likely that in Shetland natural processes were also responsible for the growth of blanket peat at several sites. However, at other sites in Shetland human impact has been linked with the spread of blanket peat. For example at Gunnister there is a marked expansion in *Calluna* at *c.* 900 cal. BC (Bennett *et al.* 1993) and at Clickimin this species increases dramatically at *c.* 1250 cal. BC (Edwards *et al.* 2005). Both of these expansions in heathland coincide with major woodland loss and charcoal peaks at these sites, leading to suggestions of human activity exacerbating the spread of heath (e.g. Edwards *et al.* 2005). As in Orkney, it would appear that while heath formation was underway at many sites well before any human impact signal is detected, anthropogenic activity could in some cases have accelerated the spread of peat in Shetland.

In terms of human activity, a mixed farming regime is depicted at several Shetland sites from the Neolithic onwards (e.g. Bennett *et al.* 1992; Edwards and Moss 1993; Edwards and Whittington 1998; Edwards *et al.* 2005). It is inferred from the appearance of cereal-type pollen, an increase in grasses and a rise in microscopic charcoal in the profile from Loch of Brunatwatt at *c.* 1800 cal. BC (early Bronze Age) that a slight intensification of agriculture occurred at this time (Edwards and Whittington 1998). However, at Dallican Water agricultural intensification seems to have occurred in the late Iron Age at *c.* 450 cal. AD (Bennett *et al.* 1992). It seems that the history of agricultural land-use is as diverse as the rest of landscape development in Shetland.

3.2.3 Comparison of Palaeoecological Records from Orkney, North-East Mainland Scotland and Shetland

There are several differences between the palaeoecological records from these three areas, notably in the timing of woodland establishment and decline. In north-east Scotland and the east of Shetland, woodland reached its fullest extent around 1700 years earlier than in Orkney, lending some support to the idea that the apparently late development of woodland in Orkney is due to the exposed western situation of the sites sampled and dated so far (Bunting 1994). Early Holocene woodland composition in Orkney and north-east Scotland is ambiguous, with only the presence of birch and hazel

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universally agreed upon. The occurrence of small amounts of pollen from other species such as oak, elm and pine has generally been attributed to long-distance transport from the south, although Charman (1994) has demonstrated a short-lived occurrence of local pine at Cross Lochs in north-east Scotland. There are also suggestions that on Orkney oak, elm and pine may have been locally present, particularly in more sheltered eastern locations (e.g. Bartlett 1983; Bunting 1994; de la Vega-Leinert *et al.* 2007). There is a clear need for more detailed study of woodland composition both in Orkney, particularly in the more sheltered eastern areas, and in the far north of mainland Scotland.

In Shetland, the timing of the major decline in tree species occurs around 2000 years later than in Orkney and north-east Scotland. Shetland's woodland composition and history is also much more diverse than that recorded for Orkney and north-east Scotland, with the presence of *Alnus glutinosa* and *Quercus* being confirmed (Bennett *et al.* 1992) and the timing of the *Corylus avellana* decline varying widely between sites (Whittington *et al.* 2003). This may be due to differences in geology, since although the surface deposits in Shetland are much less diverse than those in Orkney, mostly consisting of peat with only very small areas of more fertile boulder clay, it has been demonstrated by several of the studies described above that the spread of blanket peat in the islands is a relatively recent phenomenon, generally occurring in the mid to late Holocene (e.g. Bennett *et al.* 1992; Bennett *et al.* 1993; Edwards and Whittington 1998; Edwards *et al.* 2005). However, the bedrock geology of Shetland is much more varied than that of Orkney, comprising a mixture of igneous, metamorphic and sedimentary rocks, while Orkney mainly consists of sandstone. It is therefore possible that during the early Holocene when woodland was at its greatest extent Shetland supported a much greater range of soil types, giving rise to more diversity in vegetation. Also as a result of these differences in geology, the topography of Shetland exhibits much more variation than that of Orkney, creating more diversity of habitat and many more sheltered locations in which several tree species could grow. It is therefore possible that the differences in woodland composition between Orkney and Shetland are simply a result of the differences in underlying geology, but there is also a clear need to study pollen records from sites in the more sheltered eastern areas of Orkney in order to determine whether this variation is in fact a true reflection of the situation.

The timing of major human impact in Shetland between around 2000 and 500 cal. BC contrasts with the situation in Orkney, where major landscape change is associated with the arrival of the first Neolithic settlers in the islands at *c.* 4000 cal. BC. It also implies a possible Bronze Age population expansion in Shetland, again contrasting with Orkney where population and cultural decline is often suggested at this time (e.g. Ritchie 1995).

A common feature of the environmental records from Orkney, north-east Scotland and Shetland is a slight hint of agricultural intensification during the late Bronze Age and early Iron Age (Keatinge and Dickson 1979; Peglar 1979; Bennett *et al.* 1992), although the evidence from Orkney and north-east Scotland is poorly dated. Tipping *et al.* (2008a) have demonstrated contrasts in lowland and upland land-use within the Garbh Allt catchment in north-east Scotland and suggest that climatic change at *c.* 850 cal. BC resulted in these changes in land-use as populations adapted to the new environmental conditions, with arable cultivation becoming dominant in the lowlands and a pastoral specialism developing in more marginal upland regions. Similar processes of adaptation and response to changing environmental conditions may explain the apparent agricultural intensification seen in the early Iron Age of Orkney, although here the only evidence for this comes from poorly dated marginal sites (e.g. Keatinge and Dickson 1979). There is a clear need for well-dated, high-resolution records of prehistoric vegetation change from sites with differing degrees of marginality in order to fully understand the nature of prehistoric human activity and land-use in Orkney.

3.2.4 Woodland History and Human Impact in Scotland

In a review of the evidence for Scottish woodland history, Tipping (1994b) defines five major woodland types that occurred across the country at around 3000 cal. BC, just prior to the major period of human impact in Scotland. The distribution of these can be seen in Fig. 3.10. The 'flow country', northern mainland, and the Western and Northern Isles supported open birch-hazel woodland accompanied by a variety of other subsidiary tree species. Covering the hills to the east and south of Ben Klibreck in central Sutherland, approximately down to the Highland Boundary fault, pine-birch woods, with some oak and elm, were well established. On the west coast and on the islands of the northern Inner Hebrides, birch-hazel-oak woodlands were present. This type of woodland, although with less oak present, also occurred along the eastern and north-east seaboard north of the Firth of Tay. In this region the woodland cover was more dense than the birch-hazel woods of northern Scotland. Between the Highland Boundary and

Southern Upland faults, and on the eastern seaboard of Angus and Aberdeenshire, the primary woodland was dominated by oak, elm and hazel, with birch also present as a minor component.
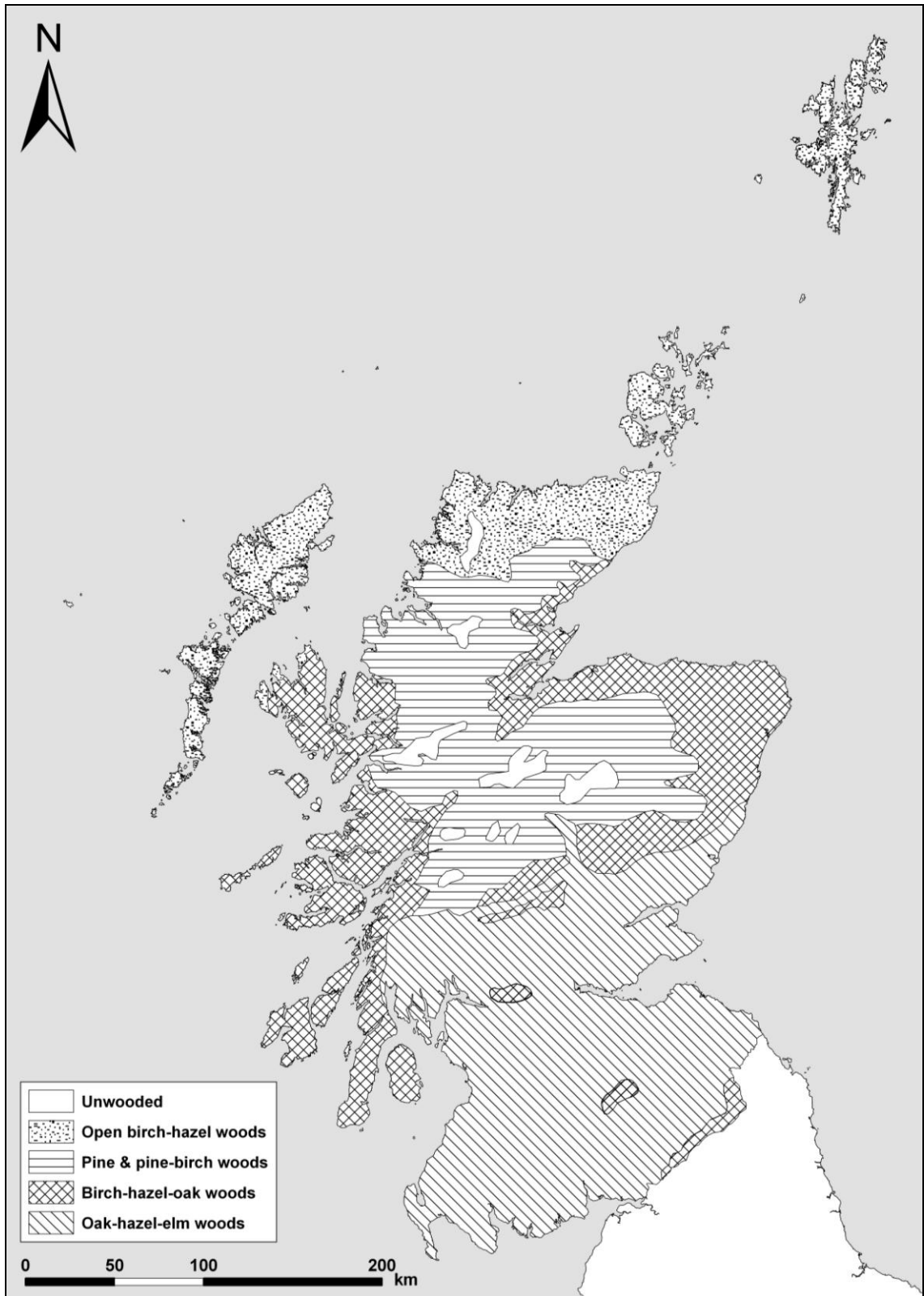
Figure 3.10 Distribution of major woodland types in Scotland at c. 3000 cal. BC (Tipping 1994b)

Despite the obvious differences in woodland cover between the various regions of Scotland described above, Tipping (1994b) identifies some common themes in the vegetation history of Scotland as a whole. The constancy of early Neolithic activity in the form of woodland clearance for agriculture is particularly striking, and raises questions about the size and mobility of the Neolithic population (Thomas 1999). Another recurring pattern throughout the country is renewed clearance, or the intensification of existing agriculture, during the early Bronze Age. This is in contrast with the 'Bronze Age decline' suggested by the archaeological record of Orkney. One aim of this thesis is to establish whether the environmental conditions and patterns of human activity in Orkney really were distinct from the rest of Scotland during the Bronze Age, and if so to suggest reasons for why this happened. Another common event, in southern Scotland at least, is a further intensification in agricultural activity during the Iron Age, which is also reflected by individual sites in other regions. This is consistent with findings from Orkney, north-east Scotland and Shetland where renewed agricultural activity is also a feature of the Iron Age record in places, although many of these records are poorly dated (Keatinge and Dickson 1979; Peglar 1979; Bennett *et al.* 1992).

Chapter 4: Methodology

This chapter describes the methods used to reconstruct the palaeoenvironmental record of Orkney from the period *c*. 3000 cal. BC - 600 cal. AD. Firstly, field methods including site selection, site survey and core collection are detailed. Laboratory methods used to investigate the record contained within the cores collected are then described and the analysis and presentation of the data obtained is explained.

4.1 Field Methods

4.1.1 Site Selection

The aim of this investigation was to reconstruct the vegetation of Orkney on a regional scale for the period *c*. 3000 cal. BC - 600 cal. AD (late Neolithic to Iron Age). As discussed in Chapter 3, existing palaeoecological records believed to cover the Bronze Age tend to cluster in west Mainland, and the areas where vegetation change is most effectively recorded (the relevant source area of pollen or RSAP) are mainly marginal, peaty land today. Sites in previously unstudied parts of the archipelago with varying degrees of marginality were therefore preferentially selected for this project in order to complement the existing data.

Simulation experiments suggest that basins of *c*. 100-500 m diameter recruit most of their pollen from an area within 300-800 m of the basin (Sugita 1994). These predictions have been empirically verified by Calcote (1995). Pollen data from basins of larger diameter (*c*. 1500 m) show little variation between sites, suggesting that they reflect much larger areas of the surrounding landscape (Sugita 1994). Therefore basins of *c*. 100-500 diameter were sought in order to compare variations in land-use between sites investigated. However, smaller basins were not excluded from consideration; they can provide a more local picture of past vegetation, for example to aid in the interpretation of archaeological sites.

Near-circular basins were preferred since pollen taphonomy is best understood for circular basins (Jacobson and Bradshaw 1981; Jackson 1994). It was also important that the basins were well-defined (clearly enclosed by contour lines), as they are more likely to have retained a constant size and shape over time, reducing the likelihood of changes in pollen assemblages reflecting changes in relative source areas of pollen due to changes in basin size rather than changes in the wider landscape.

Basins with no inflowing streams were searched for, since several studies have demonstrated that inflowing rivers are the primary source of pollen grains in lake sediments where they are present (Peck 1973; Bonny 1976; 1978; Pennington 1979; DeBusk 1997; Qinghai *et al*. 2005).   However Jackson (1994) argues that water transport is likely to be the dominant mode of pollen transport only in certain restricted situations, so otherwise suitable sites were not excluded on the basis of having an inflowing stream.

Lake deposits are generally preferred to peats, since the bottom of a lake provides a relatively stable depositional environment and changes in pollen assemblages can therefore usually be assumed to reflect changes in the composition of the pollen intercepted by the lake surface rather than changes in the depositional regime (Jackson 1994). Open water bodies are also preferable as aquatic pollen can be assumed to have derived from plants growing within the lake and therefore can confidently be removed from the pollen sum (Jackson 1994). Major taxa such as *Calluna*, *Erica*, *Vaccinium*, Poaceae and Cyperaceae grow on bog surfaces as well as in the surrounding landscape, so when working with records of open landscapes from bogs it is more difficult to exclude locally derived pollen from the pollen sum.

Although the underlying geology of Orkney means that there are few lakes suitable for sampling, it is known that valley mires in the islands often overlie lake sediments (Moar 1969; Keatinge and Dickson 1979; Bunting 1994) so these sites were considered. However, hydroseral succession in lakes and mires can complicate the interpretation of pollen records, as the establishment of different vegetation types on the sediment surface can alter the relevant source area of pollen (Bunting 2008). Therefore the spatial area represented by the pollen record will change through time and care must be taken with interpretation (Bunting *et al*. 2005; Bunting 2008).

'Ideal' sites for this investigation were defined as follows:
1) Near-circular, well-defined basins of 100-500 m diameter (although smaller basins were not excluded from consideration)
2) Lack of inflowing streams was preferred, although otherwise suitable sites were not excluded on this basis

3) Valley mire sites were searched for since they tend to hold older, more complete records and are less likely to have been disturbed by peat extraction than expanses of blanket peat

4) Sites with Neolithic, Bronze Age and Iron Age archaeological remains in the vicinity were preferentially selected

5) Since existing palaeoecological records tend to cluster in west Mainland, sites in other areas of Orkney were preferred

In practice, very few sites fulfilling all these conditions were found and a list of possible sites that fulfilled most of the criteria was drawn up by consulting Ordnance Survey 1:25,000 *Explorer* maps 461-465. These sites were visited in the field in order to further assess their suitability. During assessment of sites in the field, those that had obviously been subjected to peat cutting in the past were immediately rejected since they would not provide complete records, and the most promising of the remainder were surveyed with a Dutch auger to determine the depth and type of deposits that they contained. The exception to this was Spretta Meadow, which forms part of a SSSI. Work at this site was restricted to the collection of a single core by Scottish Natural Heritage, so no survey could be carried out. Sites that were surveyed during the first field season in June 2006 are listed in Table 4.1, and their locations are illustrated in Fig. 4.1.

Following the find of a late Bronze Age socketed axehead in an apparently 'ritual' context during peat cutting at Hobbister, Orphir in July 2006 (Cowie and O'Connor 2006), samples were taken from this site for palaeoenvironmental analysis during the second field season in September 2007. The characteristics of this site are also listed in Table 4.1 and its location is marked on Fig. 4.1.

4.1.2 Site Survey

At each of the basins selected for further study a programme of survey coring was carried out using a Dutch auger. Cores were taken at widely spaced equal intervals followed by higher resolution survey in areas of particular interest. The peat at Hobbister is currently under extraction for commercial purposes, and at this site the current active peat face was cleaned and the stratigraphy recorded at regular intervals.

Site	Site no.	Island	National Grid Reference	Approx. basin dimensions (m)	Estimated RSAP (m)	Max. depth of deposits surveyed (m)	Samples taken (depth (m) / method)
Blows Moss	1	South Ronaldsay	ND 455860	1250 × 250	600 – 800	7.00	6.50 / Russian
Burwick Loch	2	South Ronaldsay	ND 442844	250 × 250	600 – 800	2.75	2.55 / Russian
Clay Mire	3	Hoy	HY 203002	1500 × 500	600 – 800	1.45	1.34 / Dutch auger
Dyke of Sean	4	West Mainland	HY 289136	50 × 50	300 – 400	0.61	0.57 / Dutch auger
Fribo Moss	5	Westray	HY 444451	250 × 250	600 – 800	1.48	1.47 / Dutch auger
Hilldavale	6	Westray	HY 424476	250 × 125	300 – 400	0.98	0.92 / Dutch auger
Long Howe	7	East Mainland	HY 509060	60 × 40	300 – 400	2.79	2.68 / Dutch auger
Quholm	8	West Mainland	HY 255125	500 × 250	600 – 800	2.50	2.42 / Dutch auger
Spretta Meadow	9	West Mainland	HY 236147	250 × 250	600 – 800	Unknown – no survey	3.73 / Russian
Whaness Burn	10	Hoy	HY 245010	250 × 250	600 – 800	2.65	2.25 / Russian
White Moss	11	Westray	HY 473452	750 × 750	600 – 800	0.50	0.50 / Russian
Hobbister	12	Mainland	HY 396065	250 × 250		3.79	A) 3.75 / Russian B) 2.03 / monolith tins

Table 4.1 Characteristics of sites surveyed in the field during June 2006 and September 2007. Site numbers relate to those in Fig. 4.1, and estimated RSAPs are based on those in Sugita (1994). Russian cores and monolith samples were transported back to the laboratory complete, while those taken with the Dutch auger were subsampled in the field.

The sequences of deposits were described according to the Troels-Smith classification of unconsolidated sediments (1955). The location of each core was recorded using a handheld GPS and depths were measured from the present day ground surface. Where detailed site survey was carried out, transect diagrams with Troels-Smith's (1955) symbols were plotted using TSPPlus (Waller *et al*. 1995) and are presented in the appropriate results chapters.

4.1.3 Sample Collection

Coring

At each site the deepest and most complete sequence of deposits located by the stratigraphic survey was sampled for laboratory analysis using a 5 cm diameter Russian sampler, since this extracts the sediments with minimal disturbance (Jowsey 1966). Location of the coring point was recorded using a handheld GPS. The local vegetation at each coring point was noted so that any contamination by recent pollen can be related to local conditions (West 1977).
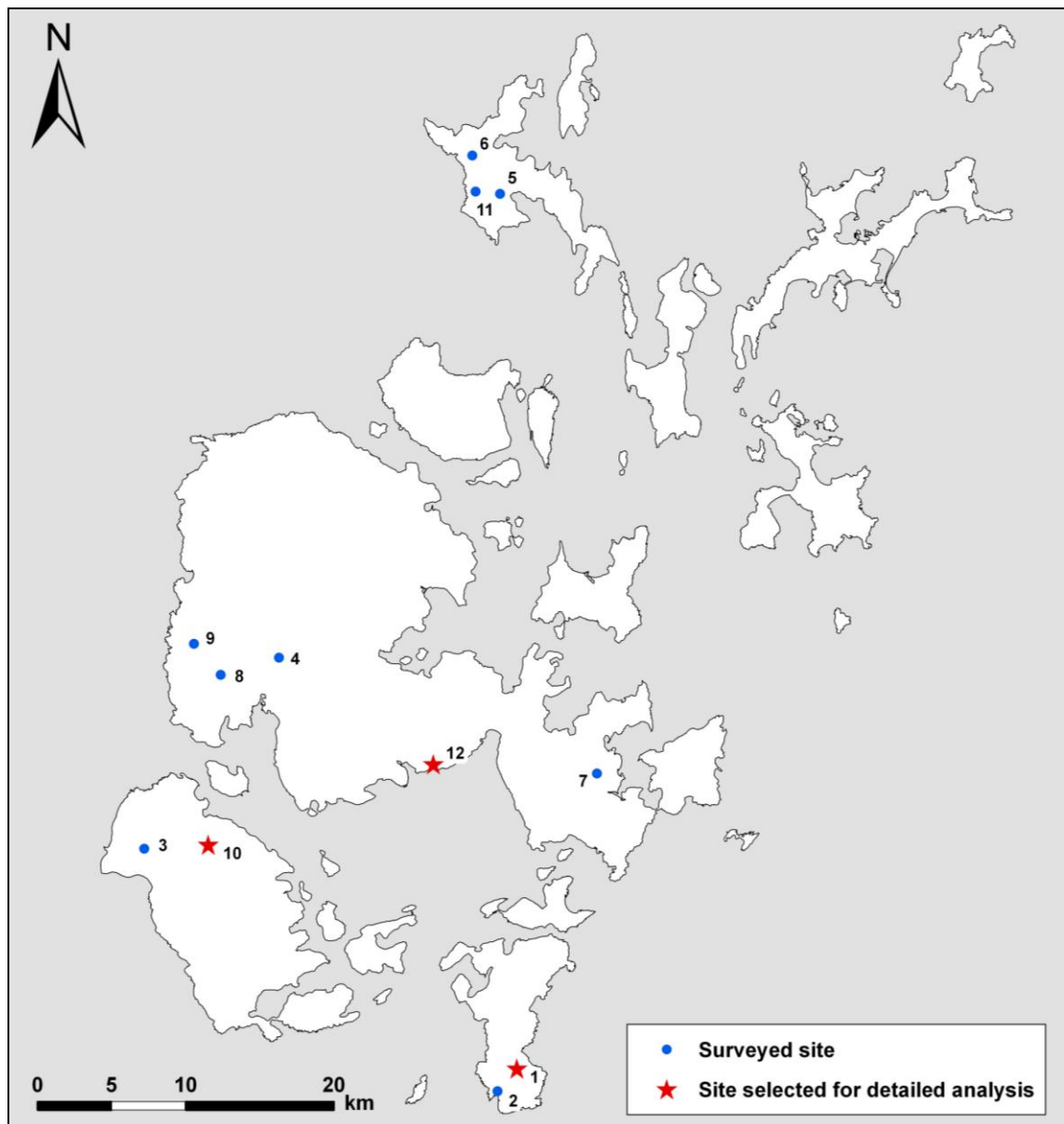
Figure 4.1 Location of all sites surveyed in the field during June 2006 and September 2007 (numbers relate to Table 4.1)

Cores were recovered in 50 cm sections and the sampler was thoroughly washed between each segment being taken. At some sites the sediment was too compact for the Russian sampler to be used, so cores were recovered using the Dutch auger, described according to Troels-Smith (1955) and subsampled in the field. Cores and subsamples were thoroughly wrapped in clingfilm and aluminium foil in the field to prevent them from drying out. Cores were transported back to the laboratory in lengths of plastic guttering to prevent them becoming compressed or otherwise disturbed. On return to the laboratory all cores and subsamples were stored in the dark at 5 ^{o}C to prevent desiccation or oxidation (Moore *et al*. 1991).

Sampling of Exposed Sections

At Hobbister, where the peat is currently being extracted for commercial purposes, the current active peat face was sampled during September 2007. A section of the face that contained pool deposits and which is thought to be closest to where the Bronze Age axe was found was sampled using 50 cm × 10 cm × 10 cm monolith tins, and the part of the sequence that was below ground level was recovered using a 5 cm diameter Russian corer. The samples were thoroughly wrapped in clingfilm and aluminium foil in the field, and since collection have been stored in the dark at 5 $^{\circ}$C.

4.2 Laboratory Methods

4.2.1 Pollen Analysis

Initially, cores and monoliths were subsampled at wide intervals to allow the production of skeleton pollen diagrams. Following radiocarbon dating based on these initial diagrams, the period of interest (*c*. 3000 cal. BC - 600 cal. AD) in each profile was identified and pollen analysis was carried out at intervals of 2 cm throughout this period for each site.

The core surface was cleaned using a scalpel before 1 cm^3 subsamples were removed. Tablets containing a known concentration of *Lycopodium clavatum* spores were added to the samples before chemical treatment to allow pollen concentrations to be calculated (e.g. Benninghoff 1962; Stockmarr 1971). The samples were treated using a range of physical and chemical processes in order to separate out the fine organic fraction of the sediment, concentrating the pollen (Moore *et al*. 1991, summarised in Fig. 4.2). Residues were stained using aqueous safranin and mounted on microscope slides in silicon oil.

Pollen counts were made along complete, evenly spaced traverses of a 40 × 24 mm coverslip using a Leica binocular microscope at a magnification of ×400, with ×1000 magnification and oil immersion used for critical identifications. Pollen and spores were identified using the keys of Moore *et al*. (1991) and Beug (2004) and the reference collections of the Department of Geography, University of Hull. Nomenclature follows Bennett *et al*. (1994) and Bennett (1995). Between 300-500 grains were counted per sample in order to reduce statistical errors (Maher 1972).
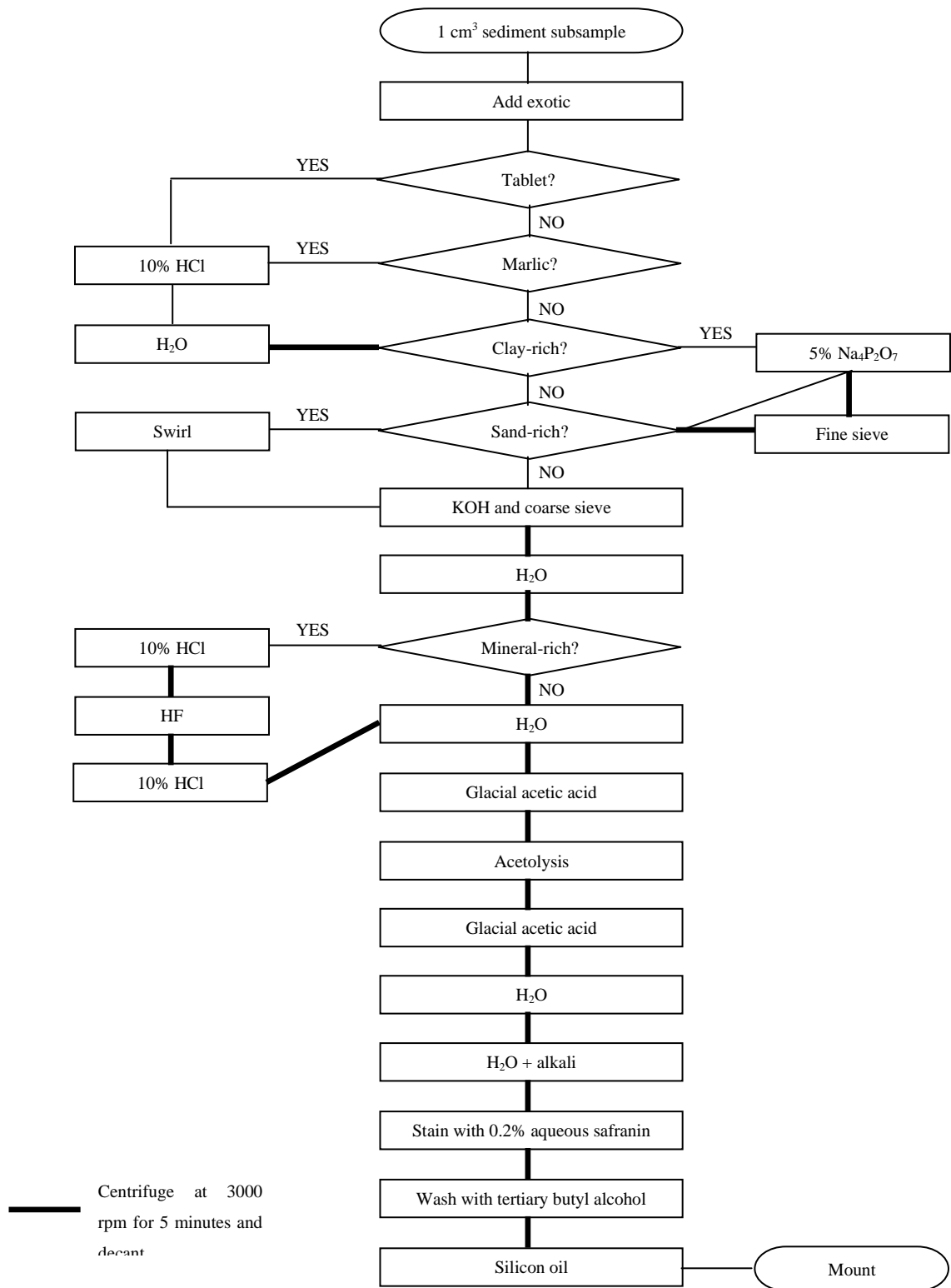
Figure 4.2 Pollen concentration procedures (after Moore *et al.* 1991)

Since cereal-type pollen is produced in low amounts and does not tend to be widely dispersed, Edwards and McIntosh (1988) devised a method for improving the rate of cereal-type pollen detection, based on the rapid scanning of microscope slides. This

method was used by Edwards *et al.* (2005) at Clickimin in Shetland, leading to the discovery of a consistent cereal-type pollen representation from the Bronze Age onwards. Since cereal-type pollen is large (usually >37 μm in diameter: Andersen 1979) it can be easily seen on microscope slides at low magnifications, e.g. ×100. From the initial count of between 300-500 pollen grains plus exotic marker grains, it is possible to calculate the total pollen count per slide. This then allows for the scanning of the equivalent of several thousand pollen grains in a relatively short time (Edwards and McIntosh 1988).

One grain of cereal-type pollen was recorded during the initial count of a basal sample from the Hobbister A core, and rapid scanning was carried out on this and adjacent samples to improve cereal detection. The equivalent of 1000-2000 pollen grains and spores were scanned but no further cereal-type pollen was recorded. It was therefore decided not to apply this method to other cores as it is still relatively time-consuming.

The sum used to calculate percentages consisted of all terrestrial pollen and spores, excluding bryophytes. Aquatic species and bryophytes are left out of the pollen sum as they reflect local rather than regional conditions (Birks and Birks 1980). Percentages of taxa not included within the main sum were calculated using the main sum plus the sum for the taxon. Pollen accumulation rates (grains $cm^{-2}yr^{-1}$) were calculated for each site with a secure age model, and where sediment accumulation rates were uncertain pollen concentrations (grains cm^{-3}) were calculated. Pollen diagrams were plotted using psimpoll 4.25 (Bennett 2005) and are presented in the relevant chapters.

4.2.2 Non-Pollen Palynomorph Analysis

Fungal spores and other non-pollen palynomorphs (NPPs) are preserved and recovered in pollen samples (e.g. van Geel 1986; 2001). Several types of fungus grow exclusively on the dung of large herbivores, and the presence of their spores is therefore valuable in determining whether changes in vegetation indicated by the pollen record are due to grazing pressure (Hoaen and Coles 2000). Coprophilous fungal spores are dispersed over relatively short distances because the fruit bodies are situated close to the ground where wind dispersal is less efficient, so the presence of these spores indicates a relatively local presence of grazing animals (van Geel *et al.* 2003). Studies of surface sample NPPs from grazed and ungrazed woodlands have shown that almost no airborne dispersal of fungal taxa occurs, including the most diagnostic grazing and dung

indicators (Blackford and Innes 2006). This would suggest that coprophilous fungal spores provide a highly localised record of grazing directly at the sampling site, and surface sample studies show that spores of these types increase with increased grazing pressure. These studies also suggest that an absence of fungal spores does not necessarily mean that no animals were present, as particular types were absent from some grazed areas (Blackford and Innes 2006). Fungal spore data is particularly useful in island locations such as Orkney, where large herbivores are believed to have been absent before their introduction by Neolithic people (e.g. Clutton-Brock 1979).

NPPs were identified using the photographs in van Geel (1978; 2001), van Geel *et al.* (1981; 1983; 1989; 2003) and Graf and Chmura (2006), and counts of each type were made during pollen counting. While standard techniques for preparation of pollen samples are not necessarily ideal for the preparation of non-pollen palynomorphs, they have been shown to be satisfactory (Clarke 1994). NPPs were plotted as percentages of the combined sum of total land pollen and spores plus NPPs (following Mighall *et al.* 2006) using psimpoll 4.25 (Bennett 2005), and diagrams are presented in the relevant chapters.

4.2.3 Charcoal Analysis

Charcoal is an inorganic carbon compound which is produced by the incomplete combustion of plant material. It is well preserved and abundant in lake sediments and peat and can be used as a record of fire history and the role of natural and human-induced fires in ecosystem change (Patterson *et al.* 1987). Since charcoal is brittle, larger pieces are easily broken into smaller ones, and Clark (1984) has demonstrated that various aspects of the pollen preparation procedure can affect the amount of charcoal recorded in a sample, illustrating the need for a standard methodology to be applied to samples that are to be compared. However, the processes used in pollen preparation vary according to the type of sediment that is being removed, and therefore caution is needed when comparing the charcoal record from sites where samples have been prepared using different methods.

The charcoal content of each pollen sample was estimated using the point count method of Clark (1982). Although this method is relatively simple, it has been shown to be as accurate as more time consuming methods (Tolonen 1986) and it can be carried out quickly and easily on pollen slides. Counting was carried out at a magnification

of ×400 using a systematic plan that covered 50 fields of view per slide, evenly spread over the area of the coverslip. Using the eyepiece reticule, 202 points were applied at each field of view, giving 10,100 points per slide. The number of 'exotic' *Lycopodium* spores seen during this procedure was also recorded and charcoal concentrations in $cm^{-2}cm^{-3}$ were calculated and plotted on the pollen diagrams for each site. Charcoal/pollen ratios were also calculated for each site in order to check whether charcoal abundances were changing as a consequence of sedimentary changes which affected all sedimentary particles rather than as a result of changes in fire frequency (Bennett *et al*. 1990). Results are plotted on the percentage pollen diagram for each site.

4.2.4 Microstructure Analysis

Material retained after sieving through a 100 μm mesh during pollen preparation was placed into a Petri dish and mixed with water. A Leica low-powered zoom microscope was used to examine the samples and the proportions of woody, graminoid, and herbaceous material, *Sphagnum* and non-*Sphagnum* mosses and unidentified organic material (UOM) were recorded on a six point scale where + = one fragment, 1 = rare, 2 = occasional, 3 = frequent, 4 = abundant and 5 = dominant (after Kent and Coker 1992). Plant material was identified using the photographs in Mauquoy and van Geel (2006). Any seeds and Characeae oospores present were recorded and identified, and the presence of charcoal fragments was also noted. Seeds were identified using the photographs in Cappers *et al*. (2006). Results for each site were plotted as histograms using psimpoll 4.25 (Bennett 2005) and are presented in the relevant chapters.

4.2.5 Lithostratigraphy

Where cores were recovered using the auger they were described in the field using the Troels-Smith (1955) system prior to subsampling. Where intact cores were recovered, the Troels-Smith (1955) system was applied in the laboratory in order to maximise time spent in the field searching for suitable sites and coring. Discrete stratigraphic units were visually identified in the cores, and the unit boundaries were measured from the top of the core. Long *et al*. (1999) have shown that there is generally good correlation between descriptions made using the Troels-Smith (1955) scheme and more sophisticated laboratory analyses, and the method was therefore considered to provide an adequate description of core stratigraphies for this study. The colour of each sediment unit was also recorded using a Munsell soil colour chart. Results for each site

are tabulated in the relevant chapter, and are also presented as a column using Troels-Smith's (1955) symbols at the left-hand side of all stratigraphic diagrams.

4.2.6 Physical Sediment Properties

Wet and dry density, organic content and carbonate content of the cores were measured according to the loss-on-ignition method of Bengtsson and Enell (1986). $0.5cm^3$ subsamples were taken from each point in the cores at which pollen analysis was carried out. Each subsample was placed into a porcelain crucible and weighed before being dried at 105 ^{o}C for at least 12 hours overnight. The dried samples were weighed, placed into a furnace for 2 hours at 550 ℃ and then re-weighed before being ignited at 950 ^{o}C for 2 hours and weighed for a final time. From the weights recorded the wet and dry density, organic content and carbonate content were calculated. Dean (1974) demonstrated that this method measures the organic matter and carbonate content of sediments with equal or improved precision and accuracy when compared to other more time-consuming methods.

The measurement of weight loss between 550 and 950 ^{o}C is referred to throughout this thesis as 'carbonate', since it is possible that some of the weight lost at this temperature is due to the loss of structural water from clay within the sediment (Grim 1962). However none of the cores studied here contained large quantities of clay and it is assumed that weight loss due to interstitial water is negligible.

Results for wet and dry density, organic content and 'carbonate' content were plotted using psimpoll 4.25 (Bennett 2005) and are shown in the relevant chapter, next to Troels-Smith columns.

4.3 Age Determination

4.3.1 Radiocarbon Dating

All sites investigated have uniform organic sediments that do not effervesce on the addition of 10% HCl or appreciably lose weight on ignition at 950 ^{o}C (following ignition at 550 ^{o}C). Sediment samples from these sites were therefore believed to be free of carbonate contamination and suitable for dating via accelerator mass spectrometry.

Samples submitted for radiocarbon dating were located at points determined by the pollen stratigraphy, and 2-3 g of sediment were submitted for each date required. Slices of sediment were taken from 0.5 cm either side of the depth for which a date was required, and it was assumed that the age estimate applied to this central point. Samples were cut from the core, the surfaces were cleaned and the samples were wrapped in foil.

Samples from Blows Moss and Whaness Burn were sent to the NERC Radiocarbon Laboratory in East Kilbride where they were prepared to graphite before being passed to the SUERC AMS Facility for radiocarbon analysis. Preparation to graphite was carried out by Dr. P. Gulliver. Samples were digested in 2M HCl for 8 hours at 80 ^{o}C, washed with de-ionised water, then digested in 1M KOH for 2 hours at 80 ^{o}C. The digestion was repeated until no further humics were extracted. The residue was then rinsed free of alkali, digested in 2M HCl for 2 hours at 80 ^{o}C, rinsed free of acid, dried and homogenised. The total carbon in a known weight of the pre-treated sample was recovered as CO_2 by heating with CuO in a sealed quartz tube. The gas was converted to graphite by Fe/Zn reduction.

Samples from Hobbister were sent to the SUERC AMS Facility in East Kilbride, where age determinations were carried out by P. Naysmith. 100 ml of 0.5M HCl was added to the samples, which were then refluxed on a hotplate for 2 hours. Following this, 100 ml of 0.5M NaOH was added and the samples were refluxed on a hotplate for a further 2 hours. The extract was decanted, 100 ml of 0.5M HCl was added, and the mixture was refluxed on a hotplate for 1 hour. The precipitate was then rinsed several times with distilled water before being freeze dried. This humic acid fraction of the peat was then dated via accelerator mass spectrometry.

Radiocarbon age estimates were calibrated using CALIB 5.1 (Stuiver and Reimer 1993) and results are tabulated in each site chapter. Various age models were constructed for each site with the aid of functions within psimpoll (Bennett 2005). None of these were found to give any real advantage over simple linear interpolation between and extrapolation from age estimates, and given the relatively small number of age estimates available for each site it was decided that this gave the most accurate age model in all cases. Age-depth plots for each site are presented in the relevant chapters.

4.3.2 Tephrochronology

All cores were examined for concentrations of tephra shards, since tephra is widely dispersed in the atmosphere following a volcanic eruption. Eruptions can be uniquely identified by the geochemical signatures in the tephra (Einarsson 1986), so layers of known age can be identified and used as isochrones. At least seven tephra isochrones have been found in northern Scotland, including H 1510 (*c*. 440 BP), Loch Portain B (*c*. 450 BP), Glen Garry (*c*. 2100 BP), Kebister (*c*. 3600 BP), Hekla-4 (*c*. 3830 BP), Hoy (*c*. 5600 BP) and Lairg A + B (*c*. 6000 BP) (Dugmore *et al*. 1995). The Saksunarvatn tephra (*c*. 9350 BP) has been found in Shetland (Bennett *et al*. 1992) and Orkney (Bunting 1994). Hekla-4 tephra also occurs in Shetland (Bennett *et al*. 1992) and possibly on Rousay (Bunting 1996) and Hoy (Blackford and Edwards 1992) in Orkney. It was therefore considered worthwhile searching for tephras to provide age estimates in this investigation.

The cores were scanned for tephra using a variation of the hydrogen peroxide digestion method described by Bennett *et al*. (1992). Subsamples were taken from the cores in 10 cm contiguous sections and placed into test tubes containing 30% H_2O_2. The test tubes were placed in a water bath at 90 ^{o}C until the reaction had ceased (after about 5 hours). This process removed the organic matter present in each sample. The residues were washed with distilled water until the supernatant was clear before being washed with ethanol to facilitate drying and oven-dried. After drying the inorganic residues were mounted on microscope slides in glycerol.

The slides were examined using a Leica binocular microscope at a magnification of ×400. Evenly spaced traverses were made across a 40 × 24 mm coverslip and objects larger than 30μm in greatest dimension were scored as either tephra or non-tephra. The determination of an object as 'tephra' was based on morphology (angular, usually vesicular and with conchoidal fracture). 100 objects were counted from each slide. No concentrations of tephra shards were identified in any of the cores, so higher resolution analysis was not carried out.

4.4 Archaeological Data

Archaeological data from the area surrounding each coring site was collected in order to compare the palaeoecological reconstructions from these sites with the evidence for prehistoric human activity. For Hobbister, data was collected for a study area of 20 km^2

centred on the coring site, since the palaeoecological record from this site is unlikely to be influenced by human activity occurring at a greater distance than this (e.g. Sugita 1994). For Blows Moss, data was obtained for the whole of the island of South Ronaldsay, and the islands of Burray and Swona were also included since they are part of the modern parish of South Ronaldsay. For Whaness Burn archaeological information for the entire island of Hoy was collected. South Walls was also included here, following its inclusion in the Royal Commission on the Ancient and Historical Monuments of Scotland (RCAHMS) list of archaeological sites and monuments for Hoy (Lamb 1989). Data was also collected for the islands of Graemsay and Flotta, since they form part of the modern parishes of 'Hoy and Graemsay' and 'Walls and Flotta'.

Firstly a gazetteer of sites in each area was compiled by searching the RCAHMS Canmore database for all sites within each of the three areas. RCAHMS have published annotated lists based on the sites in this database for several areas of Scotland, although the only one of the three study areas for which such a list is available is Hoy (Lamb 1989). This was consulted alongside the RCAHMS database for the Whaness Burn study area, and the absence of similar publications for the other two areas probably means that the archaeological records for Blows Moss and Hobbister are less complete and more poorly understood.

Each site in the gazetteer was then assigned to one of the broad archaeological periods defined in Chapter 1 and mapped using ESRI ArcMap 9.2. The Palaeolithic period was not considered, as only three possible sites dating from this period are known from Orkney. Data was collected for all periods from the Mesolithic up to the Late Norse period, since as discussed in Chapter 2, the Pictish, Viking and Late Norse periods of Orkney are still considered to be prehistoric or protohistoric as there are few documentary sources for these periods and none from Orkney itself (Grieve and Gibson 2005). Justification for the inclusion of particular classes of monument within each archaeological period is made below. Where there was no clear dating evidence for features such as enclosures, dykes and mounds these were not included in the gazetteers. Sites dating from after the end of the Late Norse period were not included, and artefact finds were also excluded since many of these are not accurately provenanced and would add little to the understanding of the distribution and intensity of prehistoric human activity. Exceptions were made in cases where objects were discovered at or very close to the sampling locations.

Although the distribution maps produced for each of the three study areas contain all recorded sites from the Mesolithic through to the Late Norse periods, they cannot be assumed to give an accurate reflection of prehistoric human activity as the relationship of survival and discovery of sites to their original distribution is strongly affected by later land-use. Sites located on agricultural land are more vulnerable to destruction, whereas those in more marginal, unimproved areas are more likely to survive. However, the greater focus of modern human activity on agricultural land means that sites here are more likely to be discovered than those situated on unimproved land, even if that discovery is a result of their partial or total destruction (Stevenson 1975). Therefore the data collected can only be used to give a rough idea of the distribution and intensity of prehistoric activity, and factors of survival and discovery must be taken into account when analysing these patterns.

4.4.1 Mesolithic Sites

There is currently little evidence for the Mesolithic occupation of Orkney, although recent research has partially addressed this and illustrates that the islands probably supported a fairly substantial human population (e.g. Wickham-Jones 1990b; 1994; Saville 1996; Cantley 2005). Evidence occurs in the form of post holes and flint scatters, and where these were recorded by the RCAHMS Canmore database within one of the study areas they are plotted on a separate map.

4.4.2 Neolithic Sites

The most numerous Neolithic monuments in Orkney are the chambered cairns, although several of these are known to have been reused in later periods. The gazetteer of Orcadian chambered cairns compiled by Davidson and Henshall (1989) was used to confirm the RCAHMS descriptions of such sites occurring within the study areas and to classify them as either Orkney-Cromarty type or Maeshowe-type. Several Neolithic settlements are currently known from the islands and many have been excavated, and where these occur in one of the study areas they are plotted on the Neolithic map for the area. The henge monuments and stone circles at the Ring of Brodgar and the Stones of Stenness have been demonstrated to date from the Neolithic by excavation (Ritchie 1976; Renfrew 1979). Several standing stones are recorded within the study areas and are categorised here as Neolithic since they are generally believed to belong to the same tradition of monumental construction, although none have been scientifically dated.

4.4.3 Bronze Age Sites

Although there is considerable debate over the date and function of burnt mounds, they are generally thought to be associated with settlement in some way (e.g. Hedges 1975; Anthony 2003; Toolis 2007). Recent research into Orcadian burnt mounds on Eday has demonstrated that although they range in date from the Early Neolithic through to the Iron Age, there was a peak in the use of these sites during the Bronze Age (Anthony 2003). Radiocarbon and thermoluminescence dating of several other burnt mound sites in Orkney also indicated that they date from the Bronze Age (Hedges 1975; Huxtable *et al*. 1976). Therefore for the purposes of this study all burnt mounds have been classified as Bronze Age, although it is known that some almost certainly date from other periods. Other types of Bronze Age settlement are gradually beginning to be recognised in the islands (e.g. Lamb 1989; Downes 2005), and where these are known they are plotted on the appropriate maps.

In terms of burial sites, the problems of dating cist and barrow burials have been discussed in Chapter 2. It is clear that not all burials in short cists are Bronze Age, since some Scottish short cists have been found to contain grave goods that date from the early Iron Age. Hedges (1980) points out that there is very little evidence for Iron Age burial practices in Orkney, and is possible that some short cists actually date to this period rather than to the Bronze Age. For the purposes of this study all short cists and barrows within the study areas are included as Bronze Age burial monuments, although it is almost certain that some date to later periods. Cairns are also included as Bronze Age burial monuments in this study (e.g. Downes 2005), although again some of these are likely to date from other periods.

4.4.4 Iron Age Sites

The most frequently recorded type of Iron Age domestic structure in Orkney is the broch, typically constructed during the second and third centuries BC (Armit 1991). Several of the 'brochs' listed in the RCAHMS Canmore database should probably be termed either 'simple Atlantic roundhouses' or 'complex Atlantic roundhouses' (a class of monument mid-way between the earlier simple roundhouses and the brochs; Armit 1991). However there is insufficient information in the RCAHMS records to allow any further distinctions to be made, so all sites listed as brochs are included as such in this study. The Canmore database does identify some Iron Age roundhouses, and these are shown on the maps with a separate symbol. Promontory forts, another type of

settlement generally presumed to be Iron Age (e.g. Lamb 1980), are also recorded within the South Ronaldsay study area. No Iron Age burials are recorded within any of the three study areas, although as discussed above some of the short cist burials classified as Bronze Age may in fact be Iron Age (Hedges 1980).

4.4.5 Later Prehistoric Sites

Souterrains have been variously interpreted as either underground storage structures (e.g. Hamilton 1956; Bradley 1978) or as having a ritual function (e.g. Downes 2005). They are generally believed to be Iron Age in date on the basis of evidence from mainland Scotland, although one in Shetland at Jarlshof is of late Bronze Age date (Hamilton 1956). According to recent research, Orcadian examples are usually late Bronze Age or Iron Age in date (M. Carruthers pers. comm.) and for the purposes of this study have been classified as 'later prehistoric'. Other monuments for which there is no clear dating evidence, such as clearance cairns, were also included in this category.

4.4.6 Pictish Sites

Within the South Ronaldsay study area, a possible Pictish settlement is recorded by the Canmore database. No details about this settlement are given, so similarities with other Pictish settlements in the islands (e.g. Ritchie 1977; Ballin Smith 1994; Buteux 1997; Hunter *et al*. 2007) cannot be ascertained. Some long cist burials are recorded within the study areas, and these may be either Pictish or Viking/Late Norse in date. Very few burials dating to the Pictish period occur within Orkney as a whole, perhaps due to similar problems of recognition as have been discussed for the earlier part of the Iron Age (Ashmore 2003). Where the probable age of chapels and churches was recorded in the Canmore database as Pictish/Viking/Norse, they have been plotted. Those that were undated were not included in the gazetteers. Symbol stones certainly date to this period (e.g. Ritchie and Ritchie 1981) and some are located within the study areas.

4.4.7 Viking/Late Norse Sites

Where the Canmore database records Viking and Late Norse settlements, these are plotted on a separate map since there is considerable overlap with the preceding Pictish period. Burials from these periods, both pagan and Christian, are also plotted on the map when dating evidence was recorded by the Canmore database. Where the database contained information relating to the probable age of chapels and churches, these are

plotted as either Viking or Late Norse. A Viking silver hoard was recorded within the South Ronaldsay study area and is marked on the relevant map.

4.5 Data Analysis

4.5.1 Topographic Modelling

The survey data from Hobbister were entered into a GIS to allow a model of the pre-peat landscape to be created. To generate a continuous surface showing the topography of the pre-peat landscape it was necessary to interpolate between measured depths using functions within ESRI ArcMap 9.2.

Conolly and Lake (2006) note that simple linear interpolation using only two points along a straight line does not always result in accurate predictions of values at unsampled locations, and methods that use values and distances from a larger sample of surrounding known points give more reliable results. A commonly used method of linear interpolation is known as inverse distance weighting, which results in a simple, generally robust approximation of surfaces from a wide variety of point data (Wheatley and Gillings 2002).

Inverse distance weighting assumes that unknown values are more likely to resemble near values than distant ones, so the values of each point used to estimate the unknown value are weighted in inverse proportion to their distance from the unknown value (Wheatley and Gillings 2002). The effectiveness of this method of interpolation is dependent upon the number of neighbouring points (n) used in the calculation (Burrough 1986). Low values of n tend to produce quite a 'blocky' surface, while very high values of n result in a very smooth background between data points, with the points themselves appearing as 'peaks' above this (Wheatley and Gillings 2002). In this case a number of different values of n were tried in order to obtain the best compromise between the 'blocky' result obtained with low values of n and the 'peaky' result obtained with higher values, with a value of 10 giving the clearest result.

The resulting model of sub-peat topography at Hobbister is presented in the results chapter for the site.

4.5.2 Zonation

Pollen diagrams were subdivided into zones in order to simplify their description and aid in their discussion and interpretation. This was carried out using a function of psimpoll 4.25 (Bennett 2005) which generates zonation schemes based on both binary and optimal splitting, using either sum-of-squares or information content criteria (Birks and Gordon 1985), and on agglomeration using constrained cluster analysis (Grimm 1987). Zonation using this function was carried out on a subset of the pollen data from each site containing all main sum taxa that constituted 2% or more of at least one sample. The taxa included in the analysis for each site are listed in the relevant chapters.

Psimpoll 4.25 (Bennett 2005) also utilises a broken-stick model to determine the number of zones that can be reliably used from the output of a numerical zonation of pollen stratigraphical data, by separating variance resulting from structure in the dataset from that caused by stochastic processes (Bennett 1996). If the reduction in variance for a particular zone is greater than the proportion expected from the model, the zone may be considered as having some statistical validity. The broken-stick model was employed during zonation in this project to aid the analyst's decision on how many zones should be used, but the final selection of zonation scheme was based on the subjective decision of the analyst.

4.5.3 Rarefaction Analysis

Palynological richness (the number of pollen and spore taxa present in a sample) is often used as a measure of change in and disturbance of vegetation. It has been demonstrated that there is a strong positive correlation between palynological richness and palynological evenness (the degree to which taxon frequencies are similar) (Peros and Gajewsik 2008; Odgaard 2008). Evenness can be used as a measure of disturbance, since stable environments will tend to have uneven frequencies of different species due to one or two dominant species being more successful competitors. When disturbance is high, only species that can tolerate the environmental conditions will be present in high frequencies, again leading to low species evenness. Evenness will therefore be highest when disturbance occurs at an intermediate level (Grime 1973). Therefore the lower palynological richness, the more likely the environment is to have been either extremely unstable or extremely stable.

While different pollen spectra do contain different numbers of pollen types, it is clear that the number of taxa recorded will be affected by the total number of grains counted, which will not be constant for all samples. Rarefaction analysis is a robust statistical technique that provides a minimum variance unbiased estimate of the expected number of taxa in a random sample of n individuals taken from N individuals containing T taxa, where n is less than or equal to N. The expected number of taxa in a count of size n is expressed as $E(T_n)$ (Birks and Line 1992). Essentially, the technique standardises the pollen count to a single sum, removing the bias in richness estimates caused by differing count sizes and allowing meaningful comparison of palynological richness between samples. If the standardised count size and other conditions such as the pollen taxonomy used are kept constant between sequences, it should also be possible to compare palynological richness between sites.

Rarefaction analysis was carried out for each site using a function of psimpoll (Bennett 2005) and the results are presented in the percentage pollen diagram for each site. Since no sample counted contained fewer than 300 grains, this was the count size specified for standardisation.

4.5.4 Principal Components Analysis

Ordination techniques find axes of the greatest variability in species composition for a set of samples, and results can be plotted as an ordination diagram showing the similarity structure for the samples and species (Lepš and Šmilauer 2003). Principal components analysis (PCA) is an ordination technique that reduces multidimensional data to a low number of dimensions (Birks and Gordon 1985). The method measures the similarity between taxa, and then the resulting matrix is subjected to the PCA procedure, looking for major directions of variation within the dataset. The axes represent successively lower amounts of variation in the matrix. Transformations are usually applied to data before carrying out PCA in order to reduce the amount of difference between taxa with high and low pollen percentages, thereby preventing the analysis being dominated by taxa with high pollen productivities (Grimm 1987).

PCA was carried out on the covariance matrix derived from the combined dataset from all three sites in order to explore relationships between species and samples. The dataset contained all the main sum taxa that reached frequencies of 2% or more in at least one sample. A square-root transformation was applied to the data before carrying

out PCA using a function of psimpoll (Bennett 2005), since this is the most routinely used data transformation in pollen analysis (Grimm 1987). The results of the analysis were plotted using Microsoft Excel 2007 and the results are presented in Chapter 8, along with a list of taxa included in the analysis.

Chapter 5: Whaness Burn

This chapter presents the results of palaeoecological analyses undertaken on a core from Whaness Burn in northern Hoy. Previous palaeoecological investigations in the study area are described in order to provide some background to this study and highlight the need for better understanding of prehistoric environmental changes and land-use on Hoy. The archaeological record of the study area is described to allow the environmental and archaeological records to be linked and interpreted. A brief description of the coring site and the landscape surrounding it is then given before the results from the Whaness Burn sequence, including age estimates, lithostratigraphy, physical sediment properties, and pollen, charcoal, non-pollen palynomorph and microstructure analyses, are presented and described. Finally, the palaeoecological record from Whaness Burn is discussed and interpreted in terms of major environmental changes and prehistoric human activity, and is compared with the archaeological record from Hoy and with palaeoecological data from other Orcadian sites.

5.1 Previous Palaeoecological Investigations

Previous palaeoecological investigations in Hoy include those of Blackford *et al*. (1996) at Keith's Peat Bank and Bunting (1996) at Loch of Torness. Locations of these sites are shown on Fig. 5.1.

5.1.1 Keith's Peat Bank (NGR ND 272 922; Blackford et al. 1996)

A 160 cm profile was recovered from a peat cutting in mid-Hoy, although only the basal 22 cm were analysed. The base of the peat was radiocarbon dated to *c*. 5400 cal. BC, and the top of the examined profile to *c*. 3450 cal. BC (Blackford *et al*. 1996). The pollen sequence therefore covers the period from the late Mesolithic to the early Neolithic.

Arboreal pollen comprises more than 40% of the total pollen sum at the base of the profile, indicating that some woodland was present locally (e.g. Bunting 2002). The main arboreal taxa represented are *Betula* and *Salix*. Percentages of *Corylus avellana*-type pollen are much lower than those recorded elsewhere in Orkney (e.g. Keatinge and Dickson 1979; Bunting 1994; 1996). At around 5350 cal. BC arboreal pollen percentages undergo a marked decline to *c*. 10% of the pollen sum, and Poaceae and
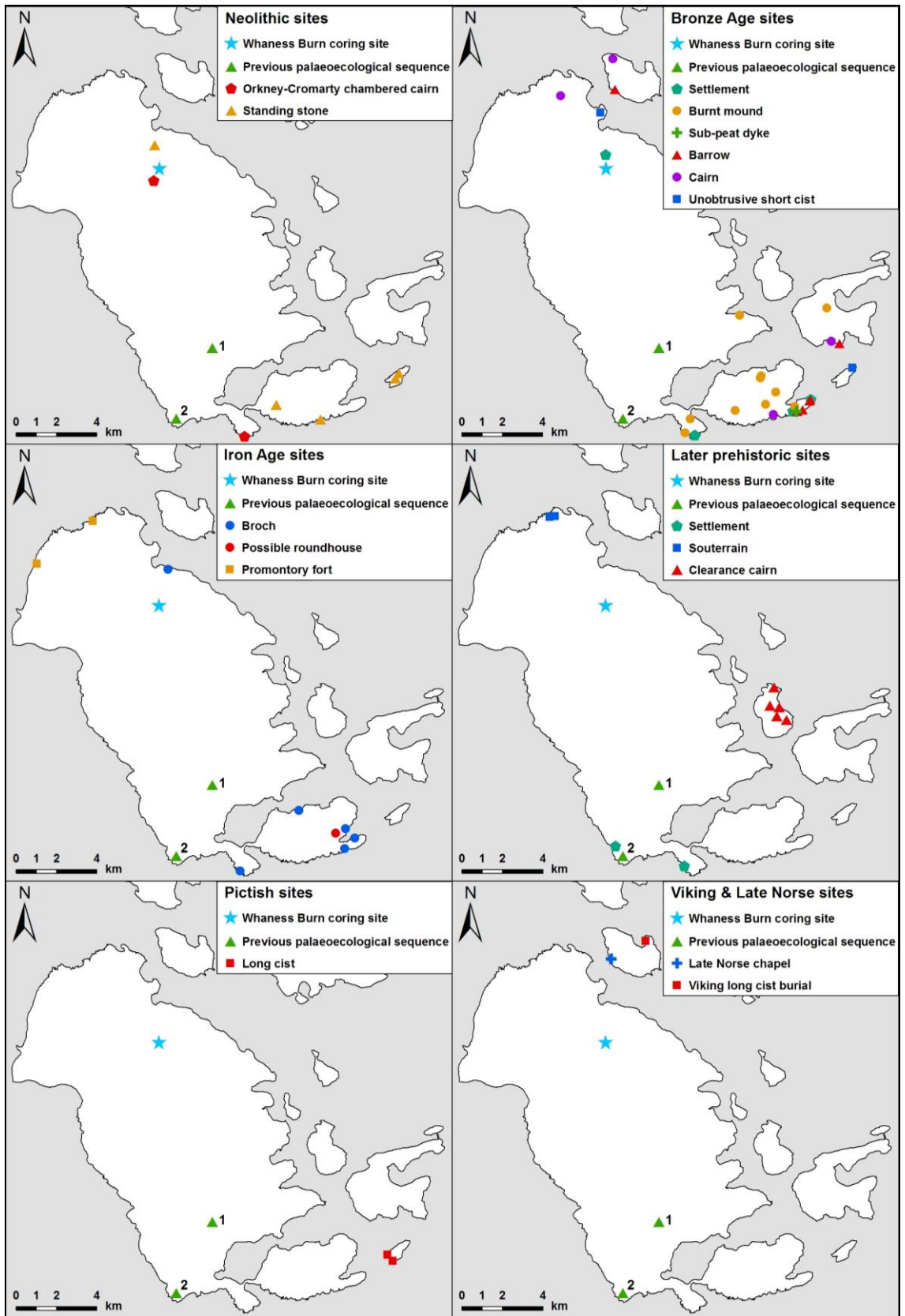
Figure 5.1 Location of archaeological sites and previous palaeoecological investigations (1. Keith's Peat Bank; 2. Loch of Torness) in the Whaness Burn study area

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Calluna vulgaris pollen proportions show a corresponding increase. Following this apparent woodland decline *Betula* pollen percentages then begin to recover, reaching around 40% of the total pollen sum by *c*. 3450 cal. BC, in the Neolithic period (Blackford *et al*. 1996).

During the period of low arboreal pollen percentages at Keith's Peat Bank there is evidence for burning in the form of high charcoal concentrations and the presence of *Melampyrum* pollen, a taxon which has been linked with burnt ground and forest clearance (Blackford *et al*. 1996). In addition, pteridophyte spores exhibit a marked decline at this time, and evidence from Shetland suggests that ferns are sensitive to grazing pressure (Bennett *et al*. 1992). However ferns require a sheltered microclimate, so the decline in percentages of pteridophyte spores may simply be a consequence of loss of habitat associated with woodland decline. At Keith's Peat Bank the decline in fern spores, along with the occurrence of spores of fungal types indicative of the presence of grazing animals and evidence for burning, is interpreted as reflecting possible anthropogenic clearance of woodland, leading Blackford *et al*. (1996) to suggest that humans were present on Hoy during the Mesolithic.

5.1.2 Loch of Torness (NGR ND 254 887; Bunting 1996)

A 218 cm sediment core was recovered from the Loch of Torness, a small loch (< 1 ha) situated in south-west Hoy. Radiocarbon dating indicates that the core covers the period from *c*. 6490 cal. BC to *c*. 4350 cal. BC, and linear extrapolation was used to infer a date of *c*. 3590 cal. BC for the top of the core (Bunting 1996). The pollen sequence from this core is therefore believed to provide evidence for environmental conditions around the site from the late Mesolithic to the early Neolithic.

At the base of the sequence, *c*. 6490 cal. BC, the vegetation surrounding the site was open, with sedges and ferns being the dominant taxa. At around 5090 cal. BC arboreal pollen percentages begin to increase, eventually forming around 50% of the total pollen sum which can be taken to indicate the local presence of open woodland (Birks 1988). The main taxa present in this woodland were *Betula* and *Corylus avellana*-type (Bunting 1996). Poaceae and heathland taxa, particularly *Empetrum nigrum* and *Potentilla*-type, show increased pollen frequencies at the same time as the arboreal taxa, suggesting that herbaceous communities were no longer dominant and were gradually replaced by a mixture of arboreal and heathland communities.

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Low frequencies of understorey taxa in the pollen record perhaps indicate that arboreal pollen either originated from woodland communities outside the immediate catchment of the loch, or that trees occurred as isolated individuals. Alternatively, the woodland may have been too open for the usual tall herb-type understorey to develop, and the ground-level vegetation may have been made up of heathland species (Bunting 1996).

At around 4820 cal. BC, in the late Mesolithic, the woodland declined over approximately 200 radiocarbon years and heathland expanded further. No increases in the pollen of anthropogenic indicator species or in microscopic charcoal occur at this time, leading Bunting (1996) to attribute the cause of heathland development at this site to climatic and autogenic processes, with the loss of local woodland being a contributing factor. Following this heathland expansion, the local vegetation around Loch of Torness appears to have become a maritime heath similar to that present today.

5.2 The Archaeological Record

Fig. 5.1 shows the distribution of archaeological sites around Whaness Burn. There is evidence for human activity during all periods from the Neolithic to the Viking/Late Norse periods, although the sites recorded are predominantly coastal and very few Pictish and Viking/Late Norse sites are present. Some sites from the period of interest for this study (*c*. 3000 cal. BC – 600 cal. AD) are recorded close to the sampling point at Whaness Burn.

Much of Hoy is above 60 m a.s.l., which Lamb (1989) considered to be the upper limit of prehistoric settlement in Orkney, and below this level considerable areas are covered by heathland which may obscure earlier archaeological remains. At Whaness Burn, for example, the discovery of prehistoric enclosures followed a fire which destroyed a large area of heathland and encouraged a systematic survey of the valley, revealing an extensive settlement complex which is presumed to be Bronze Age (Lamb 1989). Other parts of the island of Hoy have not yet been fully surveyed, although recent work by Robertson (2006) has begun to address this. Prehistoric human activity in the study area generally seems to have been focused on the island of South Walls, although this probably reflects the higher quality of the land for agriculture on this island, leading to a greater rate of discovery of prehistoric sites (e.g. Stevenson 1975).

Evidence for Neolithic activity in the Whaness Burn study area consists of five isolated standing stones and two early Neolithic chambered cairns. Very close to the coring site is the Dwarfie Stane, which is unique amongst the chambered cairns of Britain in that the chamber has been carved into an erratic sandstone boulder (Lamb 1989). The chamber consists of a central passage with a compartment on either side and is considered to be a simplification of the Bookan-type plan by Henshall (1985).

Bronze Age human activity seems to have been mainly concentrated on the island of South Walls, with several burnt mounds located here. However as has been discussed previously these mounds are not all necessarily Bronze Age and some almost certainly date to later periods (e.g. Anthony 2003). The same is true for the barrows, cairns and short cists that are scattered throughout the study area (Hedges 1980; Downes 2005).

There is evidence for considerable Bronze Age agricultural activity less than one kilometre to the north of the sampling point at Whaness Burn, where enough structures have been detected to suggest that the whole of the valley (an area of approximately 150 ha) was once in agricultural use. Plans of the features are shown in Figs. 5.2-5.6. Whaness Burn 'A' and 'B' have been described as enclosed settlements by Lamb (1989) and are believed to represent a new category in Orcadian archaeology. Whaness Burn 'C', 'D' and 'F' (not illustrated) are interpreted as folds or pens for livestock (Lamb 1989).

Whaness Burn 'A' measures approximately 90 m by 70 m internally and is surrounded by a bank, probably containing a massive stone wall, up to 4 m wide and 0.8 m high. A 4 m wide ditch surrounds the bank, and in some places there is an additional external bank up to 3 m wide and 0.6 m high. The burn flows through the enclosure, and possible fish weirs have been constructed across it. In the north-east part of the enclosure is a group of mounds probably representing prehistoric houses, and immediately outside the ditch on this side is a possible heel-shaped house fronted by a forecourt (Lamb 1989).

Whaness Burn 'B' is located within a meander of the burn approximately 250 m downstream of Whaness Burn 'A'. The site here is formed by a mound around 1.3 m high occupied by an enclosure 11.4 m by 11.9 m, within a low bank. A sub-peat dyke

seems to complete the enclosure formed by the burn to the north and west of the mound (Lamb 1989).
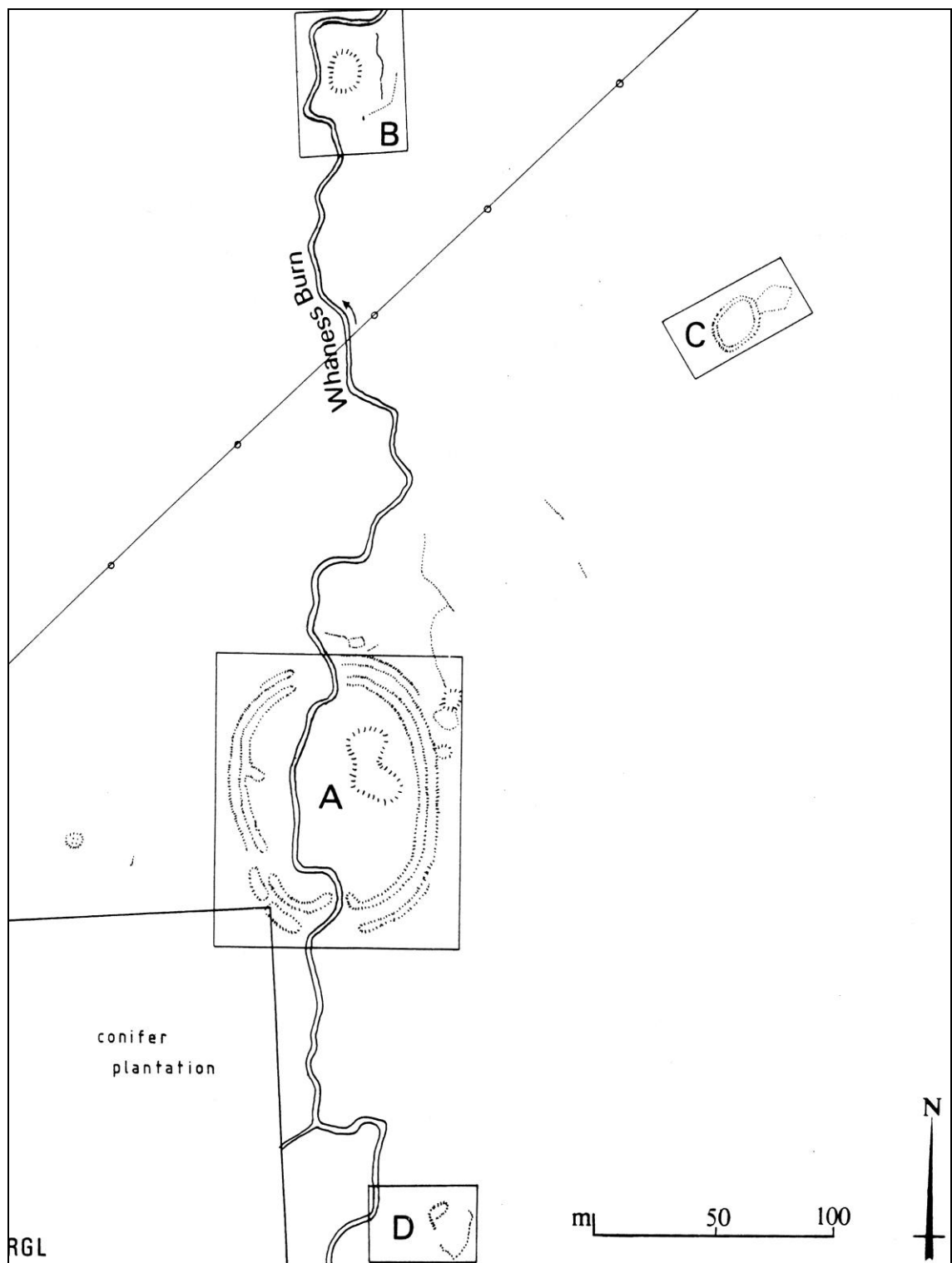
Figure 5.2 The presumed Bronze Age settlement complex at Whaness Burn (Lamb 1989)
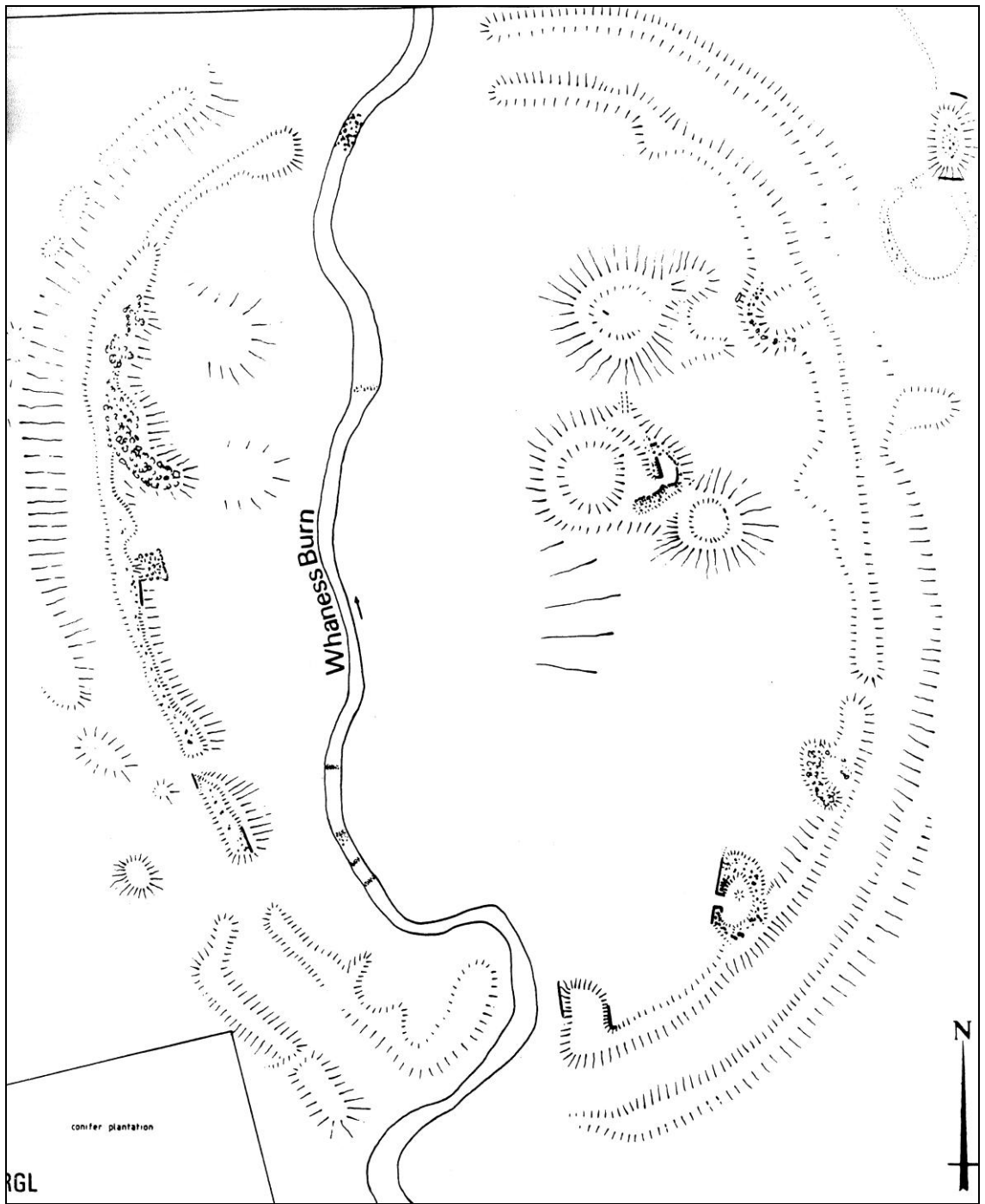
Figure 5.3 Whaness Burn 'A' (Lamb 1989)
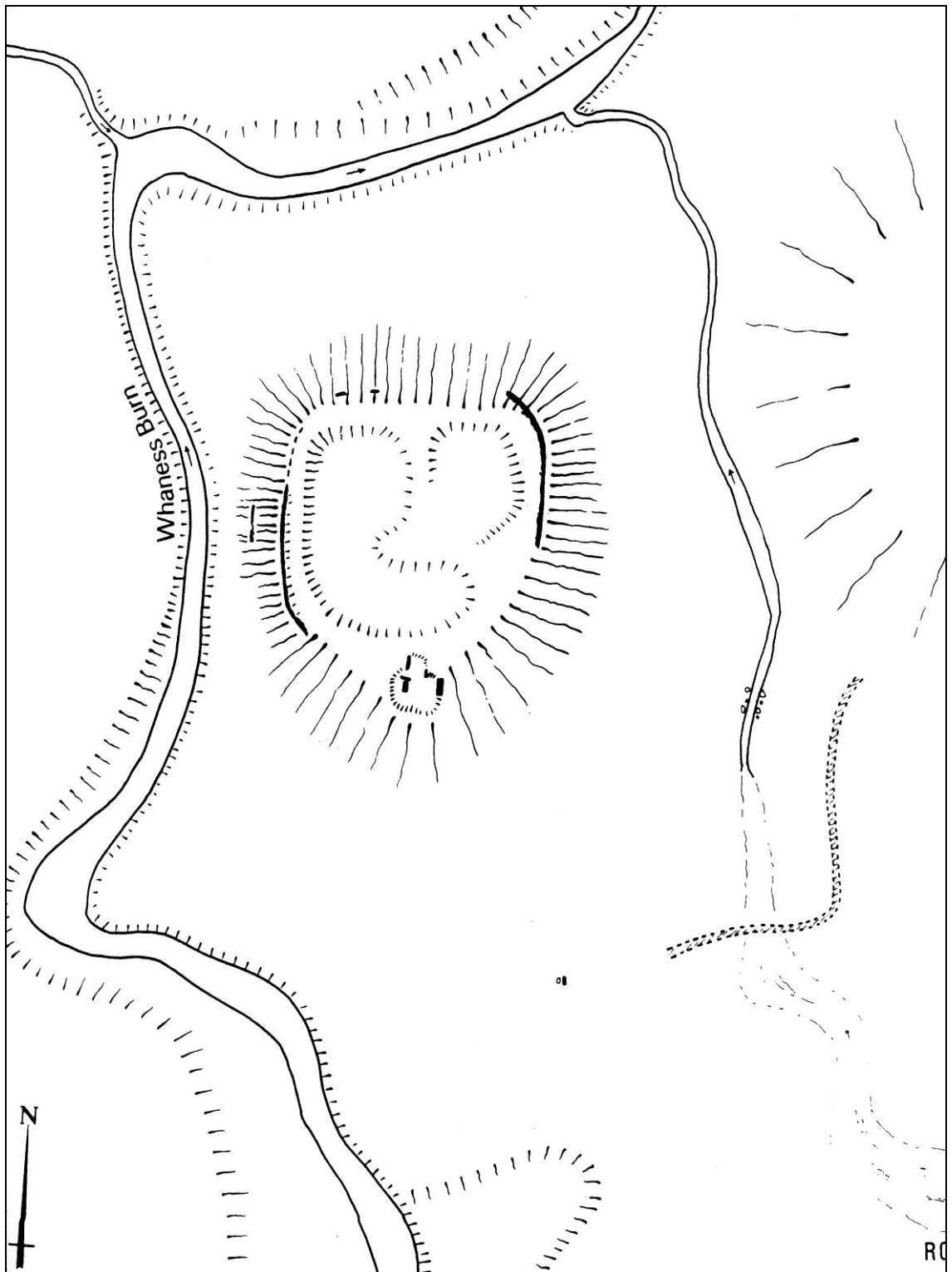
Figure 5.4 Whaness Burn 'B' (Lamb 1989)
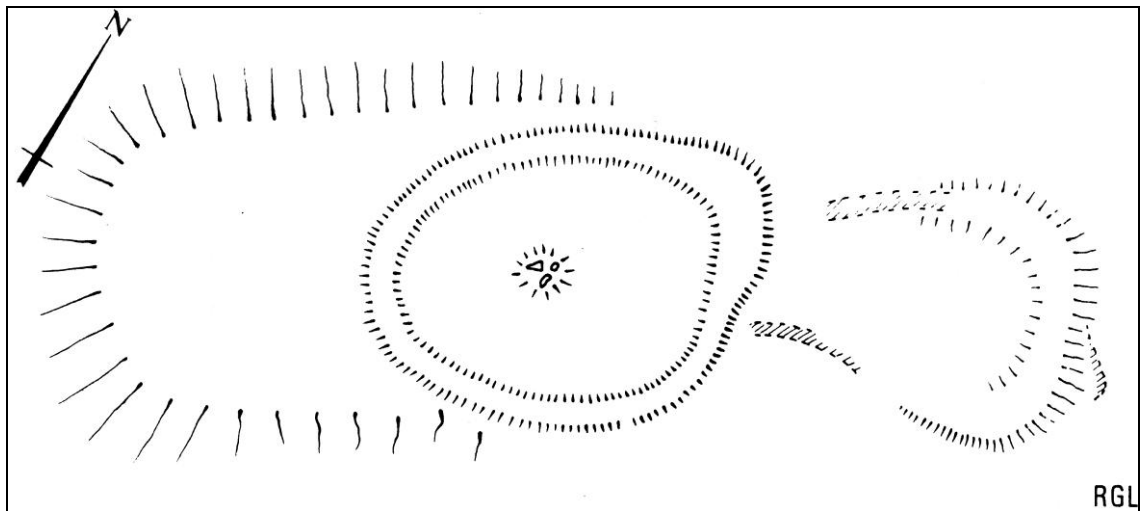
Figure 5.5 Whaness Burn 'C' (Lamb 1989)
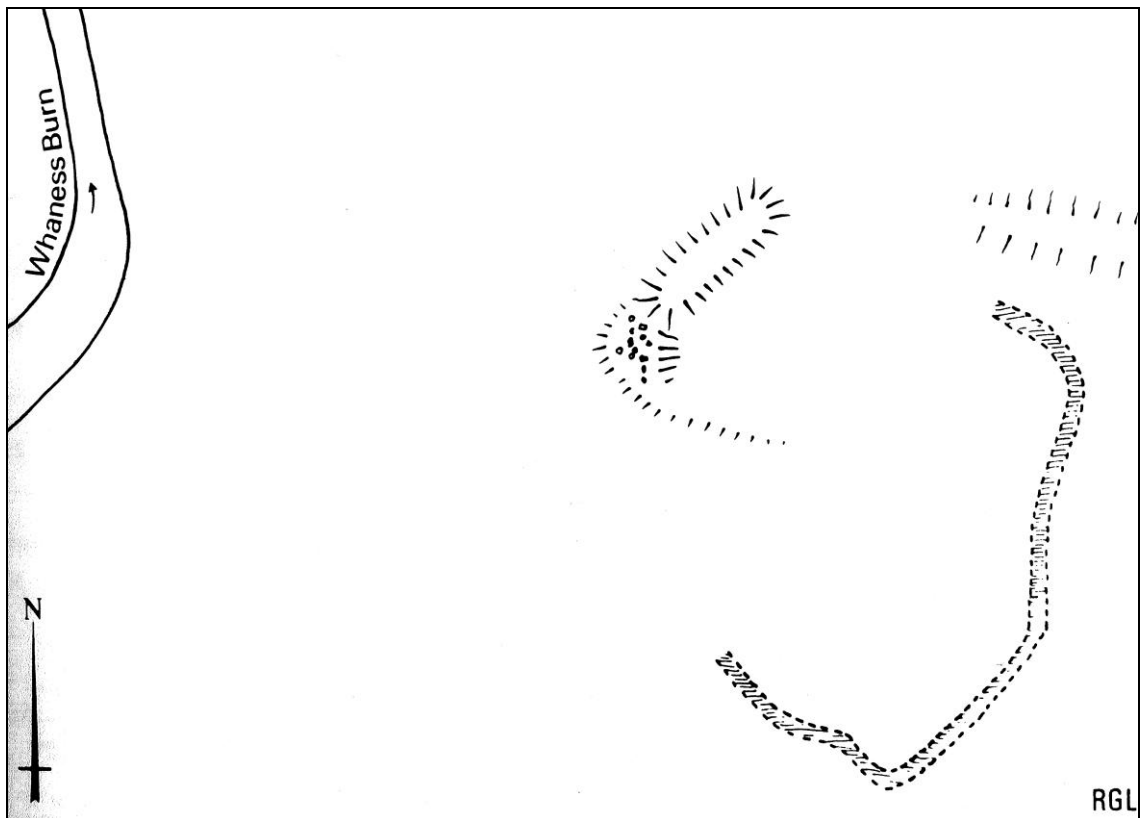
Figure 5.6 Whaness Burn 'D' (Lamb 1989)

The smaller enclosures of Whaness Burn 'C', 'D' and 'F', interpreted as livestock pens, measure 17.7 m by 14.8 m, 20 m by 15 m and 9 m in diameter respectively (Lamb 1989). A network of sub-peat dykes is located immediately to the north of Whaness Burn 'A', and these dykes also occur elsewhere within the settlement complex. The presence of these sub-peat dykes suggests an agricultural settlement of the Bronze Age

or possibly earlier, and a Bronze Age date would also fit the possible heel-shaped house adjoining the enclosure at Whaness Burn 'A'. The massive enclosure wall is in agreement with a trend towards enclosed and nucleated settlements in the late Bronze to early Iron Age (Lamb 1989).

In addition to the Bronze Age settlement at Whaness Burn, three other settlements potentially dating to this period occur within the study area. An extensive settlement occurs at Rotten Loch on Brims Ness in southern Hoy, and contains houses thought to be of Bronze Age type (Lamb 1989). The other two sites are located on Cantick Head in South Walls, and one contains a possible 'double house' (Lamb 1989).

No Iron Age burials occur within the study area, although few burials from this period are known in Orkney (e.g. Ashmore 2003) and it may be that some of the burial monuments interpreted here as Bronze Age in fact belong to this period. In terms of Iron Age settlement, several brochs and a possible roundhouse occur on South Walls, and a broch and two promontory forts are located to the north of the coring location at Whaness Burn. The recorded Iron Age settlement sites are predominantly located along the coast, perhaps for defensive purposes (e.g. Graham 1947) but more likely in order to enhance their visibility and demonstrate the status of their occupants (e.g. Hingley 1992). This may also be due to factors of discovery, since much of the interior of Hoy is covered with moorland and is therefore unsuitable for agriculture today.

Evidence for Pictish and Viking/Late Norse activity is sparse, and consists of three long cist burials and a Late Norse chapel, none of which are close to the sampling point at Whaness Burn. Two of the long cist burials are classified here as Pictish on the basis that they are covered by circular cairns (Ritchie and Ritchie 1981), and the long cist at Sandside on Graemsay has been radiocarbon dated to *c.* 1040 cal. AD (Hedges 1978b) so is classified here as Viking.

With the exception of the extensive Bronze Age settlement at Whaness Burn itself, it would seem from the currently known distribution of archaeological sites in the study area that there is little evidence for intensive human activity during the period *c*. 3000 cal. BC – 600 cal. AD.

5.3 Site Description

Whaness Burn is a small stream in northern Hoy, running from south to north for approximately 2 km from HY 246010 at the foot of the Dwarfie Hamars to HY 244029 in the Bay of Quoys (see Figs. 5.7 and 5.8 for location). The island of Hoy is anomalous within Orkney, with much of the land area being above 60 m a.s.l. (Fig. 5.8). Whaness Burn forms part of the Hoy RSPB Reserve and is presently surrounded by moorland, with the drift geology across much of the island consisting of peat (Fig. 5.9). Historic Ordnance Survey maps indicate that land-use around Whaness Burn has changed little over the last hundred years (Fig. 5.7). No agricultural activity occurs in the vicinity of the site today and there is minimal human impact due to management by the RSPB. Whaness Burn provides the marginal case study for this investigation.

The site is a valley mire within a small (*c*. 250 m diameter), well-defined basin at the head of the burn (Fig. 5.10). A survey of the site was carried out using a Dutch auger in order to determine the optimum location for sampling, and a 225 cm core was obtained from within the basin at the location HY 24575 01043, at an altitude of *c*. 30 m a.s.l (Fig. 5.11). Vegetation at the coring site is dominated by *Calluna vulgaris*, *Molinia caerulea*, *Pinguicula vulgaris* and *Menyanthes trifoliata*, which was flowering at the time of sampling.

★ Coring site

0   1
——— km

N
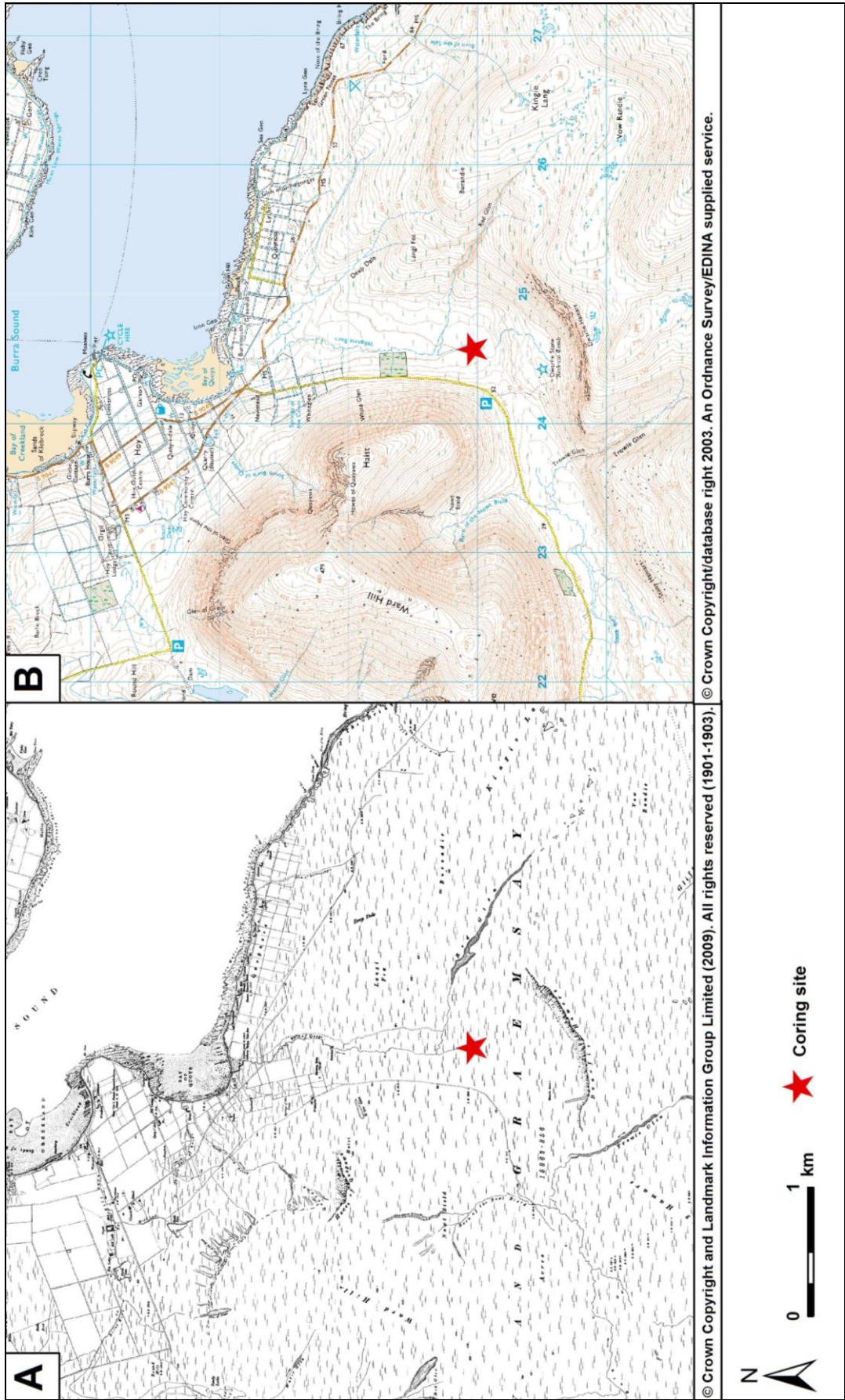
Figure 5.7 Site location and land-use around Whaness Burn
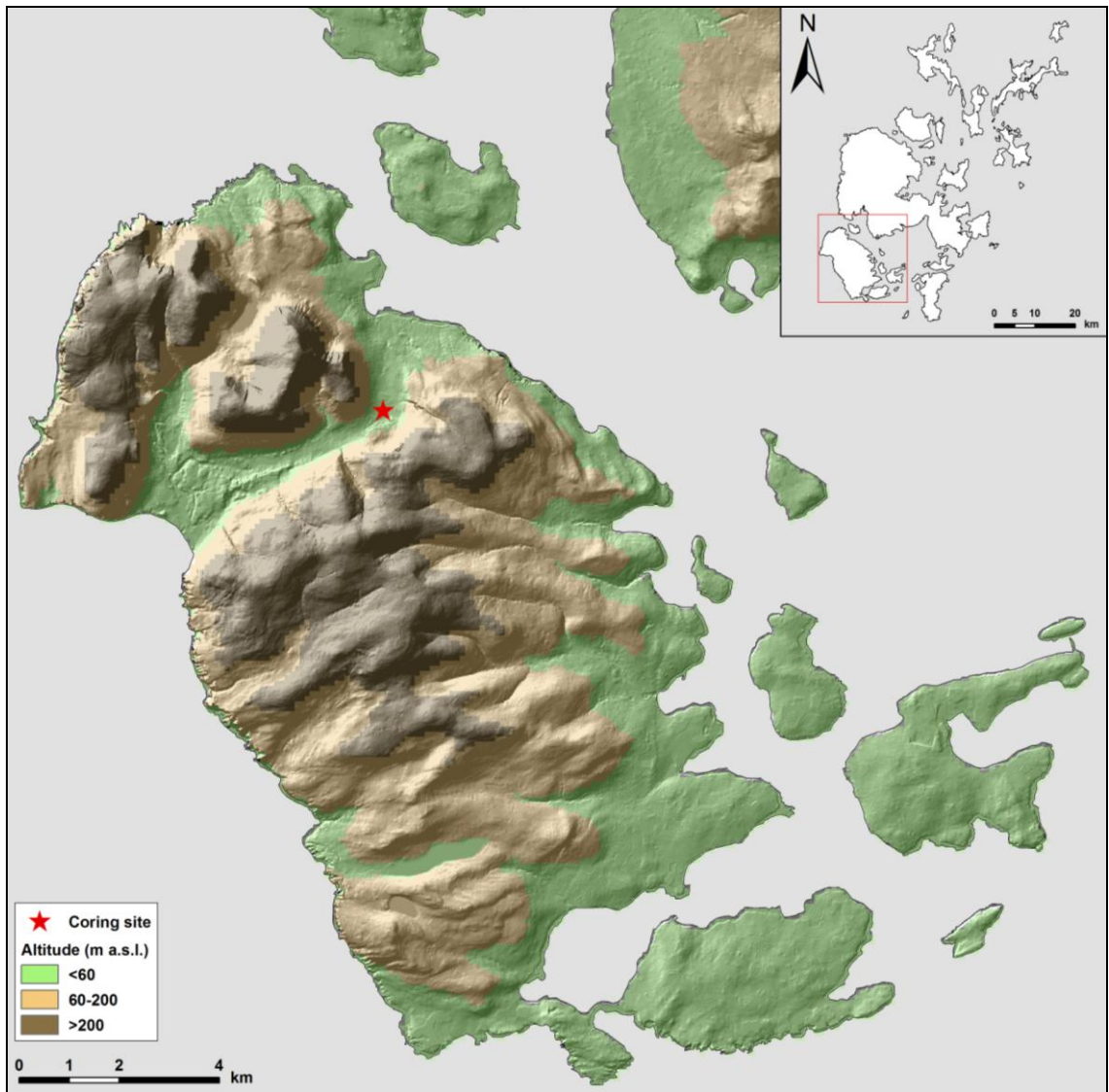
Figure 5.8 Location and topography of Whaness Burn, Hoy
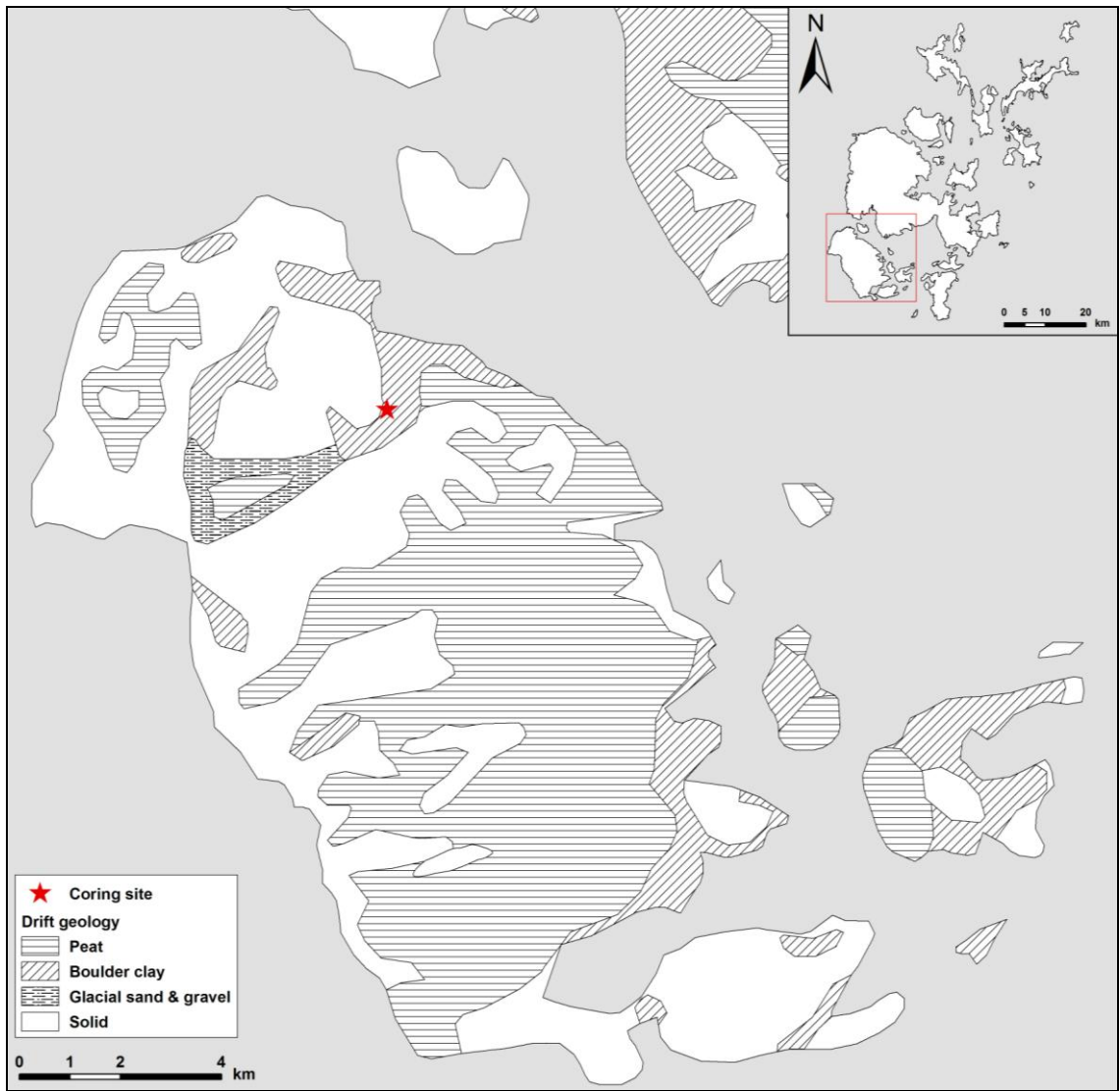
Figure 5.9 Drift geological deposits in the area surrounding Whaness Burn (© Crown Copyright/database right 2009. A British Geological Survey/EDINA supplied service).

Figure 5.10 The basin at the southern end of Whaness Burn, viewed from the north-west

Figure 5.11 View to the south-west from the coring point at Whaness Burn

5.4 Results

5.4.1 Age Estimates

Radiocarbon age estimates are presented in Table 5.1, along with calibrated ages. Various age models were tested for this site although none was found to give any real advantage over simple linear interpolation between and extrapolation from age estimates. Given the small number of age estimates, it was decided that this gave the most appropriate age model (Fig. 5.12).

Depth (cm)	Radiocarbon age (years BP) 1 σ	Laboratory reference	Calibrated age range (years BP) 2 σ	Calibrated mid-point age (BC/AD)
177	3415 ±38	SUERC-17751	3825-3568	1747 BC
81	1214 ±38	SUERC-17752	1263-1057	790 AD
26	987 ±38	SUERC-17753	961-795	1072 AD

Table 5.1 Radiocarbon age estimates from Whaness Burn
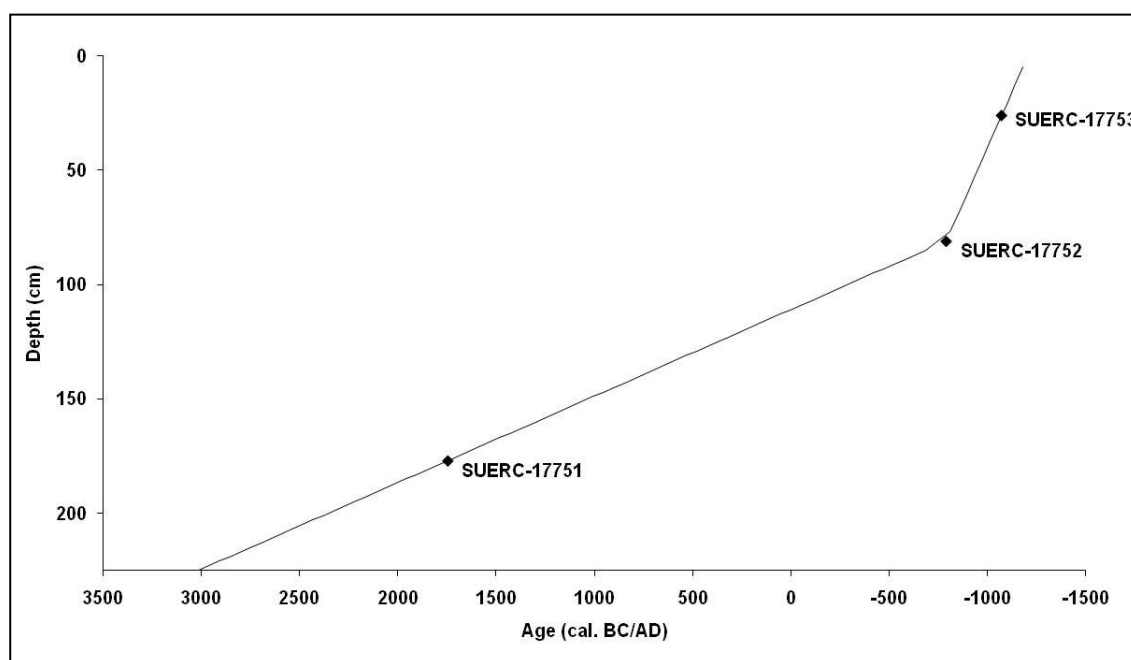
Figure 5.12 Linear age-depth model for Whaness Burn

The sequence from Whaness Burn certainly covers the period from *c*. 1750 cal. BC to *c*. 1070 cal. AD. However extrapolated ages for the base and the top of the sequence are less certain, since Fig. 5.12 shows that the relationship between age estimates and

depth is not linear, and that there has been an increase in accumulation rate towards the top of the core. For the purposes of this investigation the peat is assumed to have accumulated at a constant rate from the bottom of the core to a depth of 177 cm (radiocarbon dated to *c*. 1750 cal. BC), giving the base of the core an approximate age of 3020 cal. BC.

It is clear from Fig. 5.12 that the upper part of the sequence is missing, presumably having been removed during peat cutting at some time in the past. If the peat continued to accumulate at a constant rate from 26 cm (radiocarbon dated to *c*. 1070 cal. AD) and the top of the sequence is assumed to represent the cut surface, with no peat formation having taken place since cutting, then the top of the record has an extrapolated age of *c*. 1180 cal. AD. However it seems more likely that the stratigraphic change from well-humified peat to a more herbaceous peat containing recognisable plant fragments at 25 cm represents the cut surface. The herbaceous peat that forms the upper 25 cm of the sequence probably represents fairly recent peat formation on the previously cut surface of the mire, since the plant material has not yet had time to fully decay. This change at 25 cm is dated by linear extrapolation to *c*. 1080 cal. AD. Since this depth is very close to the uppermost radiocarbon dated depth of 26 cm, it can be assumed that this estimate is reasonably accurate.

The sequence from Whaness Burn therefore certainly covers the period from *c*. 1750 cal. BC (early Bronze Age) to *c*. 1070 cal. AD (Viking-Late Norse transition), and it seems likely that the record actually extends from *c*. 3020 cal. BC (late Neolithic) to *c*. 1080 cal. AD (Viking-Late Norse transition). The entire period of interest (*c*. 3000 cal. BC to *c*. 600 cal. AD) for this study is therefore represented at this site, allowing differences in environment and land-use between the late Neolithic, Bronze Age and Iron Age to be investigated. Sampling resolution from *c*. 3020 cal. BC to *c*. 600 cal. AD is approximately 50 years.

5.4.2 Lithostratigraphy
A summary of the major lithostratigraphic units is presented in Table 5.2, and a stratigraphic column is shown at the left-hand side of pollen, NPP, microstructure and inorganic diagrams. The sequence ends at a depth of 2.25 m, the point at which the sediment became too difficult to extract with a Russian sampler. During initial assessment of the site using a Dutch auger however, a depth of 2.65 m was reached at

the coring point, and the base of the sequence consisted of compact yellow sand. The sedimentary sequence from Whaness Burn is therefore incomplete.

Depth (cm)	Troels-Smith (1955) classification	Munsell colour	Munsell description
0-25	Dg2Dh1Sh1	7.5YR 2.5/3	Very dark brown
25-75	Sh2Dg1Ag1Dh+As+	5YR 3/3	Dark reddish brown
75-168	Sh2Dg2Dh+	10YR 2/1	Black
168-176	Sh2Dg1Dh1	10YR 2/1	Black
176-181	Sh3Dg1	10YR 2/2	Very dark brown
181-190	Sh3Ag1Dg+	10YR 2/1	Black
190-203	Sh4Dg+	10YR 2/1	Black
203-209	Sh2Ag2Dg+As+	7.5 YR 3/3	Dark brown
209-225	Sh4Ag+	10YR 2/1	Black

Table 5.2 Lithostratigraphic units in the Whaness Burn sequence

The sequence mainly consists of well-humified peat with varying proportions of identifiable plant macrofossils (mainly 0.1-2 mm in size, with lower frequencies of fragments larger than 2 mm), allowing sub-units to be identified within the sequence (Table 5.2). Within the peat sequence three units with relatively high silt content occur at 209-203 cm, 190-181 cm and 75-25 cm. At 25 cm there is a distinct change from fairly well-humified peat to a more herbaceous peat containing only partially decayed plant material, and it is possible that this unit represents recent peat formation on the previously cut surface of the mire.

5.4.3 Physical Sediment Properties

The results for wet and dry density, organic content and 'carbonate' content of the sediment core from Whaness Burn are presented in Fig. 5.13. The zonation scheme used is the same as that used for the pollen diagram (Fig. 5.14) from this site in order to aid description and interpretation, since the zone boundaries generally tend to coincide with major changes in the sediment properties.
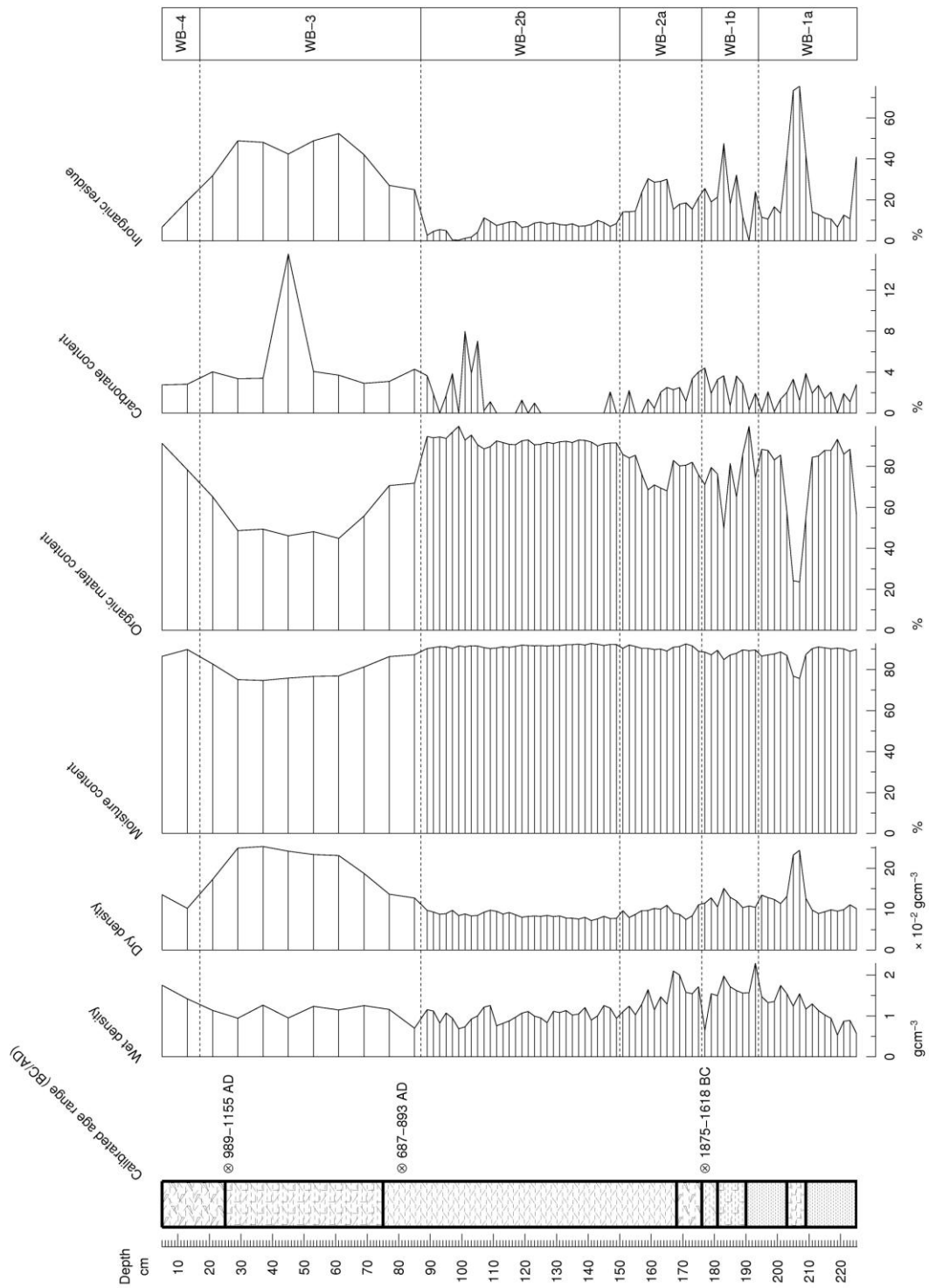
Figure 5.13 Physical sediment properties of the Whaness Burn core

Zone WB-1 (225-176 cm; c. 3020-1720 cal. BC)

This zone is generally characterised by a relatively high organic content, although percentages of organic matter do fluctuate with peaks of inorganic material occurring throughout. It is divided into two subzones, described below.

Subzone WB-1a (225-194 cm; c. 3020-2200 cal. BC)

Organic content is generally high (*c*. 80-90%) throughout this subzone, although values are lower between about 209 and 203 cm, falling to around 20%. There is a corresponding increase in inorganic material at this point, which rises to values of around 75%. This increase in percentages of inorganic matter coincides with the unit of siltier material that was identified during visual inspection of the core and recorded according to Troels-Smith (1955). Inorganic matter forms around 10% of the sediment throughout the rest of the subzone, and 'carbonate' content is low throughout, fluctuating between 1 and 2%.

Subzone WB-1b (194-176 cm; c. 2200-1720 cal. BC)

There are considerable fluctuations in organic and inorganic content throughout this subzone. Organic content falls from almost 100% at the base of the subzone to *c*. 70% at the top, and inorganic content shows a corresponding increase throughout the subzone from less than 1% at the base to around 25% at the top. There are isolated peaks of inorganic material at 187 cm (*c*. 30%) and 183 cm (*c*. 45%). These peaks are lower than that in the previous subzone, reflecting the lower silt content of the unit between 190 and 181 cm, which was identified during visual inspection and recorded according to Troels-Smith (1955). 'Carbonate' content remains low, fluctuating between 1 and 3% throughout the subzone.

Zone WB-2 (176-87 cm; c. 1720 cal. BC – 630 cal. AD)

This zone is characterised by higher organic and lower inorganic content than in zone WB-1. It is again divided into two subzones, each of which is discussed separately below.

Subzone WB-2a (176-150 cm; c. 1720-1030 cal. BC)

The sediment in this subzone was described using the Troels-Smith (1955) scheme as well-humified peat containing some recognisable plant macrofossils. This is partially supported by the results for organic and inorganic content, with percentages of organic

matter being around 70-80% throughout the subzone. Inorganic matter forms around 15% of the sediment in most of the subzone, but rises to *c*. 30% between 165 and 159 cm, indicating that there may be some silt within this unit that was not apparent on visual inspection. 'Carbonate' content remains at similar levels to in the previous zone, between 1 and 2%.

Subzone WB-2b (150-87 cm; c. 1030 cal. BC – 630 cal. AD)

Organic matter percentages rise to *c*. 90% at the beginning of this subzone and remain at similar values throughout, increasing to around 95-100% at the top of the subzone. Inorganic content is correspondingly low, forming around 10% of the sediment throughout most of the subzone and declining to between 0 and 5% towards the top. These values are supported by the Troels-Smith (1955) description of this unit as well-humified peat containing identifiable plant macrofossils between 0.1 and 2 mm in size. There is almost no 'carbonate' throughout most of this subzone, although it forms around 5% of the sediment between 105 and 101 cm.

Zone WB-3 (87-17 cm; c. 630-1120 cal. AD)

There is a marked increase in inorganic content to about 25% at the start of this zone, and values reach around 50% at *c*. 60 cm before declining to *c*. 30% again by the end of the zone. This coincides with the unit of siltier material which was identified during visual inspection of the core and recorded according to Troels-Smith (1955). Percentages of organic matter show a corresponding decline in this zone from around 70% at the base to *c*. 45% in the middle, before increasing again to about 65% at the top of the zone. 'Carbonate' forms around 2% of the sediment throughout most of the zone, although it shows an isolated peak of *c*. 11% at a depth of 45 cm.

Zone WB-4 (17-5 cm; c. 1120-1180 cal. AD)

It is possible that this zone represents recent peat formation on the previously cut surface of the mire, and this is potentially supported by the physical properties of the sediment in the zone. Organic matter content increases sharply from *c*. 70% at the base of the zone to around 90% at the top, and inorganic matter declines from about 25% to *c*. 7%. Moisture content also increases slightly in this zone, from *c*. 85 to *c*. 90%. 'Carbonate' content is again low, at around 2%.

5.4.4 Pollen and Charcoal Analysis

A percentage pollen diagram for Whaness Burn is presented in Fig. 5.14. The results of charcoal analysis are appended to the pollen diagram. The zonation scheme is based on all taxa with values greater than 2% in at least one sample, which included *Pinus sylvestris*, *Quercus*, *Betula*, *Alnus glutinosa*, *Corylus avellana*-type, *Salix*, *Empetrum nigrum*, *Calluna vulgaris*, *Vaccinium*-type, *Ranunculus acris*-type, *Filipendula*, Caryophyllaceae, Cyperaceae, *Phragmites*-type, Poaceae, *Selaginella selaginoides, Pteridium aquilinum* and Pteropsida (monolete) undiff. A pollen concentration diagram for the site is shown in Fig. 5.15. Each zone is described individually below, and the trends described in the percentage diagram are reflected by the concentration data unless otherwise stated.

Zone WB-1 (225-176 cm; c. 3020-1720 cal. BC)

Total pollen concentration is generally low (*c.* 10,000-50,000 grains cm^{-3}) throughout this zone, which is dominated by herbaceous taxa. Arboreal pollen frequencies are relatively high (*c.* 30-40% of the total pollen sum) and high percentages of pteridophyte spores are present in the lower part of the zone. The zone is split into two subzones which are described below.

Subzone WB-1a (225-194 cm; c. 3020-2200 cal. BC)

Total pollen concentration is very low throughout this subzone (10,000-20,000 grains cm^{-3}). Herbaceous and arboreal taxa are dominant, with herbaceous taxa forming a slightly higher proportion (*c.* 35-45%) of the total pollen sum than arboreal taxa, which make up around 25-35% of the total. The main herbaceous taxa represented are Cyperaceae (*c.* 10-20% of the total pollen sum), Poaceae (*c.* 10%) and *Filipendula* (*c.* 5-10%). Lower frequencies of *Ranunculus acris*-type, *Potentilla*-type, Rosaceae undiff. and Asteraceae pollen also occur throughout the subzone. A single grain of cereal-type pollen, identified as *Hordeum*-type on the basis of the annulus diameter (Andersen 1979), is present at a depth of 195 cm.

191
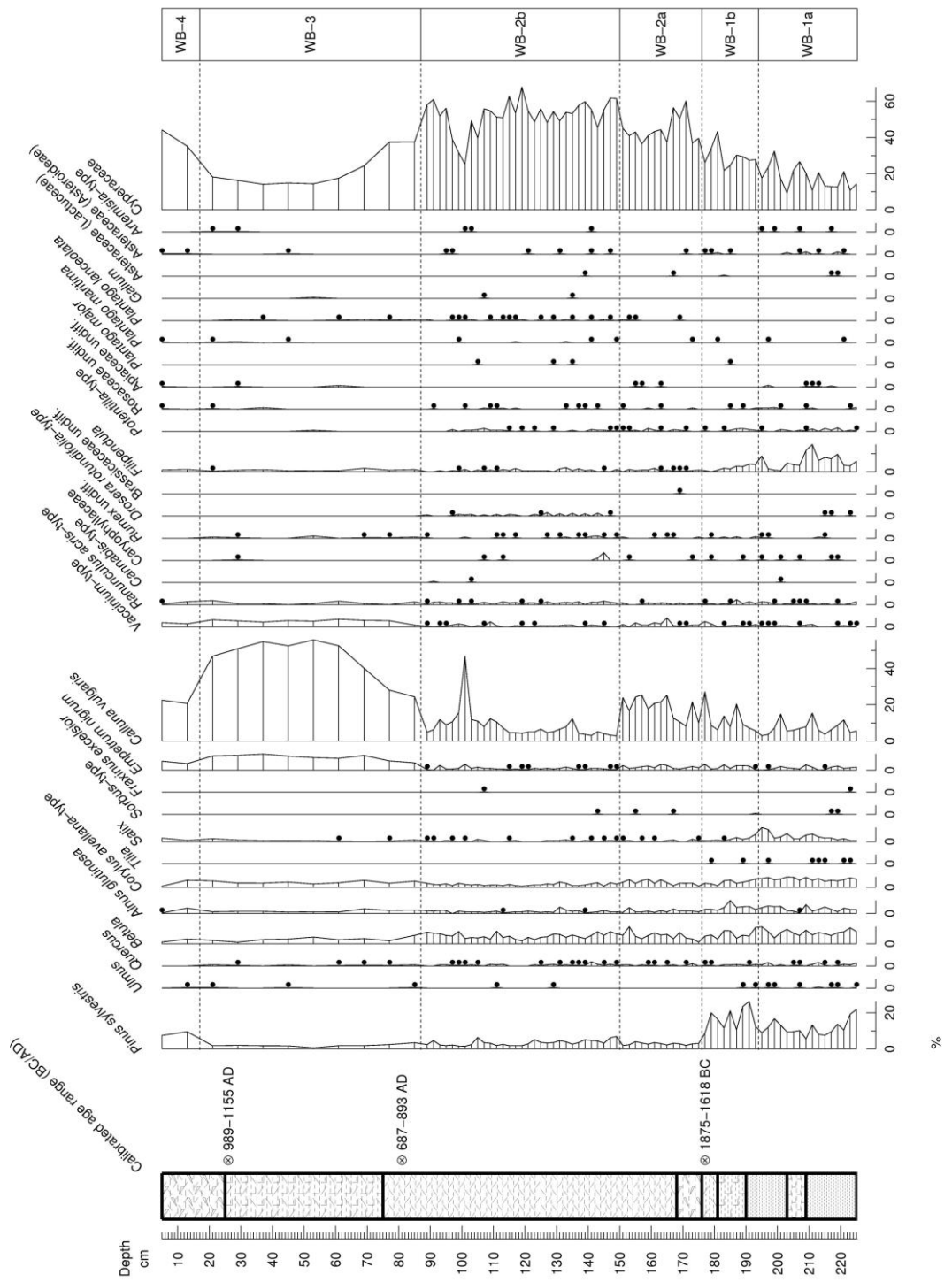
Figure 5.14 Percentage pollen and spore diagram from Whaness Burn

192
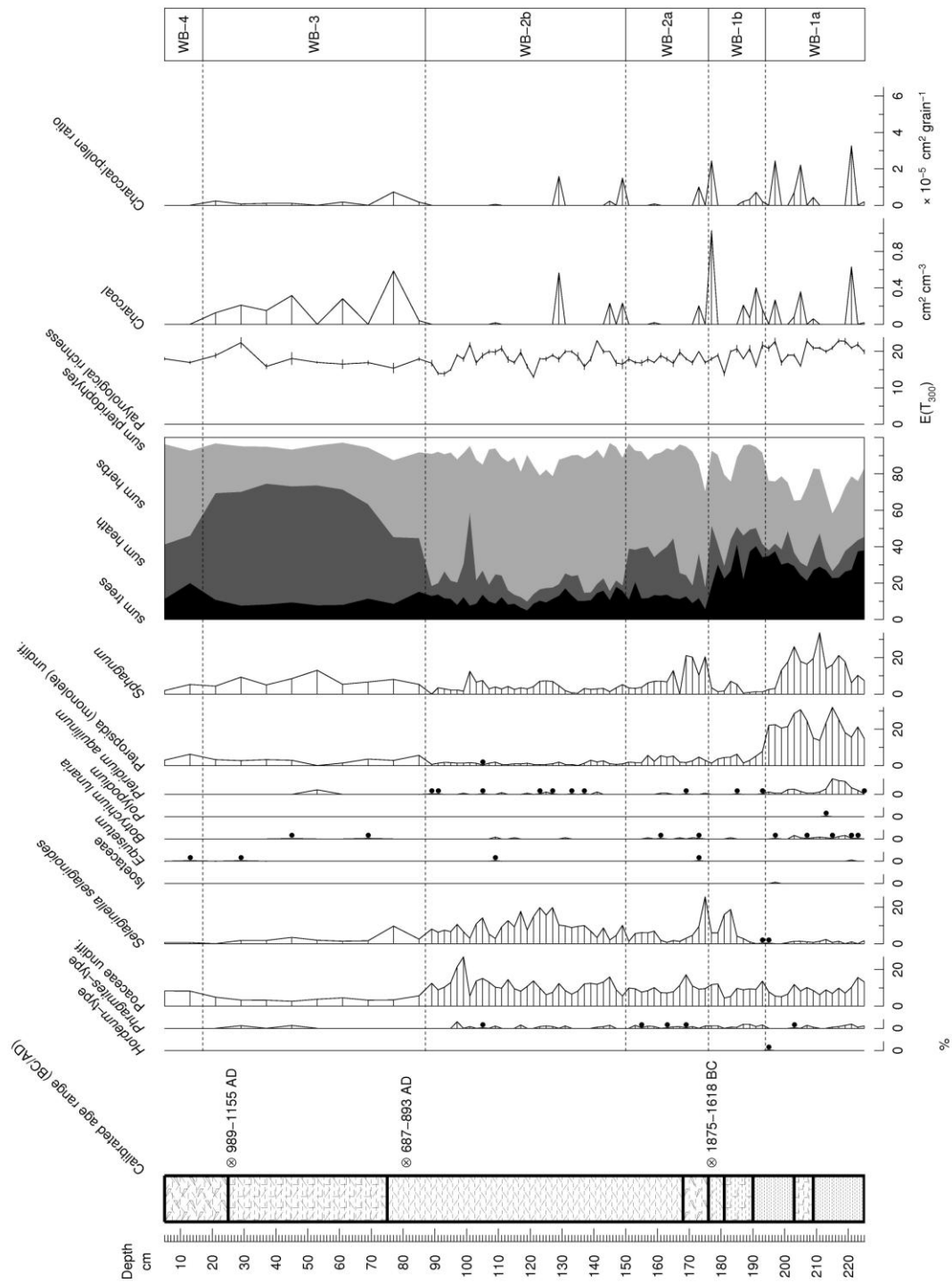
Figure 5.14 (continued) Percentage pollen and spore diagram from Whaness Burn
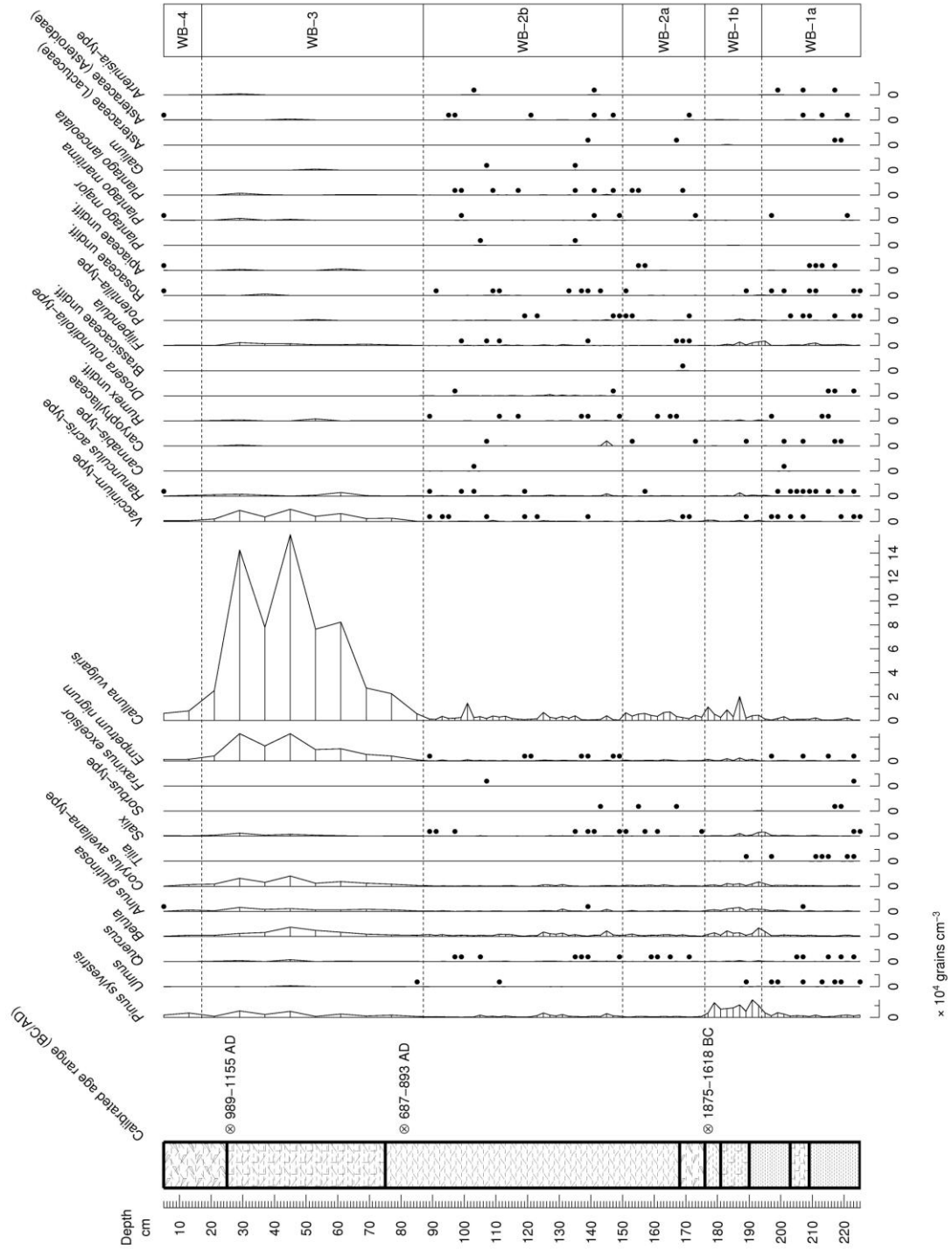
Figure 5.15 Pollen and spore concentrations from Whaness Burn
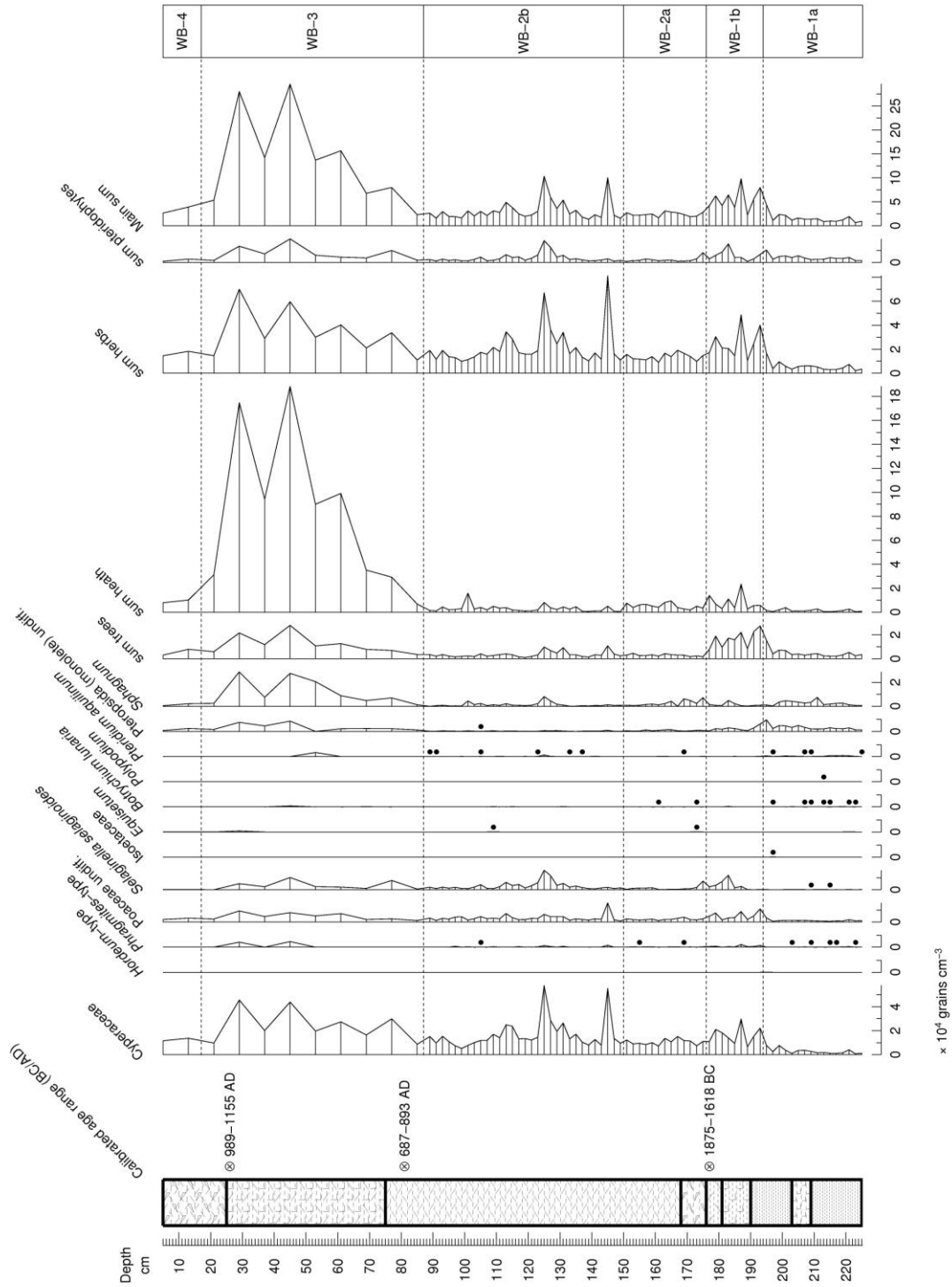
Figure 5.15 (continued) Pollen and spore concentrations from Whaness Burn

195

The arboreal component is dominated by pollen of *Pinus sylvestris* (*c*. 10-20% of the total sum), *Betula* (*c*. 10%), *Corylus avellana*-type (*c*. 5%), *Alnus glutinosa* (*c*. 3%) and *Salix* (*c*. 3%). *Ulmus* and *Quercus* pollen are also present at very low frequencies (<1%) throughout the subzone. Relatively high percentages of pteridophyte spores are recorded in this subzone, forming around 20% of the total sum throughout most of the subzone but reaching peaks of *c*. 40% at 215 cm and *c*. 35% at 205 cm. These peaks correspond with slight declines in arboreal pollen percentages which fall to around 20% of the total sum. *Pteridium aquilinum* spores form almost 10% of the total sum near the base of the subzone, although percentages of this taxon decline to <1% by the top.

Heath taxa form a minor component of the pollen assemblage in this subzone, with percentages varying between around 5 and 20% of the total. Of these taxa *Calluna vulgaris* is dominant and percentages of this taxon undergo regular increases and decreases, cycling between 5 and 15% throughout the subzone. Other heath pollen taxa represented at low frequencies include *Empetrum nigrum* and *Vaccinium*-type.

Percentages of *Sphagnum* spores are relatively high, averaging around 20% throughout most of the subzone. Palynological richness averages 20 taxa for most of the subzone, although it declines to around 16 taxa between 205 cm and 197 cm. Charcoal values range between 0.3 and 0.6 cm^{2}cm^{-3}, with charcoal more consistently present towards the top of the subzone. Peaks in the area of charcoal recorded are matched by peaks in the charcoal:pollen ratio.

Subzone WB-1b (194-176 cm; c. 2200-1720 cal. BC)

Total pollen concentration shows a slight increase in this subzone, averaging around 50,000 grains cm^{-3} throughout. Percentages of arboreal taxa increase, reaching a maximum of around 40% of the total pollen sum. Percentages of *Betula*, *Corylus avellana*-type, *Alnus glutinosa* and *Salix* pollen initially remain similar to those in WB-1a, before declining slightly towards the top of the subzone. *Quercus* pollen continues to be present in small frequencies, although above a depth of 185 cm *Ulmus* pollen is recorded only sporadically. *Pinus sylvestris* pollen percentages increase to *c*. 20-30% of the total pollen sum in this subzone.

Herbaceous taxa increase at the expense of pteridophytes in this subzone, although there is a peak in percentages of spores of *Selaginella selaginoides* at 183 cm, where they

form almost 20% of the total sum. This is matched by a peak in concentration of these spores. The major herbaceous taxa represented are again Cyperaceae (*c*. 30% of the total pollen sum), Poaceae (*c*. 10%) and *Filipendula* (*c*. 2%), with lower frequencies of *Ranunculus acris*-type and *Potentilla*-type. *Rumex* undiff. pollen shows a more regular presence, albeit at very low frequencies (< 1%), in comparison to the previous subzone.

Proportions of pollen from heath taxa show a slight increase in comparison to the previous subzone, with *Calluna vulgaris* again being the dominant taxon within this group. Percentages of this taxon increase to almost 30% of the total pollen sum by the end of the subzone. Pollen of *Empetrum nigrum* and *Vaccinium*-type continues to be present in low frequencies as in subzone WB-1a.

Frequencies of *Sphagnum* spores are very low throughout this subzone, and palynological richness fluctuates between about 16 and 21 taxa. Charcoal values are around 0.2-0.4 cm^{2}cm^{-3} at the base of the subzone, although no charcoal is present between 185 cm and 179 cm. There is another peak in charcoal values at the top of the subzone, where they reach *c*. 1 cm^{2}cm^{-3}. These fluctuations in the area of charcoal recorded are mirrored by the charcoal:pollen ratio.

Zone WB-2 (176-87 cm; c. 1720 cal. BC – 630 cal. AD)

In this zone total pollen concentrations are generally low, averaging around 20,000-30,000 grains cm^{-3} for most of the zone. The pollen assemblage is dominated by herbaceous taxa, with higher proportions of heath taxa and lower arboreal pollen percentages than in zone WB-1. The zone is divided into two subzones which are described individually below.

Subzone WB-2a (176-150 cm; c. 1720-1030 cal. BC)

There is a marked decline in arboreal pollen percentages at the start of this subzone, and they form around 10% of the total pollen sum throughout. *Betula* and *Corylus avellana*-type pollen percentages only show slight declines from their previous frequencies, comprising *c*. 5% and *c*. 3% of the total sum respectively. *Salix* pollen is now only present in very low frequencies (<1%) and *Alnus glutinosa* pollen proportions decline to around 1%. Very low percentages of *Quercus* pollen are also present throughout, as in the previous zone. The most obvious decline is in pollen of *Pinus*

sylvestris, percentages of which decrease to *c.* 3% at the start of this subzone and remain at similar values throughout.

Herbaceous taxa are dominant in this subzone, comprising *c.* 50-60% of the total pollen sum. Cyperaceae pollen frequencies show an expansion at the base of the subzone, increasing to around 40% and continuing to increase slightly towards the top of the subzone. Poaceae pollen percentages remain similar to those in the previous zone, forming *c.* 10% of the total sum. However concentrations of Cyperaceae and Poaceae pollen actually decline slightly in this subzone. *Filipendula* pollen no longer forms a major component of the total pollen sum, and is only present in low frequencies (<1%) throughout the subzone. *Ranunculus acris*-type, *Rumex* undiff. and *Potentilla*-type continue to be represented in the pollen record, whilst pollen of other herbaceous taxa only occurs intermittently. Pollen of *Plantago lanceolata* is recorded for the first time at a depth of 169 cm, although it is not consistently present until near the top of the subzone.

Heath taxa undergo a slight expansion in this subzone, making up around 20-30% of the total pollen sum from *c.* 165 cm upwards. As in the previous zone *Calluna vulgaris* is the dominant heath taxon present, comprising *c.* 20-25% of the sum. *Empetrum nigrum* and *Vaccinium*-type pollen occur throughout the subzone at frequencies of around 1-2% each. Percentages of pteridophyte spores are low (*c.* 5%) throughout the subzone and are dominated by spores of *Selaginella selaginoides*.

Frequencies of *Sphagnum* spores increase at the start of this subzone to around 20%, before declining to *c.* 5% by the top of the subzone. Palynological richness averages around 18 taxa throughout the subzone. Charcoal values are low (*c.* 0.2 cm^2cm^{-3}) at the base of the subzone, and very little charcoal is recorded throughout the rest of the subzone.

Subzone WB-2b (150-87 cm; c. 1030 cal. BC – 630 cal. AD)
Total pollen concentrations remain low (*c.* 20,000-30,000 grains cm^{-3}) throughout most of this subzone, although there are two isolated peaks in concentration at 145 cm and 225 cm, where values reach around 100,000 grains cm^{-3}. These peaks correspond with increases in the concentration of Cyperaceae pollen.

This subzone is again dominated by herbaceous taxa, which comprise around 60-70% of the total pollen sum. Percentages of arboreal pollen remain low (*c*. 10-15%) throughout the subzone, and the same arboreal taxa are represented as in the previous subzone. Cyperaceae continues to be the dominant herbaceous taxon, although frequencies of Poaceae pollen also increase in this subzone. Percentages of this pollen taxon cycle between *c*. 5% and *c*. 15% throughout most of the subzone. Pollen of other herbaceous taxa including *Ranunculus acris*-type, *Filipendula,* Rosaceae undiff. and Asteraceae continues to be present in very low frequencies throughout the subzone as before, and *Drosera rotundifolia* pollen is also represented throughout. Pollen of anthropogenic indicator species including *Plantago lanceolata*, *Rumex* undiff. and *Artemisia*-type occurs throughout the subzone.

Heath taxa decline again at the start of the subzone, and average *c*. 5-10% of the total pollen sum throughout. Again the dominant heath taxon represented is *Calluna vulgaris*, which generally comprises around 5% of the total pollen sum throughout the subzone, although there is an isolated peak at *c*. 101 cm where a value of 45% is reached. *Empetrum nigrum* and *Vaccinium*-type are the other heath taxa present, although only in low frequencies as in the previous subzone. Percentages of pteridophyte spores increase slightly to make up *c*. 15% of the total sum in this subzone, and this group of taxa is again dominated by spores of *Selaginella selaginoides*, frequencies of which are *c*. 10% throughout.

Sphagnum spore percentages are lower than in the previous subzone, averaging about 5% throughout. Palynological richness fluctuates between *c*. 15 and *c*. 22 taxa throughout the subzone. Charcoal values are around 0.2 cm^2cm^{-3} at the base of the subzone, and there is an isolated peak of *c*. 0.5 cm^2cm^{-3} at 129 cm, although no charcoal occurs in the upper part. The charcoal:pollen ratio exhibits a similar pattern.

Zone WB-3 (87-17 cm; c. 630-1120 cal. AD)

Total pollen concentrations are higher in this zone than previously, reaching their highest recorded values of *c*. 300,000 grains cm^{-3} in the upper half of the zone. This zone is dominated by heath taxa, which undergo a marked expansion at the base of the zone to form around 60% of the total pollen sum throughout. As in all previous zones, the heath component of the pollen assemblage is mainly composed of *Calluna vulgaris* with lesser amounts of *Empetrum nigrum* and *Vaccinium*-type pollen. These latter two

taxa, although still only forming a minor component of the heath taxa, occur at higher frequencies than previously, making up *c*. 8% and *c*. 4% of the total pollen sum respectively.

Herbaceous taxa make up most of the remainder of the pollen assemblage, with Cyperaceae and Poaceae again dominating this group of taxa, comprising around 20% and 5% of the total pollen sum respectively. *Ranunculus acris*-type and *Filipendula* pollen remain present in low frequencies (*c*. 1%) throughout the zone, although other herbaceous taxa are only represented intermittently and in very low quantities (<1%). Pollen of anthropogenic indicator species such as *Plantago lanceolata*, *Rumex* undiff. and *Artemisia*-type occurs less frequently than in zone WB-2.

Arboreal pollen percentages remain at about 10% throughout this zone, and spores of pteridophytes are also present only in low quantities of *c*. 5%. *Sphagnum* spore percentages are slightly higher than in the previous subzone, averaging about 10% throughout.

Palynological richness averages around 17 taxa throughout most of the zone, although it increases slightly to *c*. 20 taxa by the end of the zone. Charcoal is present throughout the zone, averaging *c*. 0.3 cm^2cm^{-3}, although the charcoal:pollen ratio is very low.

Zone WB-4 (17-5 cm; c. 1120-1180 cal. AD)

There is a sharp decrease in total pollen concentrations at the start of the zone to around 30,000 grains cm^{-3}, along with a decline in the pollen of heath taxa and an expansion in that of herbaceous taxa.

The pollen assemblage in this zone is dominated by herbaceous taxa, mainly Cyperaceae which increases to form around 40% of the total pollen sum. Frequencies of Poaceae pollen increase to *c*. 10%, and other herbaceous taxa present include *Ranunculus acris*-type, *Filipendula* and Asteraceae. No anthropogenic indicator taxa are represented in this zone.

Pollen of heath taxa declines at the base of the zone and forms *c*. 30% of the total pollen sum throughout. *Calluna vulgaris* continues to dominate this group of taxa, with

Empetrum nigrum and *Vaccinium*-type pollen comprising *c*. 5% and *c*. 2% of the total pollen sum respectively.

Arboreal pollen percentages increase slightly in this zone from around 10% to *c*. 20% of the total sum. *Betula*, *Corylus avellana*-type, *Alnus glutinosa* and *Salix* pollen continues to occur at the same frequencies as previously, but that of *Pinus sylvestris* increases to around 10% of the total pollen sum before declining slightly towards the top of the zone. Pteridophyte spores are present in similar quantities to those in zone WB-3, comprising around 5% of the total sum.

Sphagnum spore percentages decline slightly to *c*. 5% in this zone. Palynological richness averages 17 taxa, and no charcoal is present.

5.4.5 Non-Pollen Palynomorph Analysis

A diagram showing recorded frequencies of non-pollen palynomorphs (NPPs) as percentages of the combined sum of total land pollen and spores plus NPPs (following Mighall *et al*. 2006) is presented in Fig. 5.16. All NPPs recorded are fungal ascospores, all of coprophilous species (van Geel *et al*. 2003; Graf and Chmura 2006). In order to aid interpretation and discussion, the pollen zonation scheme has also been applied to this data.

Zone WB-1 (225-176 cm; c. 3020-1720 cal. BC)

Only low frequencies of NPPs were recorded in this zone. The two subzones are described individually below.

Subzone WB-1a (225-194 cm; c. 3020-2200 cal. BC)

Low frequencies of *Sordaria*-type ascospores occur between 219 and 213 cm, with a peak of *c*. 4%. An isolated occurrence of *Podospora*-type is present at 217 cm.

Subzone WB-1b (194-176 cm; c. 2200-1720 cal. BC)

Very low frequencies (*c*. 1%) of *Sordaria*-type ascospores occur at the top of the subzone.
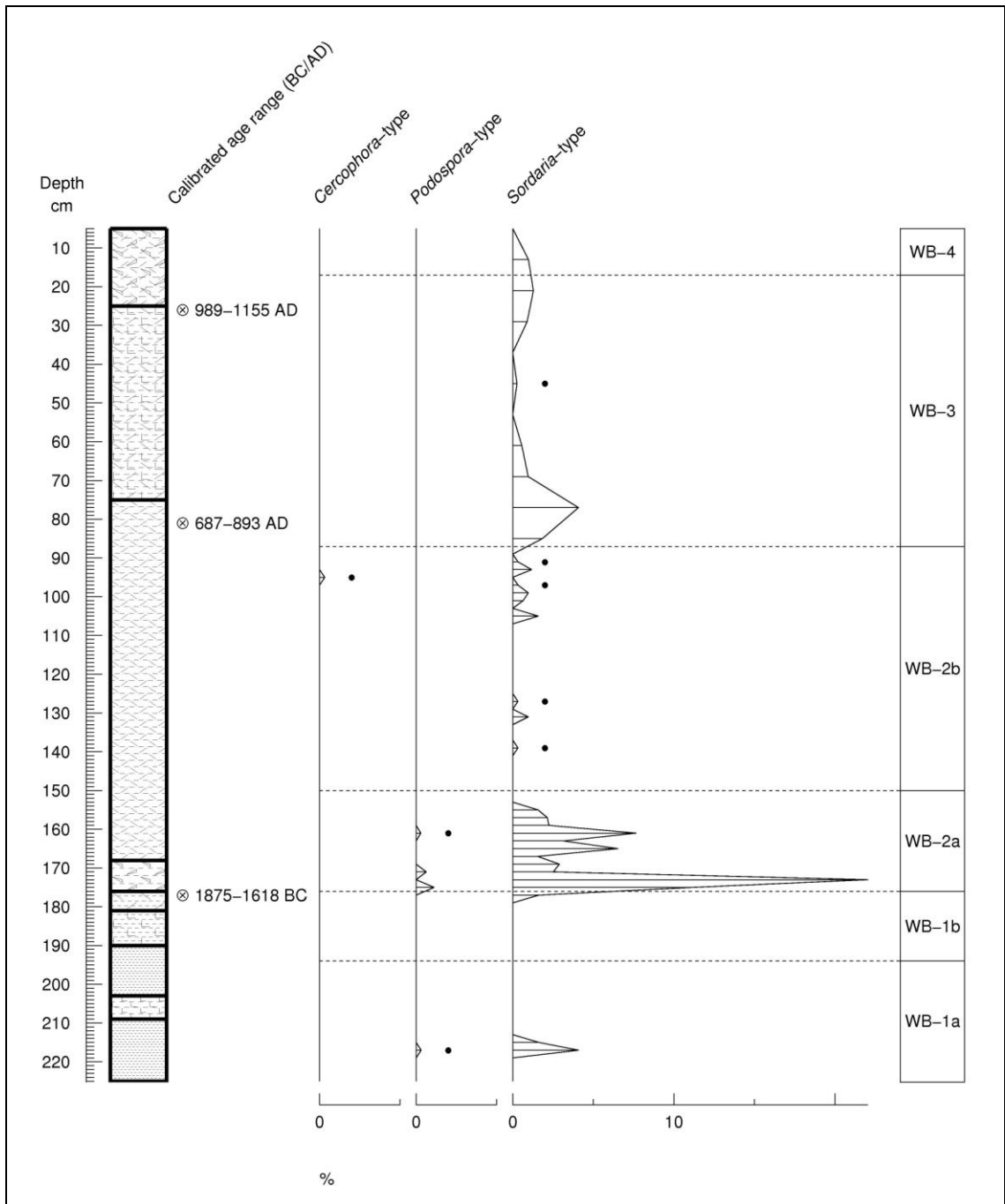
Figure 5.16 Percentages of non-pollen palynomorphs recorded in the Whaness Burn core

Zone WB-2 (176-87 cm; c. 1720 cal. BC – 630 cal. AD)

All three NPP types observed in the Whaness Burn core occur in this zone, although mostly in very low frequencies. The zone is divided into two subzones, described individually below.

Subzone WB-2a (176-150 cm; c. 1720-1030 cal. BC)

The highest recorded frequencies of *Sordaria*-type ascospores occur in this subzone, reaching their highest peak at 173 cm where they form just over 20% of the total sum. Following this their frequency declines to around 2%, increasing again to *c*. 6% between 165 and 161 cm before declining to zero by the top of the subzone. Very low frequencies (<1%) of *Podospora*-type ascospores are also recorded in the lower part of the subzone.

Subzone WB-2b (150-87 cm; c. 1030 cal. BC – 630 cal. AD)

Very low frequencies (generally less than 1%) of *Sordaria*-type ascospores occur sporadically throughout this subzone, and there is an isolated occurrence of *Cercophora*-type at 95 cm.

Zone WB-3 (87-17 cm; c. 630-1120 cal. AD)

The only NPP type recorded in this zone is *Sordaria*-type, frequencies of which reach a peak of *c*. 4% at 77 cm before declining to levels of around 1% for most of the remainder of the zone.

Zone WB-4 (17-5 cm; c. 1120-1180 cal. AD)

Again, *Sordaria*-type ascospores are the only NPP type present in this zone. They are present at frequencies of *c*. 1% at the start of the zone, declining to zero at the top of the sequence.

5.4.6 Microstructure Analysis

A diagram showing the results of the analysis of sieve residues retained during pollen processing is shown in Fig. 5.17. Table 5.3 records the frequencies of seeds and megaspores recovered during this process. Again, the zonation scheme used is the same as that for the pollen diagram in order to aid description and interpretation.

Zone WB-1 (225-176 cm; c. 3020-1720 cal. BC)

This zone is generally characterised by relatively high quantities of unidentifiable organic matter (UOM), with lesser amounts of recognisably graminoid material. There are also low frequencies of non-*Sphagnum* moss fragments and small fragments of charcoal throughout the zone. The zone is divided into two subzones, each of which is described individually below.
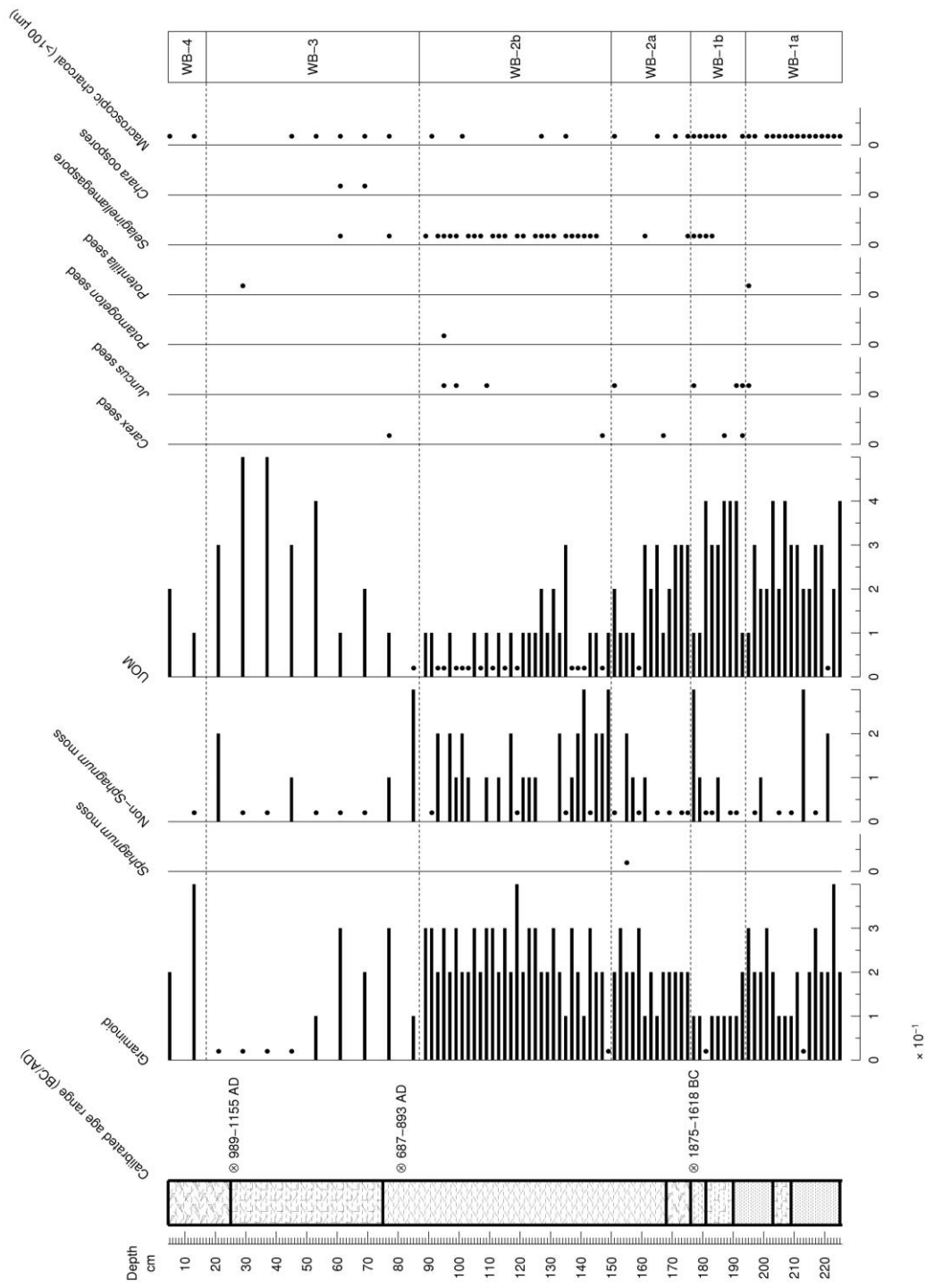
Figure 5.17 Results of microstructure analysis on sieve residues retained during pollen processing

Zone	Depth (cm)	Fen taxa				Aquatic taxa	
		Carex seed	*Juncus* seed	*Potentilla* seed	*Selaginella* megaspore	*Potamogeton* seed	*Chara* oospore
WB-3	29			1			
	61				1		4
	69						2
	77	2			1		
WB-2b	89				1		
	93				1		
	95		2		2	1	
	97				2		
	99		2		6		
	103				3		
	105				1		
	107				1		
	109		1				
	111				6		
	113				1		
	115				2		
	119				4		
	121				3		
	125				1		
	127				5		
	129				3		
	131				2		
	135				1		
	137				3		
	139				3		
	141				1		
	143				12		
	145				1		
	147	1					
WB-2a	151		2				
	161				2		
	167	1					
	175				1		
WB-1b	177		2		1		
	179				4		
	181				2		
	183				2		
	187	1					
	191		1				
	193	2	3				
WB-1a	195		1	1			

Table 5.3 Frequencies of seeds, megaspores and oospores retained from sieve residues

Subzone WB-1a (225-194 cm; c. 3020-2200 cal. BC)

Samples in this subzone contained high proportions of UOM, with slightly lower frequencies of graminoid fragments. Small quantities of non-*Sphagnum* moss occur

sporadically throughout. Small fragments of charcoal are consistently present, and single seeds of *Juncus* and *Potentilla* were recorded at 195 cm.

Subzone WB-1b (194-176 cm; c. 2200-1720 cal. BC)

This subzone is again dominated by UOM, with lower frequencies of graminoid and non-*Sphagnum* moss fragments than in the previous subzone. Charcoal again occurs throughout, and *Selaginella selaginoides* megaspores are consistently present from 183 cm to the top of the subzone. Other seeds recorded include 2 *Carex* and 3 *Juncus* at 193 cm, a single *Juncus* seed at 191 cm, one *Carex* seed at 187 cm and 2 *Juncus* seeds at a depth of 177 cm.

Zone WB-2 (176-87 cm; c. 1720 cal. BC – 630 cal. AD)

This zone is characterised by lower frequencies of UOM and higher proportions of identifiably graminoid and non-*Sphagnum* moss fragments than were recorded in zone WB-1.

Subzone WB-2a (176-150 cm; c. 1720-1030 cal. BC)

The samples in this subzone are still dominated by UOM, although this occurs in lower frequencies than previously. Graminoid material is present in slightly higher quantities than in subzone WB-1b, and non-*Sphagnum* moss fragments are intermittently present throughout the subzone. Charcoal occurs sporadically at the base of the subzone, but is only present in a single sample at the top. Seeds and megaspores recorded included a single *Selaginella selaginoides* megaspore at 175 cm, a *Carex* seed at 167 cm, 2 *S. selaginoides* megaspores at 161 cm and 2 *Juncus* seeds at 151 cm.

Subzone WB-2b (150-87 cm; c. 1030 cal. BC – 630 cal. AD)

In this subzone there is a distinct change to much lower frequencies of UOM, with the samples now being dominated by graminoid and non-*Sphagnum* moss fragments. Of these two categories graminoid material makes up the highest proportion. Charcoal occurs intermittently throughout this subzone, and *Selaginella selaginoides* megaspores are consistently present. A single *Carex* seed was recorded at 147 cm, a *Juncus* seed was present at 109 cm, and 2 *Juncus* seeds were present in samples from both 99 cm and 95 cm.

Zone WB-3 (87-17 cm; c. 630-1120 cal. AD)

In this zone, proportions of UOM begin to increase and this again becomes the dominant category at around 53 cm. Quantities of graminoid material decline to very low frequencies at the same depth, and non-*Sphagnum* moss fragments are very infrequent in this subzone. Charcoal fragments were sporadically recorded throughout. Two *Carex* seeds were present at a depth of 77 cm, and a single *Potentilla* seed was recorded at 29 cm. Individual *Selaginella selaginoides* megaspores were recorded at depths of 77 cm and 61 cm, and *Chara* oospores were present in samples from 69 cm and 61 cm.

Zone WB-4 (17-5 cm; c. 1120-1180 cal. AD)

The samples in this zone contain higher quantities of graminoid fragments and lower frequencies of UOM than in WB-3, perhaps supporting the hypothesis that a hiatus in the record occurs at about 25 cm. Charcoal was consistently present in this zone, although no seeds were recorded.

5.5 Discussion

The base of the sequence from Whaness Burn is dated to *c*. 3020 cal. BC by linear extrapolation, and the record appears to be complete up to a depth of around 25 cm, dated to *c*. 1080 cal. AD. It is clear from Fig. 5.12 that the uppermost part of the sequence is missing, and a distinct change from fairly well-humified peat to a more herbaceous peat containing only partially decayed plant material at a depth of 25 cm (*c*. 1080 cal. AD) is interpreted as representing recent peat formation on the previously cut surface of the mire. The palaeoecological record from this site therefore provides evidence for environmental conditions and land-use from the late Neolithic through to the time of the Viking-Late Norse transition.

The consistent presence of peat throughout the core from this site indicates that the basin at the southern end of Whaness Burn has always been occupied by a valley mire. Units of siltier material within the peat suggest erosive mineral input from either slope runoff, stream flood events or aeolian processes (Table 5.2; Fig. 5.13). The stream is fairly small and the mire is close to the head, and the site is approximately 2 kilometres from the coast, where windblown sediment is likely to originate. It is therefore reasonable to assume that the mineral input is predominantly the result of increased erosion on the slopes surrounding the basin. The changes in vegetation, environment

and land-use surrounding Whaness Burn will be discussed in terms of the broad archaeological periods defined in Chapter 1.

5.5.1 Neolithic (*c*. 4000 – *c*. 2000 cal. BC)

As discussed in Chapter 2, the Neolithic period in Orkney is usually divided into an early and a late phase, and the transition between these two phases is thought to have occurred at around 3000 cal. BC (e.g. Card 2005). Only the final 1000 years of the Neolithic period are represented in the palaeoecological record from Whaness Burn.

When peat began to form in the basin at *c*. 3020 cal. BC in the late Neolithic, arboreal pollen percentages of around 30% (Fig. 5.14) suggest that some woodland was present in the landscape around Whaness Burn at this time (e.g. Bunting 2002). Most of the arboreal pollen component consists of *Pinus sylvestris*, which forms up to 15% of the total pollen sum in places. Other arboreal taxa represented at lower frequencies include *Betula*, *Corylus-avellana*-type, *Alnus glutinosa* and *Salix*. These latter four taxa are all believed to have been components of the scrub woodland which was initially present across much of Orkney prior to *c*. 3950 cal. BC (e.g. Keatinge and Dickson 1979; Bunting 1994; 1996; Blackford *et al.* 1996; de la Vega-Leinert *et al.* 2000; 2007).

Whether the presence of *Pinus sylvestris* pollen in Orcadian palaeoecological sequences represents the local growth of this species or originates via long-distance transport from the Scottish mainland is a matter of some debate (e.g. Moar 1969; Keatinge and Dickson 1979; Bunting 1994). At Quoyloo Meadow in west Mainland, similarities in the pollen curve for *Pinus sylvestris* to those of *Corylus avellana*-type and *Betula* led Bunting (1994) to suggest that this species was locally present, in contrast with other studies (e.g. Moar 1969; Keatinge and Dickson 1979), where the conclusion has been that *Pinus sylvestris* pollen must have originated on the Scottish mainland. By analogy with Shetland (Bennett and Sharp 1993) and the Western Isles (Fossitt 1996), it seems likely that the woodland was more diverse in the more sheltered eastern areas of Orkney, which could have acted as a source from which taxa such as *Pinus sylvestris* and *Quercus* were able to colonise the brief opening of the woodland canopy which occurred at Quoyloo Meadow at *c*. 5450 cal. BC (Bunting 1994). Support for this hypothesis may be provided by a short, undated sequence from Liddle Bog on South Ronaldsay, where *Pinus sylvestris* pollen percentages of *c.* 20% are interpreted by

Bartlett (1983) as indicating the local presence of this species at some time during the late Neolithic/early Bronze Age.

Pine does not seem to have been present at sites further south on Hoy in the records from Keith's Peat Bank (Blackford *et al*. 1996) and Loch of Torness (Bunting 1996), and percentages of *Pinus sylvestris* pollen between 20 and 30% are generally taken as indicating that the species grew locally around a site (e.g. Bennett 1984; Gear and Huntley 1991; Charman 1994). It is therefore likely that this species was not locally present before 193 cm (*c*. 2170 cal. BC; Fig. 5.14) at Whaness Burn, and that birch-hazel scrub was present on the slopes surrounding the basin while small patches of alder and willow grew on the wetter valley floor. Birch-hazel scrub was initially present around Loch of Torness (Bunting 1996), and the scrub woodland at Keith's Peat Bank was dominated by *Betula* and *Salix* (Blackford *et al*. 1996). The understorey vegetation at Whaness Burn seems to have been rich in ferns and herbaceous taxa such as *Filipendula*, similar to that at Quoyloo Meadow and Crudale Meadow in west Mainland (Bunting 1994) and Keith's Peat Bank (Blackford *et al*. 1996).

There does not seem to have been any local woodland present at Loch of Torness after *c*. 4820 cal. BC (Bunting 1996), suggesting that woodland may have survived longer in the north of the island. How long woodland persisted at Keith's Peat Bank is unknown, since following the proposed Mesolithic disturbance at *c*. 5350 cal. BC the woodland apparently recovered and the analysed sequence ends at *c*. 3450 cal. BC (Blackford *et al*. 1996). At Whaness Burn woodland seems to persist into the Bronze Age, eventually declining at 177 cm (*c*. 1750 cal. BC). This represents quite a late survival of woodland in Orkney generally, since in west Mainland the birch-hazel scrub woodland largely declined between around 3950 cal. BC and *c*. 3450 cal. BC (e.g. Keatinge and Dickson 1979; Bunting 1994). However fragments of woodland are believed to have persisted into the Bronze Age at some Orcadian sites, for example near Burn of Rusht in west Mainland (Keatinge and Dickson 1979) and Liddle Bog on South Ronaldsay (Bartlett 1983), although the latter sequence is not radiocarbon dated.

At 193 cm (*c*. 2170 cal. BC; Fig 5.14), percentages of *Pinus sylvestris* pollen increase to form *c*. 27% of the total pollen sum. Frequencies of *Pinus sylvestris* pollen remain between *c*. 20 and 30%, values which are believed to represent the local growth of the

species (e.g. Bennett 1984; Gear and Huntley 1991; Charman 1994) until 177 cm (*c*. 1750 cal. BC), when percentages decline to around 3% of the total pollen sum.

As Charman (1994) notes, the occurrence of local pine in a pollen diagram is unusual for the far north-east of Scotland, despite widespread occurrences of macrofossils in peat deposits in the region (Birks 1975; Gear and Huntley 1991). However a short period of local pine growth has been identified between *c*. 2850 cal. BC and *c*. 2400 cal. BC in a pollen sequence from Cross Lochs in Sutherland (Charman 1994). This pine expansion at Cross Lochs occurs at around the same time as the range of pine in Scotland is hypothesised to have expanded northwards (*c*. 3400 cal. BC) in response to the drying out of blanket mire surfaces caused by changes in atmospheric circulation (Gear and Huntley 1991). Tipping *et al*. (2008b) have also demonstrated that pine was locally present around Loch Farlary in north-east Scotland between *c*. 3250 and *c*. 2050 cal. BC. Pine is believed to have been present at Quoyloo Meadow in west Mainland from around 5450 cal. BC, and this coincides with another period for which Tipping *et al*. (2008b) have suggested the presence of local pine trees around Loch Farlary, between *c*. 5650 and *c*. 4050 cal. BC. At Whaness Burn pine may have become established on the lower, shallower slopes around the valley slightly later than the second of these two periods of local pine growth in north-east Scotland, at 193 cm (*c*. 2170 cal. BC; Fig. 5.14). It is possible that there was also an earlier period of local pine growth at this site, as has been hypothesised for Loch Farlary and Quoyloo Meadow, but the palaeoecological record from Whaness Burn does not cover this time period.

At Loch of Torness it seems that the deciduous woodland community that initially surrounded the site may have been too open for a tall herb-type understorey to develop, with the lower layers of vegetation being made up of heath species such as *Empetrum nigrum* and *Potentilla*-type (Bunting 1996). Pine trees, such as those hypothesised around Whaness Burn, do not have a tall herb-type understorey due to the acidic soils that form under this type of canopy. However heath taxa such as *Empetrum nigrum* and *Potentilla*-type typically form the understorey vegetation in pine woodland, and these taxa are represented in low quantities at Whaness Burn during the period of high *Pinus sylvestris* pollen percentages (Fig. 5.14). Therefore low frequencies of pollen from typical Orcadian understorey species such as *Filipendula* at Whaness Burn are not

related to the absence of woodland at this site, since the type of woodland likely to have been present would not support these species.

The landscape around Whaness Burn does not seem to have been particularly affected by human activity during the late Neolithic, with no *Plantago lanceolata* pollen being present and only low pollen frequencies of other anthropogenic indicator taxa such as *Rumex* undiff. and *Artemisia*-type (Fig. 5.14). Increased proportions of inorganic sediment occur in the sequence between 209 and 203 cm (*c*. 2600-2430 cal. BC; Fig. 5.13), suggesting that erosion was taking place on the slopes surrounding the basin at this time. This disturbance may account for the presence of *Rumex* undiff. and *Artemisia*-type in the pollen record, although the cause of the increase in erosion is unclear. Low frequencies of *Sordaria*-type ascospores are present at 217 cm (*c*. 2800 cal. BC; Fig 5.16), indicating the presence of low numbers of grazing animals near the site just prior to the period of increased erosion. It is possible that these animals caused the increased mineral input in the basin by removing the vegetation cover on the slopes through grazing and trampling.

The presence of grazing animals at Whaness Burn does not necessarily imply that humans were present, since animals such as red deer could have reached Hoy by swimming from the Scottish mainland. Support for this hypothesis is provided by evidence from archaeological sites in the islands, where the presence of red deer bones in small quantities is thought to indicate hunting of this species rather than herding (Hedges 1983a). The occurrence of a single grain of *Hordeum*-type pollen at 195 cm (*c*. 2220 cal. BC; Fig. 5.14) is the only incidence of cereal-type pollen throughout the whole core and as such cannot be taken as evidence for arable cultivation near to the site. Whilst the annular diameter of this grain falls into the size class for *Hordeum*-type, this group also includes some species of wild wetland grasses such as *Glyceria fluitans* (Andersen 1979) and it seems more likely that this grain actually originates from a wild grass rather than from cultivated barley. The lack of Neolithic agricultural activity implied by the palaeoecological record from Whaness Burn is supported by the archaeological evidence, with the only recorded sites from this period being chambered cairns and standing stones, suggesting the landscape was not intensively used for domestic purposes during this period.

5.5.2 Bronze Age (*c*. 2000 – *c*. 800 cal. BC)

The duration of the period of high *Pinus sylvestris* pollen percentages at Whaness Burn is approximately 400 years, similar to the period for which open pine forest is hypothesised to have been present around Cross Lochs (Charman 1994). The decline of the pine forest around Cross Lochs at *c*. 2400 cal. BC roughly coincides with the widespread pine decline to the south and south-west of the site (Pennington *et al*. 1972; Birks 1975; Gear and Huntley 1991; Tipping *et al*. 2008b). The pine trees around Whaness Burn, having become established later than at sites further to the south, also decline later at around 1750 cal. BC (177 cm; Fig. 5.14).

Reasons suggested for the pine decline in northern Scotland include climatic deterioration, with increased oceanicity (Pennington *et al*. 1972; Gear and Huntley 1991), soil leaching and podsolisation on mineral soils (Birks 1975), and anthropogenic impacts (Charman 1994; Tipping *et al*. 2008b). Blackford *et al*. (1992) have also suggested that the Icelandic Hekla-4 eruption may have been a contributing factor, either directly via the deposition of acidic volatiles adsorbed onto tephra particles, or indirectly due to volcanically-induced climatic deterioration (e.g. Porter 1981; Sear *et al*. 1987), which may have led to increased bog surface wetness.

At Whaness Burn, no tephra layers were located in the peat core, ruling out the possibility that the deposition of this material increased the acidity of the soil and caused the decline in *Pinus sylvestris* indicated in the pollen record at this site. There are indications of burning at the time of the pine decline in the form of both microscopic and macroscopic charcoal, although whether this is of natural or anthropogenic origin is unclear, since standing pine forests are known to burn freely without human intervention (Rackham 1986). There is some evidence for a minor increase in the surface wetness of the mire at 176 cm (*c*. 1720 cal. BC; Fig. 5.14) in the form of slight expansions in Cyperaceae pollen and *Sphagnum* spores. In addition, the microstructure evidence shows a slight decline in UOM with a corresponding increase in proportions of identifiable graminoid material at this time, perhaps indicating wetter conditions under which more organic material was preserved (Fig. 5.17). Circumstantial evidence for a wetter climate is provided by the increased proportions of inorganic matter in the core between 190 and 181 cm (*c*. 2090-1850 cal. BC; Fig. 5.13), perhaps suggesting that there was increased runoff from the slopes around the basin at this time.

There are some indications of human activity in the pollen record following the decline in local pine growth at Whaness Burn, including pollen of anthropogenic indicator species such as *Plantago lanceolata* and *Rumex* undiff. (Behre 1981). High frequencies of *Sordaria*-type ascospores are also present in the record between 177 and 155 cm (*c*. 1750-1170 cal. BC; Fig. 5.16), implying the presence of increased numbers of grazing animals during this period. It therefore seems that the most convincing explanation for the decline in local pine trees at Whaness Burn is climatic deterioration causing increased surface wetness around the site, perhaps in combination with deliberate clearance by humans, either to provide more land for pastoral farming or to provide timber for building or fuel. Grazing pressure would also have resulted in a lower rate of tree seedling survival, and therefore human activity may have at least partially prevented woodland regeneration at the site.

There is an expansion in percentages of *Calluna vulgaris* pollen at the start of the Bronze Age, and frequencies increase gradually throughout this period (Fig. 5.14), suggesting that heathland became established around the basin at this time. However despite this general increase in *Calluna vulgaris* pollen, percentages of this taxon fluctuate between *c*. 10% and *c*. 25% throughout the Bronze Age. Occasional peaks of microscopic charcoal are present, perhaps implying that the heathland around the basin was being managed by deliberate burning in order to improve grazing, by encouraging the dense growth of new shoots of *Calluna vulgaris*, which contain more nutrients than old-growth heather (Gimingham 1975), and by allowing Poaceae to grow in the gaps created by fire. Evidence for management of heathland by burning in the Bronze Age occurs in environmental records from Denmark (e.g. Odgaard 1992; Karg 2008), and Bunting (1996) has suggested that heathland on Rousay may have been managed in this way during the Bronze and Iron Ages, although there is no evidence for this practice in the sequence from the Loch of Torness on Hoy.

The presence of fungal ascospores can be interpreted as a very local record of grazing (Blackford and Innes 2006), and it therefore seems that their increased frequency around Whaness Burn between 177 and 155 cm (*c*. 1750-1170 cal. BC; Fig. 5.16) is related to the occupation of the enclosed settlement within the valley, which incorporates several enclosures interpreted as pens or folds to contain livestock (Lamb 1989). An increase in mineral input to the basin between 165 and 157 cm (*c*. 1430-1220 cal. BC; Fig. 5.13) may be the result of greater erosion following the

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removal of woodland on the surrounding slopes, perhaps exacerbated by increased grazing pressure.

There is no evidence for cereal cultivation at Whaness Burn during the Bronze Age, contrasting with records from elsewhere in Orkney which indicate mixed agricultural practices at most sites at this time (e.g. Jones 1975; 1977; Downes 1994; Dockrill *et al*. 2007: see Chapter 3). However Keatinge and Dickson (1979) have suggested that fairly intensive pastoral farming was taking place around more marginal, upland sites in west Mainland, and the evidence from Whaness Burn points to a similar economy at this site. This may indicate that farming had expanded into more environmentally marginal areas, perhaps in response to a rise in population that resulted in increased pressure on more fertile soils and the need for more grazing land (e.g. Tipping *et al*. 2008a). Alternatively this may reflect a change in the distribution of agriculture that occurred along with reorganisation of settlement patterns during the Bronze Age (Richards 1998; Parker Pearson 2005).

Towards the end of the Bronze Age, at 150 cm (*c.* 1030 cal. BC; Fig. 5.14), there is a decline in *Calluna vulgaris* pollen percentages and a corresponding increase in those of Cyperaceae, suggesting that a further increase in the surface wetness of the mire took place at this time. This is supported by the microstructure evidence, which exhibits a further decline in UOM and increased proportions of recognisable graminoid material (Fig. 5.17). This may explain the apparent decline in pastoral activity at the site at 155 cm (*c.* 1170 cal. BC; Fig 5.14, 5.16), which might indicate that the settlement in the valley was abandoned at this time. It is possible that this shift to wetter conditions at Whaness Burn is linked to the well-documented climatic deterioration that seems to have occurred across northwest Europe at *c.* 850 cal. BC (e.g. van Geel *et al*. 1996; Mauquoy *et al*. 2004; Blundell and Barber 2005; Swindles *et al*. 2007).

5.5.3 Iron Age (*c*. 800 cal. BC – *c*. 600 cal. AD)
The pollen record from the Iron Age continues to be dominated by Cyperaceae, and *Calluna vulgaris* pollen percentages remain low throughout (Fig. 5.14), indicating that conditions around the coring point remained too wet for local heath to be maintained. A seed of *Potamogeton*, an aquatic plant, occurs at 95 cm (*c.* 420 cal. AD; Fig. 5.17), suggesting that the basin supported small areas of shallow open water at this time. The apparent lack of extensive heathland in the surrounding landscape during the Iron Age

is supported by the concentration data (Fig. 5.15), which show a drop in concentration of *Calluna vulgaris* pollen. Very little charcoal is present in the record until the start of the Pictish period, implying that no management of what little heathland was present took place during this time.

The possible lack of extensive heathland around Whaness Burn during the Iron Age contrasts with evidence from elsewhere in the islands. Heathland began to develop on the slopes surrounding Scapa Bay on Mainland from *c.* 650 cal. BC (de la Vega-Leinert *et al.* 2007), and widespread heath formation occurred at Lesliedale Moss in west Mainland at around 100 cal. AD (Jones 1979). At Loch of Torness in southern Hoy, widespread heath formation began much earlier at *c.* 5850 cal. BC during the late Mesolithic, and a sequence from Loch of Knitchen on Rousay indicates that heath began to spread near the site at around 4550 cal. BC in the early Neolithic (Bunting 1996).

Arboreal pollen continues to be present in low frequencies, *c.* 10-15%, throughout the Iron Age at Whaness Burn (Fig. 5.14) and it is likely that small patches of birch-hazel scrub remained on the slopes surrounding the site at this time. However the general indication from the pollen record indicates that the landscape at this time was largely open and the vegetation was dominated by herbaceous and heathland communities, in agreement with evidence from west Mainland (Jones 1979; Keatinge and Dickson 1979; Bunting 1994).

Very low frequencies of *Sordaria*-type ascospores occur during the early and late Iron Age at Whaness Burn (Fig. 5.16), and pollen of anthropogenic indicator species such as *Plantago lanceolata*, *Rumex* undiff. and *Artemisia*-type is present in low quantities throughout the whole period (Fig. 5.14). Since fungal ascospores are known to provide a very localised record of grazing pressure (Blackford and Innes 2006), it is possible that although the increase in wetness at the site itself meant that animals could no longer be grazed on the valley floor, heath and grassland on the valley sides were used for the rough grazing of small numbers of animals during the Iron Age. This contrasts with several suggestions of agricultural intensification during the Iron Age (e.g. Jones 1979; Keatinge and Dickson 1979; Bond 2002; 2003; Simpson *et al.* 2007), and may indicate that the change to wetter conditions that occurred across north-west Europe at around 850 cal. BC (e.g. van Geel *et al.* 1996; Mauquoy *et al.* 2004; Blundell and Barber 2005;

Swindles *et al*. 2007) forced the abandonment of more marginal areas such as Whaness Burn, leading to intensification of agriculture elsewhere in order to support the population.

The lack of evidence for intensive human activity around Whaness Burn is supported by the known archaeological record from Hoy. Iron Age sites in the study area are predominantly coastal, and are mainly clustered on the island of South Walls. Only two promontory forts and one broch are located in the north of Hoy, and these are all at a distance of greater than 2 km from the coring site at Whaness Burn. If intensive agricultural activity was associated with these sites, it is unlikely to be reflected in the palaeoecological record from Whaness Burn. Any anthropogenic activity around the coring site is likely to have been limited to low intensity pastoralism on the valley sides.

5.5.4 The Pictish Period (*c*. 600 – *c*. 800 cal. AD)

A marked expansion in the pollen of heath taxa, mainly of *Calluna vulgaris*, occurs at the beginning of the Pictish period at Whaness Burn (Fig. 5.14). At this time the surface of the mire was still relatively wet and is unlikely to have supported the growth of heather (Fig. 5.17). Therefore this implies widespread heathland development around the basin, around 6500 years later than heath expansion at Loch of Torness in southern Hoy, and *c*. 5200 years later than at Loch of Knitchen on Rousay (Bunting 1996). Heath development in west Mainland also occurred earlier than at Whaness Burn, between *c*. 1750 cal. BC in the west Mainland hills (Keatinge and Dickson 1979) and *c*. 100 cal. AD at Lesliedale Moss (Jones 1979).

Heathland development in Orkney has been attributed to a range of causes, including climatic deterioration, pedological factors and anthropogenic impact. The early expansion of heath around Loch of Torness in southern Hoy at *c*. 5850 cal. BC is believed to have been the result of climatic and autogenic processes, since no charcoal or pollen of anthropogenic indicator species were recorded in this sequence (Bunting 1996). Similar causes are invoked for initial heath spread around Loch of Knitchen on Rousay at *c*. 4550 cal. BC, although *Plantago* and cereal pollen are present in the record from this point onwards and there is also a peak in microscopic charcoal following the expansion in heath taxa. Bunting (1996) therefore suggests that although heathland development had begun long before any clear human impact signal is detected in the

pollen record, human activity may have had a significant effect on the later development of peat at this site.

Keatinge and Dickson (1979) have suggested that peat formation in the west Mainland hills during the mid-late Bronze Age may be linked to climatic deterioration coupled with human pressure on the environment. From *c.* 650 cal. BC, heathland began to develop on the slopes surrounding Scapa Bay on Mainland, and it is suggested that while human activity probably contributed to the spread of heath around the site, pedological factors operating alongside the northwest European climatic deterioration at *c.* 850 cal. BC probably played a more significant role in this development (de la Vega-Leinert *et al*. 2007). At Lesliedale Moss in west Mainland widespread heath formation in the middle Iron Age has been attributed to soil degradation resulting from intensive agricultural activity (Jones 1979). This is supported by evidence from Wideford Hill (Jones 1979) and Glims Moss (Keatinge and Dickson 1979), both in west Mainland.

At Whaness Burn climatic deterioration seems to have occurred at 150 cm (*c*. 1030 cal. BC; Fig. 5.17), although widespread heath formation did not take place until around 1500 years later. There is little evidence for agricultural practices in the vicinity of the site at this time, with very low frequencies of *Plantago lanceolata* and *Rumex* undiff. occurring only sporadically throughout the Pictish period (Fig. 5.14). The fact that some grazing was still taking place around the basin is indicated by the presence of *Sordaria*-type ascospores (Fig. 5.16), although it is unlikely that human activity around Whaness Burn was intensive enough to have contributed to the spread of heath around the site. It is therefore likely that the major cause of heath expansion here was climatic deterioration leading to soil degradation via leaching and podsolisation (Gimingham 1975), in a similar manner to the much earlier heathland formation at Loch of Torness where Bunting (1996) suggested that edaphic processes were largely responsible. Peat accumulation would have been encouraged by the formation of an impermeable iron pan leading to increased waterlogging (Ellis and Mellor 1995). The acidic soils that formed under the earlier pine woodland at Whaness Burn may also have contributed to the spread of heathland at the site.

Charcoal is consistently present in low quantities during the Pictish period, and it is possible that this is the result of deliberate management of heathland by burning in order to improve the quality of grazing. There is some evidence to suggest that this

practice took place at Loch of Knitchen on Rousay from around 250 cal. AD onwards (Bunting 1996), although heathlands are also vulnerable to natural fires (e.g. Radley 1965; Tipping 1996). Since there are few other indications of anthropogenic activity in the palaeoecological record from Whaness Burn at this time it is more likely that the charcoal present in the record during the Pictish period results from natural heathland fires than human impact. Increasing proportions of inorganic matter in the sediment core at this time (Fig. 5.13) may be the result of increased erosion following devegetation of the slopes around Whaness Burn by these fires (Gimingham 1975).

The archaeological record from Hoy supports the hypothesis that little anthropogenic activity took place around Whaness Burn during the Pictish period, with only two long cist burials recorded on the island of Switha, which lies off the east coast of South Walls. These cairns are covered by circular cairns and are therefore classified in this study as Pictish (Ritchie and Ritchie 1981), although it is possible that they actually belong to a later period. As in the preceding Iron Age, human activity around the coring site is likely to have been limited to low intensity stock grazing on the lower slopes surrounding the basin. This contrasts with evidence from elsewhere in the islands, where it has generally been suggested that a major increase in agricultural intensification occurred during Pictish times (e.g. Donaldson *et al.* 1981; Bond 2002; 2003), and may suggest that the landscape around Whaness Burn was considered too marginal for agriculture to be economically viable at this time.

5.5.5 The Viking Period (*c*. 800 – *c*. 1065 cal. AD)

There is evidence for a change to drier conditions on the surface of the mire at Whaness Burn at the start of the Viking period. Cyperaceae pollen percentages undergo a marked decline, and *Calluna vulgaris* pollen continues to increase in frequency (Fig. 5.14). There is a switch in the microstructure data (Fig. 5.17) to higher proportions of UOM and lower quantities of identifiable plant material including graminoid and moss fragments, indicating that drier conditions may have resulted in greater decay of organic material. The presence of both microscopic and macroscopic charcoal in the sediment also supports the idea of a slightly drier environment at this time.

Following the initiation of widespread heath formation at the start of the Pictish period, heathland reaches its maximum extent around Whaness Burn during the Viking period. It remains the dominant vegetation community in the area until the end of the complete

sequence at 25 cm (*c*. 1080 cal. AD), at around the time of the Viking-Late Norse transition in Orkney.

As in the preceding Pictish period, charcoal is consistently present in low quantities during Viking times at Whaness Burn, and since there are again few other indications of anthropogenic activity, and the drier conditions which began at 77 cm (*c*. 800 cal. AD) would have enhanced the flammability of the *Calluna* heath, it is likely that the charcoal present in the record during the Viking period results from natural heathland fires rather than human impact. Again, indications of increased erosion following devegetation of the surrounding slopes by these natural fires are provided by larger proportions of inorganic material in the sediment at this time (Gimingham 1975).

Low levels of arboreal pollen (*c*. 10% of the total pollen sum) are present throughout the Viking period at Whaness Burn, implying that the landscape remained largely open at this time (Fig. 5.14). Although there are few reliably dated pollen records covering this period from other sites in Orkney, evidence from Viking archaeological sites suggests that some small patches of local scrub woodland were still present with *Betula* and *Corylus* both represented in the charcoal recovered from the Brough of Birsay, although driftwood was also an important source of fuel at this site (Donaldson *et al.* 1981). At the Brough of Deerness however, the only species represented in the charcoal record is *Salix*, leading Morris *et al.* (1986) to infer that the wood had not been collected from birch-hazel woodland and probably represents the exploitation of a local source of scrub willow, the more extensive birch-hazel woodland having declined earlier around this site (Morris *et al.* 1986). Despite the continued existence of small patches of local woodland elsewhere in Orkney, it seems that very little woodland was present near Whaness Burn at this time.

Low frequencies of *Sordaria*-type ascospores are present in the Viking period record from Whaness Burn (Fig. 5.16), suggesting that almost no grazing was taking place in the surrounding landscape. This is supported by infrequent occurrences of *Plantago lanceolata*, *Rumex* undiff. and *Artemisia*-type pollen (Fig. 5.14), all of which can be interpreted as indicators of grazing activity (Behre 1981). This lack of intensive agriculture again contrasts with evidence from sites elsewhere in the islands, for example at Pool on Sanday (Bond 2007b) and Quoygrew on Westray (Barrett *et al.*

2005), suggesting that the intensive cultivation seen at these sites was not viable in the marginal landscape of northern Hoy.

The archaeological record of the Whaness Burn field area indicates that almost no human activity took place during the Viking period, with the only site recorded being a long cist burial on the island of Graemsay, which has been radiocarbon dated to *c*. 1040 cal. AD. A Late Norse chapel is also present on Graemsay, but since the palaeoecological record from Whaness Burn ends at around *c*. 1080 cal. AD, only the first few years of this period are represented. The chapel would imply that there was once a population substantial enough to warrant the construction of a religious site at some time during the Late Norse period, although the potential environmental effects of this population cannot be ascertained. The pattern of Viking and Late Norse occupation in Orkney may well be obscured by present settlements and boundaries, since these periods are relatively recent in the history of the islands and the Norse pattern of land division was still in use in the 19th century (Thomson 2003). However the islands in the Whaness Burn study area have never been densely populated, having a combined population of 2371 in 1851 (Barclay 1966). Furthermore, a study of the Ordnance Survey County Series 1st edition map of Hoy, published in 1882, shows that the northern part of the island was particularly sparsely settled. It is therefore likely that the apparent lack of Viking sites in the Whaness Burn study area is a relatively accurate reflection of their real distribution.

5.5.6 Later Developments

Support for the hypothesis that the unit of herbaceous peat which begins at a depth of 25 cm represents recent formation on the previously cut surface of the mire at Whaness Burn is provided by the pollen record. Increased pollen frequencies of *Pinus sylvestris* above this depth could represent the coniferous plantation approximately 500 m to the north of the coring location (Fig. 5.9). This plantation was originally established by the Forestry Commission in 1954 as part of an experiment to investigate the potential for commercial forestry in the islands (MacDonald 1967). This plantation was badly damaged by a fire in 1984 (Lamb 1989), and is now being replanted with native species including birch and willow. The presence of macroscopic charcoal in samples from this peat unit may be the result of this fire, supporting the idea that this unit represents very recent times.

5.6 Summary

The palaeoecological record from Whaness Burn begins at around 3020 cal. BC, in the late Neolithic period. A small amount of woodland was present in the landscape around the site at this time, dominated by *Betula* and *Corylus-avellana*. This woodland seems to have persisted into the Bronze Age, representing a relatively late survival of woodland in Orkney. The landscape around Whaness Burn does not seem to have been particularly affected by human activity during the late Neolithic, in accordance with the archaeological record for this period.

It is suggested that open pine forest may have been present on the lower, shallower slopes surrounding Whaness Burn during the late Neolithic/early Bronze Age, between *c*. 2170 and *c*. 1750 cal. BC. At around the time of the pine decline at Whaness Burn there is evidence for a slight increase in the surface wetness of the mire, along with several indicators of human activity. It therefore seems likely that the disappearance of local pine trees at Whaness Burn was a result of climatic deterioration, perhaps coupled with anthropogenic clearance or increased grazing pressure.

Following woodland decline at Whaness Burn at *c*. 1750 cal. BC, the landscape around the site remains largely open, perhaps with occasional small patches of *Betula-Corylus* or *Salix* scrub, for the rest of the sequence. Some heathland seems to have become established around the basin at the start of the Bronze Age, and peaks in microscopic charcoal throughout this period suggest that this community may have been managed by deliberate burning in order to improve grazing. Evidence for this form of heathland management during the Bronze Age occurs in environmental records from Denmark (e.g. Odgaard 1992; Karg 1008), and Bunting (1996) has suggested that heathland on Rousay may also have been managed in this way.

Evidence for relatively intensive pastoral activity in the valley at Whaness Burn occurs between *c*. 1750 and *c*. 1170 cal. BC, and is probably associated with the occupation of the enclosed settlement in the valley which is estimated to have had around 150 ha of land in agricultural use at one time (Lamb 1989). There is also evidence for fairly intensive pastoralism having taken place at this time at more marginal sites in west Mainland (Keatinge and Dickson 1979), and this coupled with the evidence for a similar economy at Whaness Burn suggests that that farming expanded into more environmentally marginal areas of Orkney in the Bronze Age.

At *c.* 1030 cal. BC in the late Bronze Age there is evidence that a further increase in surface wetness occurred. This may be associated with the climatic deterioration that seems to have taken place across northwest Europe at *c.* 850 cal. BC (e.g. van Geel *et al.* 1996; Mauquoy *et al.* 2004; Blundell and Barber 2005; Swindles *et al.* 2007). These wet conditions seem to have continued throughout the Iron Age at Whaness Burn, and an apparent lack of extensive heathland around the site contrasts with evidence from elsewhere in Orkney, where widespread heath formation seems to have occurred during the Iron Age (e.g. Jones 1979; de la Vega-Leinert *et al.* 2007). Any anthropogenic activity around Whaness Burn during the Iron Age is likely to have been limited to low intensity stock grazing on the valley sides.

Widespread heathland development seems to have begun around Whaness Burn at *c.* 620 cal. AD, at the start of the Pictish period. There continues to be very little evidence for human activity at this time and it is probable that the major cause of heath expansion at this site was climatic decline leading to soil deterioration via leaching and podsolisation. Similar processes of climatic deterioration and edaphic evolution have been inferred as the cause of heath development at Loch of Torness in southern Hoy, although here this event occurred much earlier at *c.* 5850 cal. BC (Bunting 1996).

Following heathland establishment at Whaness Burn there is little evidence for human activity, in accordance with the known archaeological record from the study area. It seems that there was a change to drier conditions on the surface of the mire at *c.* 800 cal. AD, and heathland reached its maximum extent at around the same time, at the start of the Viking period. Following this, the landscape seems to have been little changed until the record ends in *c.* 1080 cal. AD, at around the time of the Viking-Late Norse transition in Orkney.

Chapter 6: Hobbister

In this chapter the results of palaeoecological analyses undertaken on two cores from Hobbister in Orphir, Mainland are presented. Firstly, the results of previous palaeoecological investigations in the study area are described in order to provide some background to this study and highlight the need for an improved understanding of prehistoric environmental changes and land-use in this part of Mainland. The archaeological record of the study area is also described to allow the environmental and archaeological records to be linked and interpreted. A brief description of the coring site and the surrounding landscape is then given before the results of stratigraphic survey at the site are described. Two sequences from Hobbister were analysed and the results, including age estimates, lithostratigraphy, physical sediment properties, and pollen, charcoal, non-pollen palynomorph and microstructure analyses, are presented and described for each sequence in turn. Finally, the palaeoecological record from Hobbister is discussed and interpreted in terms of major environmental changes and prehistoric human activity, and is compared with the archaeological record from within a 10 km radius of the site and with palaeoecological data from other Orcadian sites.

6.1 Previous Palaeoecological Investigations

Previous palaeoecological investigations in the Hobbister study area include those of Jones (1979) at Lesliedale Moss and Wideford Hill, as well as a study by de la Vega-Leinert *et al*. (2007) which investigated a full Holocene sequence from Scapa Bay. There have also been palynological studies associated with archaeological excavations at Maeshowe (Godwin 1956; Jones 1979) and the Stones of Stenness (Caseldine and Whittington 1976). The main findings of these studies are summarised below, and the locations of the sites are shown on Fig. 6.1.

6.1.1 Lesliedale Moss (NGR HY 408 103; Davidson et al. 1976; Jones 1979)

Lesliedale Moss is a large basin, approximately 1 km in length and 0.4 km across at its widest point, from which a 275 cm core was recovered (Davidson *et al*. 1976). The base of the profile was radiocarbon dated to *c*. 2250 cal. BC, and a sample from a depth of 205 cm gave a radiocarbon date of *c*. 1650 cal. BC (Davidson *et al*. 1976; Jones 1979). The pollen assemblage from this site therefore certainly covers the period from the end of the Neolithic until the mid Bronze Age, and Jones (1979) infers that the record continues at least until the late Iron Age.
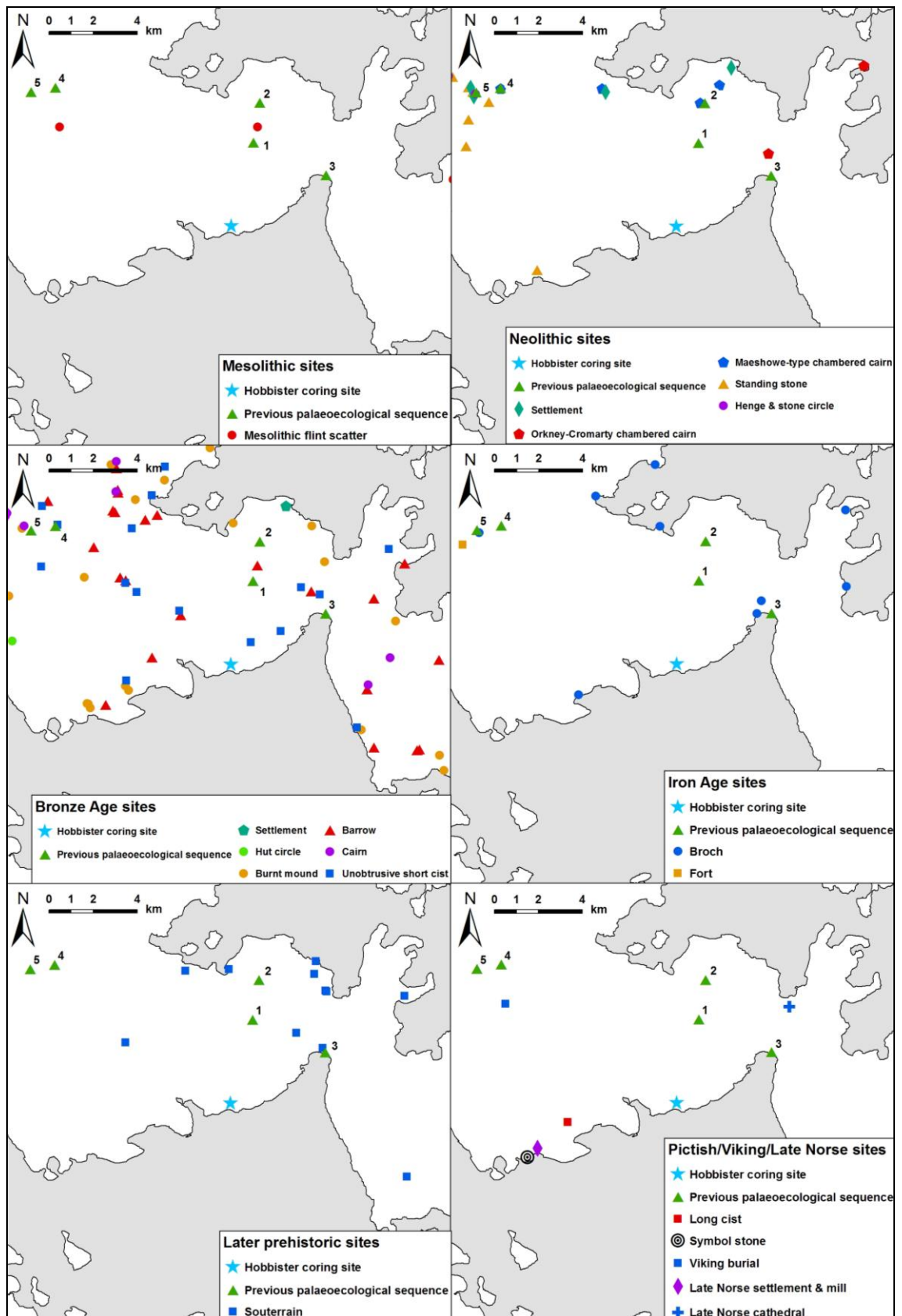
Figure 6.1 Location of archaeological sites and previous palaeoecological investigations (1. Lesliedale Moss; 2. Wideford Hill; 3. Scapa Bay; 4. Maeshowe; 5. Stones of Stenness) in the Hobbister study area

At the base of the profile arboreal pollen comprises less than 15% of the total, suggesting a very open landscape around the site during the late Neolithic. Many of the taxa recorded at this time are representative of natural non-woodland communities, although there are also some indicators of pastoral activity (Jones 1979). There appears to have been some slight woodland regeneration around the site during the middle Bronze Age, from around 1650 cal. BC, when arboreal pollen values increase to *c*. 20% of the total sum (Jones 1979). Cereal pollen is present during what is presumed to be the late Bronze Age/early Iron Age, although fewer indicators of pastoral activity are present at this time. Davidson *et al*. (1976) and Jones (1979) suggest that this indicates a reduction in human activity near Lesliedale Moss at this time. Later in the sequence, pollen of *Calluna vulgaris* increases to around 70% of the total sum, indicating widespread heath formation. Jones (1979) suggests that this may have been caused by intensive Iron Age agricultural practices combined with climatic deterioration. The landscape surrounding Lesliedale Moss seems to have been dominated by heathland communities until the top of the sequence, which is undated (Davidson *et al*. 1976; Jones 1979).

6.1.2 Wideford Hill (NGR HY 411 121; Jones 1979)

A 100 cm profile was taken from blanket peat on Wideford Hill and although no radiocarbon dates are available for this sequence, from the biostratigraphic evidence it is believed to cover the period from the late Bronze Age until at least the start of the Viking period. Cereal pollen and relatively high percentages of other anthropogenic indicator taxa such as *Plantago lanceolata* and *Rumex acetosa* occur in the basal samples, implying that mixed agriculture was taking place near to the site during what is presumed to be the late Bronze Age/early Iron Age (Jones 1979). The data are generally similar to those from Lesliedale Moss, with arboreal pollen percentages of around 20% (Davidson *et al*. 1976; Jones 1979), and later in the sequence an increase in *Calluna vulgaris* pollen percentages to around 70% of the total sum imply heathland expansion in the wider landscape. Jones (1979) again hypothesises that human activity coupled with climatic decline led to the spread of heathland around the site during and after the Iron Age.

6.1.3 Scapa Bay (NGR HY 441 088; de la Vega-Leinert et al. 2007)

This site is a coastal valley mire in central Mainland, on the northern coastline of Scapa Flow, from which an 800 cm core was recovered and analysed for pollen (de la

Vega-Leinert *et al*. 2007). The base of the core was radiocarbon dated to *c*. 9250 cal. BC, and a sample from a depth of 276 cm gave a radiocarbon date of *c*. 3500 cal. BC. Although no radiocarbon dates are available from the upper part of the sequence, the authors infer that the core contains a full Holocene record (de la Vega-Leinert *et al*. 2007). The sequence from Scapa Bay therefore certainly provides a record of vegetation and environmental changes from the early Mesolithic until the early Neolithic, and potentially until the present day.

The vegetation around the sampling site at Scapa Bay was dominated by open grassland from around 9450 cal. BC until *c*. 7450 cal. BC. *Salix* fen was probably present around the edges of the wetland. At around 7450 cal. BC the grassland was gradually replaced by *Corylus-Betula* scrub, with a herb- and fern-rich understorey. This is consistent with evidence from elsewhere in Mainland (e.g. Moar 1969; Bunting 1994). From *c*. 5850 cal. BC, this scrub woodland began to be succeeded by mixed deciduous woodland in which *Quercus* may have been present in sheltered areas on the valley sides (de la Vega-Leinert *et al*. 2007). At around the same time *Alnus glutinosa* seems to have become part of the fen community surrounding the sampled wetland.

The mixed deciduous woodland surrounding Scapa Bay probably reached its maximum extent at *c*. 3950 cal. BC, during the early Neolithic. Following this the woodland seems to have declined, and the date of this event is again consistent with the inferred timing of woodland decline at several sites in west Mainland (e.g. Keatinge and Dickson 1979; Bunting 1994). The rapid decline in arboreal and fern taxa seen in the sequence from Scapa Bay is accompanied by increases in the pollen of pastoral indicator species such as *Plantago lanceolata* and *Rumex acetosa*. De la Vega-Leinert *et al*. (2007) hypothesise that the reduction in woodland cover around the site may have been the result of anthropogenic activity.

From *c*. 650 cal. BC heathland began to develop on the slopes surrounding Scapa Bay. Anthropogenic indicator species are well represented in the pollen record at this time, and it is suggested that while human activity probably contributed to heath spread around the site, pedological factors operating alongside the northwest European climatic deterioration at *c*. 850 cal. BC probably played a more significant role in this development (de la Vega-Leinert *et al*. 2007).

6.1.4 Maeshowe (NGR HY 318 128; Godwin 1956; Jones 1979)

Godwin (1956) analysed three samples from Maeshowe; one that he presumed to represent the ground surface at the time when the tomb was constructed, and two from within the ditch surrounding the tomb. The sample from the old ground surface contained large amounts of *Calluna* and Poaceae pollen with negligible amounts of arboreal pollen. Low frequencies of pollen from weeds and ruderal taxa such as *Plantago lanceolata* were also present in this sample, implying that some agriculture was taking place locally prior to construction of the tomb. In contrast, the samples from the ditch contained very low frequencies of *Calluna* pollen and higher arboreal pollen percentages (*c*. 10-20%) than that from the old ground surface. These samples also contained much higher frequencies of pollen from anthropogenic indicator taxa including *Rumex* and *Plantago lanceolata*, as well as Poaceae and cereal pollen. Based on these pollen assemblages, Godwin (1956) suggested that prior to the building of the tomb the local vegetation consisted of a *Calluna* heath which was later taken over for agricultural purposes. It is also inferred that there was a slight increase in woodland cover following the construction of Maeshowe, despite the apparent increase in agricultural activity at this time (Godwin 1956).

Jones (1979) undertook pollen analysis of further samples from Maeshowe during later excavations at the site (Renfrew 1979). Organic sediments were present in the bottom of the ditch surrounding the monument, and profiles from the north and south ditch sections were examined. Two layers of organic material were discovered intercalated with inorganic deposits on the slope of the mound platform in the northern section, and samples from these were also analysed (Jones 1979).

A 70 cm profile was recovered from the north ditch section, the basal 10 cm of which were analysed for pollen and radiocarbon dated to *c*. 2700 cal. BC, during the late Neolithic period (Jones 1979). Arboreal pollen is poorly represented, with values below 10% of the total pollen sum throughout the sequence. Herbaceous taxa dominate the pollen assemblage, mainly Poaceae, Cyperaceae, Rosaceae and Ranunculaceae, although high frequencies of *Plantago lanceolata* (up to 20% in places) are also recorded. Cereal pollen also occurs throughout the profile (Jones 1979). It appears that the landscape was generally open at this time and that mixed agriculture was being practiced, although pastoral farming was probably dominant. It also seems that

agriculture may have decreased in intensity over the time period represented by this pollen profile (Davidson *et al*. 1976; Jones 1979).

The lower peat layer from the northern slope of the mound platform had a radiocarbon age of *c*. 2100 cal. BC, towards the end of the Neolithic period. The pollen assemblage from this layer is almost identical to that in the upper part of the sequence from the north ditch section (Jones 1979). The lower peat layer is undated, and the pollen assemblage from this is dominated by heathland and agricultural indicator taxa, including cereals (Davidson *et al*. 1976; Jones 1979).

Of the 65 cm profile obtained from the south ditch section at Maeshowe, only the basal 25 cm were analysed. The base of the profile produced a radiocarbon date of *c*. 1750 cal. BC (early Bronze Age), and the upper part of the sequence was radiocarbon dated to *c*. 800 cal. AD, around the time of the Pictish-Viking transition (Jones 1979). The basal samples are dominated by herbaceous taxa including Cyperaceae, Poaceae, Rosaceae, *Plantago lanceolata* and cereals, suggesting that mixed agriculture was practiced near to the site during the early Bronze Age. At around 400 cal. AD, in the late Iron Age, Poaceae pollen percentages decline and those of *Calluna vulgaris* pollen increase, perhaps reflecting the spread of heathland around the site (Jones 1979).

Overall, the pollen assemblages from Maeshowe demonstrate the existence of an open landscape at the time in which the tomb was constructed and used. The consistent presence of substantial amounts of cereal pollen and of other anthropogenic indicator taxa throughout all the sequences implies that the vegetation surrounding the monument was at least partially affected by human activity (Davidson *et al*. 1976; Jones 1979). During the late Neolithic it seems that pastoral faming was the dominant form of human activity, although arable cultivation was also taking place. Agriculture seems to have declined in importance in the area around the tomb towards the end of the Neolithic, although it apparently intensified again during the Bronze Age. Jones (1979) suggests that a further intensification of agricultural practices occurred during the Iron Age, along with heathland expansion in the wider landscape.

6.1.5 The Stones of Stenness (NGR HY 307 126; Caseldine and Whittington 1976)

During excavations at the Stones of Stenness, the ditch section on the south-west side of the monument was found to contain a layer of organic matter at its base, which was

sampled for pollen analysis. A sample of animal bone from within this organic layer was radiocarbon dated to *c*. 3000 cal. BC, which is the time of the transition from the early to the late Neolithic in Orkney (Card 2005). The pollen assemblage has a low arboreal pollen component of less than 10%, dominated by *Betula*, perhaps indicating the presence of small, local stands of birch scrub (Caseldine and Whittington 1976). However, it is also possible that the low frequencies of *Betula* pollen observed represent the background pollen signal, and birch was not locally present. The environment was apparently open and dominated by grassland. High values of *Rumex*, *Plantago* and Asteraceae pollen occur which, along with the presence of four cereal pollen grains, can be taken to indicate that the open nature of the vegetation was at least partly due to arable farming in the area (Caseldine and Whittington 1976). There is however some uncertainty as to the reliability of this pollen assemblage, since part of the organic layer is thought to have been deposited by human activity at an early period in the existence of the ditch and part is thought to be naturally formed (Caseldine and Whittington 1976).

A 78 cm profile was also taken from the section at the west ditch-terminal, and the pollen sequence obtained from this post-dates that described above. High percentages of Brassicaceae pollen (*c*. 7%) are present at the base of the sequence, and together with the existence of a cereal grain this suggests that the vegetation at this time was at least partly human-influenced (Caseldine and Whittington 1976). Cultivation seems to have increased in intensity throughout the profile, and pastoral farming also appears to have become more important in the area surrounding the monument over time (Caseldine and Whittington 1976).

6.2 The Archaeological Record

Fig. 6.1 shows the distribution of archaeological sites around Hobbister. There is evidence for human activity during all periods from the Mesolithic through to the Viking/Late Norse periods, although some periods are better represented than others. The Bronze Age is particularly well represented, but there are very few sites from the Mesolithic, Pictish, Viking and Late Norse periods. However several sites from the period of interest for this study (*c*. 3000 cal. BC – 600 cal. AD) occur within the Hobbister study area.

Hobbister is the only one of the three study sites for which Mesolithic activity is recorded. This activity is evidenced by three flint scatters, one from an unknown location in the parish of Stenness (on the map the location is plotted as Mayfield, the home of the collector), one from Wideford Hill, and one from Slap O'Valdigar, just within the study area in Deerness. These flints have all been confirmed by Wickham-Jones (1990b) as being of Mesolithic type.

Four Neolithic settlements are recorded within the study area, including an early Neolithic village at Stonehall, and three late Neolithic sites at Crossiecrown, Barnhouse and the Ness of Brodgar. Following excavations at Stonehall and other early Neolithic sites in Orkney, it has been suggested that rather than being characterised by individual farmsteads such as the Knap of Howar on Westray, this period in Orkney was represented by 'dispersed' village settlements (Carruthers and Richards 2000). Barnhouse and the Ness of Brodgar are situated amongst the ceremonial sites between the lochs of Stenness and Harray, and they incorporate many features that suggest that they not did have a purely domestic function (Richards 2005; Card *et al*. 2007).

Chambered cairns are also present in the study area, including two of the Orkney-Cromarty stalled cairns and four later Maeshowe-type tombs. There are also several standing stones to the west of the study site, including several associated with Stenness-Harray ceremonial complex. The henge monument and stone circle of the Stones of Stenness are also within the study area. Many of the Neolithic sites within the Hobbister study area are discussed in more detail in Chapter 2.

It can be seen from Fig. 6.1 that the Bronze Age is by far the best represented of the archaeological periods in the Hobbister study area. Several burnt mounds, barrows, cairns and short cist burials are present, although these monuments do not all necessarily date from the Bronze Age, as discussed in Chapter 2. Some of these sites almost certainly date from later periods (e.g. Hedges 1980; Anthony 2003; Downes 2005).

One particularly interesting Bronze Age site in the area is the settlement at Crossiecrown, which provides a link between late Neolithic and Bronze Age settlement, something that has until recently been lacking within Orcadian archaeology. Excavations at the site revealed one large house of typical later Neolithic layout which

was later replaced by another very similar house in a slightly different position (Card and Downes 2000). Radiocarbon dating has confirmed a late Neolithic/early Bronze Age date for these structures (Downes and Richards 1998; Downes 2005). The settlement spans the transition from Neolithic to Bronze Age and the house has a similar plan to those in the late Neolithic 'village' settlements such as Skara Brae and Rinyo, but is situated in isolation (Downes 2005).

Several brochs and forts are present within the study area, representing Iron Age human activity. These sites are predominantly situated in coastal locations, perhaps for defensive purposes (e.g. Graham 1947) but more likely in order to enhance their visibility and demonstrate the status of their occupants (e.g. Hingley 1992). No burials from this period have been discovered within the study area, but as mentioned earlier, some of the burial monuments classified here as Bronze Age may well in fact belong to the Iron Age.

Several souterrains are found within the Hobbister study area. These sites have been variously interpreted as either underground storage structures, perhaps for grain or dairy products (e.g. Hamilton 1956; Bradley 1978) or as having a ritual function (e.g. Downes 2005). They are generally believed to be Iron Age in date on the basis of evidence from mainland Scotland, although one in Shetland at Jarlshof is of late Bronze Age date (Hamilton 1956). According to recent research, Orcadian examples are usually late Bronze Age or Iron Age in date (M. Carruthers pers. comm.).

There is little evidence for Pictish and Viking/Late Norse activity around Hobbister. The sites recorded include a Pictish symbol stone, a long cist burial which could belong to either period, a burial dated to the Viking period by grave goods, the Late Norse cathedral of St Magnus, and the Late Norse settlement of Earl's Bu in Orphir. The presence of the high-status settlement of the Earl's Bu, with its associated church and mill, and of St Magnus' cathedral in Kirkwall, which became the ecclesiastical and administrative centre of the islands during the Late Norse period, within the study area indicates the importance of the area at this time. This suggests the lack of archaeological evidence is not a true reflection of activity in the landscape at that time.

Overall, it can be seen from Fig. 6.1 that there is evidence for human activity in the landscape surrounding Hobbister throughout the period of interest for this study

(*c*. 3000 cal. BC − *c*. 600 cal. AD), with the greatest concentration of activity in the immediate vicinity of the coring site occurring during the Bronze Age. However while Fig. 6.1 shows the locations of all recorded sites from the Mesolithic through to the Late Norse periods, it cannot be assumed that this is an accurate reflection of the original distribution of sites, since the location of Hobbister in an area of extensive heathland means that sites are less likely to be discovered than those located on agricultural land (Stevenson 1975).

6.3 Site Description

Hobbister is an area of fairly extensive blanket peat covering an area of approximately 4 km^2 in Orphir, on the southern coast of Mainland. The area surveyed is centred on NGR HY 398065. Most of the land in this area of Mainland is below 60 m a.s.l. (Fig. 6.2), and the drift geology is mainly a mixture of peat and boulder clay with small areas of alluvium and blown sand (Fig. 6.3). Hobbister provides the semi-marginal case study for this investigation.

The site itself is currently an RSPB reserve and land-use around the site is mixed, including both marginal heathland and agricultural land used for pasture as well as arable cultivation. A study of historic Ordnance Survey maps shows that land-use in the area has changed little over the last hundred years, with slightly more land being enclosed and used for agriculture now than in 1903 (Fig. 6.4).

The site is an area of relatively extensive blanket peat (Fig. 6.5; Fig. 6.6) with vegetation dominated by *Calluna vulgaris*, *Molinia caerulea*, *Eriophorum angustifolium* and *Sphagnum* moss. Small patches of *Salix* scrub are also present in places.
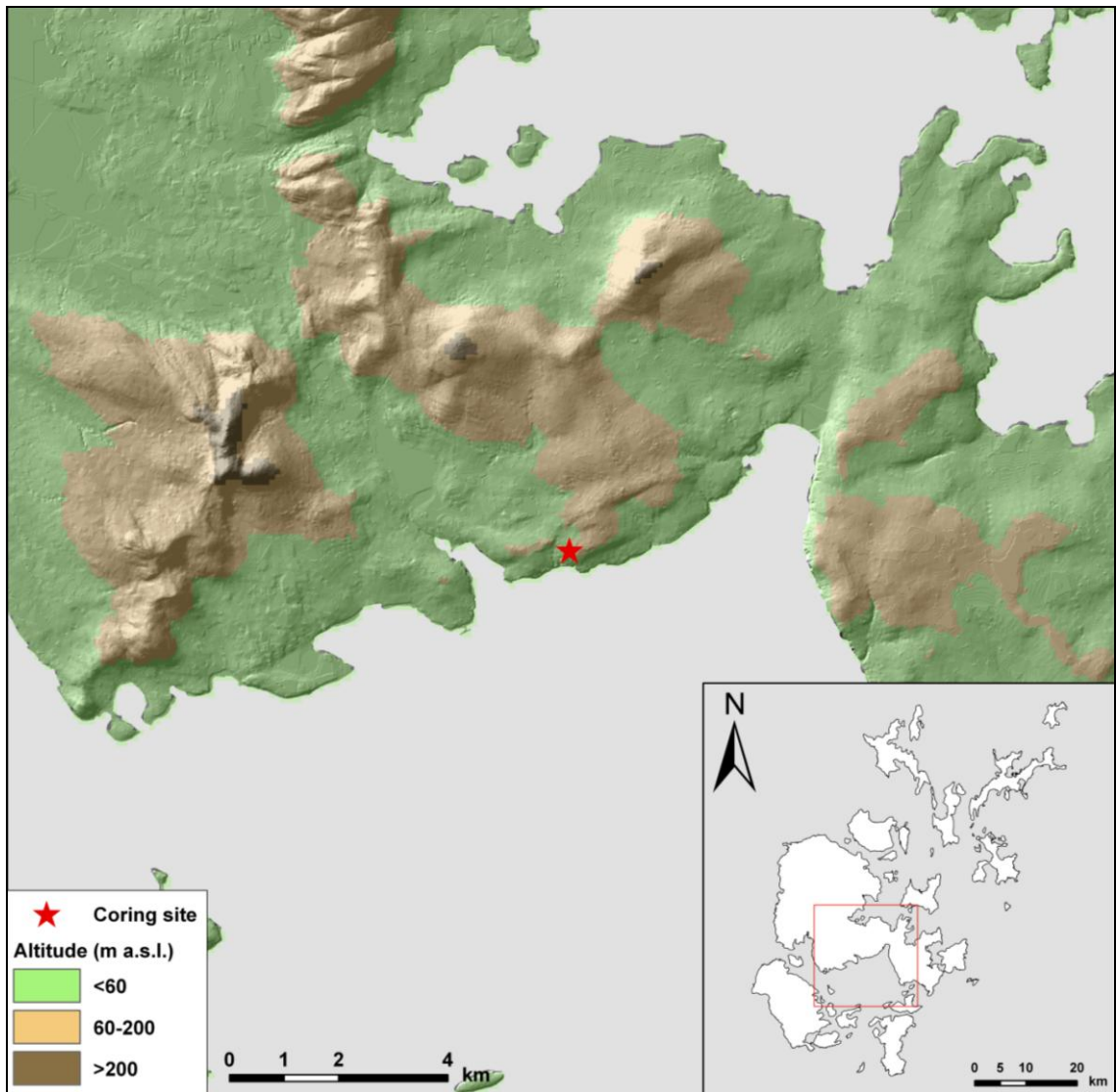
Figure 6.2 Location and topography of Hobbister, Orphir, Mainland
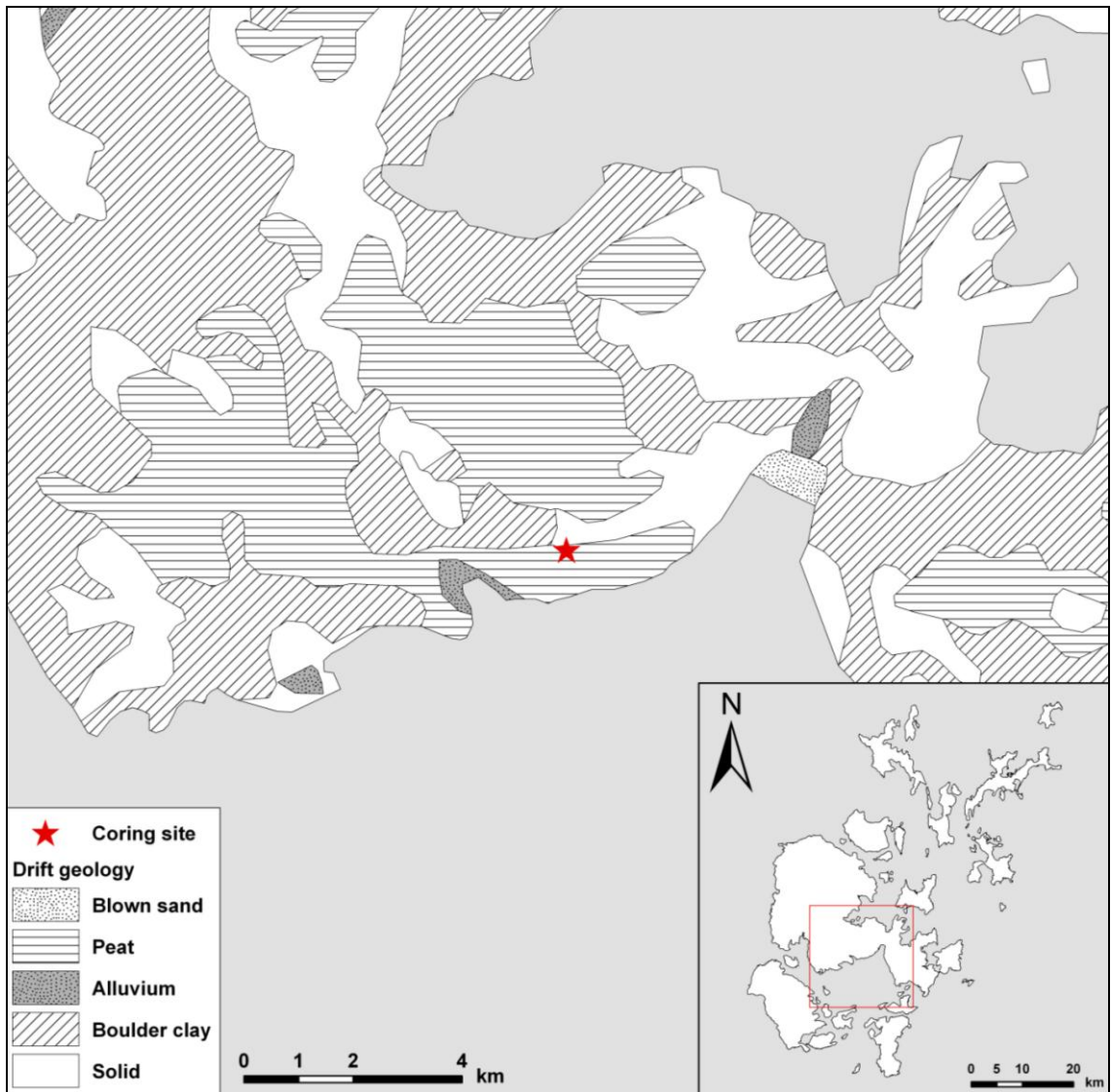
Figure 6.3 Drift geological deposits in the area surrounding Hobbister (© Crown Copyright/database right 2009. A British Geological Survey/EDINA supplied service).
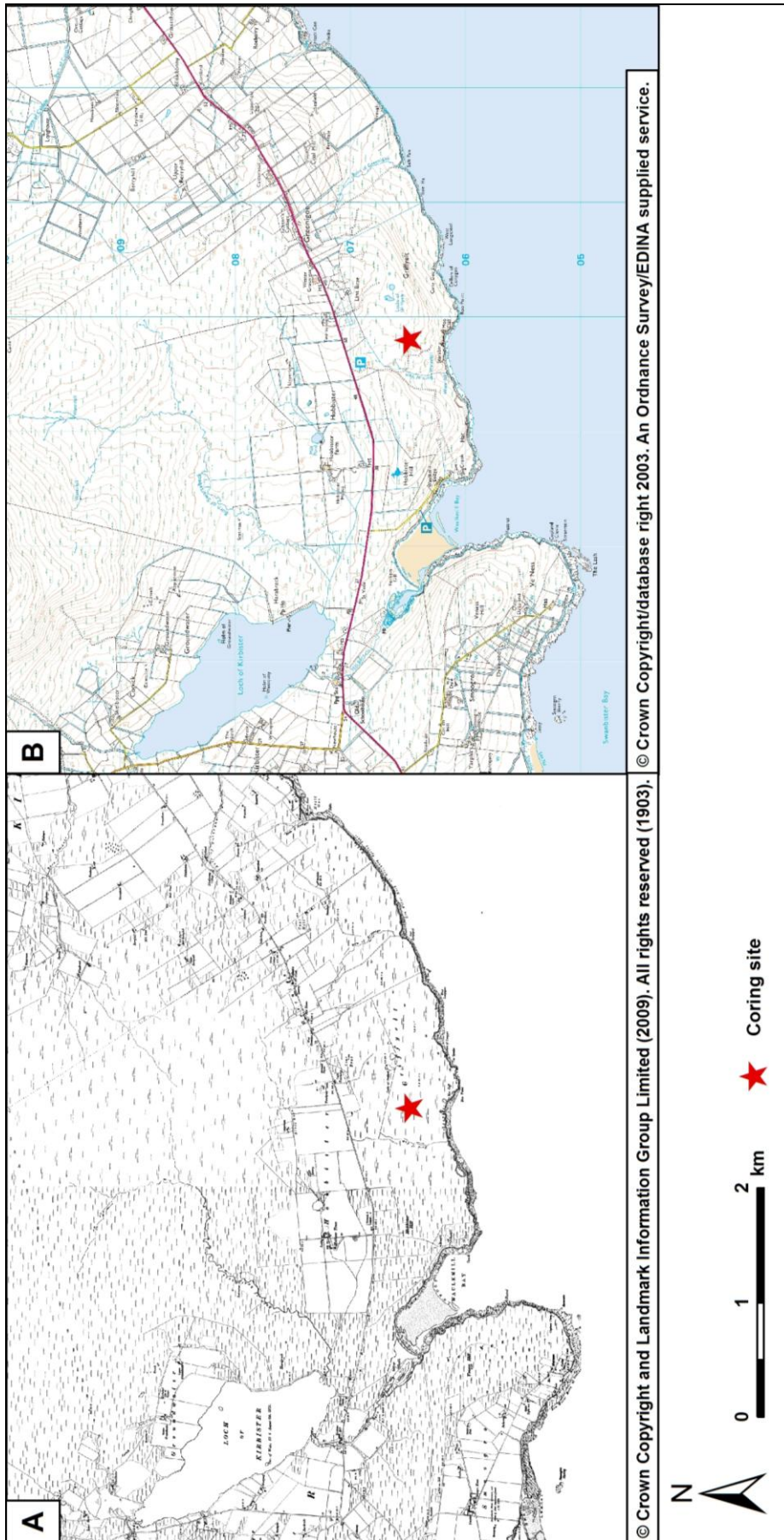
Figure 6.4 Land-use around Hobbister in A) 1903 and B)
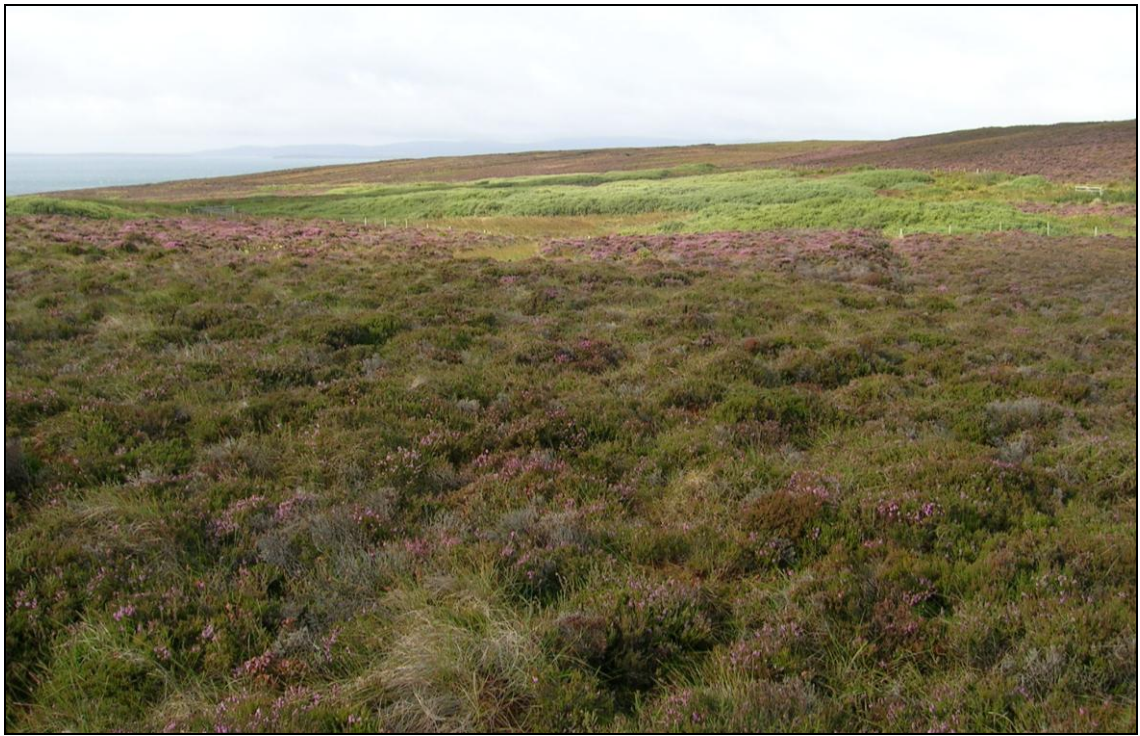
Figure 6.5 View to the west from the survey area at Hobbister

Figure 6.6 View to the east from the survey area at Hobbister

The peat at Hobbister is currently being extracted for commercial purposes, and in June 2006 a late Bronze Age socketed axehead was discovered while turning drying peat that

had been cut during the spring (Cowie and O'Connor 2006; see Fig. 6.7). The current active peat face is shown in Fig. 6.8. Following this discovery a walkover survey of the site identified the remains of four sections of sub-peat dykes and a possible structure, along with four possible Bronze Age burial mounds (Sharman 2007). Locations of these sites, along with the findspot of the axehead (not the original location, as it was discovered after the peat in which it was buried had been cut), are shown on Fig. 6.9. The area where stratigraphic survey was undertaken (the southern boundary of which is formed by the current active peat face) is also shown on Fig. 6.9, along with the two locations from which sequences were recovered for laboratory analysis.

Figure 6.7 Late Bronze Age socketed axehead from Hobbister (photograph by Sigurd Towrie)

Figure 6.8 The currently active peat face at Hobbister, viewed from the east
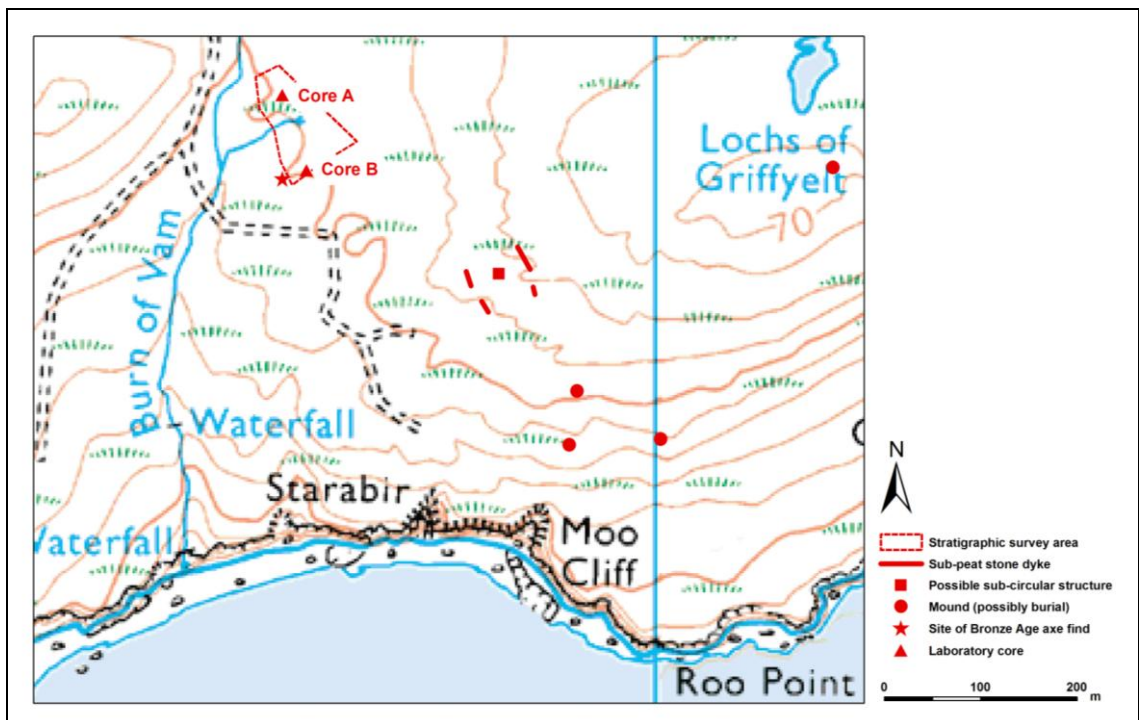
Figure 6.9 Location of archaeological sites (Cowie and O'Connor 2006; Sharman 2007) in relation to the area investigated in this study, overlain on an Ordnance Survey map of Hobbister (© Crown Copyright/database right 2003. An Ordnance Survey/EDINA supplied service).

6.4 Results

6.4.1 Stratigraphic Survey

The stratigraphy of the peat bank, running roughly from west to east, is summarised in Fig. 6.10. Three distinct peat units were noted, as well as pool deposits at the base of the western section (see Table 6.1 for a description of the sedimentary units logged during the survey). The pool deposits occur at the base of the section at several locations between 5 and 80 m from the western edge of the peat bank. However, coring indicated that the pool deposits recorded at these locations do not extend back from the bank into the bog itself. Fig. 6.10 also indicates that the pool deposits occur in a small basin with a radius of approximately 80 m, although the basin was not completely surveyed, and that the peat becomes shallower upslope to the east.

Unit	Field description
A	Sandy subsoil
B	Dark, rooty, *Sphagnum* moss peat
C	Lighter graminoid peat
D	*Sphagnum* moss peat
E	Sandy lake sediment with plant roots
F	Pure olive lake sediment with plant roots

Table 6.1 Description of sediment units logged at Hobbister

The late Bronze Age axehead found during peat cutting at Hobbister is believed to have come from unit B (J. Gibson pers. comm.), and workmen at the site indicated that the peat in which it was found came from about 20 m along the surveyed section of the peat bank.
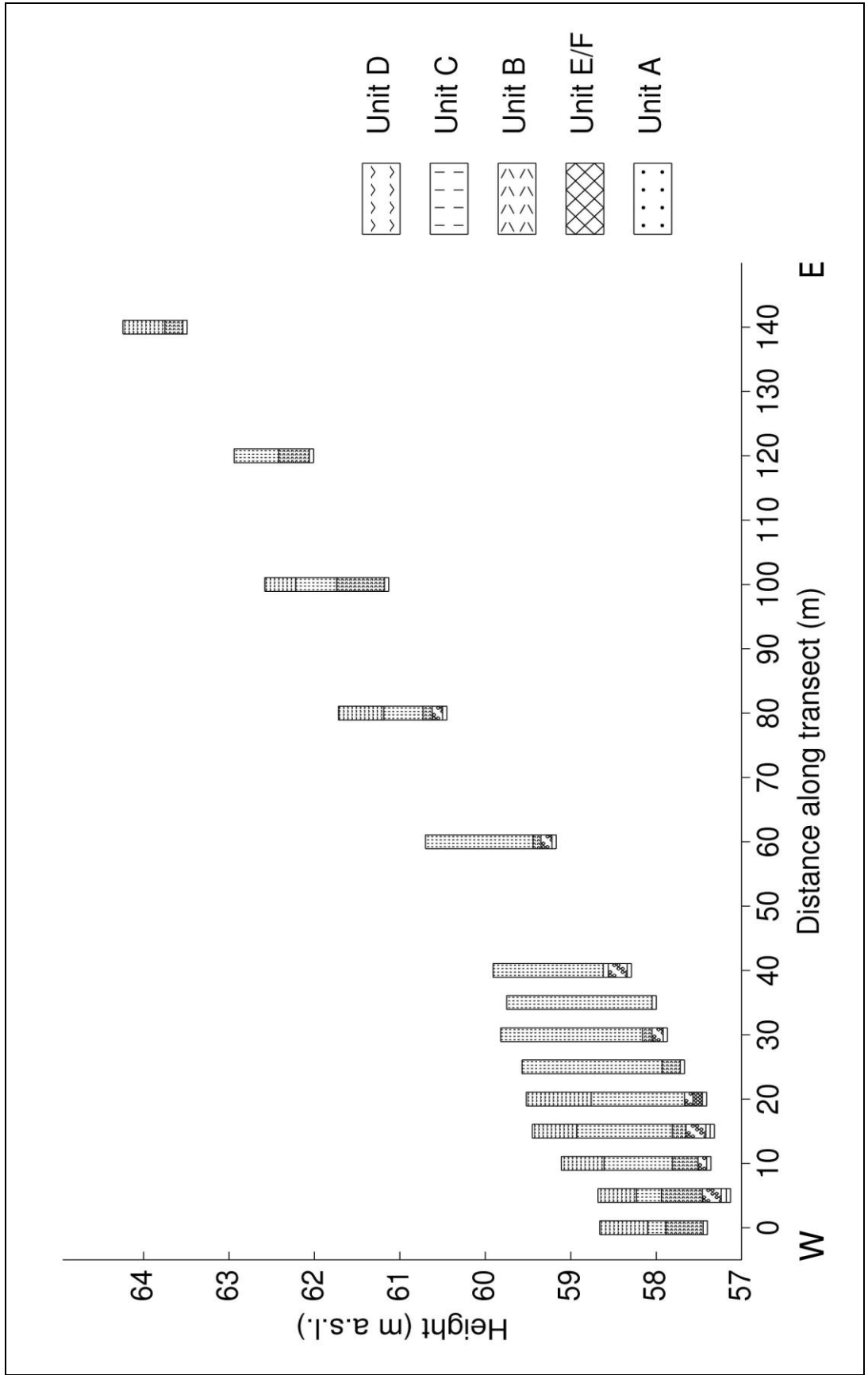
Figure 6.10 Stratigraphy of the peat bank at Hobbister

Peat depths recorded during the stratigraphic survey range from *c*. 1.2 m to *c*. 3.8 m (Fig. 6.11). The sub-peat topography in the area surveyed is also shown in Fig. 6.11, and it can be seen that there is a small (*c*. 60 m diameter) basin in the northern part of the site. This basin contains deeper peat up to 3.8 m in depth and is surrounded by shallower peat, probably reflecting paludification of the wider landscape from relatively small basin centres. Locations where pool deposits were recorded are also indicated on Fig. 6.11, and it seems that the landscape prior to peat spread contained several small pools.

Two cores were collected for laboratory analysis. One core (A) was taken from the deepest area of peat, within one of the wetland basins, and the other (B) was taken from the peat bank, near to where the Bronze Age axehead was discovered. The locations of these sequences are shown on Fig. 6.11.
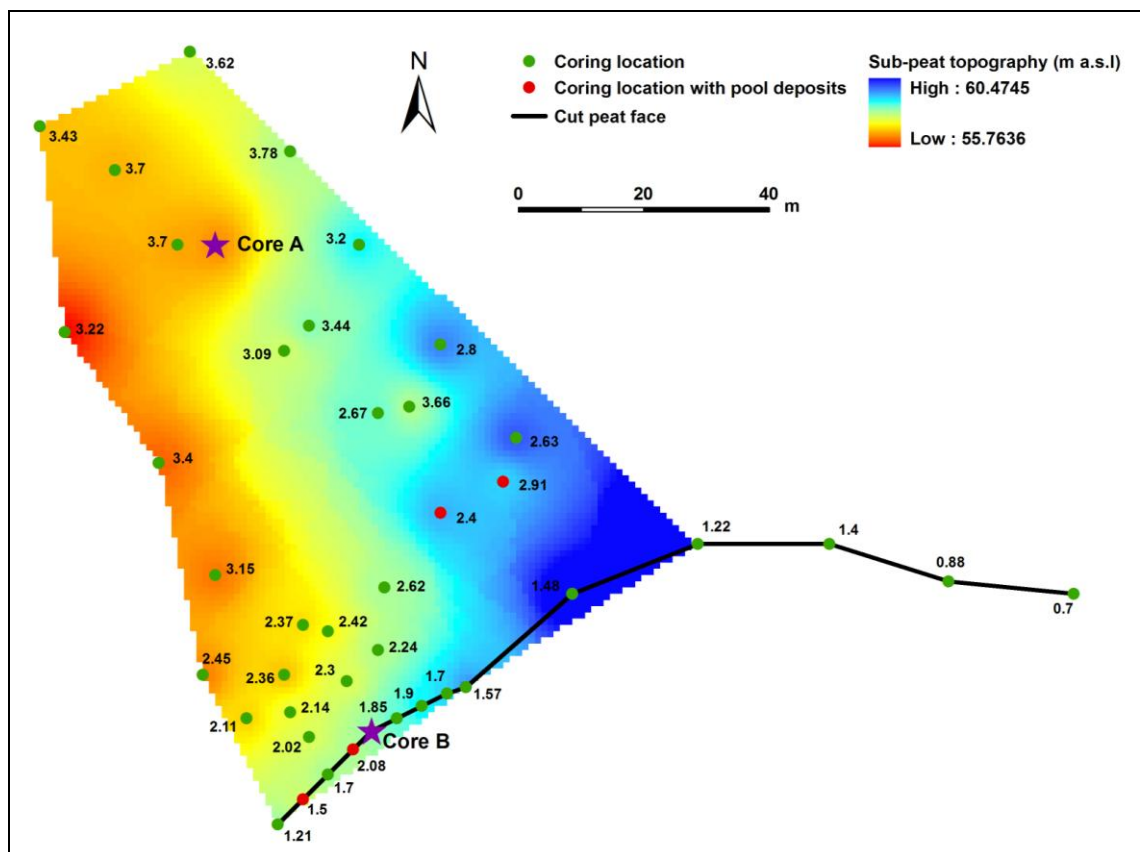
Figure 6.11 Sub-peat topography of the area surveyed at Hobbister (see Fig. 6.9 for general location). Labels indicate peat depths in metres.

6.4.2 Age Estimates

Radiocarbon age estimates for sequence A are presented in Table 6.2, along with calibrated ages. Those for sequence B are presented in Table 6.3. Various age models were tested for these sequences although none was found to give any real advantage over simple linear interpolation between and extrapolation from age estimates. In the absence of a large number of age estimates it was decided that this method gave the most accurate age model for these profiles. The age model for sequence A is presented in Fig. 6.12, and Fig. 6.13 shows the age model for sequence B.

Hobbister A

Depth (cm)	Radiocarbon age (years BP) 1 σ	Laboratory reference	Calibrated age range (years BP) 2 σ	Calibrated mid-point age (BC/AD)
370	6205 ±35	SUERC-19832 GU-17087	7244-7002	5173 BC
253	3820 ±30	SUERC-22859 GU-18281	4402-4093	2298 BC
173	3005 ±35	SUERC-19831 GU-17086	3330-3077	1254 BC
61	1550 ±30	SUERC-22858 GU-18280	1524-1375	500 AD

Table 6.2 Radiocarbon age estimates from sequence A
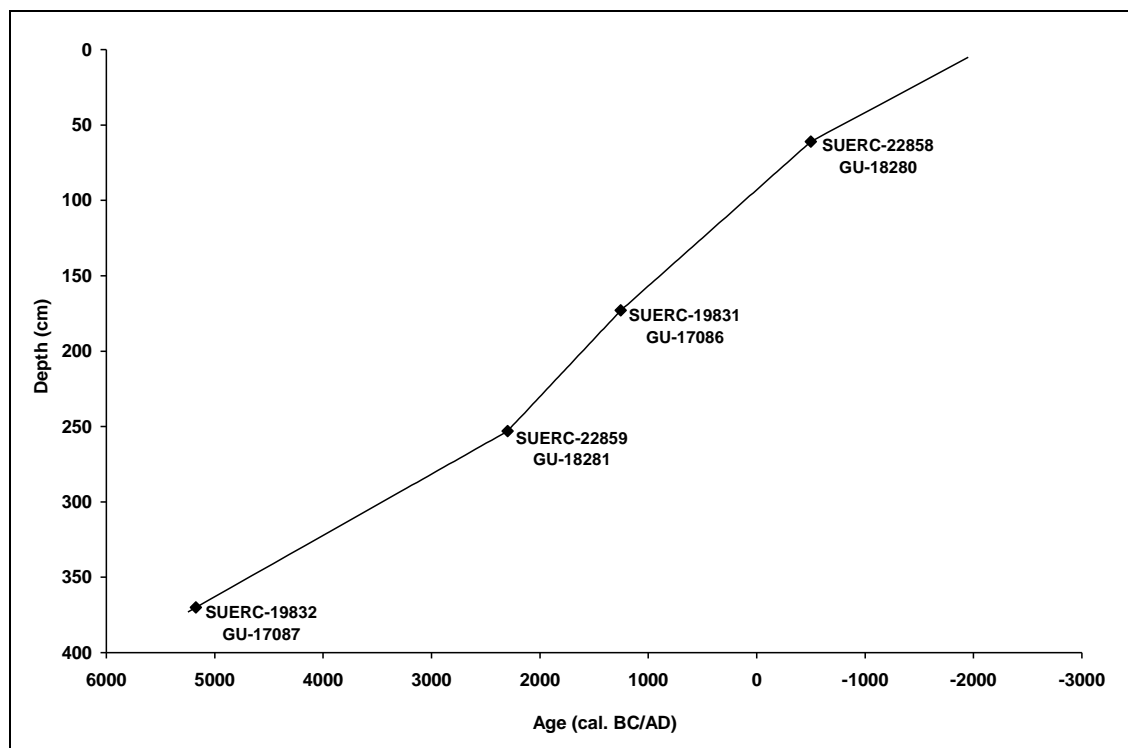
Figure 6.12 Linear age-depth model for sequence A

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Sequence A certainly covers the period from *c*. 5170 cal. BC to *c*. 500 cal. AD, and since Fig. 6.12 shows that the relationship between age estimates and depth is approximately linear throughout the profile, a reasonable amount of confidence can be placed in the extrapolated ages for the base and top of the sequence. The top of the sequence is assumed to be modern, since although the blanket peat at Hobbister is currently being extracted for commercial purposes, it is being cut from the side and there were no signs that it had ever been cut from the top. It is therefore likely that the record extends from *c*. 5250 cal. BC to *c*. 1950 cal. AD.

Sequence A therefore definitely covers the period from the late Mesolithic through to the late Iron Age, and it is likely that it extends into modern times. The entire period of interest for this investigation (*c*. 3000 cal. BC to *c*. 600 cal. AD) is therefore represented in this core. Sampling resolution across this period is approximately 35 years.

Hobbister B

Depth (cm)	Radiocarbon age (years BP) 1 σ	Laboratory reference	Calibrated age range (years BP) 2 σ	Calibrated mid-point age (BC/AD)
195	3920 ±35	SUERC-19837 GU-17089	4496-4242	2419 BC
167	3340 ±30	SUERC-22864 GU-18283	3677-3477	1627 BC
124	2205 ±35	SUERC-19833 GU-17088	2330-2140	285 BC
81	1230 ±35	SUERC-22860 GU-18282	1261-1068	785 AD

Table 6.3 Radiocarbon age estimates from sequence B
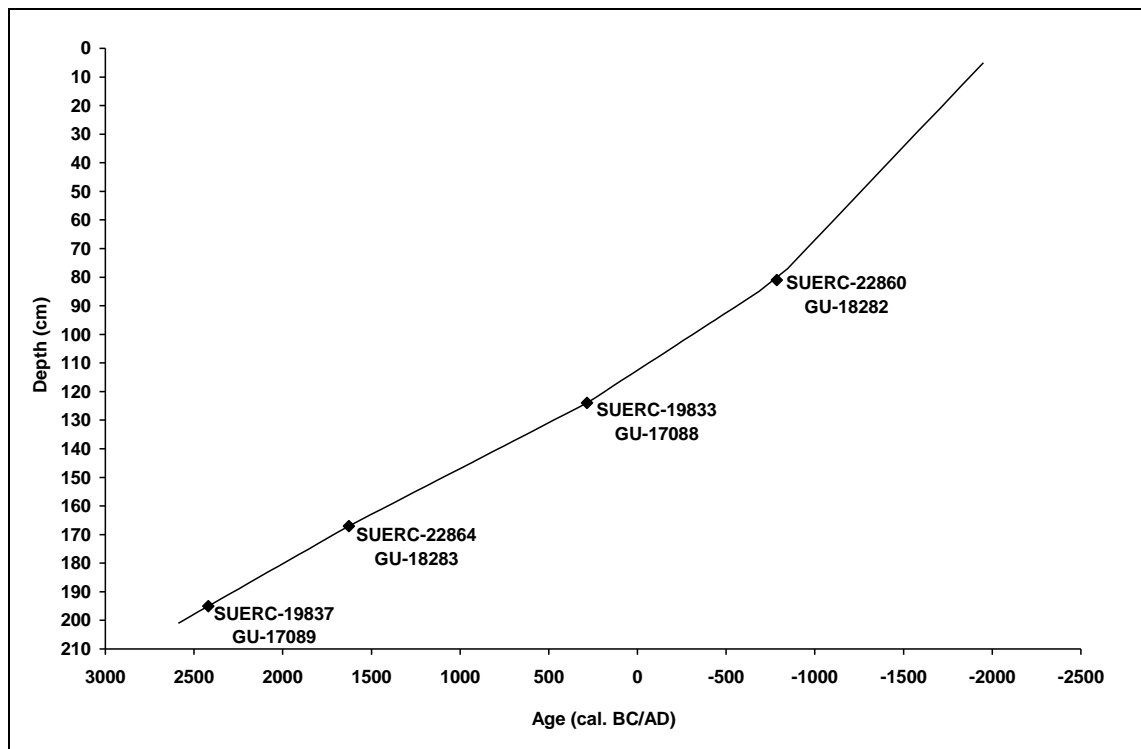
Figure 6.13 Linear age-depth model for the sequence B

Sequence B has been shown by radiocarbon dating to cover the period from *c*. 2420 cal. BC to *c*. 790 cal. AD. It can be seen from Fig. 6.13 that the relationship between age estimates and depth is roughly linear throughout the profile, indicating that a reasonable amount of confidence can be placed in the extrapolated ages for the base and top of the sequence. As for the profile from Hobbister A, the top of the sequence is assumed to be modern. It is therefore likely that the record extends from *c*. 2590 cal. BC to *c*. 1950 cal. AD.

The pollen record from sequence B therefore definitely covers the period from the late Neolithic through to the later part of the Pictish period, and it is likely that it extends into modern times. Approximately the first 600 years of the period of interest for this study (*c*. 3000 cal. BC to *c*. 600 cal. AD) are not represented in this sequence, although differences in environment and land-use between the late Neolithic, Bronze Age and Iron Age can still be investigated. Sampling resolution across the period *c*. 2590 cal. BC – *c*. 600 cal. AD is approximately 55 years.

6.4.3 Lithostratigraphy

A summary of the major lithostratigraphic units in sequence A is presented in Table 6.4, and those in sequence B are given in Table 6.5. Stratigraphic columns are shown at the left-hand side of pollen, NPP, microstructure and inorganic diagrams for each sequence.

Sequence A ends at a depth of 3.75 m, the point at which the sediment became too difficult to extract with a Russian sampler. During initial assessment of the site using a Dutch auger however, a depth of 3.79 m was reached at the coring point, and the base of the sequence consisted of compact yellowish-grey sand. This sand is also present at the base of sequence B, which ends at a depth of 2.03 m.

Hobbister A

Depth (cm)	Troels-Smith (1955) classification	Munsell colour	Munsell description
0-100	Dh3Dg1Sh+	7.5YR 2.5/1	Black
100-250	Dh2Dg1Sh1	10YR 2/2	Very dark brown
250-312	Dh3Sh1Dh+	2.5YR 2.5/1	Black
312-340	Ld3Dg1Ag+	10YR 4/3	Brown
340-375	Sh4Dg+	10YR 2/1	Black

Table 6.4 Lithostratigraphic units in sequence A

The basal unit of sequence A (375-340 cm) consists of very well-humified peat. Above this is a unit of fine organic lake mud containing small (0.1-2.0 mm) plant macrofossils, which occurs from a depth of 340 cm until 312 cm. From 312 cm, the sequence mainly consists of herbaceous peat with varying proportions of identifiable plant macrofossils (mainly greater than 2 mm in size, with lower frequencies of fragments in the size range 0.1-2.0 mm), allowing three smaller units to be identified within the upper part of the sequence (Table 6.4).

Hobbister B

Depth (cm)	Troels-Smith (1955) classification	Munsell colour	Munsell description
0-50	Dh3Dg1Sh+	7.5YR 3/4	Dark brown
50-160	Dh2Dg2	10YR 2/2	Very dark brown
160-175	Dg2Dh1Sh1	7.5YR 2.5/1	Black
175-197	Sh2Dg1Dh1	7.5YR 2.5/1	Black
197-202	Ld3Ag1	10YR 4/2	Dark greyish brown
202-203	Gmin4	2.5Y 4/2	Dark greyish brown

Table 6.5 Lithostratigraphic units in sequence B

At the base of sequence B is a 1 cm thick band of greyish-brown sand. From 202-197 cm a unit of fine organic lake mud mixed with silt occurs, and above this is a layer of partially humified peat containing some identifiable plant macrofossils, which ends at a depth of 175 cm. Following this the sediment consists of herbaceous peat with varying proportions of plant macrofossils in two size classes (greater than 2 mm and 0.1-2 mm), which allow three smaller units to be identified within the upper part of the sequence (Table 6.5). Smaller plant fragments (0.1-2 mm in size) dominate until a depth of 160 cm, and above this depth fragments larger than 2 mm increase in proportion until they form the major component of the sediment by the top of the sequence.

6.4.4 Physical Sediment Properties

The results for wet and dry density, organic content and 'carbonate' content of sequence A are illustrated in Fig. 6.14, and the same properties for sequence B are shown in Fig. 6.15. The zonation schemes used are the same as those used for the pollen diagrams (Figs. 6.16 and 6.18) from this site in order to aid description and interpretation, since the zone boundaries generally tend to coincide with major changes in the sediment properties.
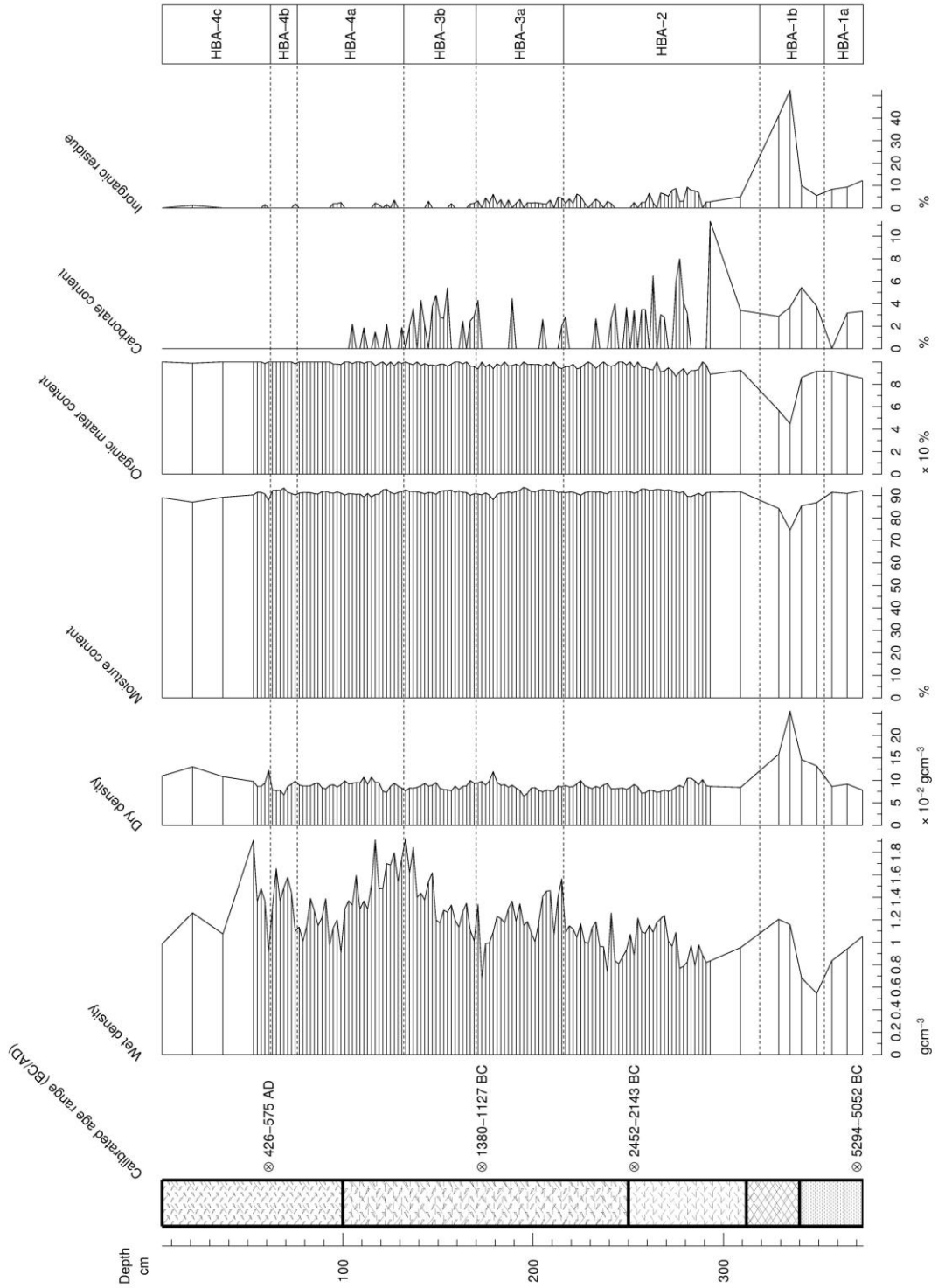
Figure 6.14 Physical sediment properties of sequence A (note change in scale for organic matter content)

Hobbister A

Zone HBA-1 (373-319 cm; c. 5250-3920 cal. BC)

Organic matter content throughout this zone is generally lower than in the rest of the profile, and percentages of inorganic material are correspondingly higher. There is also a fairly consistent presence of 'carbonate' material throughout the zone. It can be split into two subzones, which are described individually below.

Subzone HBA-1a (373-353 cm; c. 5250-4760 cal. BC)

Organic matter percentages are between 80 and 90% throughout this subzone, and inorganic matter fluctuates around 10%. 'Carbonate' content is around 2% at the base of the subzone but drops to zero at the boundary with HBA-1b.

Subzone HBA-1b (353-319 cm; c. 4760-3920 cal. BC)

At the start of this subzone organic matter percentages are similar to in the previous subzone, although a sharp decrease to *c*. 45% is seen at a depth of 335 cm. This is matched by a decline in organic material to around 50% at the same depth, and suggests that the unit of organic lake mud identified between 340 and 312 cm has a higher silt content than was apparent during visual inspection and recorded according to Troels-Smith (1955; see Table 6.4 for details). 'Carbonate' content is slightly higher than in HBA-1a, fluctuating between *c*. 2% and *c*. 4% throughout.

Zone HBA-2 (319-216 cm; c. 3920-1820 cal. BC)

Organic matter content increases to *c*. 90% again at the start of this zone, and fluctuates between 90 and 100% throughout. Percentages of inorganic material are less than 10% throughout the zone. 'Carbonate' content reaches a peak of *c*. 8% at a depth of 293 cm, and fluctuates between 2 and 6% from 281 to 233 cm.

Zone HBA-3 (216-132 cm; c. 1820-610 cal. BC)

This zone is characterised by a very high organic matter content (95-100%) and low percentages of inorganic material (less than 5%). It is divided into two subzones which are described below.

Subzone HBA-3a (216-170 cm; c. 1820-1210 cal. BC)

This subzone has a high organic matter content of between 95 and 100% throughout, and low values for inorganic matter of less than 5%. There are infrequent low peaks (*c*. 2-3%) of 'carbonate' material.

Subzone HBA-3b (170-132 cm; c. 1210-610 cal. BC)

Percentages of organic and inorganic matter remain similar to previously (95-100% and less than 5% respectively). However, 'carbonate' material is almost consistently present throughout this subzone, fluctuating between *c*. 2 and *c*. 4% from a depth of 155 cm until the top of the zone.

Zone HBA-4 (132-5 cm; c. 610 cal. BC – 1950 cal. AD)

The sediment in this zone is almost entirely organic, with infrequent occurrences of very low amounts (*c*. 2%) of inorganic material throughout. There is very little 'carbonate' material in this zone. The zone is divided into three subzones which are described below.

Subzone HBA-4a (132-76 cm; c. 610 cal. BC – 270 cal. AD)

This subzone is characterised by a very high organic matter content of 95-100% and correspondingly low values for inorganic material, which average around 1%. There are occasional low peaks (*c*. 1-2%) of 'carbonate' material in the lower part of the subzone, but none is present above a depth of 105 cm.

Subzone HBA-4b (76-62 cm; c. 270-480 cal. AD)

This sediment in this subzone is almost entirely composed of organic material, with the only inorganic sediment occurring at a depth of 75 cm where it forms around 2% of the sediment. No 'carbonate' material occurs in this subzone.

Subzone HBA-4c (62-5 cm; c. 480-1950 cal. AD)

This subzone again contains very high percentages (almost 100% throughout) of organic material, with a very low (*c*. 2%), occasional presence of inorganic material. Again, no 'carbonate' was recorded in this subzone.
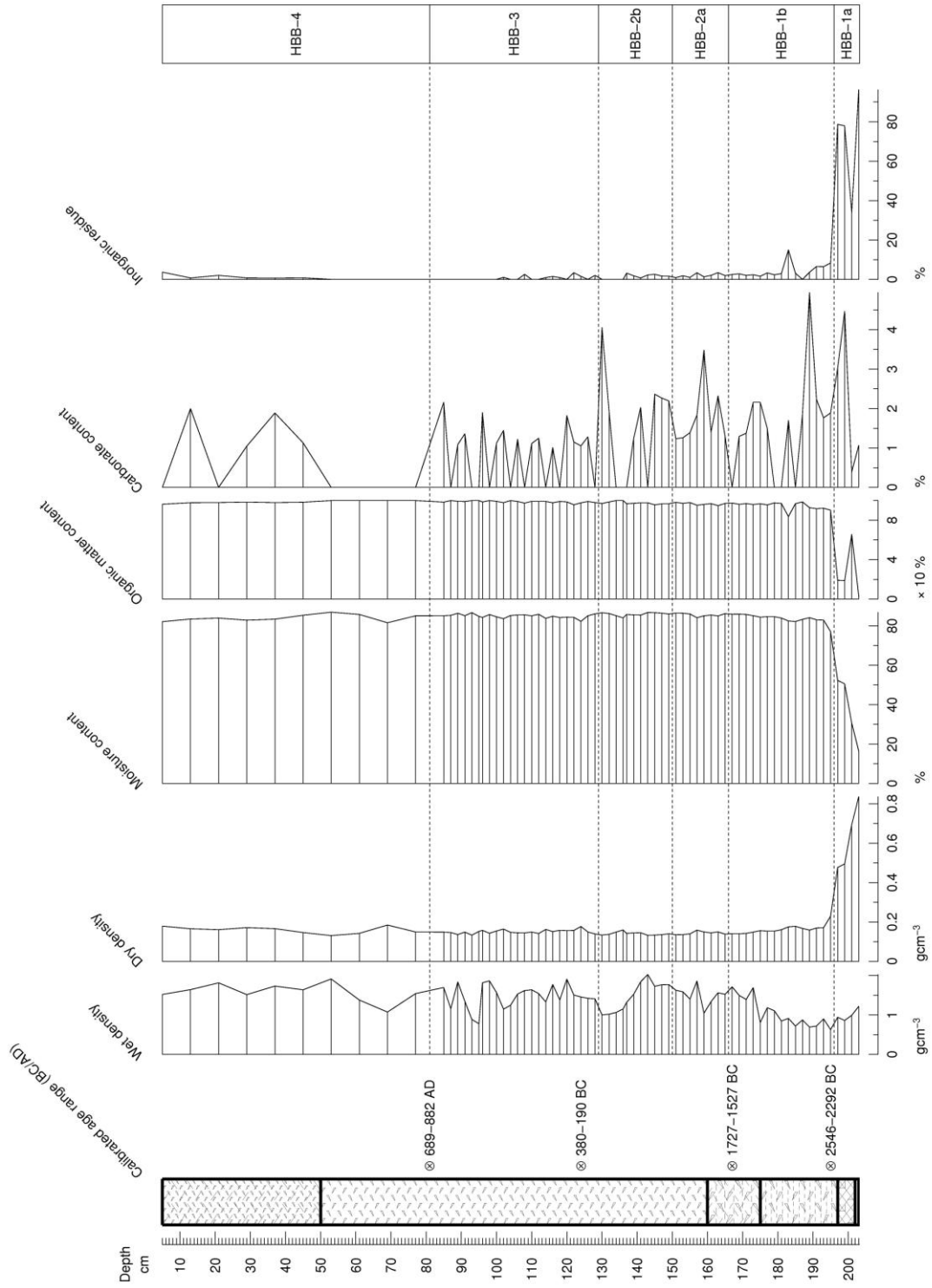
Figure 6.15 Physical sediment properties of sequence B (note change in scale for organic matter content)

Hobbister B

Zone HBB-1 (201-166 cm; c. 2590-1600 cal. BC)

This zone is divided into two very distinct subzones, which are described individually below.

Subzone HBB-1a (201-196 cm; c. 2590-2450 cal. BC)

This subzone is characterised by very high values for inorganic material, generally between 80 and 90%. Inorganic content is highest at the base of the zone, corresponding with the unit of fine greyish-brown sand identified during visual inspection and recorded according to the Troels-Smith (1955) system (see Table 6.5 for details). Another unit of sediment with a relatively high inorganic content (*c*. 80%) occurs between 199 and 197 cm, following a decline to *c*. 35% at a depth of 201 cm. This second unit of highly inorganic sediment roughly corresponds with the unit of organic lake mud mixed with silt that was identified during visual inspection (see Table 6.5). Organic matter is generally low throughout the subzone, between 20 and 40%. 'Carbonate' content is relatively low when compared with some parts of the Hobbister A sequence, although a peak of *c*. 3% is reached at a depth of 199 cm. Moisture content is very low (*c*. 20%) at the start of this subzone, although it increases to around 70% at the boundary with HBB-1b.

Subzone HBB-1b (196-166 cm; c. 2450-1600 cal. BC)

At the base of this subzone there is a marked increase in organic matter content to *c*. 90%, and it remains between 90 and 100% for most of the rest of the subzone. The amount of inorganic residue is generally low (less than 10%), although there is a small peak of 15% at a depth of 183 cm. There is also a slight decline in organic content to around 80% at this depth. There is a fairly consistent presence of 'carbonate' material in this subzone, mainly at frequencies of around 1%, although there is a slight peak where the value reaches *c*. 3.5% at 189 cm.

Zone HBB-2 (166-129 cm; c. 1600-440 cal. BC)

This zone is characterised by a high organic matter content of 95-100%, and very small values for inorganic residue of 0-3%. 'Carbonate' material is fairly consistently present throughout the zone. The zone can be split into two subzones, each of which is described below.

Subzone HBB-2a (166-150 cm; c. 1600-1100 cal. BC)

Organic matter content remains high (between 95 and 100%), and inorganic material makes up around 2% of the sediment. There is a low (1-2.5%) but consistent presence of 'carbonate' material throughout this subzone.

Subzone HBB-2b (150-129 cm; c. 1100-440 cal. BC)

Values for organic and inorganic matter are similar to those in HBB-2a. 'Carbonate' material is also present in similar frequencies to in HBB-2a for the lower part of this subzone, before declining to zero at depth of 137 cm. Values of 'carbonate' material reach around 2% again at the top of the subzone.

Zone HBB-3 (129-81 cm; c. 440 cal. BC – 770 cal. AD)

This zone is again characterised by high values for organic matter content (95-100%) and very low quantities of inorganic residue (*c*. 2% in the lower half of the subzone). No inorganic residue was recorded above a depth of 120 cm for the remainder of the zone. 'Carbonate' content fluctuates between around 1% throughout the zone.

Zone HBB-4 (81-5 cm; c. 770-1950 cal. AD)

The sediment in this zone consists almost entirely of organic matter, with values of almost 100% throughout. No inorganic residue was recorded until a depth of 45 cm, above which values are around 1% until a slight rise to *c*. 4% occurs at the end of the zone. No 'carbonate' material is present at the base of the zone, although after a depth of 45 cm it forms around 1% of the sediment for the remainder of the zone.

6.4.5 Pollen and Charcoal Analysis

A percentage pollen diagram for sequence A is presented in Fig. 6.16, and accumulation rate data is shown in Fig. 6.17. Pollen percentages and accumulation rates for sequence B are presented in Fig. 6.18 and Fig. 6.19 respectively. The results of charcoal analysis are appended to the percentage diagrams.

The zonation schemes are based on all taxa with values greater than 2% in at least one sample, which for sequence A included *Pinus sylvestris*, *Quercus*, *Betula*, *Alnus glutinosa*, *Corylus avellana*-type, *Salix*, *Empetrum nigrum*, *Calluna vulgaris*, *Vaccinium*-type, *Ranunculus acris*-type, Caryophyllaceae, *Rumex* undiff., *Filipendula*, *Potentilla*-type, Rosaceae undiff., Apiaceae undiff., *Plantago lanceolata*, Cyperaceae,

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Phragmites-type, Poaceae, *Selaginella selaginoides*, *Pteridium aquilinum* and Pteropsida (monolete) undiff.

For sequence B the taxa included in the zonation scheme were *Pinus sylvestris*, *Quercus*, *Betula*, *Alnus glutinosa*, *Corylus avellana*-type, *Salix*, *Empetrum nigrum*, *Calluna vulgaris*, *Vaccinium*-type, *Ranunculus acris*-type, Chenopodiaceae, Caryophyllaceae, *Filipendula*, *Potentilla*-type, Rosaceae undiff., *Plantago major*, *Plantago lanceolata*, Asteraceae (Lactuceae), Asteraceae (Asteroideae), Cyperaceae, *Phragmites*-type, Poaceae, and Pteropsida (monolete) undiff.

The two sequences are described below, with each zone discussed individually. The trends described in the percentage diagrams are reflected by the accumulation rate data unless otherwise stated.

Figure 6.16 Percentage pollen and spore diagram from sequence A
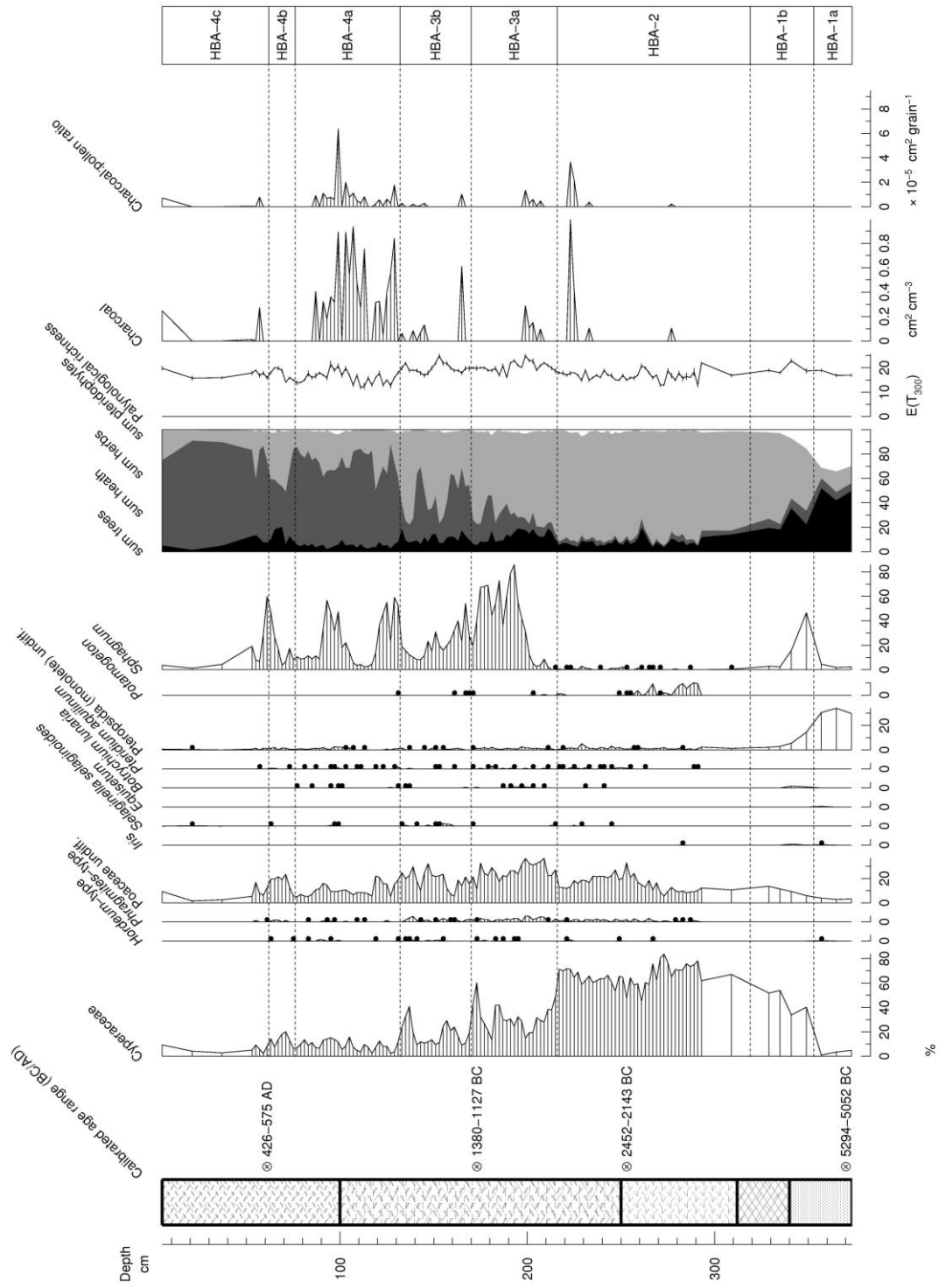
Figure 6.16 (continued) Percentage pollen and spore diagram from sequence A
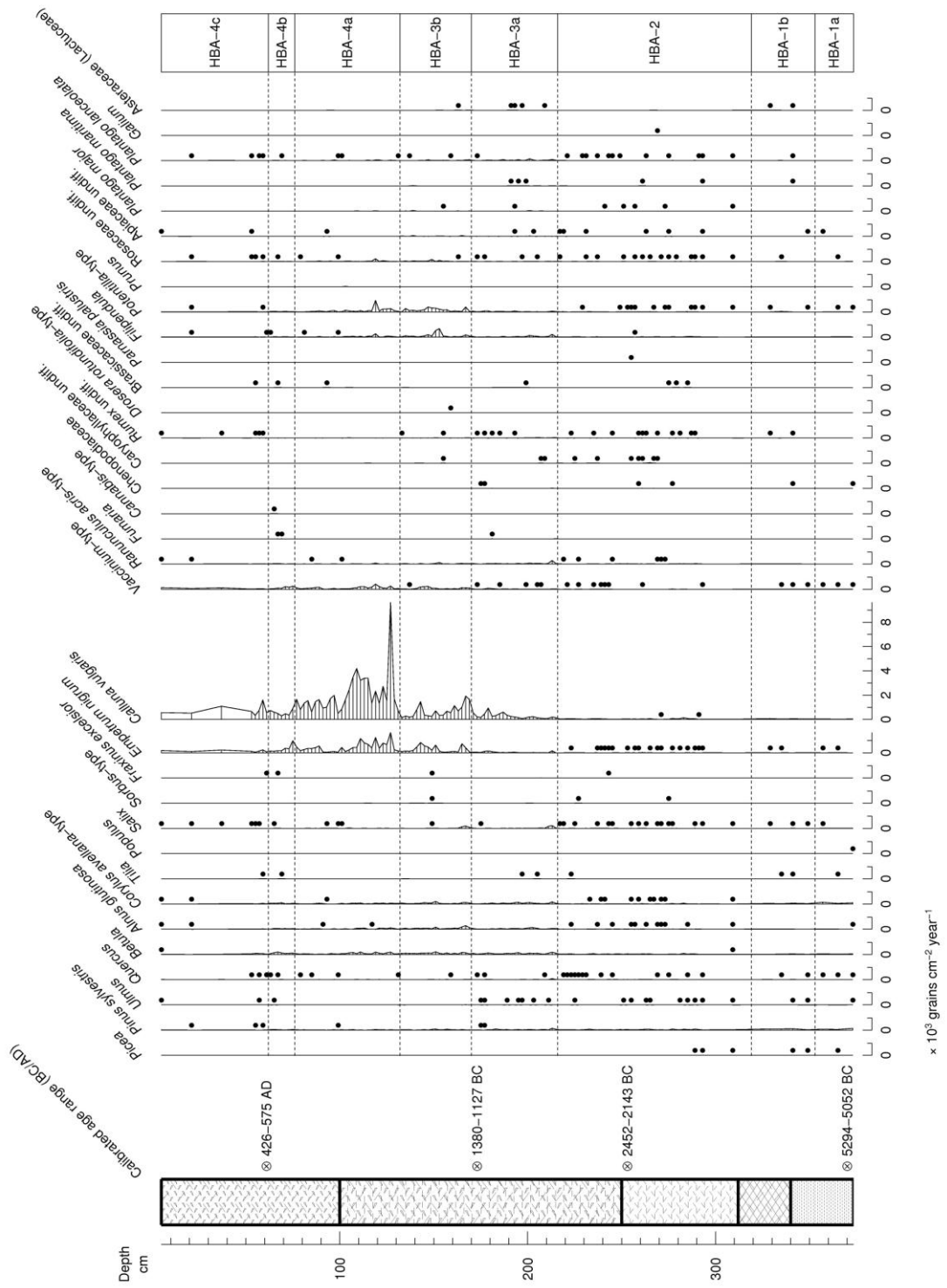
Figure 6.17 Pollen and spore accumulation rate diagram from sequence A

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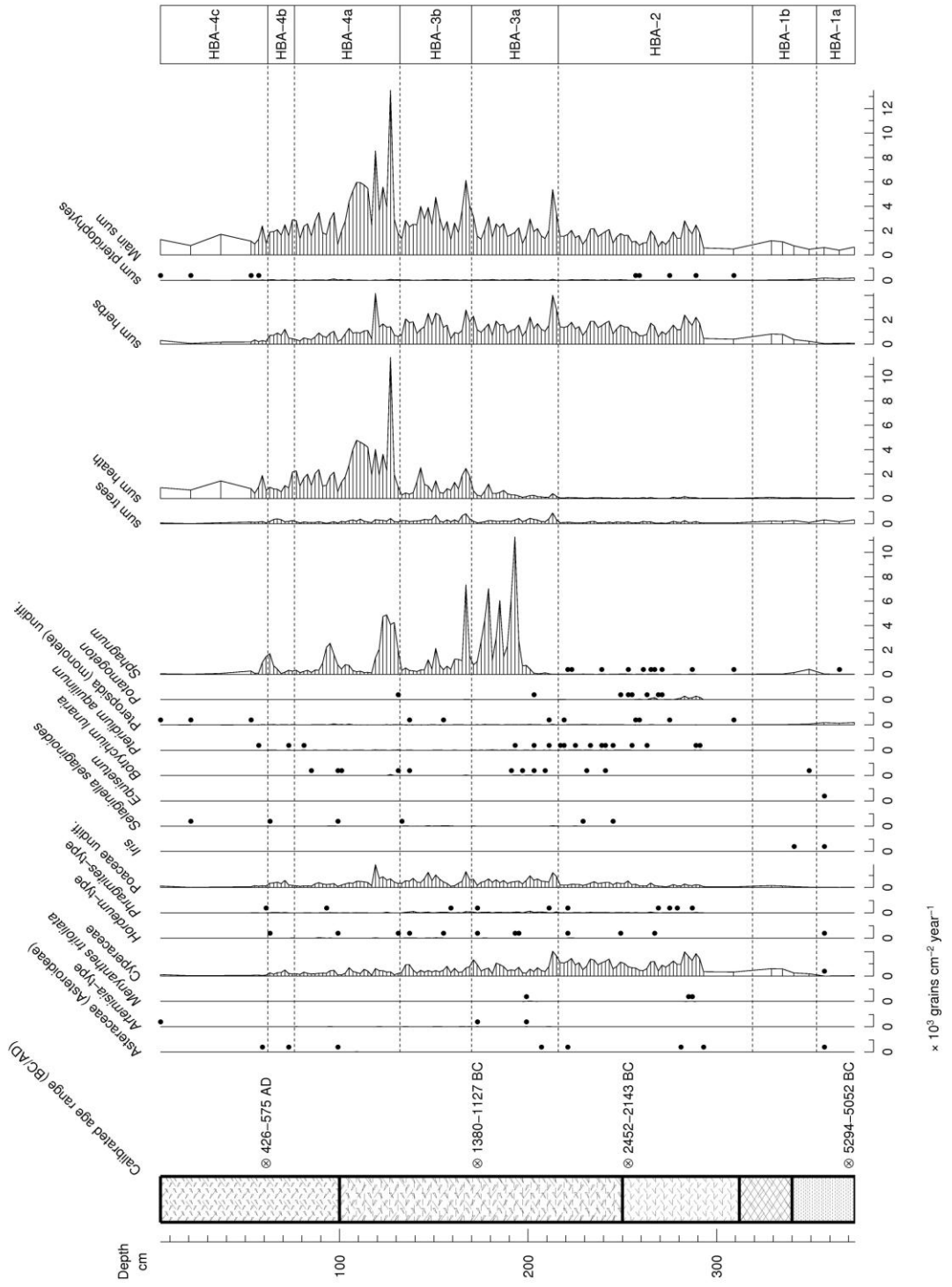
Figure 6.17 (continued) Pollen and spore accumulation rate diagram from sequence A

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Hobbister A

Zone HBA-1 (373-319 cm; c. 5250-3920 cal. BC)

Pollen accumulation rates are low (*c*. 1000 grains cm^{-2}year^{-1}) throughout this zone. Arboreal pollen percentages are at their highest in this zone (*c*. 20-50%) and high frequencies of pteridophyte spores are present in the lower part of the zone. Herbaceous taxa become dominant in the upper part of the zone. The zone is split into two subzones which are described below.

Subzone HBA-1a (373-353 cm; c. 5250-4760 cal. BC)

Pollen accumulation rates are low (*c*. 800 grains^{-2}year^{-1}) throughout this subzone. Arboreal taxa form *c*. 50% of the total pollen sum, and the main components of this group are *Pinus sylvestris* (*c*. 15%), *Betula* (*c*. 8%), *Alnus glutinosa* (*c*. 3%), *Corylus avellana*-type (*c*. 15%) and *Salix* (*c*. 2%). Very low frequencies (<1%) of *Ulmus* and *Quercus* also occur. Percentages of pteridophyte spores are also high, reaching 30% of the total sum throughout this subzone.

Herbaceous taxa form around 15% of the total pollen sum in this subzone. The main taxa represented are *Filipendula*, *Potentilla*-type, Rosaceae undiff. and Poaceae. A single grain of cereal-type pollen, identified as *Hordeum*-type on the basis of the annulus diameter (Andersen 1979), is present at a depth of 357 cm.

Percentages of heath taxa in this subzone are low (around 7%), with *Calluna vulgaris* forming the dominant component of this group at around 5% of the total sum. *Empetrum nigrum* and *Vaccinium*-type are also present at much lower frequencies. Palynological richness averages around 17 taxa for most of the subzone, and no microscopic charcoal is recorded.

Subzone HBA-1b (353-319 cm; c. 4760-3920 cal. BC)

Pollen accumulation rates are slightly higher than in HBA-1a (*c*. 1000 grains cm^{-2}year^{-1}). Arboreal pollen percentages decline at the start of this subzone to around 30% of the sum, and by the end of the subzone arboreal taxa form only 20% of the total pollen sum. The main taxa featuring in this decline are *Pinus sylvestris*, *Betula, Corylus avellana*-type and *Salix*. Percentages of pteridophyte spores decline throughout the zone in a similar manner to those of arboreal pollen.

Frequencies of herbaceous taxa increase in this subzone, forming *c*. 50-70% of the total pollen sum throughout. Cyperaceae are the dominant taxon in this group, reaching frequencies of around 40% at the start of the subzone and comprising *c*. 60% of the total pollen sum by the end. Other herbaceous taxa represented include *Ranunculus acris*-type, *Filipendula* (although in much lower frequencies than in HBA-1a), *Potentilla*-type, Asteraceae (Asteroideae) and Poaceae, which reaches frequencies of *c*. 13% by the end of the subzone. Low frequencies (*c*. 1%) of anthropogenic indicator taxa including *Rumex* undiff. and *Plantago lanceolata* are present from a depth of 341 cm upwards.

Percentages of heath taxa remain low, forming 5-10% of the total pollen sum throughout this subzone. *Calluna vulgaris* is again the dominant taxon in this group, with lower proportions of *Empetrum nigrum* and *Vaccinium*-type pollen.

Sphagnum spore percentages are high at the start of the subzone, reaching around 45%, although they decline again to *c*. 2% by the boundary with HBA-2. Palynological richness is slightly higher than in HBA-1a, with values between 18 and 20 for most of the subzone. Again, no charcoal was recorded.

Zone HBA-2 (319-216 cm; c. 3920-1820 cal. BC)

Pollen accumulation rates increase slightly in this zone and fluctuate between *c*. 1000 grains cm^{-2}year^{-1} and *c*. 3000 grains cm^{-2}year^{-1} throughout. Arboreal taxa form around 10% of the total pollen sum for most of the zone, although there is an isolated peak of *c*. 20% at a depth of 261 cm. The main taxa recorded are still *Pinus sylvestris*, *Betula, Alnus glutinosa* and *Corylus avellana*-type. Fern spores, including *Pteridium aquilinum*, occur at low frequencies of *c*. 2%.

This zone is dominated by herbaceous taxa, mainly Cyperaceae, which make up *c*. 60% of the total pollen sum throughout most of the zone. Poaceae pollen comprises *c*. 10% of the sum at the start of the zone, rising to about 20% by the boundary with HBA-3a. Other herbaceous taxa present include *Ranunculus acris*-type, Caryophyllaceae, *Filipendula*, *Potentilla*-type, Rosaceae undiff. and *Phragmites*-type. Pollen of anthropogenic indicator species such as *Rumex* undiff. and *Plantago lanceolata* continues to be present at low frequencies (generally less than 1%). Occasional grains of *Hordeum*-type pollen occur throughout the upper part of the zone.

Proportions of heath taxa are lower than in the previous zone, and their pollen forms around 5% of the sum throughout most of this zone. Again, the main taxon in this group is *Calluna vulgaris*, although low frequencies of *Empetrum nigrum* and *Vaccinium*-type are still present.

Potamogeton pollen occurs between 291 and 249 cm, reaching values of up to 10% in some places. Palynological richness fluctuates between about 13 and 20 taxa throughout the zone, and on average is slightly lower than previously. Isolated peaks of microscopic charcoal occur at depths of 277 cm ($0.1 \text{ cm}^2\text{cm}^{-3}$), 233 cm ($0.1 \text{ cm}^2\text{cm}^{-3}$) and 223 cm ($1 \text{ cm}^2\text{cm}^{-3}$). These are matched by peaks in the charcoal:pollen ratio.

Zone HBA-3 (216-132 cm; c. 1820-610 cal. BC)

Pollen accumulation rates are relatively high (c. 3000 grains $\text{cm}^{-2}\text{year}^{-1}$) throughout this zone, with occasional higher peaks of c. 6000 grains $\text{cm}^{-2}\text{year}^{-1}$. The zone is again dominated by herbaceous taxa, although heathland taxa also begin to expand. There is also a slight increase in arboreal pollen percentages in comparison with HBA-2. This zone can be divided into two subzones, each of which is described separately in more detail below.

Subzone HBA-3a (216-170 cm; c. 1820-1210 cal. BC)

Pollen accumulation rates are around 2500 grains $\text{cm}^{-2}\text{year}^{-1}$ throughout this subzone. Percentages of arboreal pollen show a slight increase in comparison to the previous zone, forming around 15% throughout, with the main taxa in this group remaining the same as before. Pteridophyte spore percentages are around 2%, mainly comprising *Pteridium aquilinum* and *Botrychium lunaria*.

Herbaceous taxa are again the dominant component of the pollen sum in this subzone, making up around 60-80% of the total. In this group Cyperaceae are present less frequently than before, forming only 30-40% of the total sum. Poaceae pollen percentages increase to *c*. 30% in this subzone. Other herbaceous taxa represented include *Ranunculus acris*-type, *Filipendula*, *Potentilla*-type, Rosaceae undiff., Apiaceae undiff. and *Phragmites*-type. *Plantago lanceolata* pollen is present at frequencies of 2-5% throughout the subzone, and other anthropogenic indicator taxa present at low frequencies of *c*. 1% include *Rumex* undiff. and *Artemisia*-type. *Hordeum*-type pollen occurs sporadically throughout the upper half of the subzone.

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Percentages of heath taxa begin to increase in this subzone, forming around 20% of the total pollen sum by the boundary with HBA-3b. The dominant taxon in this group is still *Calluna vulgaris*, although frequencies of *Empetrum nigrum* and *Vaccinium*-type increase slightly in the upper part of the subzone.

High frequencies (*c*. 50-80%) of *Sphagnum* spores are present in this subzone, and *Potamogeton* pollen is occasionally found in very low quantities. Palynological richness is highest at the base of the subzone, averaging around 22 taxa, and declines to around 18 taxa towards the top of the subzone. Small amounts of charcoal (*c*. 0.1-0.2 cm^2cm^{-3}) are present in the lower part of the subzone, between 207 and 199 cm.

Subzone HBA-3b (170-132 cm; c. 1210-610 cal. BC)
Pollen accumulation rates are slightly higher than in the previous subzone, fluctuating between *c*. 3000 and *c*. 5000 grains $cm^{-2}year^{-1}$. Percentages of arboreal pollen fluctuate between about 10 and 15% throughout this subzone, with the main taxa remaining the same as before. Pteridophyte spore frequencies also remain similar, although *Selaginella selaginoides* spores now form part of this group of taxa.

Herbaceous and heathland taxa are present in similar proportions in this subzone, alternatively dominating the pollen assemblage. From 169-159 cm and 145-141 cm, heath taxa are dominant, and from 157-147 and 139-133 cm herbaceous taxa comprise the main part of the pollen sum. These fluctuations in the proportion of heath taxa are mainly due to variations in percentages of *Calluna vulgaris*, which remains the major component of the group of heathland taxa. However, from a depth of 145 cm frequencies of *Empetrum nigrum* and *Vaccinium*-type pollen increase to form *c*. 20% and *c*. 5% of the total pollen sum respectively.

Of the herbaceous taxa present, Cyperaceae and Poaceae are again dominant, although proportions of Cyperaceae pollen are lower than previously, making up around 10-20% of the total pollen sum for most of the subzone. A short-lived peak of 40% Cyperaceae pollen occurs towards the end of the subzone, which roughly coincides with a decline in *Calluna vulgaris* pollen percentages. Poaceae pollen frequencies fluctuate between about 20 and 30% throughout. Other herbaceous taxa present at low frequencies include *Ranunculus acris*-type, *Rumex* undiff., Rosaceae undiff., Apiaceae undiff. and

Phragmites-type. *Potentilla*-type pollen is present in much higher quantities than before, forming around 10% of the sum in places. Low frequencies (*c*. 2%) of *Filipendula* pollen are present throughout, although there is a peak of *c*. 20% at a depth of 153 cm. *Plantago lanceolata* pollen occurs at slightly lower frequencies (*c*. 1%) than previously, and *Hordeum*-type pollen is sporadically present throughout the subzone.

Very low frequencies of *Potamogeton* pollen are present at the base of the zone, and high percentages (*c*. 50%) of *Sphagnum* spores also occur, although these decline to around 20% by the boundary with HBA-4a. Palynological richness is similar to the previous subzone, between 17 and 23 taxa. An isolated peak of microscopic charcoal (*c*. 0.6 cm^2cm^{-3}) occurs near the base of the subzone, and charcoal is present again in low quantities (*c*. 0.1 cm^2cm^3) from a depth of 145 cm upwards.

Zone HBA-4 (132-5 cm; c. 610 cal. BC – 1950 cal. AD)
Pollen accumulation rates are high (*c*. 6000 grains $cm^{-2}year^{-1}$) at the start of this zone, although they decline to around 1000 grains $cm^{-2}year^{-1}$ by the end of the sequence. The pollen assemblage is dominated by heathland taxa, with lower herbaceous and arboreal pollen percentages than in zone HBA-3. Pteridophyte spore percentages are negligible. The three subzones making up this zone are described individually below.

Subzone HBA-4a (132-76 cm; c. 610 cal. BC – 270 cal. AD)
Pollen accumulation rates reach their highest values in this subzone, being around 6000 grains $cm^{-2}year^{-1}$ at the base and decreasing to *c*. 2000 grains $cm^{-2}year^{-1}$ towards the top. However values fluctuate considerably throughout the subzone, with occasional peaks as high as *c*. 9000 and *c*. 14,000 grains $cm^{-2}year^{-1}$. Percentages of arboreal pollen decline at the start of this subzone and remain at <10% of the total pollen sum throughout. Frequencies of pteridophyte spores are very low (*c*. 1-2%).

Heath taxa dominate this subzone, although their frequencies fluctuate between *c*. 50% and *c*. 85% throughout, averaging around 60%. *Calluna vulgaris* dominates this group, forming up to 60% of the total pollen sum, although percentages fluctuate throughout the subzone. Pollen accumulation rates for this taxon vary cyclically in the upper half of the subzone. Percentages of both *Empetrum nigrum* and *Vaccinium*-type pollen are greater than previously, forming 10-20% and 2-5% of the total sum respectively.

Herbaceous taxa make up around 20-30% of the pollen sum, and as before the dominant taxa are Cyperaceae (*c*. 10-15%) and Poaceae (*c*. 10-20%). Other taxa in this group include *Ranunculus acris*-type, *Filipendula*, *Potentilla*-type, Rosaceae undiff., Asteraceae (Asteroideae) and *Phragmites*-type. *Plantago lanceolata* pollen continues to occur at frequencies of *c*. 1%, although pollen of other anthropogenic indicator taxa such as *Rumex* undiff. and *Artemisia*-type occurs less frequently than before. *Hordeum*-type pollen is found sporadically throughout the subzone.

Potamogeton pollen was observed at the base of the subzone, and *Sphagnum* spore percentages fluctuate throughout. They reach values of *c*. 50% between 131 and 121 cm and again between 99 and 91 cm, but between these peaks their frequency is around 10%. Palynological richness fluctuates between about 12 and 20 taxa throughout, being slightly higher in the upper half of the subzone. Microscopic charcoal is fairly consistently present between 129 and 87 cm, with values ranging between 0.2 and 0.9 cm^2cm^{-3}.

Subzone HBA-4b (76-62 cm; c. 270-480 cal. AD)

Pollen accumulation rates are around 2000 grains $cm^{-2}year^{-1}$ in this subzone. Arboreal taxa show a slight increase in comparison with HBA-4a, reaching frequencies of *c*. 20% in places, although they decline to *c*. 10% again by the end of the subzone. The main taxa present are *Betula*, *Alnus glutinosa* and *Corylus avellana*-type. Pteridophyte spore percentages remain negligible.

Percentages of herbaceous taxa increase slightly in this subzone to around 40% of the total pollen sum, at the expense of heathland taxa which decline to *c*. 40%. Heathland taxa are no longer dominated by *Calluna vulgaris*, with *Empetrum nigrum* and *Vaccinium*-type pollen both increasing in frequency in this subzone. Of the herbaceous taxa, Cyperaceae and Poaceae are still the main components, forming *c*. 15% and *c*. 20% of the pollen sum respectively. The range of other herbaceous taxa represented at low frequencies is similar to that in the previous subzone. *Plantago lanceolata* still occurs at frequencies of about 1% throughout, and *Hordeum*-type pollen was observed at the base and the top of the subzone.

Sphagnum spore frequencies are low (*c*. 10%) at the base of the subzone but increase rapidly to almost 50% at the top. Palynological richness is between 15 and 20 taxa, and

is higher towards the top of the subzone than at the base. No microscopic charcoal was observed.

Subzone HBA-4c (62-5 cm; c. 480-1950 cal. AD)

Pollen accumulation rates remain at around 2000 grains $cm^{-2}year^{-1}$ in this subzone. Arboreal pollen percentages decline steadily throughout the subzone from *c*. 10% at the start to *c*. 5% by the end of the sequence, and frequencies of pteridophyte spores are still about 1%.

Heath taxa expand again following their decline in HBA-4b, forming around 70-80% of the total pollen sum. Percentages of *Calluna vulgaris* pollen are *c*. 60%, and *Empetrum nigrum* and *Vaccinium*-type pollen frequencies are *c*. 15% and *c*. 10% respectively.

Herbaceous pollen makes up around 15% of the total pollen sum for most of the subzone, although there is an increase to *c*. 25% at the top of the sequence, mainly due to increases in the frequencies of Cyperaceae and Poaceae pollen. *Ranunculus acris*-type, *Filipendula*, *Potentilla*-type and *Plantago lanceolata* pollen are present in low quantities as previously. No cereal pollen occurs in this subzone.

Frequencies of *Sphagnum* spores decline from *c*. 60% at the beginning of the subzone to around 5% by the top of the sequence. Palynological richness is low, about 15 taxa, for much of the subzone but increases to *c*. 20 taxa at the end. Peaks of microscopic charcoal occur at the base (*c*. 0.3 $cm^{2}cm^{-3}$) and top (*c*. 0.25 $cm^{2}cm^{-3}$) of the subzone.
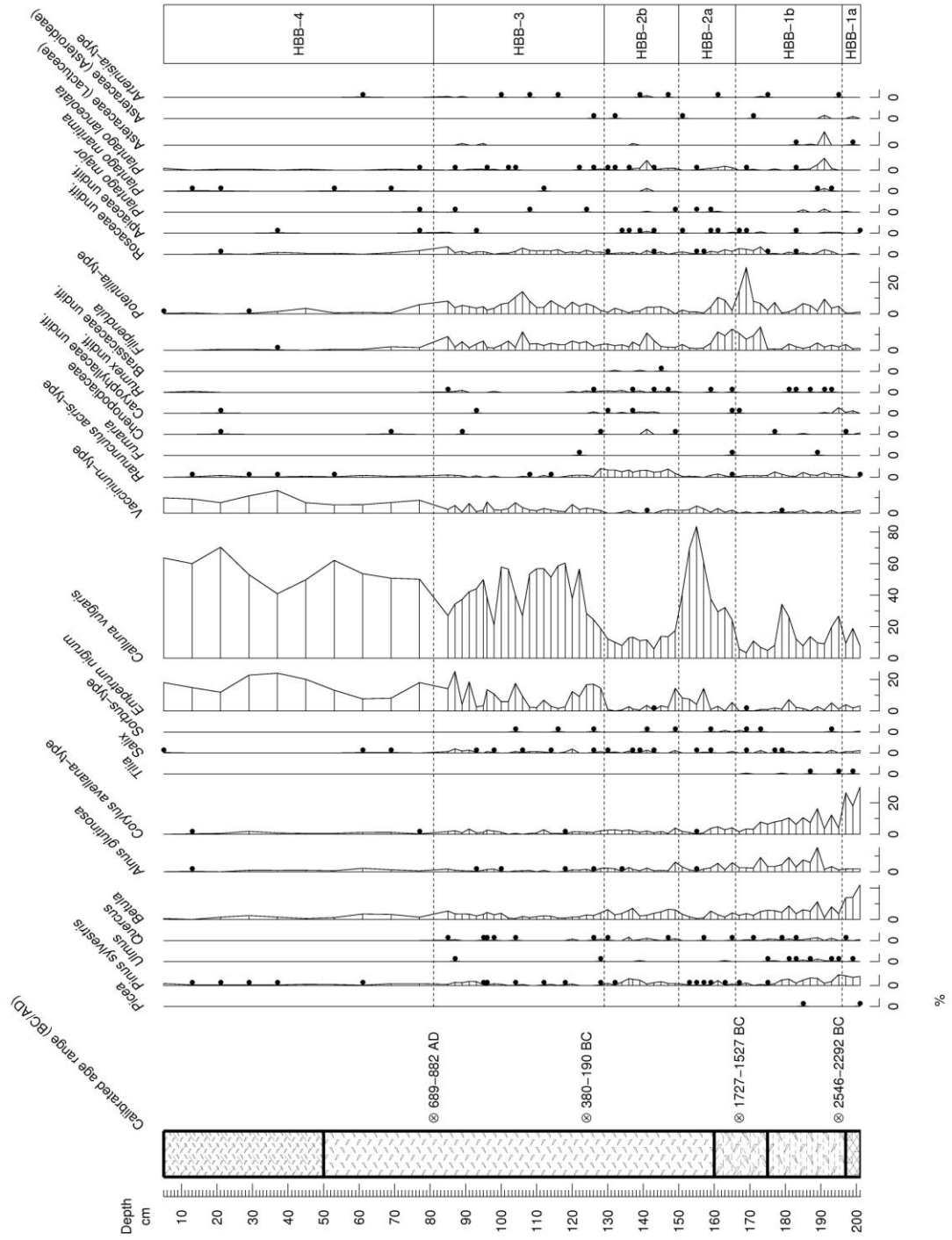
Figure 6.18 Percentage pollen and spore diagram from sequence B

265
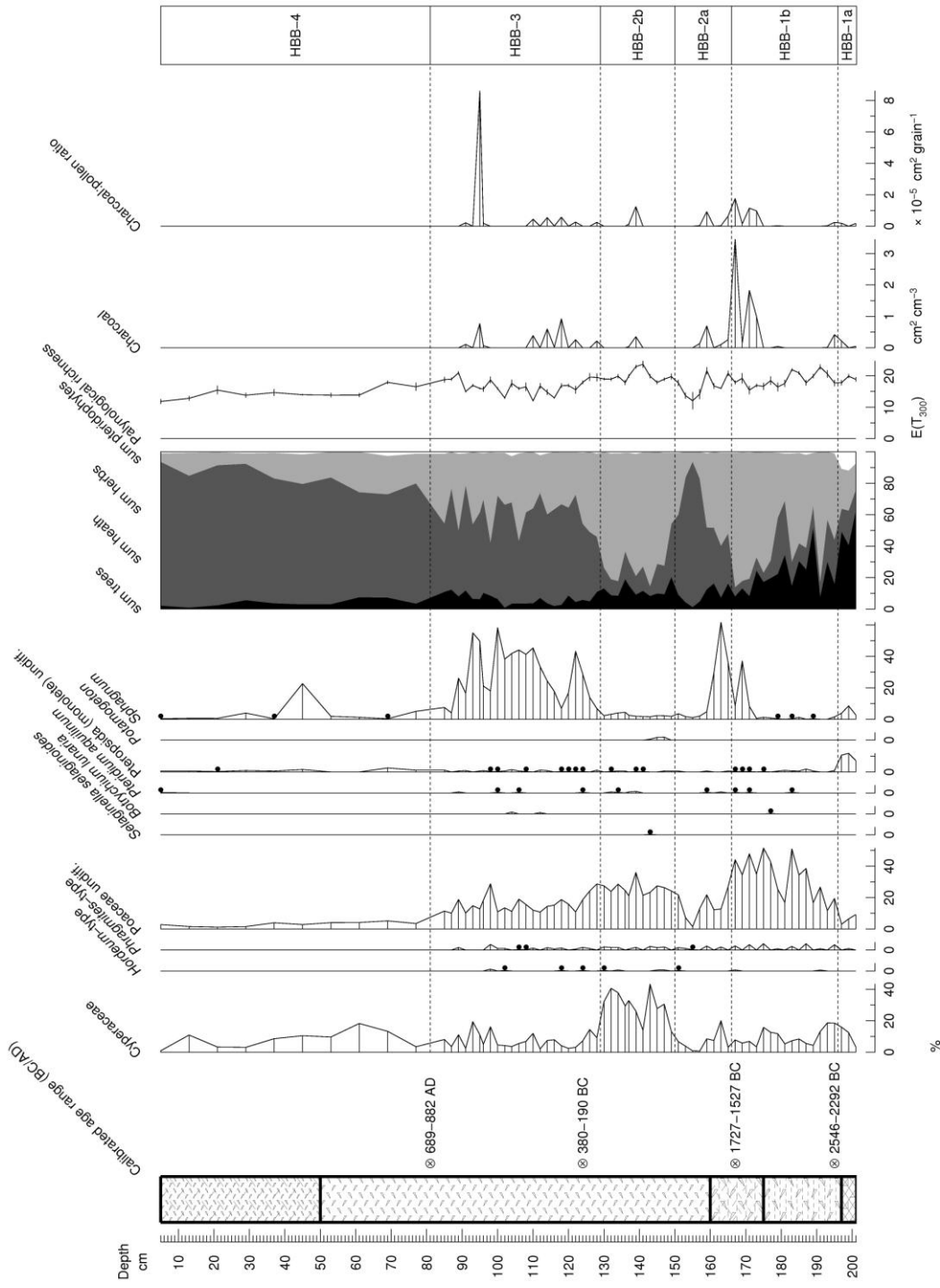
Figure 6.18 (continued) Percentage pollen and spore diagram from sequence B

266
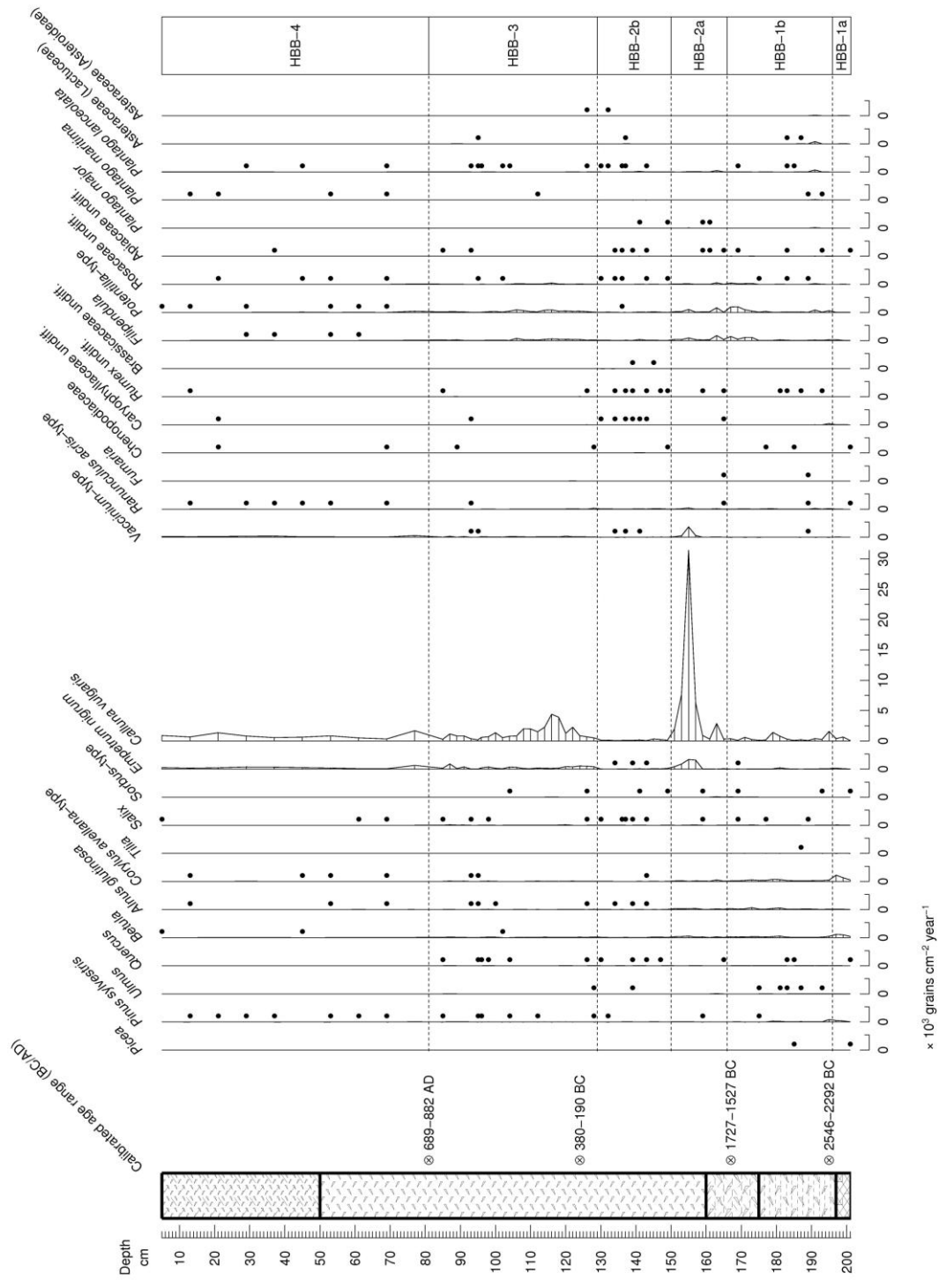
Figure 6.19 Pollen and spore accumulation rate diagram from sequence B

267
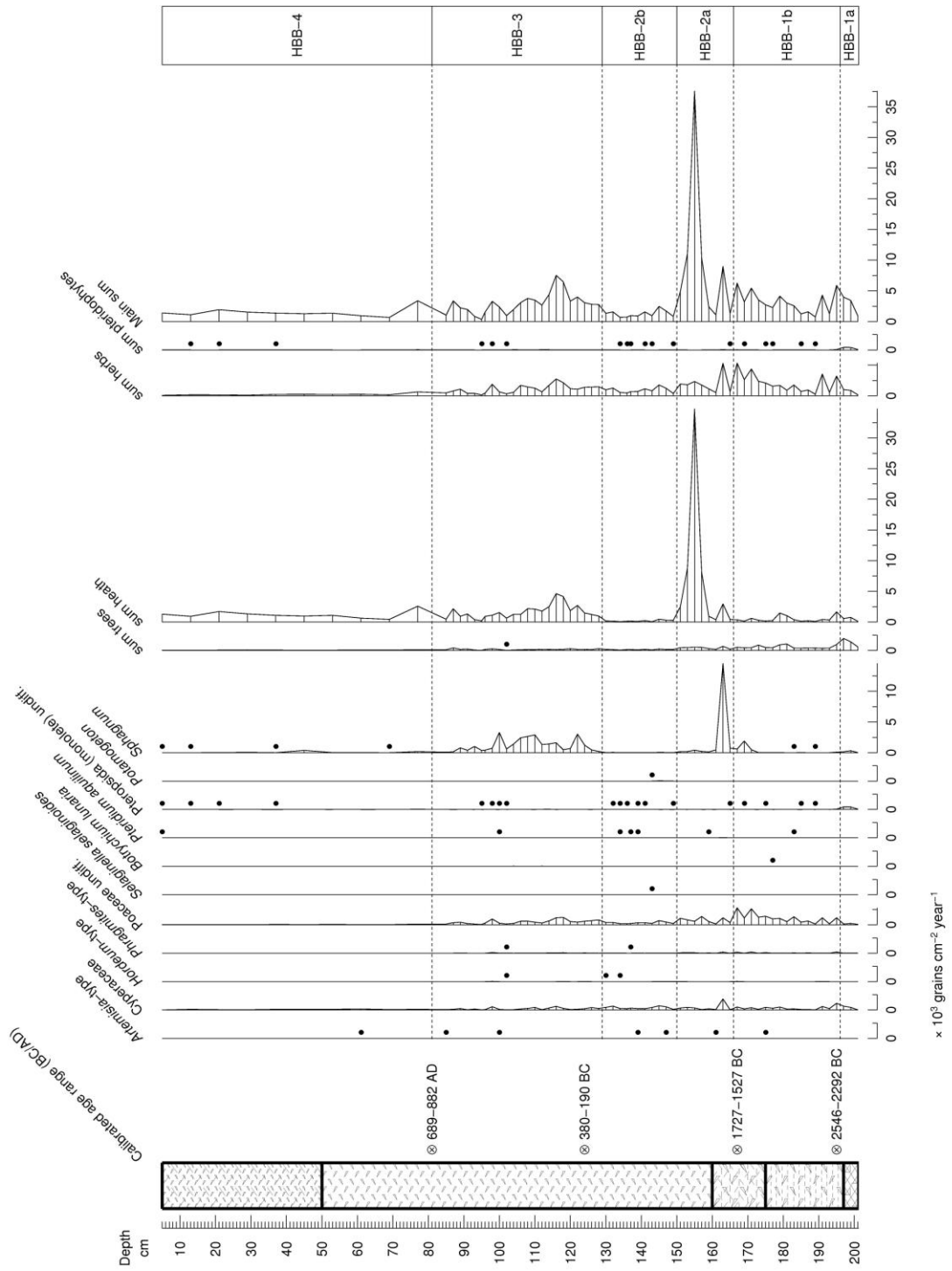
Figure 6.19 (continued) Pollen and spore accumulation rate diagram from sequence B

Hobbister B

The basal sample from this sequence, from a depth of 203 cm, was highly inorganic (see Table 6.5; Fig. 6.15) and had a very low pollen concentration. On this basis it was suspected that the pollen assemblage contained within it may be biased. Bunting and Tipping (2000) have devised nine possible tests aimed at determining the interpretative potential of pollen assemblages, since extensive or differential destruction of a pollen assemblage can render it meaningless (Bunting *et al*. 2001; Tipping *et al*. 2009). In order to assess the state of pollen preservation and hence the interpretability of the sample from 203 cm, seven of these 'quality tests' were applied to the data from it. Results are presented in Table 6.6.

SUMMARY POLLEN DATA	
Total identifiable land pollen and spores sum	65
Percentage trees	18%
Percentage heath taxa	11%
Percentage herbaceous taxa	48%
Percentage pteridophytes	26%
Identifiable land pollen and spore concentration (grains cm^{-3})	2997
Number of main sum taxa	17
Percentage indeterminable grains	12%
Percentage severely deteriorated grains	66%
Percentage 'resistant' taxa	20%
Sordaria-type ascospores	1
Area of microscopic charcoal (cm^{2}cm^{-3})	0.21067
'QUALITY TESTS' (Bunting and Tipping 2000; Bunting *et al*. 2001)	
Total identifiable land pollen and spores sum (<300)	✗
Pollen and spore concentration (<3000 grains cm^{-3})	✗
Number of main sum taxa (<10)	✓
Percentage severely deteriorated grains (>35%)	✗
Percentage indeterminable grains (>30%)	✓
Percentage 'resistant' taxa (>6%)	✗
Percentage Pteropsida (monolete) undiff. spores (>25%)	✗

Table 6.6 Summary pollen data and results of preservation tests on the basal sample from sequence B

The first test applied here is based on the fact that a sum of 300 land pollen and spores is required for statistical purposes (e.g. Maher 1972; Moore *et al*. 1991). The second test considers that a minimum pollen concentration of 3000 grains cm^{-3} is necessary for interpretation (Bryant and Hall 1993; Bunting and Tipping 2000; Tipping *et al*. 2009). Assemblages with low numbers of pollen taxa are generally considered to represent the loss of taxa that are more vulnerable to decay (Tipping *et al*. 2009), and this is the basis

for the third test applied here. Tipping *et al*. (1994) have suggested that high numbers of severely deteriorated pollen grains can indicate that pollen assemblages have been distorted, either by differential pollen preservation or by mixing with older material. High proportions of indeterminable grains do not always correlate with other measures of biasing in pollen assemblages, but Tipping *et al*. (1994) regard high levels of indeterminable grains as a reason to reject samples from further analysis. The basis for test 6 is that differential resistance to deterioration of different taxa can lead to substantial biasing of pollen assemblages (Bunting *et al*. 2001). The taxa included in the 'resistant' category here include Caryophyllaceae, Brassicaceae, and Asteraceae (Lactuceae), following Bunting *et al*. (2001) and Tipping *et al*. (2009), and it is felt that high proportions of these taxa may indicate distorted assemblages. Spores of Pteropsida are also known to be relatively resistant to decay, and a value of 25%+ is used as an indication of a biased assemblage here, following Bunting *et al*. (2001).

As Tipping *et al*. (2009) point out, the cut-off values used to fail samples are somewhat arbitrary as there are currently no data from which to identify these more accurately. However, the sample from a depth of 203 cm in sequence B fails five out of the seven tests applied here, and it is considered that the pollen assemblage contained within it is probably too biased for interpretation. The sample is therefore not included in the pollen diagrams for this sequence, which are described below.

Zone HBB-1 (201-166 cm; c. 2590-1600 cal. BC)

Pollen accumulation rates are generally higher throughout the sequence than those from sequence A, and fluctuate between *c*. 2000 and *c*. 6000 grains cm^{-2}year^{-1} throughout zone HBB-1. Average arboreal pollen percentages are at their highest in this zone, although there is considerable variation in the frequencies of arboreal taxa throughout, with proportions ranging from 10% to 60%. The zone is dominated by herbaceous taxa, which make up 60-80% of the pollen sum, and heath taxa are present at frequencies of between 10% and 30% throughout. Overall there is considerable variation in the proportions of the main taxa represented in this zone. The zone is divided into two subzones, each of which is described below.

Subzone HBB-1a (201-196 cm; c. 2590-2450 cal. BC)

Pollen accumulation rates in this subzone are around 2000-4000 grains cm^{-2}year^{-1}. Arboreal pollen percentages are high (*c*. 50%), and the main taxa included in this group

are *Pinus sylvestris* (*c.* 5%), *Betula* (*c.* 20%), and *Corylus avellana*-type (*c.* 30%). Proportions of pteridophyte spores are also relatively high in this subzone, comprising *c.* 10% of the total sum.

Herbaceous taxa form around 25% of the pollen sum in this subzone, and mainly comprise Cyperaceae (*c.* 10%) and Poaceae (*c.* 5%), with lower frequencies (1-2%) of Caryophyllaceae, *Filipendula*, *Potentilla*-type. Rosaceae undiff. and Asteraceae (Asteroideae). Heathland taxa are represented at frequencies of *c.* 20%, mainly comprising *Calluna vulgaris* with lower proportions (2-3%) of *Empetrum nigrum* and *Vaccinium*-type.

Sphagnum spores are present at low frequencies of 5-10%, and palynological richness is relatively high, around 19 taxa. Microscopic charcoal is present in low amounts (*c.* 0.2 cm^2cm^{-3}) at the top of the subzone.

Subzone HBB-1b (196-166 cm; c. 2450-1600 cal. BC)
Pollen accumulation rates increase slightly in this subzone, from *c.* 2000 grains $cm^{-2}year^{-1}$ at the base to *c.* 6000 grains $cm^{-2}year^{-1}$ towards the top. Proportions of arboreal pollen are lower in this subzone, although values fluctuate between *c.* 10% and *c.* 60% throughout. In general, there is a decline in arboreal pollen from the base to the top of the subzone. The main taxa present are *Pinus sylvestris*, *Betula* and *Corylus avellana*-type as before, although frequencies of all these taxa decline at the start of the subzone and continue to decrease steadily throughout. However, at a depth of 189 cm percentages of *Alnus glutinosa* pollen increase to around 15% of the total, and this taxon forms between 5 and 10% of the sum for the remainder of the subzone. Low frequencies (*c.* 1%) of *Ulmus* and *Quercus* pollen are recorded throughout. Percentages of pteridophyte spores are low (<1%).

This subzone is dominated by herbaceous taxa, the proportion of which fluctuates considerably between 40 and 80% throughout. Within this group of taxa, percentages of Cyperaceae pollen decline at the start of the subzone and make up *c.* 10-15% of the pollen sum throughout. Poaceae pollen frequencies increase at the base of the subzone, reaching values of *c.* 50% at a depth of 183 cm. Frequencies of this taxon then decrease to *c.* 15%, before increasing to about 50% again by the boundary with HBB-2a. Other herbaceous taxa present include *Ranunculus acris*-type (*c.* 2%), *Filipendula* (*c.* 2% at

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the start, increasing to *c.* 15% by the end), *Potentilla*-type (around 5% for most of the subzone, with a peak of *c.* 30% at 169 cm), Rosaceae undiff., and *Phragmites*-type. There is a peak of about 8% *Plantago lanceolata* pollen at a depth of 191 cm, although proportions of this taxon are much smaller (<1%) for the rest of the subzone. A peak of Asteraceae (Lactuceae) occurs at the same depth, where this taxon forms around 10% of the total pollen sum. *Hordeum*-type pollen occurs towards the base and the top of the subzone.

Percentages of heath taxa also vary markedly throughout this subzone, with frequencies of between 10 and 35%. Peaks in percentages of heath taxa occur at 195 and 179 cm, where values reach *c.* 30% and *c.* 35% respectively. These peaks are mainly due to increases in the frequencies of *Calluna vulgaris* pollen, which are highest between 195 and 191 cm and between 183 and 179 cm. Percentages of *Empetrum nigrum* pollen are between 2 and 5% throughout the subzone, and there are lower (*c.* 1%) proportions of *Vaccinium*-type pollen.

Sphagnum spore frequencies are low for most of the subzone, but increase markedly at a depth of 169 cm to reach a value of *c.* 35%, then decrease almost immediately to *c.* 10% at the boundary with HBB-2a. Palynological richness is higher at the start of the subzone than at the end, decreasing from around 22 taxa to *c.* 17 taxa. Microscopic charcoal is present from a depth of 173 cm until the end of the subzone, with values ranging from *c.* 1.0 to *c.* 3.4 cm^2cm^{-3}.

Zone HBB-2 (166-129 cm; c. 1600-440 cal. BC)

Pollen accumulation rates are generally around 2000 grains $cm^{-2}year^{-1}$, although there are occasional higher peaks. This zone is mainly dominated by herbaceous pollen, although there is a short-lived peak of heathland taxa in the earlier part of the zone. Frequencies of arboreal pollen are low, around 10%, throughout most of the zone, although there are occasional higher peaks of *c.* 15-20%. Proportions of pteridophyte spores are negligible, being less than 1% throughout the whole zone. There are two subzones within this zone, each of which is described below.

Subzone HBB-2a (166-150 cm; c. 1600-1100 cal. BC)

In this subzone pollen accumulation rates reach their highest values, though these are not sustained throughout. Values are *c.* 8000 grains $cm^{-2}year^{-1}$ at the start of the

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subzone, increasing rapidly to peak at around 35,000 grains cm^{-2}year^{-1} at a depth of 155 cm before declining to c. 4000 grains cm^{-2}year^{-1} by the end of the subzone.

Arboreal pollen percentages are around 15% at the base of the subzone and decline to almost 1% at a depth of 155 cm, before increasing again to c. 10% at the top of the subzone. Proportions of *Betula*, *Alnus glutinosa* and *Corylus avellana*-type pollen are fairly similar, around 5% for most of the subzone. Values of other taxa such as *Pinus sylvestris*, *Ulmus* and *Quercus* are less than 1% throughout.

Herbaceous taxa dominate at the base of the subzone, and mainly consist of Cyperaceae (c. 20%) and Poaceae (c. 25%) pollen. *Filipendula* and *Potentilla*-type pollen occur at frequencies of c. 10% each at the base of the subzone, but both decline to around 2% of the pollen sum by the end. Other herbaceous taxa represented at low frequencies of 1-2% include *Ranunculus acris*-type, Rosaceae undiff., *Plantago lanceolata*, and *Phragmites*-type. *Hordeum*-type pollen is present at the top of the subzone.

Percentages of heath taxa are around 30% at the start of the subzone, but increase markedly at a depth of 153 cm to form about 90% of the total pollen sum, before declining again to c. 40% at the boundary with HBB-2b. The main component of this group is *Calluna vulgaris*, pollen percentages of which vary between 25% and 80% in this subzone. A sudden influx of *Calluna vulgaris* pollen at a depth of 155 cm, where the accumulation rate of this taxon is c. 30,000 grains cm^{-2}year^{-1}, accounts for the sharp increase in percentages of heath taxa seen at this depth. One explanation for this sudden influx of *Calluna vulgaris* may be that an anther of this species was incorporated into the sediment at this depth. Other taxa in the heath group include *Empetrum nigrum*, pollen frequencies of which increase from c. 3% at the base of the subzone to around 10% at the top, and *Vaccinium*-type, which forms around 2% of the total pollen sum throughout.

Proportions of *Sphagnum* spores are high (c. 60%) at the base of the subzone, but decline rapidly and are only about 2% at the boundary with HBB-2b. Palynological richness is around 20 taxa at the beginning of the subzone, but drops markedly to c. 12 taxa before increasing to around 18 taxa at the end. Charcoal is recorded in the lower part of the subzone at values of 0.1-0.6 cm^{2}cm^{-3}, although none is present above a depth of 157 cm.

Subzone HBB-2b (150-129 cm; c. 1100-440 cal. BC)

Pollen accumulation rates in this subzone are between 2000 and 3000 grains $cm^{-2}year^{-1}$. Arboreal pollen percentages are around 10% for most of this subzone, although there are occasional peaks of *c.* 15-20% in places. The range of taxa present are as before, although percentages of *Betula* pollen are slightly higher than those in HBB-2a and those of *Alnus glutinosa* and C*orylus avellana*-type pollen are lower. *Pinus sylvestris* pollen frequencies increase slightly to *c.* 3%, and *Quercus* proportions are also slightly higher than previously at around 2% in places.

This subzone is dominated by herbaceous pollen, which makes up around 70% of the total pollen sum in most samples. This group is again mainly comprised of Cyperaceae and Poaceae pollen, which occur at frequencies of *c.* 30% and *c.* 25% respectively. *Ranunculus acris*-type pollen is more abundant than previously, reaching values of about 5%, and frequencies of *Filipendula* and *Potentilla*-type pollen are about 3-5% for most of the subzone, although *Filipendula* pollen reaches an isolated peak of around 10% at a depth of 141 cm. Other herbaceous taxa represented at low frequencies include Caryophyllaceae, Brassicaceae, Rosaceae, Apiaceae and *Phragmites*-type. Anthropogenic indicator taxa such as *Rumex* undiff. and *Plantago lanceolata* also occur at low frequencies, around 1%, except at a depth of 141 cm where *P.lanceolata* forms *c.* 6% of the total pollen sum. *Hordeum*-type pollen is present throughout the subzone.

Frequencies of heathland taxa are low throughout this subzone, forming between 10 and 20% of the total pollen sum. Again, the dominant taxon in this group is *Calluna vulgaris*, with lower proportions of *Empetrum nigrum* and *Vaccinium*-type pollen than in the previous subzone.

Sphagnum spores occur at low frequencies of around 2% throughout, and *Potamogeton* pollen is recorded between 147 and 143 cm at values of *c.* 2%. Palynological richness fluctuates between about 20 and 25 taxa, and a small, isolated peak of charcoal occurs at 139 cm (0.35 $cm^{2}cm^{-3}$).

Zone HBB-3 (129-81 cm; c. 440 cal. BC – 770 cal. AD)

Pollen accumulation rates in this zone are mainly around 3000 grains $cm^{-2}year^{-1}$, although they fluctuate between *c.* 1000 and *c.* 7000 grains $cm^{-2}year^{-1}$ throughout. In

general, pollen accumulation rates tend to be higher in the lower half of the zone than in the upper.

Arboreal pollen percentages are *c*. 5% at the base of the zone, although they increase slightly to around 10% of the total sum towards the top. This expansion is due to increases in the percentages of *Betula* and *Corylus avellana*-type pollen, although there is also a slight increase in the pollen of *Pinus sylvestris* at around the same depth. Proportions of *Alnus glutinosa* pollen are very low (*c*. 1%) in this zone.

There is a marked expansion in the proportion of heathland taxa at the start of this zone, with values increasing to *c*. 40% of the total pollen sum. Frequencies of this group of taxa fluctuate markedly throughout the zone, ranging from 30-65%. These fluctuations are due to variations in the percentages of *Calluna vulgaris* and *Empetrum nigrum* pollen, which form the main components of this group of taxa. Frequencies of *Calluna vulgaris* pollen vary between 20 and 60%, and those of *Empetrum nigrum* pollen range from 5 to 25%. Pollen accumulation rates for *Calluna vulgaris* are higher in the lower half of the zone than in the upper part, although they do exhibit fluctuations which correspond with those in the percentage diagram. *Vaccinium*-type pollen forms *c*. 3% of the total pollen sum throughout the zone.

Proportions of herbaceous taxa also fluctuate throughout this zone, ranging between *c*. 20% and *c*. 60% of the total pollen sum and corresponding with variations in the proportions of heath taxa. The dominant taxon in this group is Poaceae, percentages of which vary between 10 and 20%, with occasional higher peaks of *c*. 30%. Cyperaceae pollen percentages are much lower than in HBB-2b, ranging from *c*. 5-15%. Frequencies of *Filipendula* and *Potentilla*-type pollen average around 5% for most of the zone, although both taxa reach peak values at a depth of 106 cm (*c*. 10% and *c*. 15% respectively). *Ranunculus acris*-type pollen percentages decline at the beginning of the zone and remain at values of around 1% throughout. Rosaceae undiff. and *Phragmites*-type pollen occur throughout the zone at low frequencies, and pollen of anthropogenic indicator species including *Rumex* undiff., *Plantago lanceolata* and *Artemisia*-type is present sporadically and at low frequencies. *Hordeum*-type pollen is occasionally present, but does not occur above 98 cm.

Percentages of *Sphagnum* spores are high (*c.* 50%) throughout most of this zone, although they are less frequent between 120 and 114 cm and from 91 cm until the end of the zone. Palynological richness varies between about 15 and 20 taxa. Low values of microscopic charcoal were recorded at the base of the zone, averaging around 0.5 cm^{2}cm^{-3} up to a depth of 114 cm, after which none was recorded until a depth of 95 cm, where values reach *c.* 0.8 cm^{2}cm^{-3}. This peak corresponds with a distinct peak in the charcoal:pollen ratio. No microscopic charcoal is recorded above 91 cm.

Zone HBB-4 (81-5 cm; c. 770-1950 cal. AD)

In this zone, pollen accumulation rates are much lower than previously, averaging around 2000 grains cm^{-2}year^{-1}. Frequencies of arboreal pollen are extremely low throughout the zone, making up less than 10% of the total pollen sum. The taxa represented are again *Betula, Alnus glutinosa* and *Corylus avellana*-type.

Pollen of heathland taxa dominates this zone, percentages of which exhibit a steady increase throughout. Frequencies of heath taxa are around 75% at the base of the zone, increasing to *c.* 90% at the end of the sequence. Again the dominant taxon in this group is *Calluna vulgaris*, with pollen percentages of around 50-60% for most of the zone. There is a slight decrease in frequencies of this taxon between 45 and 29 cm however, where percentages of *Empetrum nigrum* and *Vaccinium*-type pollen increase slightly. For most of the zone these taxa make up *c.* 15% and *c.* 8% of the total pollen sum respectively, but where *Calluna pollen* percentages decline *Empetrum nigrum* pollen percentages increase to *c.* 25% and those of *Vaccinium*-type rise to *c.* 15%.

At the start of this zone herbaceous taxa make up *c.* 25% of the total pollen sum, before declining to *c.* 10% at the end of the sequence. This is mainly due to variations in percentages of Cyperaceae pollen, which decrease from *c.* 15% at the base of the zone to *c.* 5% at the top. Frequencies of Poaceae pollen decline at the start of the zone and remain at around 3% of the total pollen sum throughout. Other herbaceous taxa represented at low frequencies of *c.* 1% include *Ranunculus acris*-type, *Filipendula*, *Potentilla*-type and Rosaceae undiff. Percentages of anthropogenic indicator taxa such as *Rumex* undiff., *Plantago lanceolata* and *Artemisia*-type are extremely low and infrequent, and no cereal-type pollen is present.

Frequencies of *Sphagnum* spores are generally low throughout this zone, although there is an isolated peak at a depth of 45 cm where values reach about 20%. Palynological richness decreases steadily throughout the zone, from around 18 taxa at the start to *c*. 12 taxa by the end of the sequence. No microscopic charcoal is recorded.

6.4.6 Non-Pollen Palynomorph Analysis

A diagram showing recorded frequencies of non-pollen palynomorphs (NPPs) as percentages of the combined sum of total land pollen and spores plus NPPs (following Mighall *et al*. 2006) is presented in Fig. 6.20 for sequence A, and Fig. 6.21 for sequence B. All NPPs recorded are fungal ascospores, all of coprophilous species (van Geel *et al*. 2003; Graf and Chmura 2006). In order to aid interpretation and discussion, the pollen zonation schemes have also been applied to this data.

Hobbister A
Zone HBA-1 (373-319 cm; c. 5250-3920 cal. BC)
The only NPP type recorded in this zone is *Sordaria*-type ascospores, of which low frequencies are recorded. The two subzones are described individually below.

Subzone HBA-1a (373-353 cm; c. 5250-4760 cal. BC)
Very low (<1%) frequencies of *Sordaria*-type ascospores are recorded throughout this subzone.

Subzone HBA-1b (353-319 cm; c. 4760-3920 cal. BC)
Frequencies of *Sordaria*-type ascospores reach around 4% near the base of this subzone, although they decline to *c*. 1.5% by the end.

Zone HBA-2 (319-216 cm; c. 3920-1820 cal. BC)
Sordaria-type ascospores are consistently present throughout this zone, generally fluctuating between frequencies of 1 and 5% throughout. They reach a peak of *c*. 15% at a depth of 293 cm, and other occasional peaks of *c*. 7-9% occur in the upper part of the zone. An isolated occurrence of *Podospora*-type is present at 219 cm.
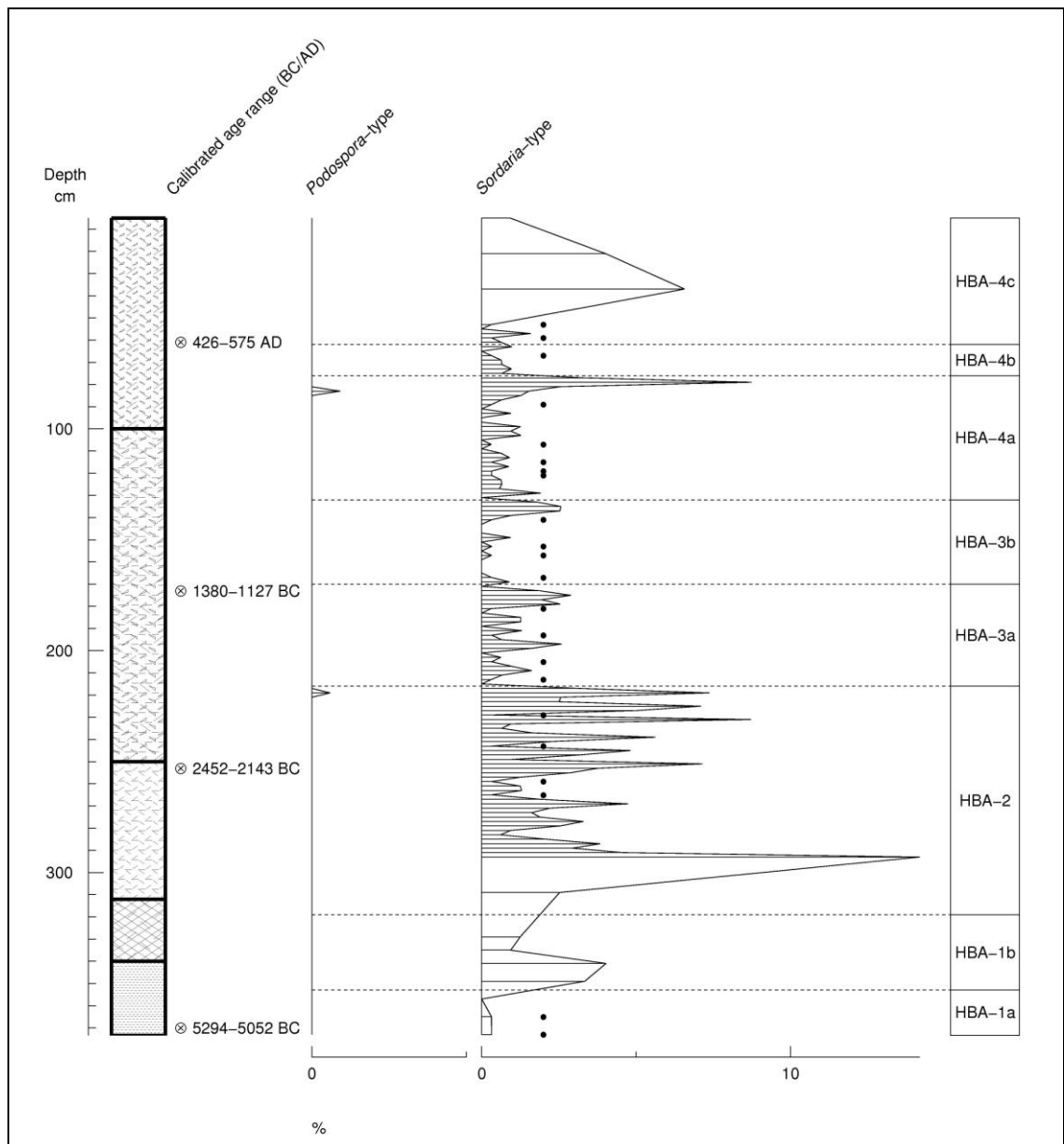
Figure 6.20 Percentages of non-pollen palynomorphs recorded in sequence A

Zone HBA-3 (216-132 cm; c. 1820-610 cal. BC)

Sordaria-type ascospores are the only NPP type present in this zone, and they occur at lower frequencies than in HBA-2. The two subzones are described in turn below.

Subzone HBA-3a (216-170 cm; c. 1820-1210 cal. BC)

Sordaria-type ascospores are present in quantities of 1-2% throughout most of the subzone.

Subzone HBA-3b (170-132 cm; c. 1210-610 cal. BC)

Very low frequencies (less than 1%) of *Sordaria*-type ascospores occur in the lower two-thirds of this subzone, although percentages increase to *c*. 2% above a depth of 137 cm.

Zone HBA-4 (132-5 cm; c. 610 cal. BC – 1950 cal. AD)

Low frequencies of *Sordaria*-type ascospores occur throughout much of this zone, although values increase significantly towards the end of the zone.

Subzone HBA-4a (132-76 cm; c. 610 cal. BC – 270 cal. AD)

Percentages of *Sordaria*-type ascospores fluctuate around 1% for much of this subzone, although a peak of *c*. 9% occurs at a depth of 79 cm. An isolated occurrence of *Podospora*-type ascospores (*c*. 1%) occurs at 83 cm.

Subzone HBA-4b (76-62 cm; c. 270-480 cal. AD)

Very low percentages (less than 1%) of *Sordaria*-type ascospores are present throughout this subzone.

Subzone HBA-4c (62-5 cm; c. 480-1950 cal. AD)

Sordaria-type ascospores occur at frequencies of *c*. 1% at the start of this subzone. At a depth of 37 cm they reach values of *c*. 6%, before declining steadily to around 1% again by the end of the sequence.

Hobbister B

Zone HBB-1 (201-166 cm; c. 2590-1600 cal. BC)

Low frequencies of *Sordaria*-type ascospores occur intermittently in this zone.

Subzone HBB-1a (201-196 cm; c. 2590-2450 cal. BC)

No NPPs were observed in this subzone.

Subzone HBB-1b (196-166 cm; c. 2450-1600 cal. BC)

Sordaria-type ascospores occur in the lower part of this subzone at frequencies of less than 1%, except at a depth of 185 cm where a peak of *c*. 3.5% is reached.
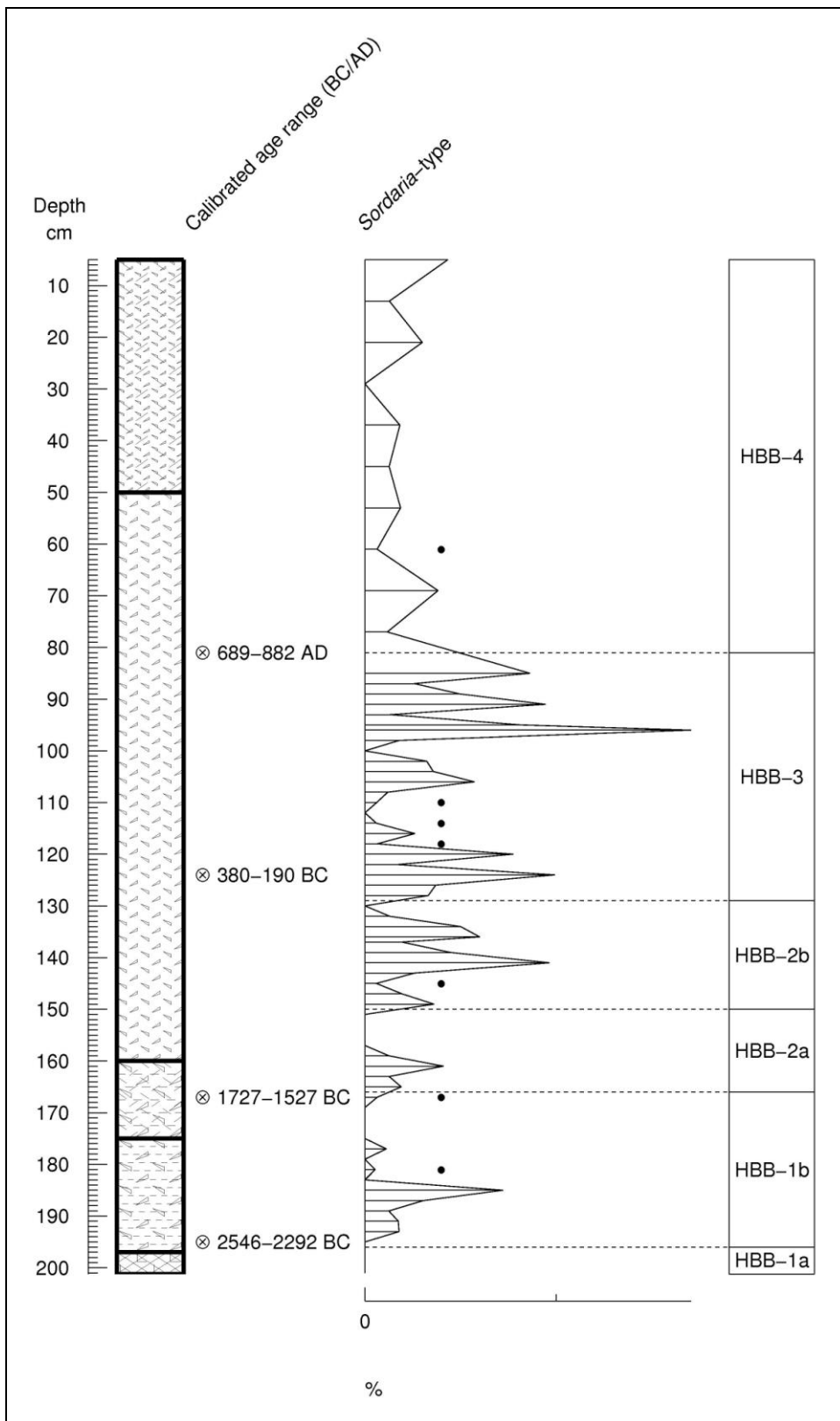
Figure 6.21 Percentages of non-pollen palynomorphs recorded in sequence B

Zone HBB-2 (166-129 cm; c. 1600-440 cal. BC)

Sordaria-type ascospores were recorded at values of less than 5% in most of the samples from this zone.

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Subzone HBB-2a (166-150 cm; c. 1600-1100 cal. BC)

At the base of this subzone *Sordaria*-type ascospores occur in frequencies of 1-2%, although none were recorded in the upper part of the subzone.

Subzone HBB-2b (150-129 cm; c. 1100-440 cal. BC)

Sordaria-type ascospore percentages fluctuate between 1 and 2% for most of the subzone, although peaks of *c*. 5% and *c*. 3% occur at depths of 141 and 136 cm respectively.

Zone HBB-3 (129-81 cm; c. 440 cal. BC – 770 cal. AD)

Frequencies of *Sordaria*-type ascospores are higher in the lower and upper thirds of this zone than in the middle, where they decline to 1-2% between 118 and 198 cm. Prior to this they fluctuate around 4%, and following the decline their frequency reaches a peak of *c*. 8% at 96 cm, before declining again to around 4% by the boundary with HBB-4.

Zone HBB-4 (81-5 cm; c. 770-1950 cal. AD)

Sordaria-type ascospores are present in low frequencies throughout this zone, with quantities varying between 1 and 2% in most samples.

6.4.7 Microstructure Analysis

A diagram showing the results of the analysis of sieve residues retained during pollen processing of sequence A is shown in Fig. 6.22. Table 6.7 records the frequencies of seeds and megaspores recovered during this process. The results of microstructure analysis on sequence B are presented in Fig. 6.23 and Table 6.8. Again, the zonation schemes used are the same as those for the pollen diagrams in order to aid description and interpretation.

Figure 6.22 Results of microstructure analysis on sieve residues retained during pollen processing of sequence A

Figure 6.22 (continued) Results of microstructure analysis on sieve residues retained during pollen processing of sequence A

Zone	Depth (cm)	Aboreal taxa		Fen taxa							Aquatic taxa		
		Betula seed	*Salix* seed	*Carex* seed	*Juncus* seed	*Potentilla* seed	cf. *Potentilla* seed	*Scirpus* seed	*Selaginella* megaspore	*Spergularia* seed	*Potamogeton* seed	*Chara* oospore	*Nitella* oospore
HBA-4b	65				1								
HBA-4a	87				1								
	95				3				1				
	119					1							
HBA-3b	149			1		1							
	157					1							
HBA-3a	179					1							
	187				1								
	191				1								
	195				3								
	199				3								
	201				3								
	209				2								
	213				2								
	215	1				1							
HBA-2	219				1								
	235			1	1								
	237			1									
	241			1		1							
	245				1								
	247			1									
	253			1									
	257					1							
	261			1		2				1			
	265										1		
	267										2		
	273							1					
	275							3					
	279			1							1		
	281			2	1								
	283		1										
	285	1											
	287				1								
	291	1											
	293										1		
	309										1		
HBA-1b	329				4		1					1	1
	335				2								
	341				6							1	
	349				4								

Table 6.7 Frequencies of seeds, megaspores and oospores retained from sieve residues from sequence A

Hobbister A

Zone HBA-1 (373-319 cm; c. 5250-3920 cal. BC)

This zone is characterised by more or less equal proportions of graminoid material, non-*Sphagnum* moss fragments, and unidentified organic matter (UOM). Macroscopic

charcoal (>100 μm) occurs in most samples, and seeds of certain fen plants were also recorded. Characeae oospores occur sporadically. The zone is split into two subzones which are each described in turn below.

Subzone HBA-1a (373-353 cm; c. 5250-4760 cal. BC)

The samples in this subzone contain high proportions of graminoid material, although the quantity of these fragments declines slightly towards the boundary with HBA-1b. Lower quantities of non-*Sphagnum* moss fragments and UOM also occur, and macroscopic charcoal is consistently present throughout the subzone.

Subzone HBA-1b (353-319 cm; c. 4760-3920 cal. BC)

Proportions of graminoid material are lower in this zone, and UOM becomes the dominant component of the samples. Fragments of non-*Sphagnum* moss occur in higher frequencies. Seeds noted in this zone include several *Juncus* seeds (see Table 6.7 for frequencies and depths), and a possible *Potentilla* seed at a depth of 329 cm. Characeae oospores, from both *Chara* and *Nitella*, were present at 341 and 329 cm. Charcoal fragments were only recorded in the basal samples of this subzone.

Zone HBA-2 (319-216 cm; c. 3920-1820 cal. BC)

This zone is generally characterised by high proportions of UOM with lower frequencies of graminoid material and non-*Sphagnum* moss fragments, although the differences between the proportions of these different types of organic material are not large. Occasional pieces of *Sphagnum* moss occur sporadically throughout the zone, and small pieces of wood were noted at depths of 285 and 283 cm. Two *Betula* seeds occur at 291 and 285 cm, and other taxa represented by seeds in this zone include *Carex*, *Juncus*, *Potamogeton*, *Potentilla*, *Salix*, *Scirpus* and possibly *Spergularia*. Charcoal fragments were recorded in the middle of the zone, between 283 and 267 cm, and towards the top of the zone above a depth of 233 cm.

Zone HBA-3 (216-132 cm; c. 1820-610 cal. BC)

The samples in this zone mainly comprise similar proportions of graminoid fragments, non-*Sphagnum* moss and UOM. More *Sphagnum* moss was recorded than in the previous zone. Seeds of fen taxa are recorded throughout, and charcoal is present in almost every sample. The zone is divided into two subzones which are described below.

Subzone HBA-3a (216-170 cm; c. 1820-1210 cal. BC)

Proportions of UOM and graminoid material are roughly equal in most of the samples in this subzone, and amounts of both decline slightly towards the boundary with HBA-3b. Non-*Sphagnum* moss fragments show a corresponding increase in the upper part of the subzone. Pieces of *Sphagnum* are also present occasionally above a depth of 191 cm. Seeds of *Betula*, *Juncus* and *Potentilla* were recorded (see Table 6.7 for depths and frequencies), and macroscopic charcoal occurred in most samples.

Subzone HBA-3b (170-132 cm; c. 1210-610 cal. BC)

Proportions of UOM are lower in this subzone than previously. Graminoid fragments are present in similar frequencies to in HBA-3a initially, but undergo a slight decline in the upper part of the subzone. The major component of most samples in this subzone is non-*Sphagnum* moss, and there are also higher frequencies of *Sphagnum* moss in the top half of the subzone. *Carex*, *Juncus* and *Potentilla* seeds are occasionally present (see Table 6.7), and macroscopic charcoal was recorded in every sample until a depth of 143 cm, above which none is present until the boundary with HBA-4a.

Zone HBA-4 (132-5 cm; c. 610 cal. BC – 1950 cal. AD)

Frequencies of UOM are higher in this zone than previously. Of the identifiable component of the samples, graminoid material and non-*Sphagnum* moss form approximately equal proportions, and *Sphagnum* is occasionally present. *Calluna vulgaris* stem fragments were also identified in several samples. Lower numbers of seeds were recorded than previously, and charcoal still occurs in the majority of samples.

Subzone HBA-4a (132-76 cm; c. 610 cal. BC – 270 cal. AD)

This subzone is characterised by high proportions of UOM at the base, which decline slightly in the middle of the zone before increasing again towards the boundary with HBA-4b. All samples contained fairly large amounts of graminoid material, and most also contained similar quantities of non-*Sphagnum* moss fragments. Pieces of *Sphagnum* are present occasionally, although they are particularly frequent at a depth of 93 cm. Wood was noted at a depth of 79 cm and *Calluna vulgaris* stem fragments were present in several samples. Seeds of *Juncus* and *Potentilla* and a *Selaginella selaginoides* megaspore were recorded at various depths (see Table 6.7), and charcoal is consistently present throughout the subzone.

Subzone HBA-4b (76-62 cm; c. 270-480 cal. AD)

The proportions of most of the major components of the samples remain the same as in HBA-4a, except for graminoid fragments which decrease slightly in frequency. *Sphagnum* is present in low quantities in most samples, and occasional fragments of *Calluna vulgaris* still occur. A single *Juncus* seed was noted at a depth of 65 cm. Macroscopic charcoal is consistently present throughout the subzone.

Subzone HBA-4c (62-5 cm; c. 480-1950 cal. AD)

UOM forms the dominant component of the organic sediment in most samples from this subzone, with graminoid fragments occurring at similar frequencies to in HBA-4b. Non-*Sphagnum* moss is recorded less frequently, and *Sphagnum* is only present in a single sample at the base of the zone. *Calluna vulgaris* stem fragments occur sporadically, and no seeds are present. Charcoal fragments are recorded in every sample except the uppermost.

Hobbister B

Zone HBB-1 (201-166 cm; c. 2590-1600 cal. BC)

The samples in this zone are dominated by UOM, with lower proportions of graminoid material and non-*Sphagnum* moss. Seeds of several fen taxa are present, as is macroscopic charcoal (>100 μm). The two subzones are described individually below.

Subzone HBB-1a (201-196 cm; c. 2590-2450 cal. BC)

The sediment in this subzone is mainly inorganic (Table 6.5; Fig. 6.15), and very few organic fragments were recovered. Those that are present are mainly graminoid, with some unidentifiable material. Macroscopic charcoal was recorded at the top of the subzone.

Subzone HBB-1b (196-166 cm; c. 2450-1600 cal. BC)

Most of the organic fraction in this subzone comprises UOM, with the next most dominant component being graminoid material. There are lower proportions of non-*Sphagnum* moss in most samples, and a fragment of *Calluna vulgaris* is present at 173 cm. Approximately 100 *Juncus* seeds were recorded at a depth of 195 cm, and fewer seeds of this taxon were also recorded at various other depths throughout the subzone. Other seeds identified include *Carex* and *Potentilla* (see Table 6.8 for details). Fragments of charcoal occur in most samples.
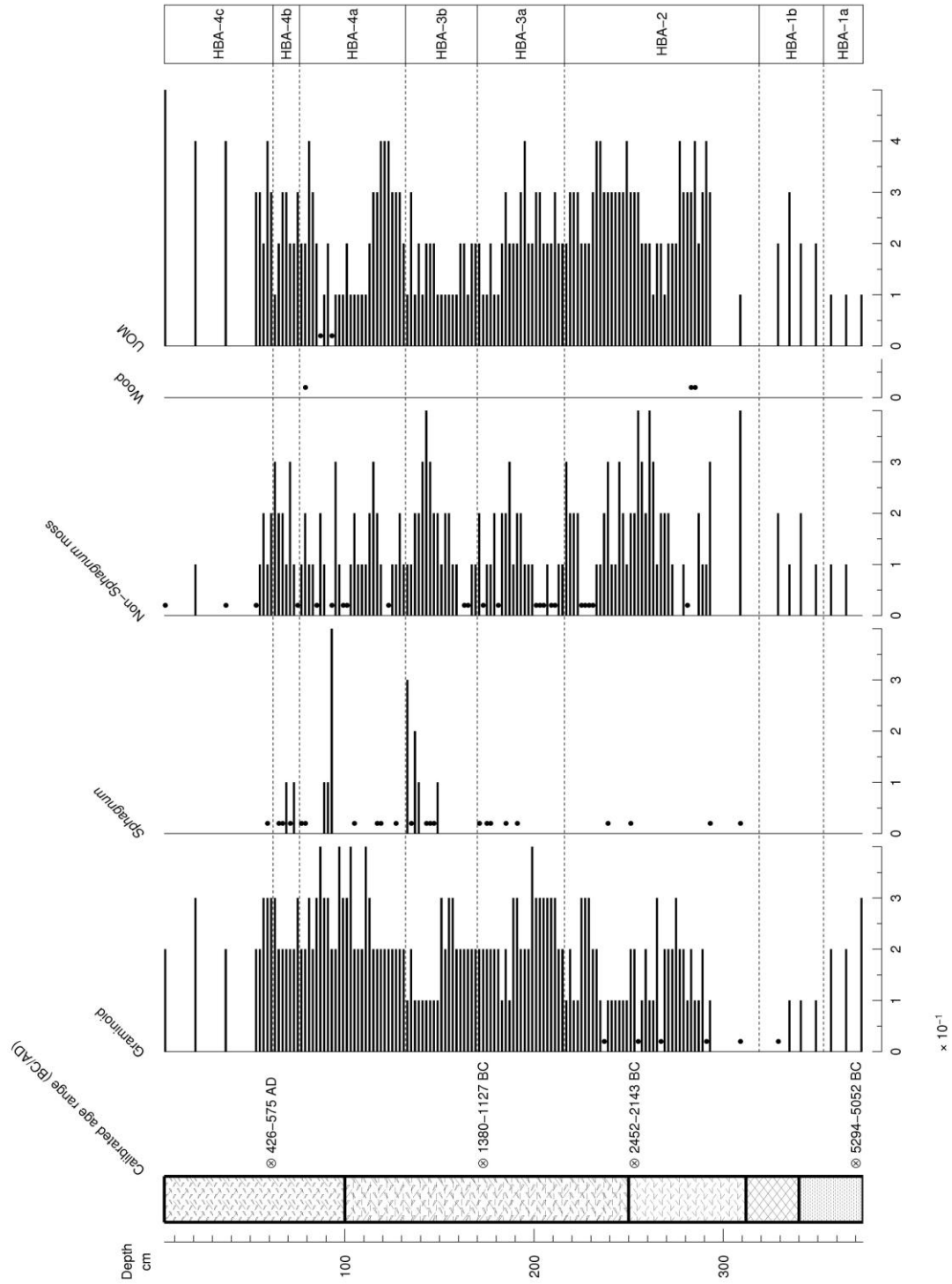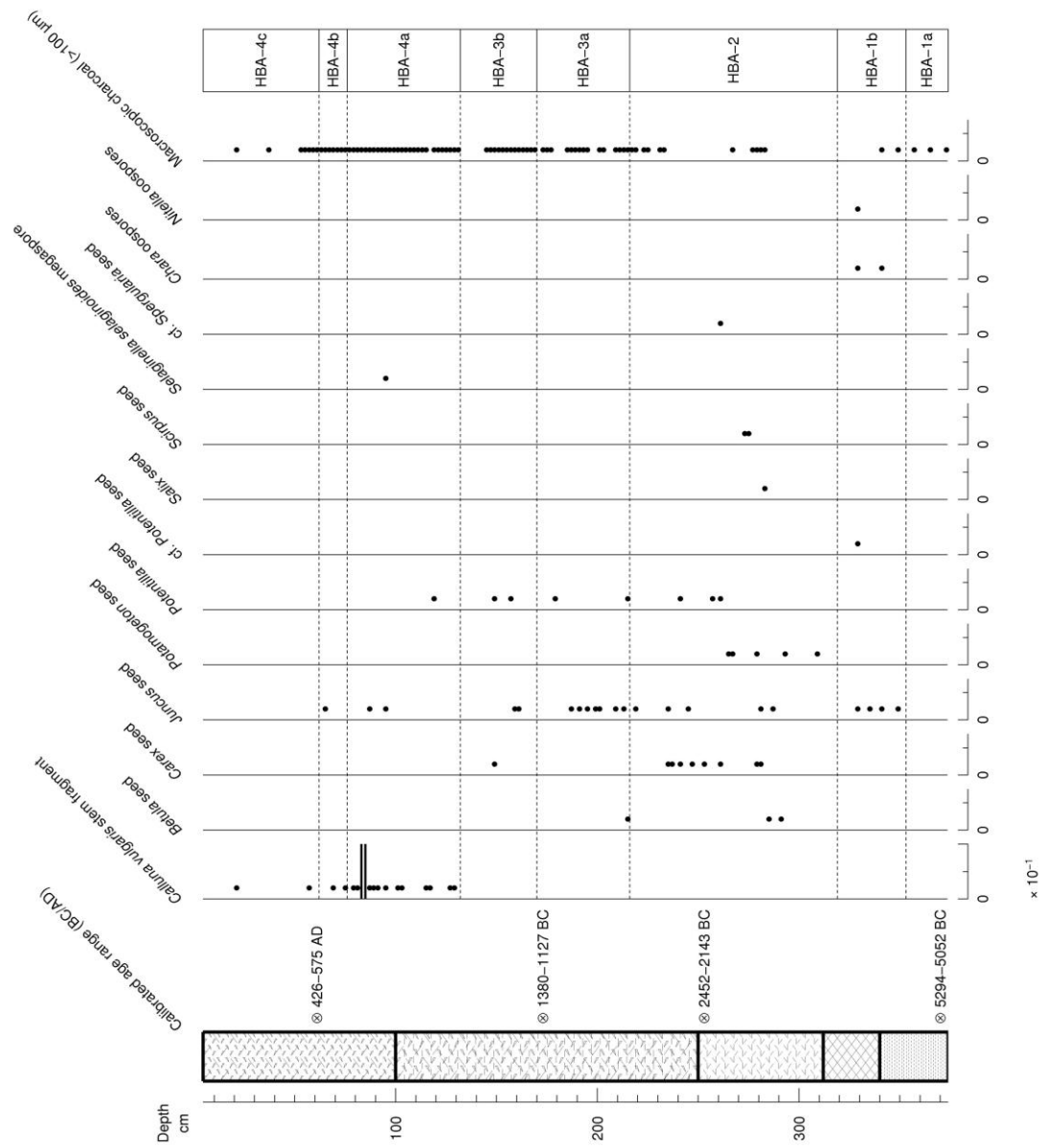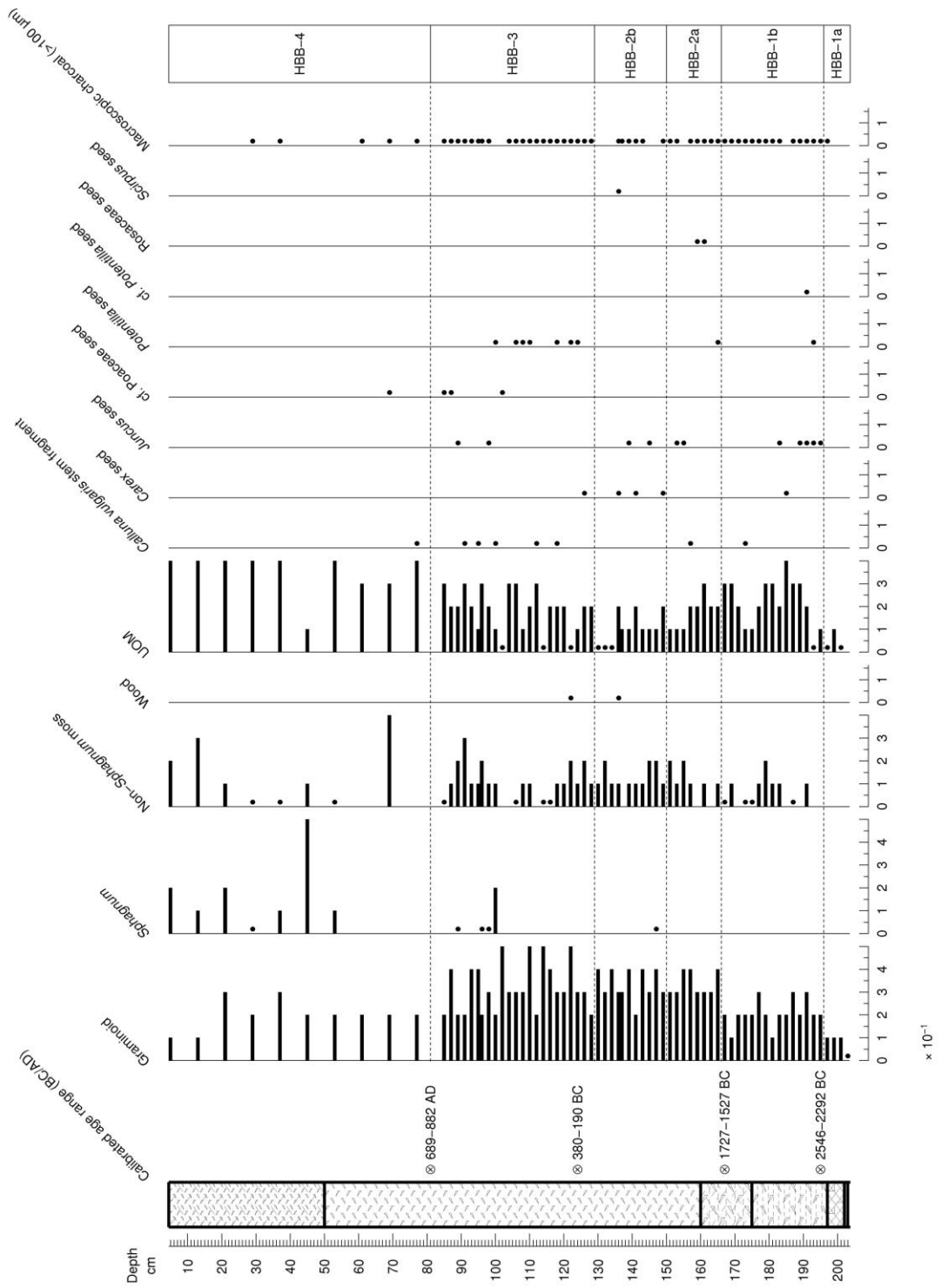
Figure 6.23 Results of microstructure analysis on sieve residues retained during pollen processing of sequence B

| Zone | Depth (cm) | Fen taxa | | | | | | |
		Carex seed	*Juncus* seed	cf. Poaceae seed	*Potentilla* seed	cf. *Potentilla* seed	Rosaceae seed	*Scirpus* seed
HBB-4	69			*c.* 30				
HBB-3	85			*c.* 5				
	87			*c.* 5				
	89		11					
	98		7					
	100				1			
	102			*c.* 100				
	106				1			
	108				1			
	110				1			
	118				1			
	122				1			
	124				1			
	126	1						
HBB-2b	136	1						1
	139		1					
	141	5						
	145		2					
	149	1						
HBB-2a	151		1					
	153		1					
	155		1					
	159						1	
	161						1	
	165				1			
HBB-1b	183		2					
	185	1						
	189		1					
	191		2			1		
	193		7		1			
	195		*c.* 100					

Table 6.8 Frequencies of seeds retained from sieve residues from sequence B

Zone HBB-2 (166-129 cm; c. 1600-440 cal. BC)

This zone is mainly characterised by high proportions of graminoid material, with lower quantities of UOM and non-*Sphagnum* moss. Seeds of fen taxa and charcoal fragments occur throughout. There are two subzones in this zone, each of which is described below.

Subzone HBB-2a (166-150 cm; c. 1600-1100 cal. BC)

The dominant component of the organic fraction in this subzone is graminoid material, which occurs at higher frequencies than in HBB-1b. There are lower proportions of

UOM than previously, although proportions of non-*Sphagnum* moss remain similar to in the previous subzone. A single occurrence of *Calluna vulgaris* was noted at a depth of 157 cm. Seeds of *Juncus*, *Potentilla*, and an unidentified Rosaceae species occur in this subzone (see Table 6.8 for depths and frequencies). Charcoal is present throughout.

Subzone HBB-2b (150-129 cm; c. 1100-440 cal. BC)

This subzone is similar to HBB-2a, although proportions of UOM are slightly lower and decrease further towards the boundary with HBB-3. Non-*Sphagnum* moss fragments show a more consistent presence, and there is a single occurrence of *Sphagnum* at a depth of 147 cm. Wood was also noted at a depth of 136 cm and *Juncus*, *Carex* and *Scirpus* seeds were identified at various depths (Table 6.8). Charcoal is present throughout the lower part of the subzone but was not recorded in the upper part.

Zone HBB-3 (129-81 cm; c. 440 cal. BC – 770 cal. AD)

Proportions of UOM increase again in this zone, although differences in the quantity of unidentifiable material between this zone and the previous are not particularly large. Proportions of graminoid material remain similar to in HBB-2b, although non-*Sphagnum* moss fragments are less consistently present. Pieces of *Sphagnum* were identified between 100 and 89 cm, and fragments of *Calluna vulgaris* stem were observed at various depths. Seeds of *Carex*, *Juncus* and *Potentilla* are present, along with possible Poaceae seeds, *c*. 100 of which are present at a depth of 102 cm (see Table 6.8). Charcoal is present throughout much of the zone.

Zone HBB-4 (81-5 cm; c. 770-1950 cal. AD)

Quantities of UOM are much higher in this zone than previously, and proportions of graminoid material are lower. Proportions of moss, both *Sphagnum* and non-*Sphagnum*, are higher in this zone than in any other, and *Sphagnum* is consistently present from 53 cm until the end of the sequence. Fragments of *Calluna vulgaris* are recorded at the base of the zone but are not present elsewhere. The only seeds present are *c*. 30 possible Poaceae seeds occurring at a depth of 69 cm. Charcoal is less consistently present than previously, but is still found at most depths in the lower part of the zone.

6.5 Discussion

The results of the stratigraphic survey at Hobbister indicate that, in the area surveyed at least, the landscape prior to peat spread contained several small pools, suggesting the presence of pre-paludification wetlands. The survey also showed that there is a deeper basin, around 60 m in diameter, to the north of the site. This basin contains peat up to 3.8 m in depth, and the results of the survey show that the peat becomes shallower upslope. This suggests that paludification of the landscape at Hobbister took place from multiple relatively small basin centres.

Sequence A was taken from within the deeper northern basin. The base of the core is dated to *c*. 5250 cal. BC by linear extrapolation, and the record appears to extend up until the modern period. This interpretation does not require a substantial change in sediment accumulation rate, and although peat is currently extracted from the site it is removed from the side, and there is no evidence to suggest that the peat has ever been cut from the top. The palaeoecological record from this site therefore provides evidence for environmental conditions and land-use from the late Mesolithic through to the present day. Sequence B begins at *c*. 2420 cal. BC, and is believed to cover the period from the late Neolithic until the present day. The changes in vegetation, environment and land-use surrounding Hobbister will be discussed in terms of the broad archaeological periods defined in Chapter 1.

6.5.1 Mesolithic (*c*. 9000 – *c*. 4000 cal. BC)

Only the final 1250 years of this period are represented in the palaeoecological record from Hobbister, and only by sequence A. During the Mesolithic period, high percentages of Cyperaceae pollen combined with high proportions of graminoid and moss fragments in the microstructure data suggest that the site supported fen vegetation. When peat began to form in the small basin to the north of the site at around 5250 cal. BC, arboreal pollen percentages of around 50% (Fig. 6.16) suggest that some woodland was present in the landscape around the mire (e.g. Birks 1988). Most of the arboreal pollen component consists of *Pinus sylvestris*, *Betula* and *Corylus avellana*-type. The latter two taxa, along with *Alnus glutinosa* and *Salix*, which are represented in the record from sequence A at low frequencies, are all generally accepted to have been components of the scrub woodland which was present across much of Orkney prior to *c*. 3950 cal. BC (e.g. Keatinge and Dickson 1979; Bunting 1994; 1996; Blackford *et al.* 1996; de la Vega-Leinert *et al.* 2000; 2007). The Hobbister woodland

also seems to have had a tall-herb and fern-rich understorey, similar to that hypothesised for west Mainland (e.g. Bunting 1994).

Whether the presence of *Pinus sylvestris* pollen in Orcadian palaeoecological sequences represents the local growth of this species or originates via long-distance transport from the Scottish mainland is a matter of some debate (e.g. Moar 1969; Keatinge and Dickson 1979; Bunting 1994). At Quoyloo Meadow in west Mainland, similarities in the pollen curve for *Pinus sylvestris* to those of *Corylus avellana*-type and *Betula* led Bunting (1994) to suggest that this species was locally present, in contrast with other studies (e.g. Moar 1969; Keatinge and Dickson 1979), where the conclusion has been that *Pinus sylvestris* pollen must have originated on the Scottish mainland. By analogy with Shetland (Bennett and Sharp 1993) and the Western Isles (Fossitt 1996), it seems likely that the woodland was more diverse in the more sheltered eastern areas of Orkney, and support for this hypothesis may be provided by a short, undated sequence from Liddle Bog on South Ronaldsay, where *Pinus sylvestris* pollen percentages of *c.* 20% are interpreted by Bartlett (1983) as indicating the local presence of this species at some time during the late Neolithic/early Bronze Age.

At Hobbister, the curve for *Pinus sylvestris* pollen frequencies does share some similarities with those for *Betula* and *Corylus avellana*-type, and at the base of the sequence this taxon forms just over 20% of the total pollen sum. Since pollen percentages of between 20 and 30% are usually taken to indicate that this species grew locally (e.g. Bennett 1984; Gear and Huntley 1991; Charman 1994) it is possible that pine formed part of the woodland around Hobbister at this time. Some support for this argument is provided by pine pollen values of less than 10% in the sequence from Scapa Bay, around 5 km to the east of Hobbister, at this time (de la Vega-Leinert *et al*. 2007). It seems unlikely that there would be such large differences between the two sites if all the pine pollen at Hobbister was the result of long-distance transport.

The local presence on Orkney of *Quercus* has also been widely debated. The general conclusion has again been that pollen from this taxon originates from the Scottish mainland (e.g. Moar 1969; Keatinge and Dickson 1979), although Bunting (1994) has suggested that it may have been locally present in some parts of west Mainland. Evidence for the local presence of *Quercus* in the east of Orkney is provided by the Scapa Bay sequence, where pollen percentages of this taxon of up to 8% led de la

Vega-Leinert *et al*. (2007) to infer that this species grew in sheltered areas on the valley sides and formed part of a mixed deciduous woodland community from *c*. 5850 cal. BC. Small amounts of *Quercus* pollen (*c*. 5%) also occur in a poorly dated sequence from Deerness, although these are interpreted as representing long distance transport from the Scottish mainland (Donaldson 1986). There is no support for the local presence of *Quercus* at Hobbister during the Mesolithic, with pollen frequencies of only 1-2%.

Arboreal pollen percentages begin to decline steadily at 353 cm (*c*. 4760 cal. BC; Fig. 6.16), and by 329 cm (*c*. 4170 cal. BC) they form only 20% of the total pollen sum. This suggests that the woodland surrounding Hobbister had largely disappeared by this time, although arboreal pollen frequencies of *c*. 20% may indicate that some small patches of scrub woodland were still present in the wider landscape. This event occurs slightly earlier than the widespread woodland decline on Mainland, which has been dated to between *c*. 3950 cal. BC and *c*. 3450 cal. BC (Keatinge and Dickson 1979; de la Vega-Leinert *et al*. 2007).

At most Mainland sites the woodland loss took place over a few hundred years and coincided with the first solid records of pastoral vegetation communities. This has led to suggestions that the primary cause of woodland decline was human activity, either by clearance to make way for pastoral farming or by suppression of woodland regeneration by increased grazing pressure from domesticated animals. However, at Crudale Meadow the decline took place much more slowly, over a period of about a thousand years (although dating of this site is poor), and is interpreted as being due to autogenic processes as much as to direct anthropogenic influence (Bunting 1994). Keatinge and Dickson (1979) have also suggested that climatic changes may have been at least partly responsible for woodland decline in west Mainland, since blown sand deposits from coastal dunes at the Bay of Skaill stretch inland along the Loch of Skaill, and sand-blow events appear to have been occurring in the area since about 4950 cal. BC (de la Vega-Leinert *et al*. 2000). Keatinge and Dickson (1979) suggest that the increase in wind speed implied by these sand deposits may have contributed to the woodland decline either by causing physical damage to the woodland species, or indirectly via salt spray and sand abrasion.

At Hobbister, there is some evidence for a slight increase in surface wetness at the site at around the same time as the woodland decline. There are increased frequencies of

Sphagnum spores and Cyperaceae pollen (Fig. 6.16), along with high proportions of identifiable organic matter in the sediment which suggest better preservation under wetter conditions (Fig. 6.22). In addition, there is a change in sediment type from well-humified peat to fine organic lake mud, indicating the existence of small pools. Occasional Characeae oospores are also present (Fig. 6.22), again suggesting the presence of shallow water 0-5 m in depth (Haas 1994). There are few indications of human activity at Hobbister following the woodland decline, with very low frequencies of anthropogenic indicators such as *Rumex* undiff. and *Plantago lanceolata* (Fig. 6.16). Small quantities of *Sordaria*-type ascospores also occur (Fig. 6.20). No microscopic charcoal is present, although macroscopic charcoal (>100 μm) was recorded in some samples (Fig. 6.16; 6.22).

A single grain of *Hordeum*-type pollen occurs at 357 cm (*c*. 4850 cal. BC; Fig. 6.16), just prior to the woodland decline. This is a very early date for cereal cultivation in Britain, and on the basis of this the equivalent of 1000-2000 pollen grains from the basal samples from sequence A were scanned using the method of Edwards and McIntosh (1988). No further cereal-type pollen was recorded until 267 cm (*c*. 2640 cal. BC) in the late Neolithic, and while the annular diameter of the grain from 357 cm (*c*. 4850 cal. BC) falls into the size class for *Hordeum*-type, this group also includes some species of wild wetland grasses such as *Glyceria fluitans* (Andersen 1979). In view of the early date and the fact that no other cereal-type grains were present, it is probable that this grain actually originates from a wild grass rather than from cultivated barley.

The cause of the woodland decline at Hobbister is unclear. It took place over an extended period of time, approximately 600 years, and began around 800 years earlier than elsewhere on Mainland. Mesolithic human disturbance has been invoked as the cause of temporary woodland declines at Keith's Peat Bank on Hoy (Blackford *et al*. 1996) and at Quoyloo Meadow in west Mainland (Bunting 1994). There is some evidence that Mesolithic people were present in the area surrounding Hobbister in the form of flint scatters (Wickham-Jones 1990b), and it is possible that they were partly responsible for the early woodland decline seen at the site. There are very few indicators of human activity in the palaeoecological record from Hobbister at this time, although the presence of *Sordaria*-type ascospores can be taken to imply the local presence of grazing animals since surface sample studies have shown that almost no

airborne dispersal of fungal taxa occurs (Blackford and Innes 2006). However the presence of these ascospores could just as easily be the result of natural processes as of human activity, since there is some debate as to whether red deer are native to Orkney or whether they were introduced by Mesolithic settlers (e.g. Clutton-Brock 1979; Hedges 1983a). In view of the early date of woodland loss at Hobbister and the lack of any clear evidence for human disturbance, it seems likely that main cause was a change in local hydrological conditions, perhaps exacerbated by Mesolithic human activity.

6.5.2 Neolithic (*c*. 4000 – *c*. 2000 cal. BC)

The early Neolithic at Hobbister is covered only by sequence A, with the record from sequence B beginning at *c*. 2590 cal. BC and covering the later Neolithic onwards. Peat formation at the location of sequence B began at *c*. 2480 cal. BC, about 2800 years later than at site A. This provides support for the hypothesis developed based on the results of the stratigraphic survey, that paludification of the wider landscape at Hobbister occurred from within relatively small basin centres, such as that present at site A. The spread of peat at this site was therefore underway during the Neolithic period. Site A still seems to have been a fen at this time, and site B provides evidence in the microstructure data (Fig. 6.23) for the local growth of *Calluna vulgaris* around the margins of the fen towards the end of the Neolithic period.

Arboreal pollen percentages of *c*. 20% occur in sequence A until 291 cm (*c*. 3230 cal. BC; Fig. 6.16), after which they form only 10% of the total pollen sum for the rest of the Neolithic period. However at the base of sequence B, dated to *c*. 2590 cal. BC, frequencies of arboreal pollen are around 50% (Fig. 6.18). This would suggest that fairly substantial amounts of birch-hazel scrub woodland were present around site B that were not detected in the pollen record at the location of sequence A, approximately 80 m to the north of sequence B. Bunting (2002) has shown that in north-west Scotland, arboreal pollen percentages of less than 20% frequently occur within 100 m of a woodland edge. Coupled with the fact that the pollen record from sequence A (Fig. 6.16) is dominated by Cyperaceae throughout the entire Neolithic period, suggesting that the core is only recording very local events, this may account for the differences in arboreal pollen percentages between the two Hobbister sequences during the Neolithic period. At the location of core A it is likely that fen vegetation was the dominant community present at this time.

The main arboreal taxa represented in the pollen record from sequence B (Fig. 6.18) at this time are *Betula* and *Corylus avellana*-type, with *Pinus sylvestris* frequencies similar to those from sequence A (*c.* 5%). Relatively high proportions of Pteropsida spores again suggest that the understorey was rich in ferns. Frequencies of *Betula* and *Corylus avellana*-type pollen both decline sharply at 196 cm (*c.* 2450 cal. BC), and it would therefore seem that there were two woodland decline events at Hobbister. The primary woodland decline began at around 4760 cal. BC, in the late Mesolithic, (353 cm; Fig. 6.16) and took place over an extended period of time, approximately 600 years. The main taxa affected were *Betula* and *Corylus avellana*-type, and these taxa declined still further at the time of the secondary woodland decline, evidenced in sequence B at *c.* 2450 cal. BC (196 cm; Fig. 6.18). Percentages of these taxa are very low at this time in sequence A, and the secondary woodland decline is not recorded in this core. It seems to have taken place much more rapidly than the primary decline, with arboreal pollen frequencies declining from *c.* 50% to *c.* 20% over a period of approximately 60 years (Fig. 6.18). The secondary decline occurs much later than the woodland decline at other sites on Mainland, which has been dated to between *c.* 3950 cal. BC and *c.* 3450 cal. BC (Keatinge and Dickson 1979; de la Vega-Leinert *et al.* 2007). This indicates that woodland decline was not synchronous across Orkney and therefore probably did not have one single regional cause, such as climatic change, but in fact seems to have occurred as several local events, the causes of which differ at each site.

Proportions of Poaceae expand markedly in both sequences just after the secondary woodland decline, and several indicators of human activity are present, suggesting that its cause may have been at least partly anthropogenic (Fig. 6.16; 6.18). Both micro- and macroscopic charcoal is present in sequence B, although whether this is the result of natural or anthropogenic fires is unclear. Also in sequence B, *Plantago lanceolata* frequencies reach almost 8% (Fig. 6.18) and low values of *Sordaria*-type ascospores occur (Fig. 6.21). Since fungal ascospores have been shown to provide a very localised record of grazing activity directly at the sampling site (Blackford and Innes 2006), higher frequencies would not be expected since it is unlikely that animals would have been grazing on the bog itself. However their presence in low frequencies, along with relatively high percentages of *Plantago lanceolata* pollen, can be taken as evidence for grazing activity in the wider landscape at this time. Low frequencies of *Hordeum*-type pollen occur in both sequences just after the secondary woodland decline (Fig. 6.16; 6.18), and since cereal pollen is produced in low quantities and is not well-dispersed

(Edwards and McIntosh 1988) this can be taken as evidence of arable cultivation fairly close to the sampling site.

Following the secondary woodland decline at Hobbister, percentages of *Corylus avellana*-type and *Betula* pollen remain at around 10% for the rest of the Neolithic period in both sequences. However, arboreal pollen percentages in sequence B increase to around 40% at 189 cm (*c.* 2250 cal. BC; Fig. 6.18). This is due to an expansion in *Alnus glutinosa* pollen frequencies, which reach *c.* 15% at this time, suggesting that alder carr woodland became established near the edge of the site. High values of *Alnus glutinosa* pollen are not present in sequence A at this time (Fig. 6.16), suggesting that alder carr did not extend across the whole site. Following the establishment of alder carr near to the location of sequence B, *Alnus glutinosa* pollen forms around 10% of the total pollen sum in this sequence until 181 cm (*c.* 2020 cal. BC; Fig. 6.18), suggesting that although the alder carr was not as extensive as previously, some small patches of this community may still have been present at the edge of the wetland until the end of the Neolithic period.

6.5.3 Bronze Age (*c.* 2000 – *c.* 800 cal. BC)

Pollen percentages of heath taxa begin to increase at the start of the Bronze Age in sequence A (Fig. 6.16), although they remain low at this time in sequence B (Fig. 6.18). However there is a marked expansion in these taxa, mainly in *Calluna vulgaris*, during the middle Bronze Age in sequence B, when frequencies reach *c.* 90% of the total pollen sum, although by the end of the Bronze Age percentages have dropped to around 15% again (Fig. 6.18). This peak occurs between 165 and 149 cm (*c.* 1570-1070 cal. BC), and a similar peak occurs in sequence A between 170 and 157 cm (*c.* 1200-1000 cal. BC; Fig. 6.16), although frequencies here only reach *c.* 50% of the total pollen sum. There is some evidence for the local growth of *Calluna vulgaris* at site B during the Bronze Age in the form of fragments of stem material (Fig. 6.23), and this may partially account for this short-lived period of high heath pollen frequencies. Macroscopic charcoal is almost continuously present in both sequences from the start of the Bronze Age onwards, providing further evidence of burning, whether natural or anthropogenic. However very little microscopic charcoal is present in the record, perhaps providing further support for the local growth of heathland species at Hobbister at this time.

Management of heathland by burning can improve the quality of grazing by encouraging the dense growth of new shoots of *Calluna vulgaris*, which contain more nutrients than old-growth heather (Gimingham 1975), and by allowing Poaceae to grow in the gaps created by fire. Poaceae pollen percentages do increase slightly during the Bronze Age in sequence A (Fig. 6.16), lending some additional support to this hypothesis. Evidence for management of heathland by burning in the Bronze Age occurs in environmental records from Denmark, and it has been shown to cause increased flowering in *Calluna vulgaris* and hence increased pollen percentages for this species (e.g. Odgaard 1992; Karg 2008). Bunting (1996) has suggested that heathland on Rousay may have been managed in this way during the Bronze and Iron Ages.

The landscape around the site appears to have been dominated by pastoral vegetation and there are several indications of grazing activity near the site during the Bronze Age, including relatively high frequencies of *Plantago lanceolata* and *Rumex* undiff. pollen in both sequences, along with other anthropogenic indicator taxa such as *Artemisia*-type (Fig. 6.16; 6.18). Low frequencies of *Sordaria*-type ascospores occur in both sequences (Fig. 6.20; 6.21), and there is also evidence for cereal cultivation in the vicinity of the site during the Bronze Age. The presence of sub-peat dykes at the site (Sharman 2007; see Fig. 6.9), which may be the remains of Bronze Age field systems, might provide further evidence for agricultural activity.

The fact that the landscape around Hobbister was clearly being exploited for agriculture suggests that the increased pollen percentages of *Calluna vulgaris* seen during the mid-late Bronze Age are the result of deliberate burning to improve grazing on the site itself, since the presence of *Sordaria*-type ascospores implies the very local presence of grazing animals (Blackford and Innes 2006). It may be that population expansion or reorganisation of settlement patterns at this time forced the exploitation of more marginal land such as areas of blanket peat.

There is also some circumstantial evidence that the landscape around Hobbister was valued for agriculture during the Bronze Age. Although the exact findspot is unknown, the late Bronze Age axehead found during peat cutting at Hobbister in 2006 is believed to have come from a peat unit which immediately overlay pool deposits, leading to suggestions that it was placed or thrown into a bogpool or pond as a ritual act, possibly in response to an increase in wetness and expansion of blanket peat into an

agriculturally valued landscape (Towrie 2006). Throughout northern and western Europe, ritual deposits of precious metalwork were made in rivers and marshes during the Bronze and Iron Ages (Bradley 1990), and in some cases this may have been in response to environmental changes that were taking place (e.g. Pryor 2001). Bronze Age metalwork (particularly that of the late Bronze Age) found in peat has been reported throughout Scotland, although these are rarely interpreted as votive deposits (Coles 1959; 1963; 1968). In Orkney, Bronze Age objects have been discovered during peat cutting in the past (e.g. Cursiter 1887; 1908; Stevenson 1958; O'Connor and Cowie 1995), although the provenance of these objects is not well recorded and it is not possible to determine whether they were casual losses or intentional deposits.

There is some evidence that the surface of the bog at Hobbister became slightly wetter during the mid-late Bronze Age, with higher proportions of identifiable organic material in both sequences than previously, interpreted as better preservation under wetter conditions. There are also increases in the abundance of mosses in the microstructure evidence in both sequences (Fig. 6.22; 6.23). There is an increase in Cyperaceae pollen percentages towards the end of the Bronze Age in sequence B (Fig. 6.18), along with declines in *Calluna vulgaris* pollen frequencies in both sequences, again suggesting an increase in wetness at the site. These changes take place between *c*. 1130 and *c*. 880 cal. BC, and it is possible that this shift to wetter conditions at Hobbister is linked to the well-documented climatic deterioration that seems to have occurred across northwest Europe at *c*. 850 cal. BC (e.g. van Geel *et al*. 1996; Mauquoy *et al*. 2004; Blundell and Barber 2005; Swindles *et al*. 2007). The evidence for increasing surface wetness and the spread of heathland across the landscape provides some support for the hypothesis that the axehead was ritually deposited in response to the loss of agricultural land.

6.5.4 Iron Age (*c*. 800 cal. BC – *c*. 600 cal. AD)

Major expansions in pollen frequencies of heathland taxa, mainly of *Calluna vulgaris*, occur in both sequences during the early Iron Age. This event is dated to *c*. 600 cal. BC in sequence A (131 cm; Fig. 6.16) and occurs around 200 years later in sequence B, at *c*. 410 cal. BC (128 cm; Fig. 6.18), and probably reflects the gradual spread of heath into the wider landscape. Although there is evidence for the local growth of *Calluna vulgaris* on the site itself in the form of stem fragments in sequence A (Fig. 6.22), some support for the idea of heathland expansion in the surrounding landscape is provided by

increased presence of microscopic charcoal during the Iron Age. The continued presence of macroscopic charcoal implies on-site burning, but the change in frequency of microscopic charcoal perhaps suggests that burning of heathland vegetation was also taking place in the landscape around the site at this time.

Heathland expansion at Hobbister occurs later than at sites in the west Mainland hills, where heath development took place between *c.* 1750 cal. BC and *c.* 1100 cal. BC (Keatinge and Dickson 1979). However heathland began to develop on the slopes surrounding Scapa Bay from around 650 cal. BC (de la Vega-Leinert *et al*. 2007), at roughly the same time as widespread heath formation occurred at Hobbister. Around Lesliedale Moss it is thought that heath formation did not begin until around 100 cal. AD (Jones 1979), although this sequence is poorly dated.

Heathland development in Orkney has been attributed to a range of causes, including climatic deterioration, pedological factors and anthropogenic impact. The early expansion of heath around Loch of Torness in southern Hoy at *c*. 5850 cal. BC is believed to have been the result of climatic and autogenic processes, since no charcoal or pollen of anthropogenic indicator species were recorded in this sequence (Bunting 1996). Similar causes are invoked for initial heath spread around Loch of Knitchen on Rousay at *c*. 4550 cal. BC, although *Plantago* and cereal pollen are present in the record from this point onwards and there is also a peak in microscopic charcoal following the expansion in heath taxa. Bunting (1996) therefore suggests that although heathland development had begun long before any clear human impact signal is detected in the pollen record, human activity may have had a significant effect on the later development of peat around this site.

Keatinge and Dickson (1979) suggest that peat formation in the west Mainland hills during the mid-late Bronze Age may be linked to climatic deterioration coupled with human pressure on the environment. At Scapa Bay it has been suggested that while human activity probably contributed to heath spread around the site, pedological factors operating alongside the northwest European climatic deterioration at *c.* 850 cal. BC probably played a more significant role in this development (de la Vega-Leinert *et al*. 2007). At Lesliedale Moss in west Mainland widespread heath formation in the middle Iron Age has been attributed to soil degradation resulting from intensive agricultural

activity (Jones 1979). This is also argued from evidence from Wideford Hill (Jones 1979) and Glims Moss (Keatinge and Dickson 1979), both in west Mainland.

At Hobbister 'climatic deterioration' seems to have occurred at *c*. 1130 cal. BC, although widespread heath formation did not take place until around 500 years later. There is some evidence for agricultural practices in the vicinity of the site at this time, with pollen of anthropogenic indicator species such as *Plantago lanceolata*, *Rumex* undiff. and *Artemisia*-type occurring throughout the Iron Age in both sequences (Fig. 6.16; 6.18). Relatively high frequencies of *Sordaria*-type ascospores are also present in both sequences (Fig. 6.20; 6.21), and *Hordeum*-type pollen occurs sporadically throughout the Iron Age. There is therefore evidence for relatively intensive human activity around the site at this time, and it would appear from Fig. 6.1 that settlement in the study area was denser than during preceding periods. It is likely that the cause of heath formation at Hobbister was a combination of climatic deterioration leading to soil deterioration via leaching and podsolisation (Gimingham 1975) and human pressure on the environment. Similar reasons were invoked by de la Vega-Leinert *et al*. (2007) for heathland development at the nearby site of Scapa Bay.

The presence of charcoal in the record from Hobbister during the Iron Age may be the result of deliberate management of heathland by burning in order to improve the quality of grazing. There is some evidence to suggest that this practice took place at Loch of Knitchen on Rousay from around 250 cal. AD onwards (Bunting 1996), although heathlands are also vulnerable to natural fires (e.g. Radley 1965; Tipping 1996). However, coupled with other evidence for anthropogenic activity in the palaeoecological record from Hobbister at this time it is likely that the charcoal present in the record during the Iron Age is at least partially the result of deliberate burning by humans.

6.5.5 The Pictish Period (*c*. 600 – *c*. 800 cal. AD)

In sequence A the Pictish period is represented by only 8 cm of sediment, and it seems that the landscape remained largely similar to in the preceding Iron Age. The period is better represented in sequence B, which confirms the similarities with the Iron Age landscape. Heathland continued to expand during Pictish times, and a decline in percentages of Poaceae pollen suggests that the amount of pasture land around the site was reduced (Fig. 6.16; 6.18). A lack of microscopic charcoal in both sequences

implies that no management of the heathland took place at this time, suggesting that the landscape was no longer being used intensively for grazing. However, evidence that low levels of grazing activity were sustained during the Pictish period is provided by low frequencies of *Plantago lanceolata* pollen and *Sordaria*-type ascospores in both sequences. It appears that arable cultivation did not take place near Hobbister at this time, with no cereal pollen recorded in either sequence.

The archaeological record from the Hobbister study area supports the hypothesis that little anthropogenic activity took place around Hobbister during the Pictish period, with the only evidence being a long cist burial (which is undated and may therefore date to a later period) and a symbol stone. There is no settlement evidence and it seems that human activity around the coring site was limited to low intensity stock grazing. This contrasts with evidence from elsewhere in the islands, where it has generally been suggested that a major increase in agricultural intensification occurred during Pictish times (e.g. Donaldson *et al.* 1981; Bond 2002; 2003) and may suggest that the spread of heathland at Hobbister had caused the area to be considered too marginal for agriculture to be economically viable at this time.

6.5.6 The Viking Period (*c*. 800 – 1065 cal. AD)

The Viking period is represented in sequence A by only 14 cm of sediment, and there is little evidence for changes in environmental conditions and land-use in this sequence. This period is better represented in sequence B, and it seems that there was little change from the preceding Pictish period. Heathland continued to dominate the landscape in the immediate vicinity of Hobbister, and it would appear from the charcoal records that this was not managed by deliberate burning (Fig. 6.16; 6.18). No arable cultivation took place near to the site at this time, although it is possible that the area was still used for rough grazing. The inferred presence of small numbers of grazing animals at the site during the Viking period is supported by low frequencies of *Plantago lanceolata* pollen and *Sordaria*-type ascospores. This lack of intensive agriculture again contrasts with evidence from archaeological sites elsewhere in the islands, for example at Pool on Sanday (Bond 2007b) and Quoygrew on Westray (Barrett *et al*. 2005), suggesting that the intensive cultivation seen at these sites was not viable in the increasingly marginal landscape near Hobbister. This is supported by the archaeological evidence from the study area, with the only site dating to the Viking period being a burial.

Very low levels of arboreal pollen (*c*. 5% of the total pollen sum) are present throughout the Viking period at Hobbister, implying that the landscape remained largely open at this time. Although there are few reliably dated pollen records covering this period from other sites in Orkney, evidence from Viking archaeological sites suggests that some small patches of local scrub woodland were still present with *Betula* and *Corylus* both represented in the charcoal recovered from the Brough of Birsay, although driftwood was also an important source of fuel at this site (Donaldson *et al*. 1981). At the Brough of Deerness, the only species represented in the charcoal record is *Salix*, leading Morris *et al*. (1986) to infer that the wood had not been collected from birch-hazel woodland and probably represents the exploitation of a local source of scrub willow, the more extensive birch-hazel woodland having declined earlier around this site (Morris *et al*. 1986). Despite the continued existence of small patches of local woodland elsewhere in Orkney, it seems that no woodland was present in the landscape around Hobbister at this time.

6.5.7 Later Developments

Following the end of the Viking period, which in Orkney is generally taken to mark the end of prehistory (Grieve and Gibson 2005), the landscape around Hobbister seems to have been little changed up to the present day. Evidence for low levels of grazing activity continues until the end of both sequences, and no cereal cultivation seems to have taken place since the Iron Age.

There seems to have been a slight drying out of the bog surface since *c*. 1120 cal. AD, evidenced by lower frequencies of Cyperaceae pollen and increased quantities of unidentifiable organic matter in the sediment (37 cm; Fig. 6.22). Apart from this, the landscape seems to have remained largely open and dominated by extensive heathland until the present day.

The high-status settlement of the Earl's Bu and the location of St Magnus' cathedral in Kirkwall suggest that this area of Mainland was important during the Late Norse period, and a mill is associated with the settlement at Earl's Bu, suggesting that intensive arable cultivation must have been taking place somewhere on the island at this time. However this is not reflected in the palaeoecological record from Hobbister, although since cereal pollen is produced in low quantities and is not well-dispersed (Edwards and McIntosh

1988), its absence from the record at Hobbister does not mean that no arable cultivation took place in the study area during the Late Norse period.

6.6 Summary

The palaeoecological record from Hobbister begins at *c.* 5250 cal. BC, in the late Mesolithic period. Some woodland was present at this time, dominated by *Betula* and *Corylus avellana* and with a tall-herb and fern-rich understorey. It is also possible that some pine grew locally around Hobbister, although there is no support for the local growth of *Quercus* in the islands. The woodland at Hobbister seems to have declined over a period of about 600 years beginning at *c.* 4760 cal. BC. It seems that the main cause was probably a change in local hydrological conditions, perhaps exacerbated by low levels of Mesolithic human activity.

Peat began to spread at Hobbister during the Neolithic period, and paludification of the wider landscape seems to have taken place from within relatively small basin centres such as that present at sampling point A. Peat formation at the location of sequence B began at *c.* 2380 cal. BC, about 2800 years later than at site A.

Sequence B indicates that stands of birch-hazel scrub woodland were still present at Hobbister following the initial woodland decline seen in sequence A at *c.* 4760 cal. BC. A secondary woodland decline occurred at *c.* 2450 cal. BC, much later than the main woodland decline seen on Mainland (Keatinge and Dickson 1979; Bunting 1994; de la Vega-Leinert *et al.* 2007). This decline took place much more rapidly than the primary decline and is accompanied by several indicators of human activity, suggesting that the cause of the secondary woodland decline at Hobbister may have been at least partly anthropogenic. Following the secondary woodland decline, alder carr seems to have developed around the edges of the wetland near site B at *c.* 2250 cal. BC. This persisted for around 200 years, until *c.* 2020 cal. BC.

Heathland began to expand at the start of the Bronze Age, although widespread heath formation did not occur until later. There is some evidence to suggest that the heath was being managed by deliberate burning during the Bronze Age, and several indicators of grazing activity are present at this time, along with evidence for cereal cultivation in the vicinity of the site. There is also archaeological evidence for Bronze Age agricultural activity at Hobbister in the form of sub-peat dykes (Sharman 2007). It

seems that the surface of the bog at Hobbister became slightly wetter during the mid-late Bronze Age, which may be linked to the widespread climatic deterioration that seems to have occurred across north-west Europe at *c*. 850 cal. BC (e.g. van Geel *et al*. 1996; Mauquoy *et al*. 2004; Blundell and Barber 2005; Swindles *et al*. 2007) and may provide an explanation for the deposition of a late Bronze Age socketed axehead at the site.

During the Iron Age widespread heath formation took place, beginning at *c*. 600 cal AD. There is evidence for relatively intensive human activity at Hobbister during the Iron Age, and it is likely that the cause of heath formation at this site was climatic decline leading to soil deterioration via leaching and podsolisation, acting in combination with human pressure on the environment. There is continuing evidence for the management of heathland by burning throughout the Iron Age.

During the Pictish and Viking periods, it seems that the landscape around Hobbister was used only for low intensity stock grazing. This impression of very little human activity in the area is supported by the archaeological evidence for these periods. Following the end of the Iron Age, the landscape around Hobbister has remained dominated by heathland and seems to have been little changed up to the present day.

Chapter 7: Blows Moss

In this chapter, the results of palaeoecological analyses undertaken on a core from Blows Moss in South Ronaldsay are presented and discussed. Previous palaeoecological investigations in the study area are described in order to provide some background to this study and highlight the need for better understanding of prehistoric environmental changes and land-use on South Ronaldsay. The archaeological record of the study area is described to allow the environmental and archaeological records to be linked and interpreted. A brief description of the coring site and the landscape surrounding it is then given before the results from the Blows Moss sequence, including age estimates, lithostratigraphy, physical sediment properties, and pollen, charcoal, non-pollen palynomorph and microstructure analyses, are presented and described. Finally, the palaeoecological record from Blows Moss is discussed and interpreted in terms of major environmental changes and prehistoric human activity, and is compared with the archaeological record from South Ronaldsay and with palaeoecological data from other Orcadian sites.

7.1 Previous Palaeoecological Investigations

Previous palaeoecological investigations in South Ronaldsay include those of Bartlett (1983) at Liddle Bog, and Jones (1975) who worked on samples recovered during excavations at Liddle burnt mound. Locations of these sites are shown on Fig. 7.1.

7.1.1 Liddle Bog (NGR ND 463 841; Bartlett 1983)

Two 90 cm cores were recovered from a *c.* 250 m diameter peat deposit known as Liddle Bog, situated *c.* 250 m from the burnt mound of Liddle I and *c.* 1 km from Isbister chambered cairn. The upper 30-50 cm of these cores had been disturbed by ploughing so the later part of the record from this site is missing. Although the records are not radiocarbon dated, they have been correlated with diagrams from other published Orcadian sequences and Bartlett (1983) suggests that the pollen record from Liddle Bog covers the period from the Neolithic to the earlier Iron Age, which is approximately the period of interest for the current study.
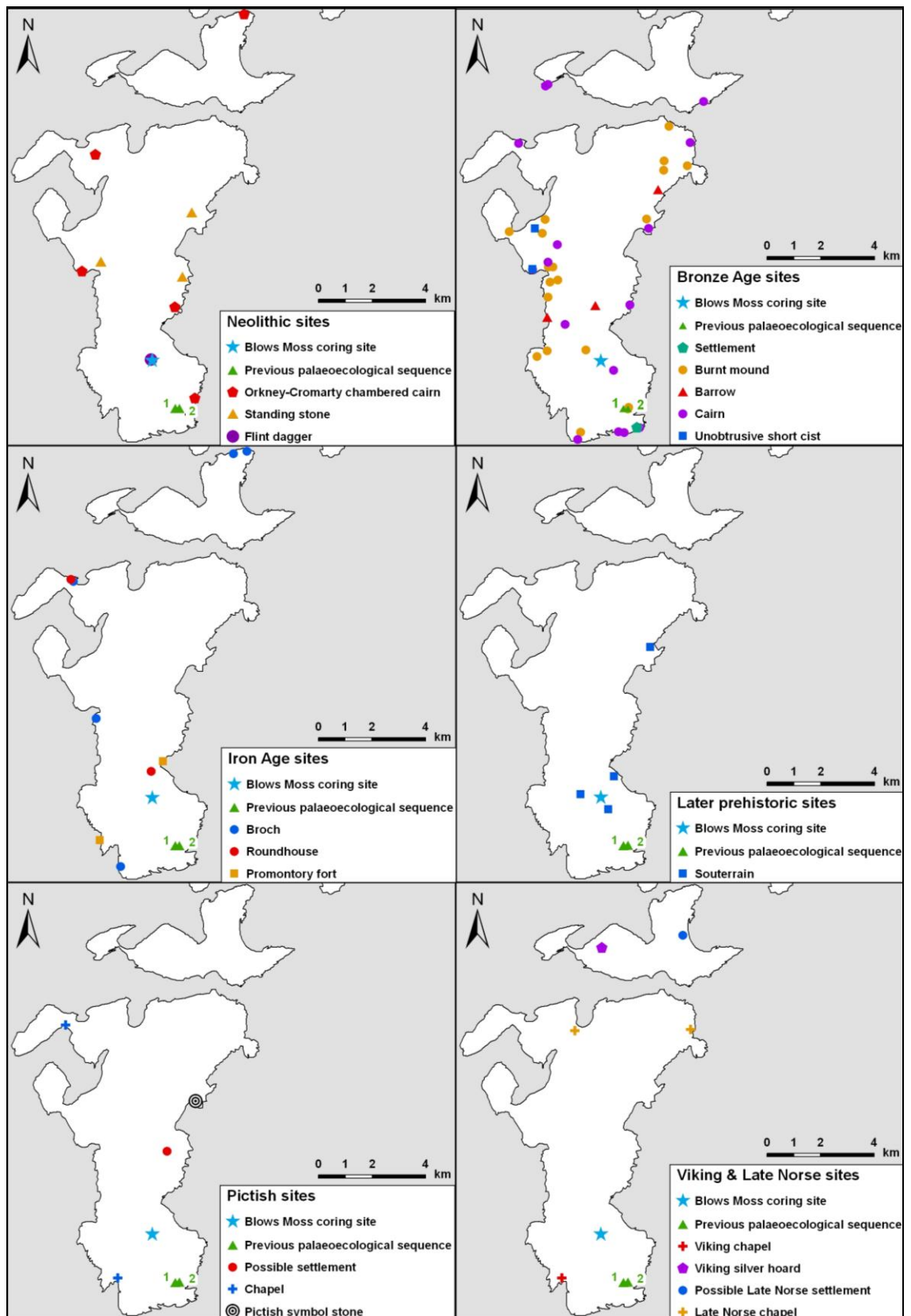
Figure 7.1 Location of archaeological sites and previous palaeoecological investigations (1. Liddle Bog; 2. Liddle I Burnt Mound) in the Blows Moss field area

Relatively high proportions of arboreal pollen (*c*. 50%) are recorded in the earlier parts of these sequences, implying that some patches of woodland were present in the wider landscape (e.g. Bunting 2002) during the late Neolithic/early Bronze Age. Of particular interest are the values for *Pinus sylvestris* and *Quercus* pollen (*c*. 20% and *c*. 10% respectively), which may imply that these trees were growing locally (Bartlett 1983). This contrasts with the traditional interpretation that pollen of these species in Orcadian sequences originates from long distance transport from the Scottish mainland (e.g. Moar 1969; Keatinge and Dickson 1979), although Bunting (1994) and de la Vega-Leinert *et al*. (2007) have more recently suggested that these species may have been present on west Mainland during the later Mesolithic.

An increase in wetness at the site at some time during the Bronze Age is indicated by rises in the pollen of *Alnus glutinosa* and aquatic plants (Bartlett 1983). Woodland decline occurs at the same time and is associated with increases in the pollen of cereals, Poaceae, and *Plantago* undiff., leading Bartlett (1983) to suggest that the woodland was cleared in order to provide more land for agriculture. The economy seems to have been predominantly pastoral with some arable cultivation occurring on the drier valley sides (Bartlett 1983). Despite the general decline in arboreal pollen at this time, *Corylus avellana*-type pollen shows a slight increase, implying that woodland management in the form of coppicing may have been taking place (Bartlett 1983). A more extensive woodland decline occurs later at Liddle Bog and seems to be initially associated with mainly pastoral activity, with evidence for arable farming increasing over time although never becoming dominant (Bartlett 1983).

7.1.2 Liddle I Burnt Mound (NGR ND 46468411; Jones 1975)

Two organic deposits associated with the stone-built structure at Liddle I burnt mound were analysed for pollen. The Liddle A profile consisted of 10 cm of silty mud which formed the basal fill of a flag-lined gully. The base of the profile was radiocarbon dated to *c*. 1200 cal. BC, placing the events recorded in the late Bronze Age. The Liddle B profile was made up of 35 cm of silty peat from the deposit into which the flag-lined gully had been cut. Although this profile was not radiocarbon dated, for stratigraphic reasons it is believed to represent the early-mid Bronze Age (Jones 1975), and is therefore discussed here before Liddle A.

The pollen assemblage from the Liddle B profile is dominated by herbaceous species, although arboreal pollen values of up to 15% led Jones (1975) to infer that a small amount of woodland was present. Values of *Plantago lanceolata* increase towards the top of the profile, and this along with the occurrence of Poaceae and *Rumex* pollen suggests pastoral farming was taking place. There is some indication of arable farming as well, with small amounts of cereal pollen along with that of *Urtica* and Asteraceae. The evidence suggests that mixed agriculture was being practised, although arable cultivation only seems to have been a minor component of this and the overall level of human activity appears to have been quite low at this site during the early-mid Bronze Age (Jones 1975).

Plantago lanceolata pollen continues to increase in the Liddle A profile, and again the sequence is dominated by non-arboreal pollen. Cereal pollen is recorded throughout the profile, as is that of Asteraceae, Brassicaceae and *Urtica*, all weeds generally associated with cultivation. Jones (1975) suggests that fairly intensive mixed farming was being practised in the vicinity of the site during the middle and late Bronze Age.

Two soil samples from below the burnt mound were also analysed, although these add little to the understanding of Bronze Age environmental conditions at the site. The pollen assemblages from both samples imply an open environment with little evidence for human activity, although Jones (1975) also notes that substantial amounts of fern spores were present. Fern spores are known to be relatively resistant to decay, and therefore a high proportion of them can indicate biasing of pollen assemblages (e.g. Bunting *et al*. 2001; Tipping *et al*. 2009). Therefore it is possible that the soil samples from below the burnt mound do not represent an accurate record of the surrounding vegetation at the site.

7.2 The Archaeological Record

Fig. 7.1 shows the distribution of archaeological sites around Blows Moss. All periods from the Neolithic to the Iron Age are well represented with a fairly dense distribution of sites dating from the period of interest for this study (*c*. 3000 cal. BC - 600 cal. AD), although relatively few Pictish and Viking/Late Norse sites are present.

No Neolithic settlements are recorded, although five early Neolithic chambered cairns are located in the study area and several standing stones are also present. The

chambered cairn of Isbister, which was intensively used for burials between *c.* 3200 cal. BC and *c.* 3050 cal. BC (Hedges 1983a), lies approximately 2 km south-east of the coring point at Blows Moss. Activity during the Neolithic seems to have been focused along the coast, and this fits well with theories that chambered cairns were sited in prominent positions overlooking the sea (e.g. Woodman 2000; Phillips 2003; Cummings and Pannett 2005). According to Callander (1931: 82), a 'beautifully flaked flint dagger' was recovered from Blows Moss itself during peat cutting at the site in 1888. This is assumed to be Neolithic in date and is plotted on the map for this period.

Bronze Age sites are well represented throughout the study area, with several burnt mounds, barrows, cairns and cist burials being present. However as discussed in Chapter 2, these monuments do not necessarily all date from the Bronze Age and some almost certainly belong to later periods. One burnt mound that has been proved to date from the Bronze Age by radiocarbon dating is Liddle (Hedges 1975), situated approximately 2 km to the south of Blows Moss. Liddle burnt mound is the most thoroughly excavated example of its type in Orkney and has an associated stone-built structure which has been interpreted as a domestic building (Hedges 1975), although this interpretation has since been questioned (e.g. Øvrevik 1985; Ritchie 1995; Anthony 2003). A possible Bronze Age settlement has recently been identified at Old Head, consisting of several houses, field systems and clearance cairns (J.W. Hedges pers. comm.).

In terms of activity during the Iron Age, four brochs and two promontory forts are located within the study area. Recent excavations at The Cairns in Windwick Bay, approximately 800 m to the north of Blows Moss, have revealed a very substantial, thick-walled roundhouse containing a souterrain, possibly dating from the earlier Iron Age (Carruthers 2007). The recorded Iron Age settlement sites are predominantly located along the coast, perhaps for defensive purposes (e.g. Graham 1947) but more likely in order to enhance their visibility and demonstrate the status of their occupants (e.g. Hingley 1992). No Iron Age burials occur within the Blows Moss study area, but evidence for Iron Age burials in Orkney is generally lacking (e.g. Ashmore 2003) and it may be that some of the burial sites mapped as Bronze Age in fact belong to this period. Several souterrains occur clustered around Blows Moss, and these are believed to date

from the late Bronze Age or Iron Age (M. Carruthers pers. comm.) so are mapped here as 'later prehistoric'.

Evidence for Pictish and Viking/Norse activity around Blows Moss is sparse. A possible Pictish settlement is located *c.* 3 km to the north of the site, and a possible Late Norse settlement has been identified on the island of Burray. Other than these the rest of the sites for these periods are mainly chapels, which implies that at one time there must have been a population large enough to warrant the construction of these buildings. As the Viking and Late Norse periods are comparatively recent, and the Norse pattern of land division continued in use until the 19th century (Thomson 2003), it may be that other sites from this period occur under present settlements and boundaries and are yet to be identified.

Overall, it can be seen from Fig. 7.1 that there is evidence for fairly intensive human activity in the area surrounding Blows Moss throughout the period of interest for this study (*c.* 3000 cal. BC - 600 cal. AD).

7.3 Site Description

Blows Moss (NGR ND 455860) is a large elongate wetland on South Ronaldsay (see Fig. 7.2 for location). The site is approximately 30 ha in extent (*c.* 1250 m by 250 m), running from south-west to north-east, and is clearly defined by the 15 m contour (Fig. 7.3). Land-use around this low-lying site is mainly agricultural, with large areas of improved pasture and arable land present (Fig. 7.4, Fig. 7.5). This reflects the underlying drift geology of boulder clay, which forms relatively fertile soils in Orkney (Fig. 7.6). Blows Moss provides the non-marginal or 'optimal' case study for this investigation.

At present the wetland is a basin mire supporting fen vegetation (Fig. 7.7). Some small areas of open water exist within the mire, and a study of historic Ordnance Survey maps clearly indicates that these open water areas were more extensive in the recent past (Fig. 7.8).
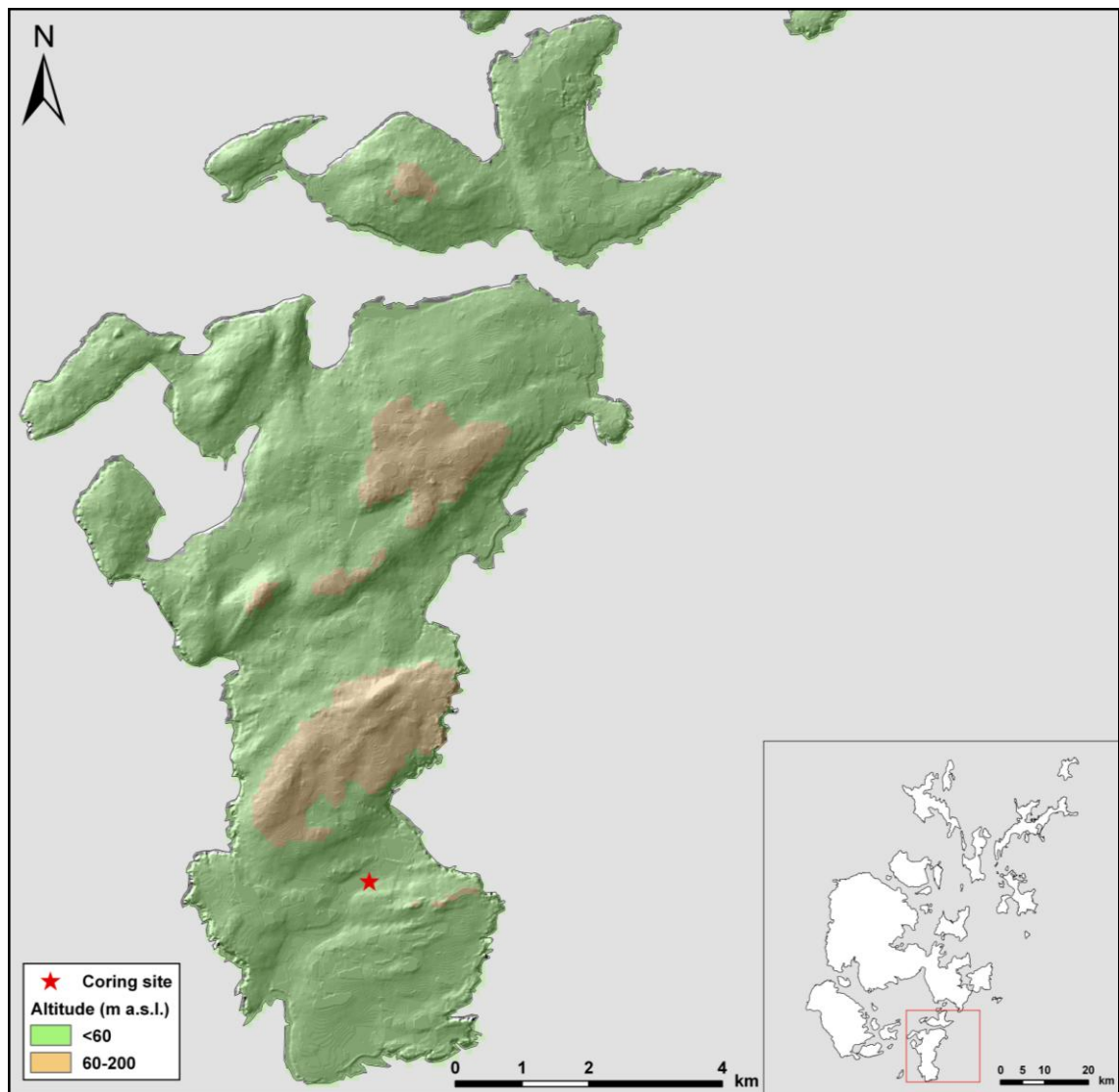
Figure 7.2 Location and topography of Blows Moss, South Ronaldsay

Blows Moss has been extensively cut for peat in the past (e.g. Callander 1931) and the bog surface is extremely wet, so it was not possible to undertake a gouge survey at this site. Therefore a coring location on one of the more stable peat baulks was selected, at ND 45457 85895 (approximately 10 m a.s.l., see Fig. 7.2). The vegetation at the coring point consisted of *Caltha palustris*, *Filipendula ulmaria*, *Equisetum palustre*, *Mentha aquatica* and Poaceae. *Menyanthes trifoliata* was abundant in slight surface depressions within the basin, and Apiaceae were also observed. Occasional patches of *Salix* scrub were also present.

Figure 7.3 Blows Moss, viewed from approximately 800 m to the north from the site of the Iron Age roundhouse at The Cairns

Figure 7.4 Aerial photograph of Blows Moss, viewed from the east (© RCHAMS)
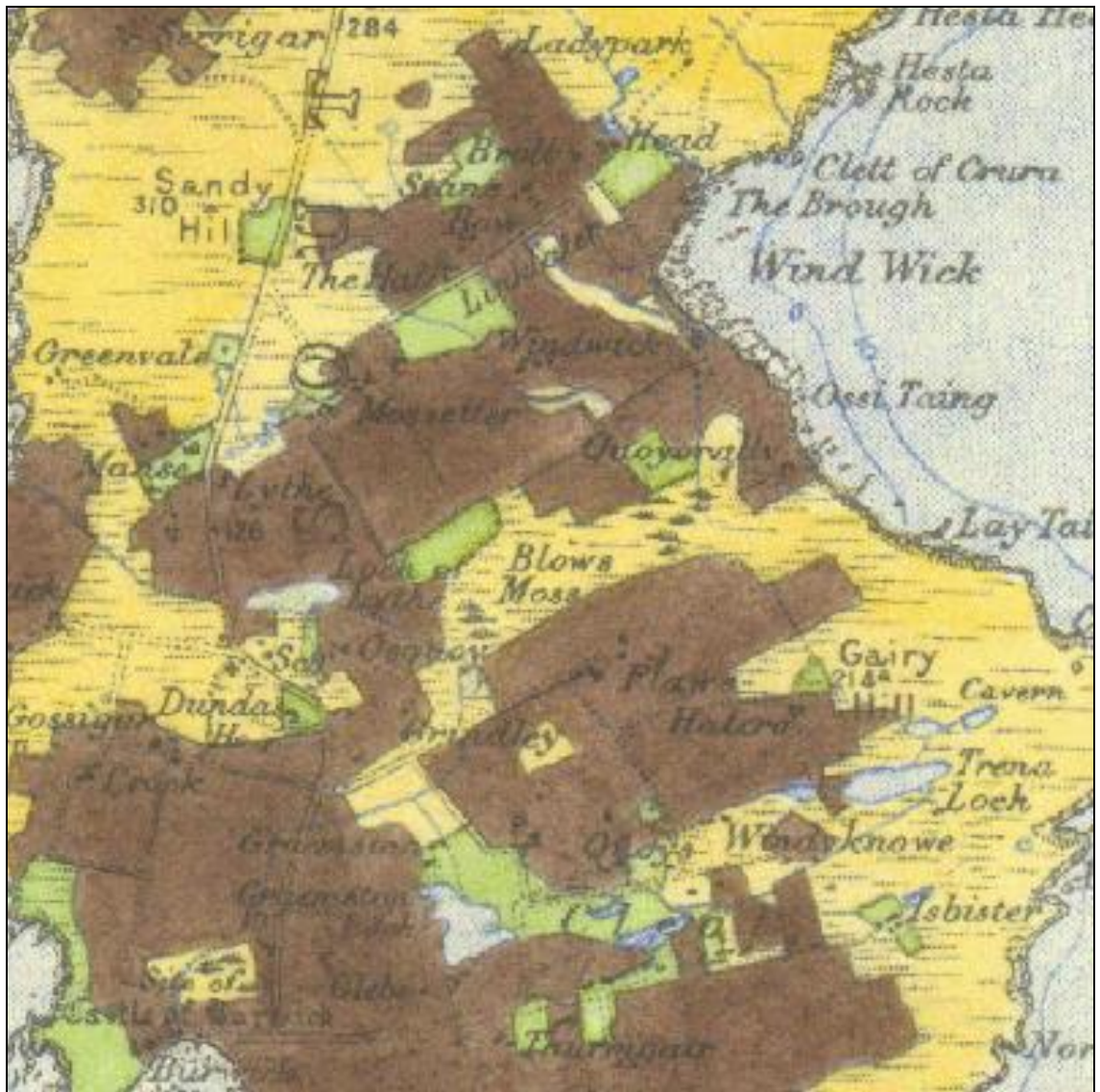
Figure 7.5 Land-use surrounding Blows Moss, taken from the Land Utilisation Survey of Britain (Stamp 1931-1935). © L. Dudley Stamp/Geographical Publications Ltd, Audrey N. Clark, Environment Agency/DEFRA and Great Britain Historical GIS. Key: brown = arable land; green = meadowland and permanent grassland; yellow = heathland, moorland and rough grassland.
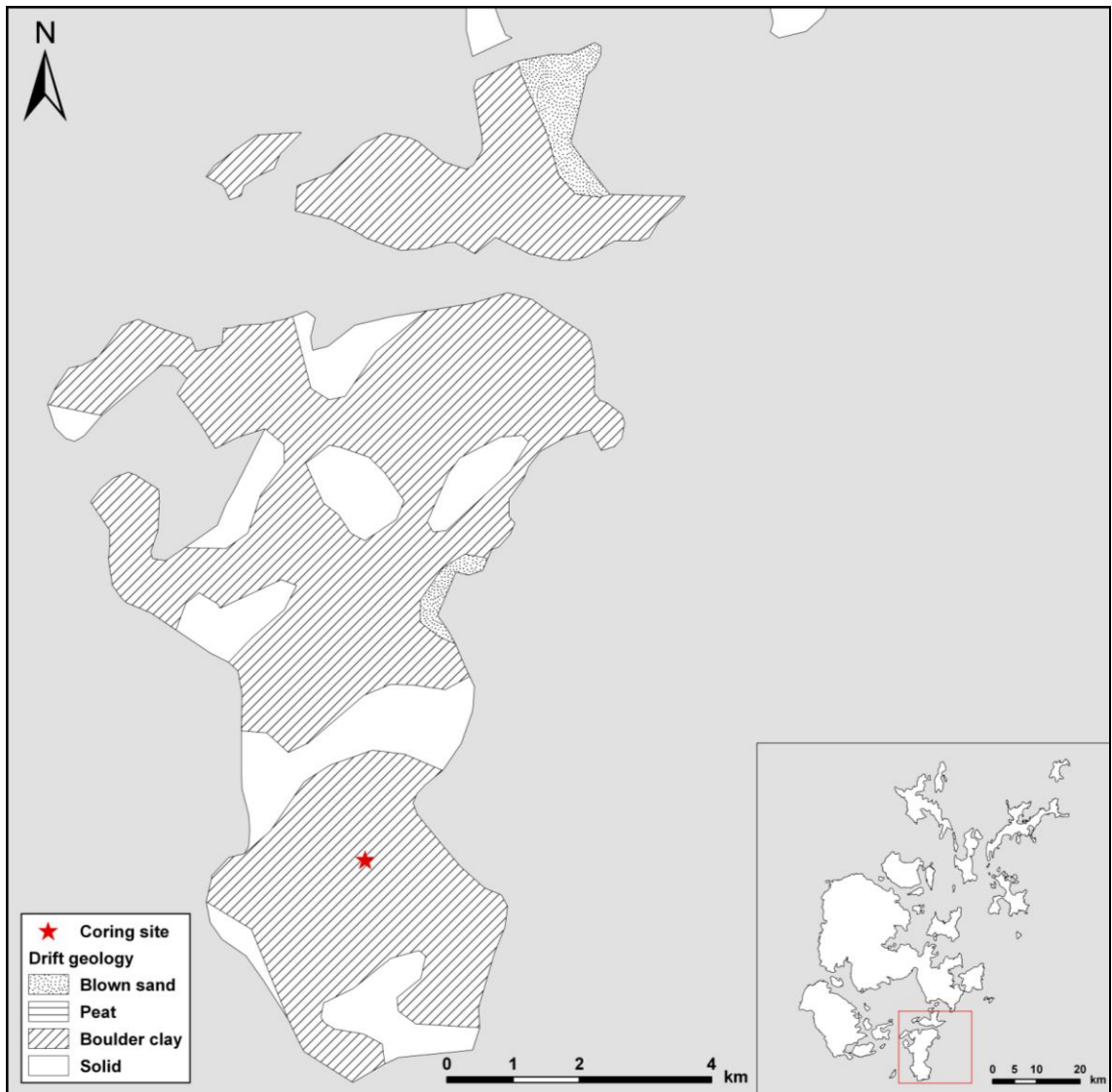
Figure 7.6 Drift geological deposits in the area surrounding Blows Moss (© Crown Copyright/database right 2009. A British Geological Survey/EDINA supplied service).

Figure 7.7 View to the south-west from the coring point at Blows Moss. The site currently supports a fen vegetation and small areas of open water are present within the mire.
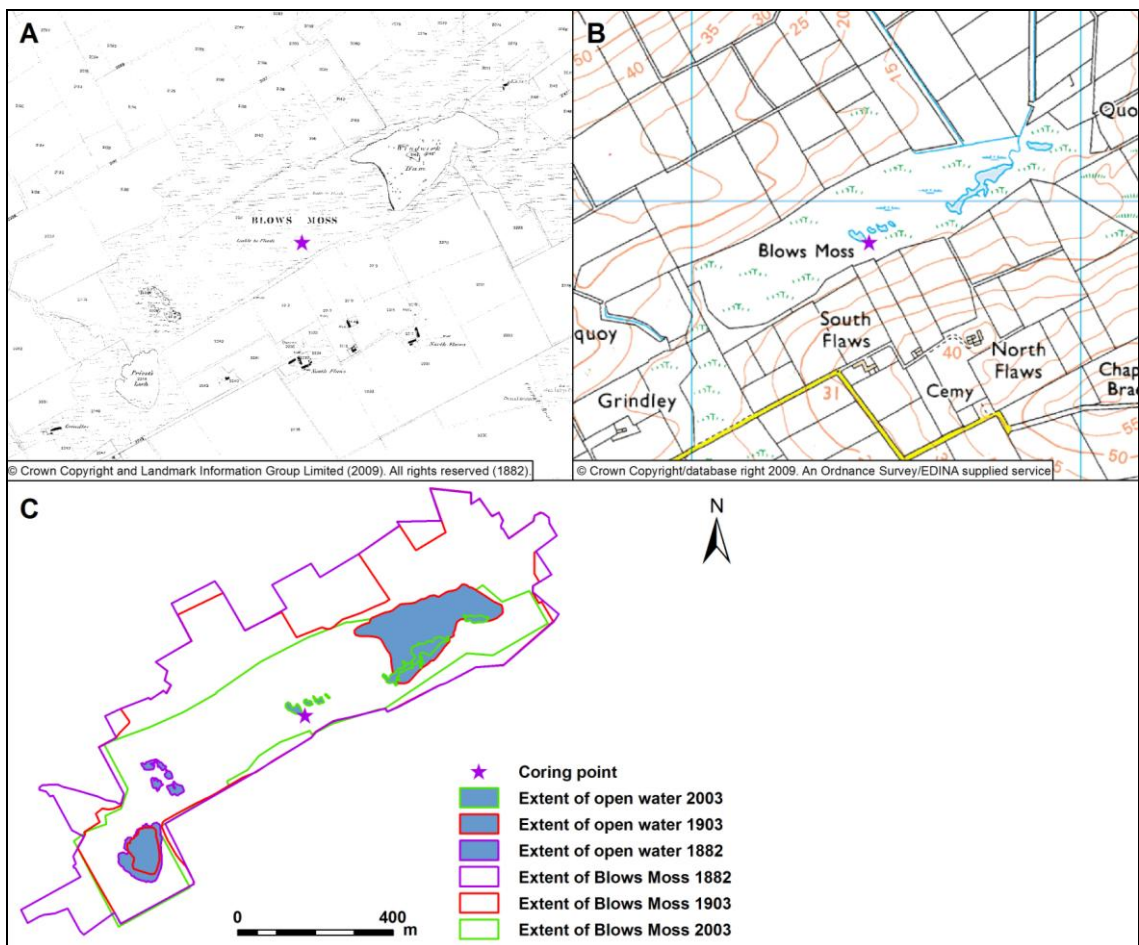
Figure 7.8 Changes in the extent of Blows Moss from 1882 to 2003: A) Ordnance Survey map from 1882; B) Ordnance Survey map from 2003; C) Map showing the changes in extent of Blows Moss and associated areas of open water from between 1882 and 2003

7.4 Results

7.4.1 Age Estimates

Radiocarbon age estimates are presented in Table 7.1, along with calibrated ages. Various age models were tested for this site although none was found to give any real advantage over simple linear interpolation between and extrapolation from age estimates. In the absence of a large number of age estimates it was decided that this gave the most reasonable age model (see Fig. 7.9).

Depth (cm)	Radiocarbon age (years BP) 1 σ	Laboratory reference	Calibrated age range (years BP) 2 σ	Calibrated mid-point age (BC/AD)
353	6402 ±39	SUERC-17185	7419-7268	5394 BC
177	4864 ±38	SUERC-17186	5660-5482	3621 BC
50	3238 ±37	SUERC-17187	3557-3384	1521 BC

Table 7.1 Radiocarbon age estimates from Blows Moss
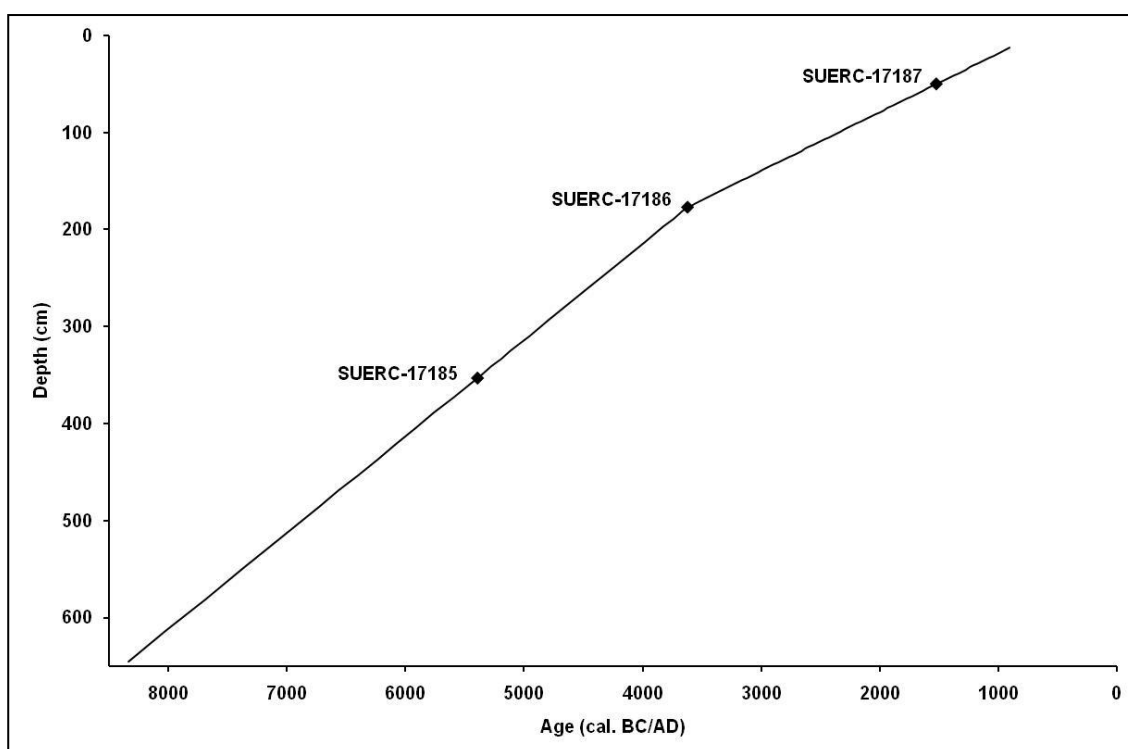
Figure 7.9 Linear age-depth model for Blows Moss

Fig. 7.9 implies that the upper part of the sequence is missing, presumably having been removed during peat cutting at some time in the past. If the top of the sequence is assumed to represent the cut surface, with no peat formation having taken place since cutting, then the top of the record has an age of *c*. 910 cal. BC, or late Bronze Age. However it seems more likely that one of the stratigraphic changes in the upper 50 cm of the sequence, at either 31 cm or 19 cm (see Table 7.2), represents the cut surface and that the units above this contain relatively recent peat that formed following cutting. The most likely depth for the previously cut surface is 19 cm, since the unit above this is made up of peat that mainly consists of recognisable plant fragments, implying there has not been sufficient time for decay to occur. Therefore the uppermost unit is likely to represent relatively recent peat formation. The basal age of this unit is approximately 1010 cal. BC.

If the peat is assumed to have accumulated at a constant rate from the bottom of the core to a depth of 353 cm (radiocarbon dated to *c*. 5390 cal. BC), then the base of the core has an approximate age of 8340 cal. BC. Therefore the sequence from Blows Moss certainly covers the period from *c*. 5390 cal. BC (late Mesolithic) to *c*. 1520 cal. BC (mid Bronze Age), and it is likely that the record actually extends from *c.* 8340 cal. BC (early Mesolithic) to *c*. 1010 cal. BC (late Bronze Age). The final part of the period of interest for this study (*c*. 3000 cal. BC to *c*. 600 cal. AD) is therefore not represented at this site, and so differences in land-use between the Bronze and Iron Ages cannot be ascertained. However, evidence for land-use from the late Neolithic to late Bronze Age should be present within the Blows Moss sequence. Sampling resolution across the period *c*. 3000-1010 cal. BC is approximately 35 years.

7.4.2 Lithostratigraphy

A summary of the major lithostratigraphic units is presented in Table 7.2, and a stratigraphic column is shown at the left-hand side of pollen, NPP, microstructure and inorganic diagrams. The sequence ends at a depth of 6.5 m, the point at which the sediment became too difficult to extract with a Russian sampler. During initial assessment of the site using a Dutch auger, a depth of 7 m was reached at the coring point, and the base of the sequence consisted of compact grey clay. The sedimentary sequence studied here is therefore incomplete.

Depth (cm)	Troels-Smith (1955) classification	Munsell colour	Munsell description	Notes
0-19	Dh2Dg1Sh1	10YR 2/1	Black	Top 3 cm not recovered
19-31	Sh3Dg1Dh+	10YR 2/2	Very dark brown	
31-51	Dg3Sh1Dh+	10YR 2/1	Black	
51-175	Dg2Dh1Sh1Dl+	10YR 2/1	Black	Large plant fragments, including *Phragmites* stems
175-186	Sh3Dg1Dh+	10YR 2/1	Black	
186-235	Sh2Dg2Dh+	10YR 2/2	Very dark brown	
235-250	Sh3Dg1Dh+	10YR 2/1	Black	
250-345	Sh2Dg2Dh+Dl+	10YR 2/1	Black	
345-400	Ld3Dg1Dh+	10YR 2/1	Black	
400-482	Ld4Dg+Dh+Ag+	10YR 2/2	Very dark brown	
482-496	Ld3Gmin1Ag+	10YR 3/3	Dark brown	
496-506	Ld4Gmin+Ag+	10YR 3/3	Dark brown	
506-525	Ld3Gmin1Ag+	10YR 3/3	Dark brown	
525-555	Ld4Gmin+Ag+	10YR 2/2	Very dark brown	Darker organic bands *c*. 543-550 cm
555-650	Ld4Ag+	10YR 3/4	Dark yellowish brown	Lighter inorganic bands *c*. 589-590 and 598-599 cm

Table 7.2 Lithostratigraphic units in the Blows Moss sequence

The lower part of the sequence is made up of fine organic lake mud with a very low silt content. Two narrow bands of sandier material occur at 525-506 cm and 496-482 cm. From 400 cm, humified plant remains make up a proportion of the sediment, and at 345 cm there is a change from fine organic lake mud to well-humified peat containing visible plant remains. This unit essentially continues to the top of the profile although the proportions of humified organics and recognisable plant macrofossils vary, allowing smaller units to be identified within this (Table 7.2). Pieces of wood are occasionally present from 345-250 cm and 175-51 cm. At 19 cm there is a very distinct change from well-humified peat to a more herbaceous peat containing only partially decayed plant material, and this is interpreted as recent peat formation on the previously cut surface of the mire.

7.4.3 Physical Sediment Properties

The results for wet and dry density, organic content and 'carbonate' content of the sediment core from Blows Moss are illustrated in Fig. 7.10. The zonation scheme used is the same as that used for the pollen diagram (Fig. 7.11) from this site in order to aid description and interpretation, since the zone boundaries generally tend to coincide with major changes in the sediment properties.
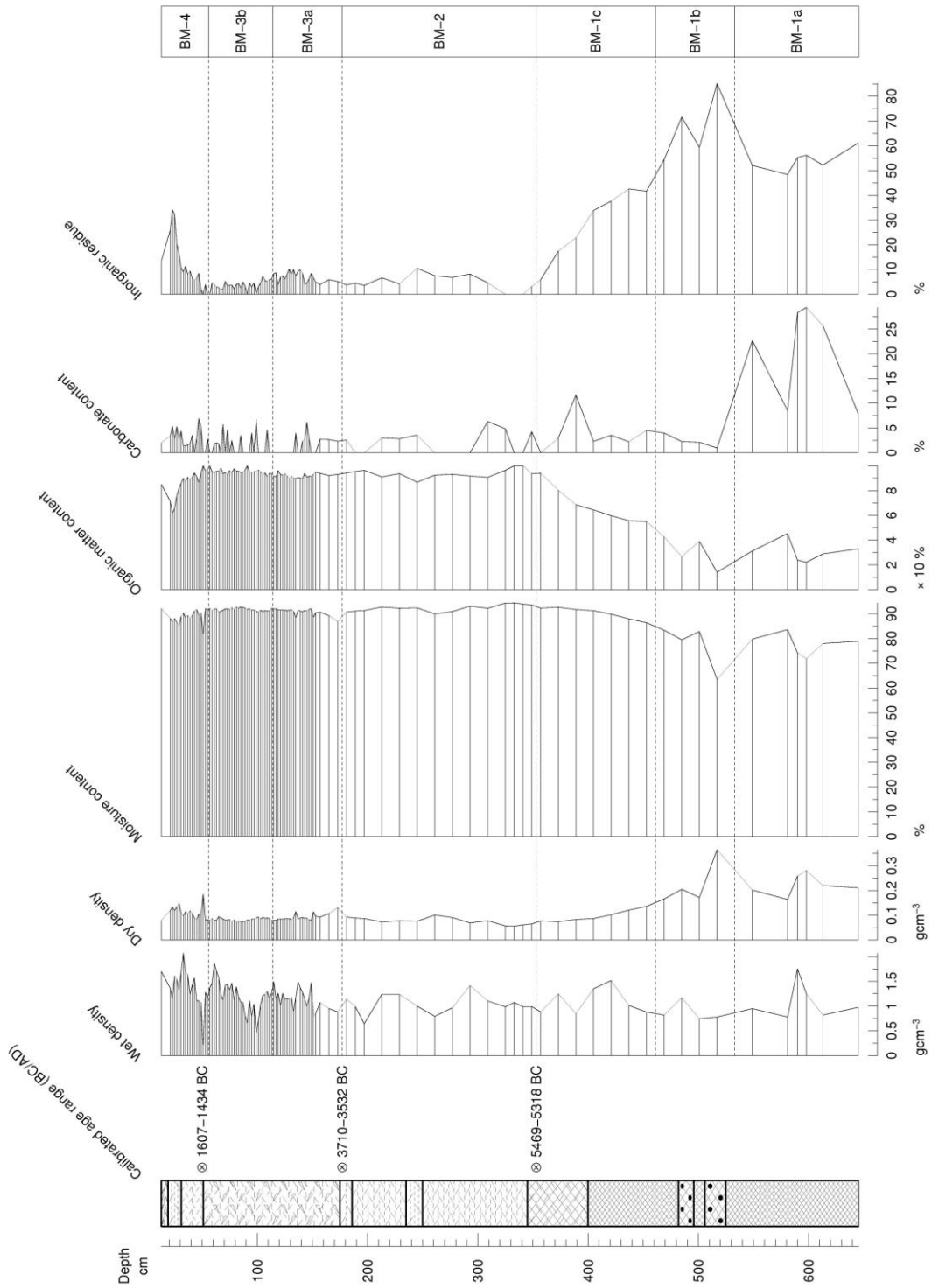
Figure 7.10 Physical sediment properties of the Blows Moss core (note change in scale for organic matter content)

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Zone BM-1 (645-353 cm; c. 8340-5390 cal. BC)

This zone is generally characterised by a comparatively high inorganic content, indicating that the silt content may be higher than was apparent during visual inspection and recorded using the Troels-Smith (1955) system. It can be split into three subzones, described below.

Subzone BM-1a (645-533 cm; c. 8340-7210 cal. BC)

The sediment in this subzone is a fine organic lake mud with a fairly high silt content, indicated by inorganic values of c. 50-60%. 'Carbonate' content is also high, particularly between 613 and 590 cm where it reaches c. 20%. This roughly corresponds with the lighter inorganic bands at c. 599-598 cm and c. 590-589 cm noted during Troels-Smith description and recorded in Table 7.2 above. Organic content is c. 25-45% throughout this subzone.

Subzone BM-1b (533-461 cm; c. 7210-6480 cal. BC)

The organic silty lake mud continues through this subzone, but at 525-506 cm and 496-482 cm there are bands of sandier material. This observation is supported by the inorganic content of the sediment, which increases to c. 85% and c. 70% respectively. 'Carbonate' content falls to less than 4% in this subzone, and organic content remains at c. 20-45% throughout.

Subzone BM-1c (461-353 cm; c. 6480-5390 cal. BC)

The sediment in this subzone again consists of a fine organic silty lake mud, although silt content appears to decline through the subzone. This is indicated by the inorganic percentages which fall from c. 45% at the start of the subzone to c. 8% at the end. Organic content shows a corresponding increase throughout the subzone, rising from c. 55% to c. 95%. 'Carbonate' content is generally low throughout ($< 4\%$), although there is a peak of around 9% at 389 cm.

Zone BM-2 (353-177 cm; c. 5390-3610 cal. BC)

This zone consists of well-humified peat with varying proportions of graminoid and herbaceous plant fragments. Organic content is high throughout (c. 90-100%) and inorganic content is correspondingly low. 'Carbonate' content is also low, between 0 and 5% throughout, with the highest proportion occurring from 325-309 cm. Wood fragments are recorded between 345 and 250 cm.

Zone BM-3 (177-56 cm; c. 3610-1620 cal. BC)

This zone is again characterised by a very high organic matter content, and has been split into two subzones on the basis of the pollen data. The differences in sediment characteristics between the two subzones are very slight but will be described below.

Subzone BM-3a (177-114 cm; c. 3610-2580 cal. BC)

The sediment in this subzone consists of herbaceous plant remains of varying sizes (0.1-2 mm) mixed with well-humified peat containing no identifiable organic remains. Organic matter content is high, consistently around 90% throughout the subzone. Inorganic content is between 8 and 10%, and 'carbonate' content is again low.

Subzone BM-3b (114-56 cm; c. 2580-1620 cal. BC)

This subzone is broadly similar to subzone BM-3a. Organic content is slightly higher, reaching 95-100% in places, and inorganic content shows a corresponding decrease. 'Carbonate' content remains low but fluctuates between 0 and *c*. 5% throughout the subzone.

Zone BM-4 (56-13 cm; c. 1620-910 cal. BC)

Although this zone covers the rest of the sequence up to a depth of 13 cm (the uppermost sample that was analysed), as discussed earlier it is likely that the transition from well-humified peat with few visible plant fragments to a more herbaceous peat containing only partially decayed plant material that occurs at 19 cm represents recent peat formation on the previously cut surface of the mire.

The lower part of the zone is similar to subzone BM-3b, although organic content is slightly lower (*c.* 90%) and the inorganic residue is correspondingly higher. However organic content begins to decrease in the upper part of the zone, from around 31 cm. It reaches its lowest value of *c*. 70% at a depth of 23 cm. Following this decrease the organic content then rises again to *c*. 85% at 13 cm, providing support for the idea that the upper peat unit represents recent growth. Inorganic content increases as organic content declines, reaching a maximum value of *c*. 35% at 23 cm. 'Carbonate' content continues to fluctuate between values of 1 and 5% throughout this zone.

7.4.4 Pollen and Charcoal Analysis

A percentage pollen diagram for Blows Moss is presented in Fig. 7.11. The results of charcoal analysis are appended to the pollen diagram. The zonation scheme is based on all taxa with values greater than 2% in at least one sample, which included *Pinus sylvestris*, *Ulmus*, *Quercus*, *Betula*, *Alnus glutinosa*, *Corylus avellana*-type, *Salix*, *Empetrum nigrum*, *Calluna vulgaris*, *Vaccinium*-type, *Ranunculus acris*-type, *Rumex* undiff., *Filipendula*, *Potentilla*-type, *Plantago lanceolata*, Chenopodiaceae, Caryophyllaceae, Rosaceae undiff., Asteraceae (Asteroideae), Cyperaceae, *Phragmites*-type, Poaceae, *Selaginella selaginoides* and Pteropsida (monolete) undiff. A pollen concentration diagram for the site is shown in Fig. 7.12. Each zone is described individually below, and the trends described in the percentage diagram are reflected by the concentration data except where otherwise stated.

Zone BM-1 (645-353 cm; c. 8340-5390 cal. BC)

This zone is characterised by high total pollen concentrations (*c.* 60,000-100,000 grains cm^{-3}), high arboreal pollen percentages (*c.* 50-80% of the total pollen sum) and the presence of pollen of aquatic taxa including *Myriophyllum spicatum*-type, *Myriophyllum alterniflorum*, and *Littorella uniflora*. The zone is divided into three subzones which are described below.

Subzone BM-1a (645-533 cm; c. 8340-7210 cal. BC)

Total pollen concentration is relatively high throughout this subzone (*c.* 55,000-80,000 grains cm^{-3}). Arboreal pollen dominates, rising from *c.* 40% of the total at the base of the subzone to a maximum of *c.* 80%. *Corylus avellana*-type pollen makes up less than 5% of the sum at the start of the zone but increases at the expense of *Betula* to become the dominant arboreal component, forming around 55% of the total pollen sum. Other tree species represented in this subzone make up very small proportions of the total pollen sum, and include *Pinus sylvestris* (*c.* 5-10%), *Quercus* (*c.* 1%), *Ulmus* (*c.* 1-2%) and *Salix* (*c.* 2-3%).
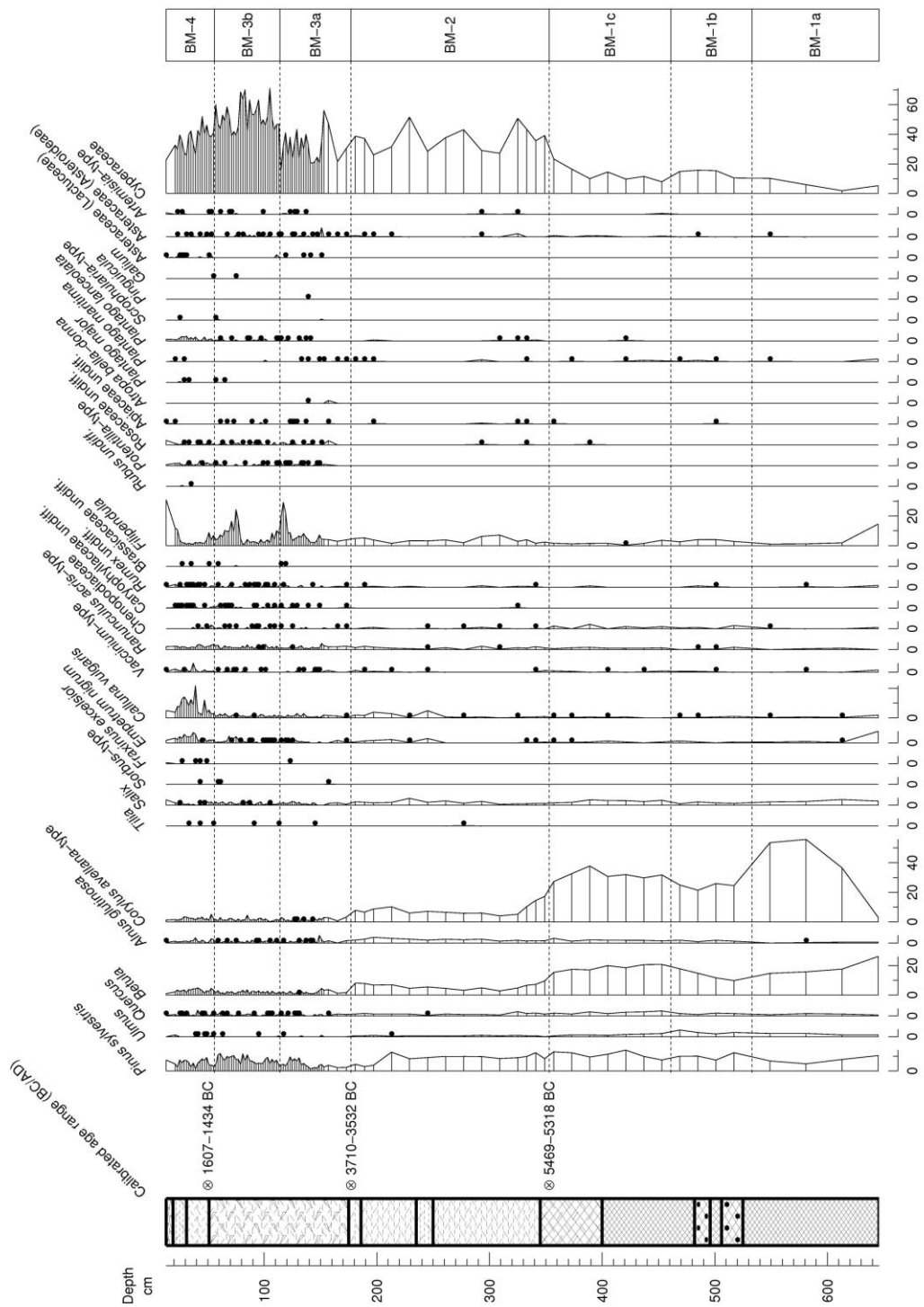
Figure 7.11 Percentage pollen and spore diagram from Blows Moss

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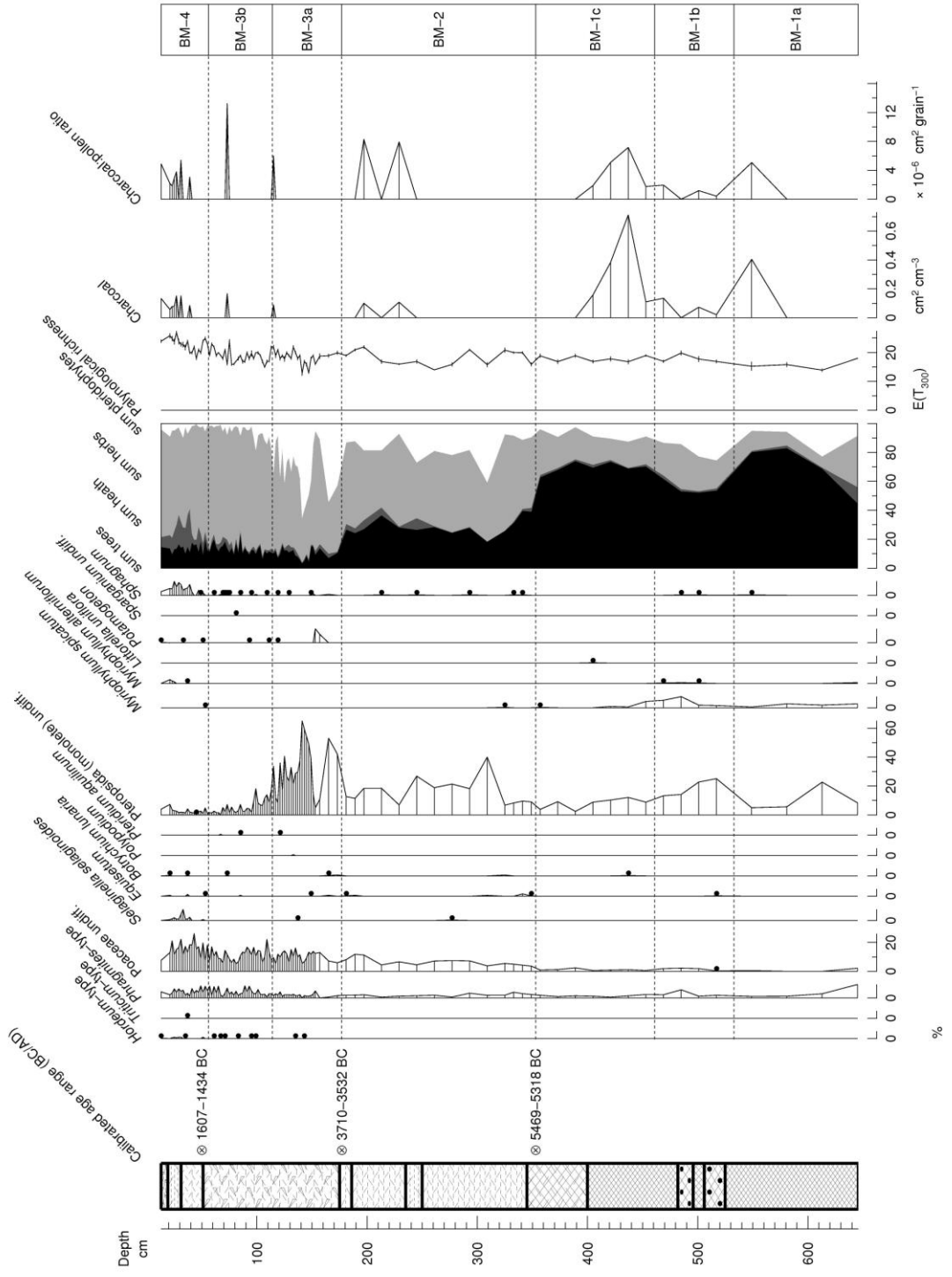
Figure 7.11 (continued) Percentage pollen and spore diagram from Blows Moss

Figure 7.12 Pollen and spore concentrations from Blows Moss

Figure 7.12 (continued) Pollen and spore concentrations from Blows Moss

Spores of pteridophytes are also present within this subzone, reaching a peak of *c*. 22% of the total sum at 613 cm but declining to *c*. 5% by the end of the subzone. Of the herbaceous taxa present, *Filipendula* forms *c*. 15% of the pollen sum at the beginning of the subzone but rapidly decreases to levels of 1-2% within the rest of the subzone. Cyperaceae and *Phragmites*-type are the only other herbaceous taxa present in any significant quantity. Cyperaceae pollen is present in quantities of about 5% throughout, and *Phragmites*-type pollen makes up around 10% of the sum at the base of the subzone but decreases to *c*. 1% by the boundary with subzone BM-1b. Few heath taxa are represented, and although *Empetrum nigrum* forms around 8% of the pollen sum at the base of the subzone it declines to less than 1% by the top of the subzone.

Myriophyllum spicatum, an aquatic taxon, is also present in this subzone in low amounts (around 2%). Palynological richness is fairly constant throughout this subzone, fluctuating between around 14 and 19 taxa. No charcoal is present at the start of the subzone but there is an isolated peak at 549 cm where it reaches a value of around 0.4 cm^2cm^{-3}, with a corresponding increase in the charcoal:pollen ratio.

Subzone BM-1b (533-461 cm; c. 7210-6480 cal. BC)

Total pollen concentration is lower in this subzone, between *c*. 45,000 and *c*. 70,000 grains cm^{-3}. Arboreal pollen percentages show a marked decrease at the beginning of this subzone, falling from *c*. 80% to *c*. 55%. The main taxon featuring in this decline is *Corylus avellana*-type, percentages of which decrease from around 55% to *c*. 20-25%. Values of *Betula* pollen also show a slight decline, but those of other arboreal taxa remain relatively constant throughout this subzone. *Alnus glutinosa* pollen forms around 1% of the total sum throughout this subzone.

Pteridophyte spore counts are higher within this subzone, forming around 15-25% of the total sum. Poaceae and Cyperaceae pollen percentages also show a slight expansion, reaching around 2% and 15% respectively. Proportions of *Filipendula* pollen also increase slightly, to *c*. 4%. The importance of heath taxa is minimal, and in total they reach values of about 2% in this subzone.

Aquatic taxa continue to be present, including *Myriophyllum spicatum* and *Myriophyllum alterniflorum*. *M. spicatum* shows a slight increase in frequency at 485 cm and remains at values of between 5 and 7% until the end of the subzone.

Palynological richness remains relatively constant, with values of *c*. 17-20 taxa. Charcoal is present in low amounts, around 0.02-0.13 cm^2cm^{-3}, throughout.

Subzone BM-1c (461-353 cm; c. 6480-5390 cal. BC)

Total pollen concentration increases again in this subzone, reaching values of between 60,000 and 100,000 grains cm^{-3}. Proportions of arboreal pollen rise at the beginning of the subzone, reaching maximum values of *c*. 70%. *Corylus avellana*-type is again the dominant pollen taxon, forming around 30-40% of the total sum. The percentages of *Pinus sylvestris, Betula, Alnus glutinosa, Quercus* and *Salix* pollen show slight increases in comparison with the previous subzone.

Pteridophyte spore percentages show a slight decline in this subzone, falling to around 5-10% of the total sum. Poaceae, Cyperaceae and *Filipendula* pollen is present in similar quantities to the previous subzone. Other herbaceous taxa represented include *Ranunculus acris*-type and Chenopodiaceae, although their pollen is only present in low frequencies. Percentages of heath taxa remain negligible throughout this subzone, forming only 1-2% of the total pollen sum.

Aquatic taxa are still present but at lower frequencies than before, and percentages decline to almost zero by the middle of the subzone. Palynological richness remains at similar values to those in the previous subzone. Charcoal values reach a peak of about 0.7 cm^2cm^{-3} at 437 cm, before showing a steady decrease to zero at a depth of 389 cm, and the charcoal:pollen ratio exhibits a similar pattern.

Zone BM-2 (353-177 cm; c. 5390-3610 cal. BC)

There is a distinct decline in total pollen concentration at the beginning of this zone, and for most of the zone concentrations range between 10,000 and 20,000 grains cm^{-3}. The beginning of this zone is also marked by a decline in arboreal pollen percentages to *c*. 25-40% of the total pollen sum. The main pollen taxa featuring in this decline are *Betula* and *Corylus avellana*-type, while percentages of *Pinus sylvestris*, *Quercus*, *Alnus glutinosa* and *Salix* remain more or less constant. However it can be seen from Fig. 7.12 that all arboreal taxa decrease in concentration at the start of the zone.

At the start of the zone there is an increase in the spores of pteridophytes to *c*. 40% of the total sum, although this is an isolated peak and following this they comprise around

20% of the total sum for the remainder of the zone. Cyperaceae and Poaceae pollen percentages also begin to increase, to around 40% and 10% respectively, and the zone is dominated by herbaceous taxa. *Filipendula* pollen percentages increase slightly to around 5%, and pollen of anthropogenic indicator species such as *Plantago lanceolata* and *Artemisia*-type is sporadically present in very low quantities. Percentages of heath taxa begin to increase slightly from 245 cm, forming around 5-8% of the total pollen sum for the rest of the zone.

Of the aquatic pollen taxa, *Myriophyllum spicatum* makes an isolated appearance at 325 cm. *Sphagnum* occurs sporadically at very low values throughout the zone. Palynological richness is around 22 taxa at the start of the zone, before falling to 15 taxa at 261 cm and increasing again to around 20 taxa by the end of the zone. Low quantities (*c*. 0.1 cm^2cm^{-3}) of charcoal occur at 229 cm and 197 cm, matched by peaks in the charcoal:pollen ratio.

Zone BM-3 (177-56 cm; c. 3610-1620 cal. BC)

This zone is characterised by low total pollen concentrations, very low arboreal pollen percentages (*c*. 10-20%) and higher values for palynological richness than previously. The pollen assemblage throughout is dominated by herbaceous taxa. The zone is split into two subzones which are described below.

Subzone BM-3a (177-114 cm; c. 3610-2580 cal. BC)

Total pollen concentration is low, with values of around 23,000 grains cm^{-3} in the lower part of the subzone declining to *c*. 10,000 grains cm^{-3} towards the top. At the beginning of the subzone arboreal pollen values decline to around 15%, and they remain between 10 and 20% throughout. Percentages of *Pinus sylvestris* pollen begin to increase towards the top of the subzone, reaching values of around 4%.

Percentages of pteridophyte spores are higher than in the previous zone, forming *c*. 40-65% of the total sum in the lower part of the subzone before declining to around 30% in the upper part. There is also an isolated decline in the earlier part of the subzone, when the proportion of pteridophyte spores drops to *c*. 5% at 153 cm before recovering to previous levels. The peak value of *c*. 65% at 141 cm is matched by an increase in the concentration of these spores (Fig. 7.12).

Herbaceous taxa are dominant, forming between 50 and 85% of the total pollen sum throughout most of the subzone. Of these taxa Cyperaceae pollen forms the highest proportion (*c.* 25-40%), although concentrations of this taxon are generally slightly lower than in the previous zone. There is an isolated peak of Cyperaceae pollen at around 157 cm, where the concentration reaches *c.* 10,000 grains cm^{-3}. This peak approximately coincides with the decline in pteridophyte spores. Proportions of Poaceae pollen increase slightly in this subzone to around 10-15%.

Of the other herbaceous taxa present, *Ranunculus acris*-type pollen occurs at levels of *c.* 2%, and *Filipendula* pollen forms around 5% of the total pollen sum throughout most of the subzone. Towards the end of the subzone *Filipendula* pollen percentages increase to *c.* 30% of the total at 117 cm. Other herbaceous taxa represented include Caryophyllaceae, *Potentilla*-type, Rosaceae undiff., Apiaceae undiff., *Plantago maritima* and Asteraceae, although the pollen of these taxa is present only in very small quantities.

Pollen of anthropogenic indicator species such as *Rumex* undiff., *Plantago lanceolata* and *Artemisia*-type is also present at low frequencies (<1%) from around 140 cm onwards. Cereal-type pollen, identified as *Hordeum*-type on the basis of the annulus diameter (Andersen 1979), occurs for the first time in this zone at a depth of 143 cm.

Heath taxa including *Empetrum nigrum, Calluna vulgaris* and *Vaccinium*-type form around 1-3% of the total pollen sum in this subzone. Low frequencies of *Sphagnum* spores continue to occur sporadically, and amongst the aquatic taxa there is a small peak (*c.* 10%) of *Potamogeton* pollen at around 153 cm.

Palynological richness drops to around 13 taxa at *c.* 149 cm, before increasing to *c.* 25 taxa at about 135 cm. By the end of the subzone palynological richness is fluctuating between *c.* 21 and 24 taxa. No charcoal is present until the boundary with subzone BM-3b, where an isolated peak of around 0.1 cm^{2}cm^{-3} occurs.

Subzone BM-3b (114-56 cm; c. 2580-1620 cal. BC)
Total pollen concentration remains similar to that in the previous subzone (*c.* 10,000-20,000 grains cm^{-3}). Arboreal pollen percentages also remain at *c.* 10-20% throughout this subzone, although they appear to be slightly higher than in subzone

BM-3a. *Pinus sylvestris* pollen continues to be present in slightly higher amounts, forming around 10% of the total sum by the end of the subzone. Percentages of pteridophyte spores decline from *c*. 15% at the base of the subzone to less than 5% by the end.

Herbaceous taxa are again dominant, forming 70-85% of the total pollen sum. Cyperaceae continue to dominate this group of taxa, although with higher pollen percentages than previously. Frequencies of this taxon fluctuate markedly between *c*. 40% and *c*. 70% throughout the subzone. Proportions of Poaceae pollen vary between about 5% and 15%, although concentrations of this taxon remain relatively constant.

Filipendula pollen exhibits a marked decrease to *c*. 10% at the start of the subzone, falling to <5% by about 105 cm. A sharp increase in the frequency of this taxon to *c*. 25% then occurs at 75 cm, followed by a steady decline to around 5% of the total sum by the end of the subzone. In terms of other herbaceous taxa, the same species represented in subzone BM-3a continue to be present at low frequencies (*c*. 1-2%). *Rumex* undiff. and *Plantago lanceolata* are present in very low quantities (*c*. 1%), and low frequencies of *Artemisia*-type occur sporadically. *Hordeum*-type pollen is consistently present in low amounts (<1%) throughout the subzone.

Heath taxa are present in slightly greater frequencies (*c*. 2-5%) than in the previous subzone. *Sphagnum* spores continue to occur sporadically, and very small quantities of aquatic taxa including *Potamogeton* and *Sparganium* pollen are occasionally represented. Palynological richness fluctuates between about 16 and 25 taxa throughout the subzone. An isolated peak of charcoal (*c*. 0.15 cm^2cm^{-3}) occurs at a depth of 73 cm.

Zone BM-4 (56-13 cm; c. 1620-910 cal. BC)

As discussed earlier, it is likely that the transition from well-humified peat with few visible plant fragments to a more herbaceous peat containing only partially decayed plant material that occurs at 19 cm represents recent peat formation on the previously cut surface of the mire. This is supported by marked changes in the pollen sequence at this depth, including a sudden increase in total pollen concentration and in percentages of *Filipendula* pollen, and declines in the pollen percentages of other taxa such as

Calluna vulgaris, Cyperaceae and Poaceae. These changes appear to support the idea of a hiatus in the record at this depth.

In the rest of this zone, total pollen concentrations are higher than previously, varying between *c*. 20,000 and *c*. 45,000 grains cm^{-3}. Arboreal pollen percentages remain between about 10% and 20%, although there are differences in the proportions of individual arboreal taxa. *Pinus sylvestris* pollen proportions decline slightly from *c*. 10% to *c*. 7%, although there are slight peaks in concentration of this taxon at 45 cm and 29 cm. Proportions of *Betula* pollen show a minor increase from *c*. 2% to *c*. 4% in this zone, and there is also a slight rise in the concentration of *Corylus avellana*-type pollen. Frequencies of other arboreal taxa remain similar to those in the previous zone.

Herbaceous taxa dominate this zone and vary between *c*. 70% and *c*. 80% in the lower part of the zone, declining to *c*. 50-60% above 40 cm. Cyperaceae pollen percentages are lower than previously, although the concentration of this taxon shows an increase. Poaceae pollen shows a slight expansion in this zone, reaching frequencies of around 20%. *Ranunculus acris*-type, Caryophyllaceae, *Filipendula*, *Potentilla*-type, Rosaceae undiff. and Asteraceae pollen continues to occur in low frequencies throughout this zone.

Low quantities of pollen of anthropogenic indicator species such as *Rumex* undiff. and *Artemisia*-type remain, and frequencies of *Plantago lanceolata* pollen are higher than in the previous zone, reaching *c*. 2-3% of the total pollen sum. *Hordeum*-type pollen continues to occur throughout the zone at slightly higher frequencies than previously (*c*. 1%). A single grain of cereal-type pollen identified as *Triticum*-type on the basis of the larger annulus diameter (Andersen 1979) is present at 37 cm.

Above 40 cm percentages of heath taxa are much higher than previously, forming *c*. 15-20% of the total pollen sum for the rest of the zone. Of the heath taxa present *Calluna vulgaris* pollen occurs in the highest frequencies (*c*. 10-15%), with smaller quantities of *Empetrum nigrum* and *Vaccinium*-type (*c*. 1-2%). Pteridophyte spores form around 3% of the total sum throughout the zone. *Selaginella selaginoides* spores are consistently present at low frequencies (*c*. 2-5%) above 40 cm.

Aquatic taxa such as *Myriophyllum spicatum, Myriophyllum alterniflorum* and *Potamogeton* occur sporadically and in very low frequencies (*c.* 1%) throughout this zone. Spores of *Sphagnum* occur in higher quantities (*c.* 5-10%) than in the previous zone. Palynological richness scores reach their highest levels in this zone, fluctuating between 20 and 26 taxa throughout. Charcoal is present in low amounts (*c.* 0.1 cm^{2}cm^{-3}) above 40 cm.

7.4.5 Non-Pollen Palynomorph Analysis

A diagram showing recorded frequencies of non-pollen palynomorphs (NPPs) as percentages of the combined sum of total land pollen and spores plus NPPs (following Mighall *et al.* 2006) is presented in Fig. 7.13. All NPPs recorded are fungal ascospores, all of coprophilous species (van Geel *et al.* 2003; Graf and Chmura 2006) except for those of *Diporotheca*-type, which regularly occur in Holocene deposits formed under mesotrophic to eutrophic conditions (van Geel *et al.* 1986). The same zonation scheme is used as for the pollen diagrams in order to aid description and discussion.

Zone BM-1 (645-353 cm; c. 8340-5390 cal. BC)

The only NPP type observed in this zone was *Sordaria*-type, which occurred at very low frequencies. This zone is divided into three subzones. No NPPs were observed in subzone BM-1a, so only the final two subzones are described below.

Subzone BM-1b (533-461 cm; c. 7210-6480 cal. BC)

Very low percentages (<1%) of *Sordaria*-type ascospores occur towards the top of this subzone, above 470 cm.

Subzone BM-1c (461-353 cm; c. 6480-5390 cal. BC)

Sordaria-type ascospores were recorded sporadically at very low frequencies (<1%), at around 453, 405 and 357 cm.

Zone BM-2 (353-177 cm; c. 5390-3610 cal. BC)

Sordaria-type ascospores are the predominant NPP type present in this zone, occurring at frequencies of *c.* 2-6% throughout. They occur most frequently between a depth of *c.* 261 cm and *c.* 229 cm. Ascospores of *Podospora*-type were recorded at percentages of less than 1% at around 260 cm, and again towards the top of the zone.
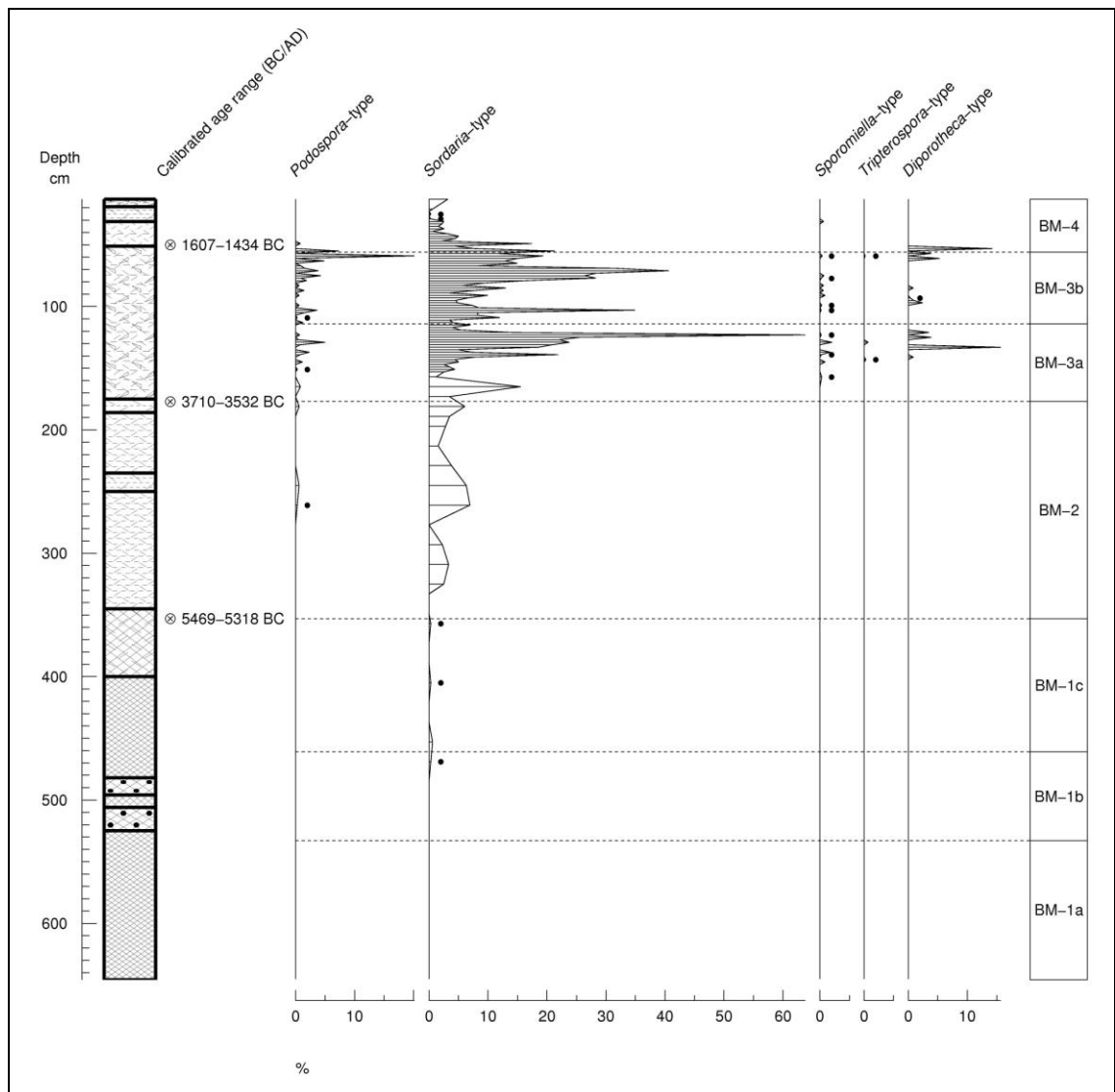
Figure 7.13 Percentages of non-pollen palynomorphs recorded in the Blows Moss core

Zone BM-3 (177-56 cm; c. 3610-1620 cal. BC)

This zone is characterised by high frequencies of *Sordaria*-type ascospores, although ascospores of all other NPP types recorded in the core are also present. The zone is split into two subzones, described individually below.

Subzone BM-3a (177-114 cm; c. 3610-2580 cal. BC)

Ascospores of *Sordaria*-type dominate this subzone, forming *c.* 15% of the total sum at around 165 cm and then declining to around 4%. Following this decline percentages of *Sordaria*-type ascospores exhibit a rapid expansion, reaching a frequency of *c.* 65% at 123 cm before rapidly declining again to around 7% of the total by the end of the subzone.

Podospora-type ascospores are present in higher quantities than previously, fluctuating between 1% and 4% for most of the subzone. Other NPPs such as *Sporomiella*-type and *Tripterospora*-type ascospores occur in this subzone for the first time, albeit sporadically and at very low frequencies (1-2% and <1% respectively). The first appearance of *Diporotheca*-type ascospores also occurs at around 141 cm, and reaches a peak of *c*. 15% at a depth of 133 cm.

Subzone BM-3b (114-56 cm; c. 2580-1620 cal. BC)

This subzone continues to be dominated by *Sordaria*-type ascospores, values of which show extreme fluctuations between *c*. 5% and *c*. 40% throughout. Peak frequencies of these ascospores occur at 103 cm (*c*. 35%), 71 cm (*c*. 40%), and 59 cm (*c*. 2%).

Podospora-type ascospores also fluctuate at around 1-3% of the total sum between 114 cm and 65 cm, before increasing rapidly to a peak value of *c*. 20% towards the top of the subzone. There are also sporadic occurrences of *Sporomiella*-type and *Diporotheca*-type ascospores in very low frequencies (<1% and 3-5% respectively) throughout the subzone.

Zone BM-4 (56-13 cm; c. 1620-910 cal. BC)

This zone continues to be dominated by ascospores of *Sordaria*-type, although these decline from *c*. 20% of the total sum at the base of the zone to <1% towards the top. At the start of the zone *Podospora*-type ascospores form *c*. 7% of the total sum but are not present above 48 cm. A single occurrence of *Sporomiella*-type (<1%) occurs at 31 cm, and no other NPP types were observed in this zone. An increase in *Sordaria*-type ascospores to *c*. 3% at 13 cm probably occurs within relatively recent sediment as discussed previously.

7.4.6 Microstructure Analysis

A diagram showing the results of the analysis of sieve residues retained during pollen processing is shown in Fig. 7.14. Table 7.3 records the frequencies of seeds and megaspores recovered during this process. Again, the zonation scheme used is the same as that for the pollen diagram in order to aid description and interpretation.
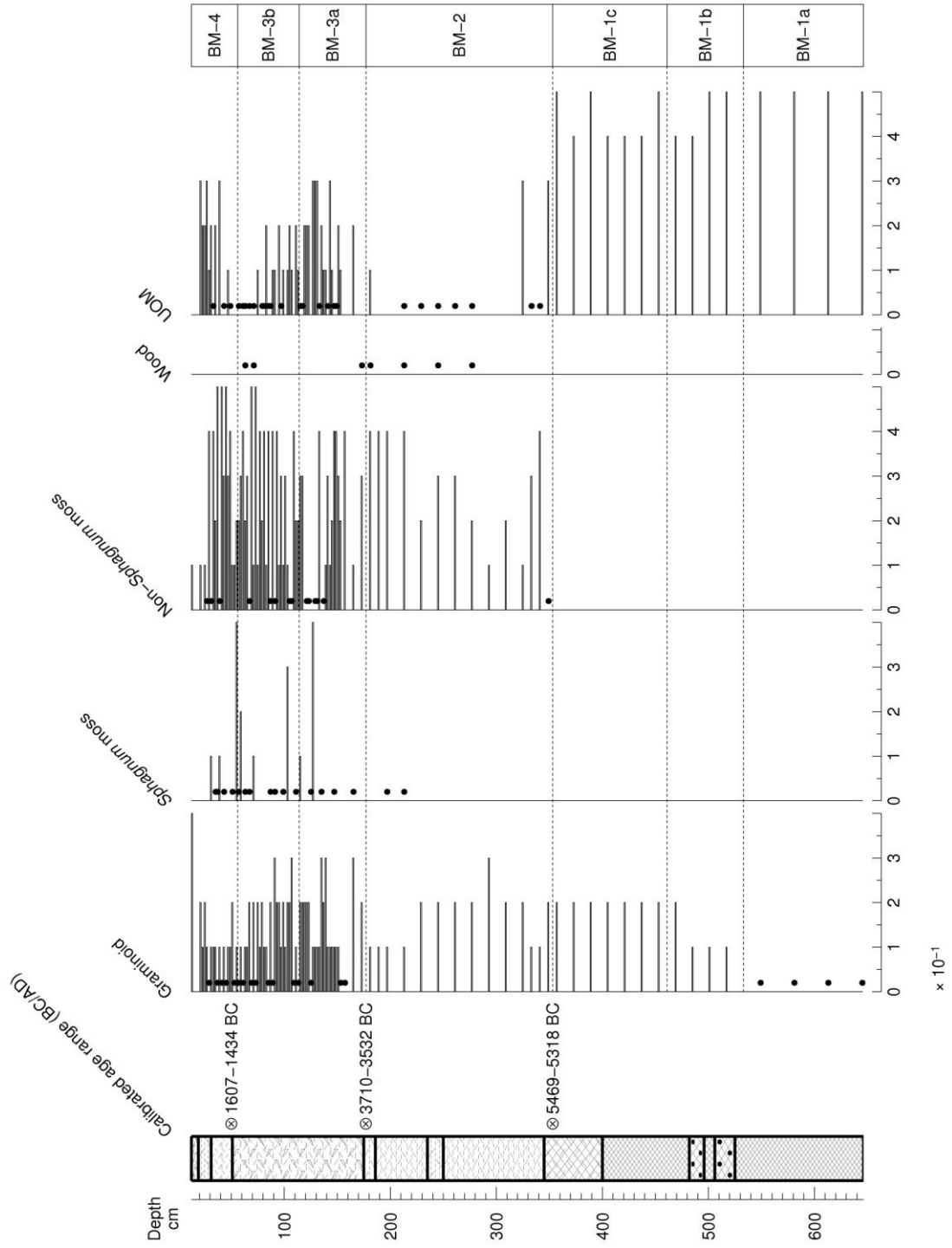
Figure 7.14 Results of microstructure analysis on sieve residues retained during pollen processing
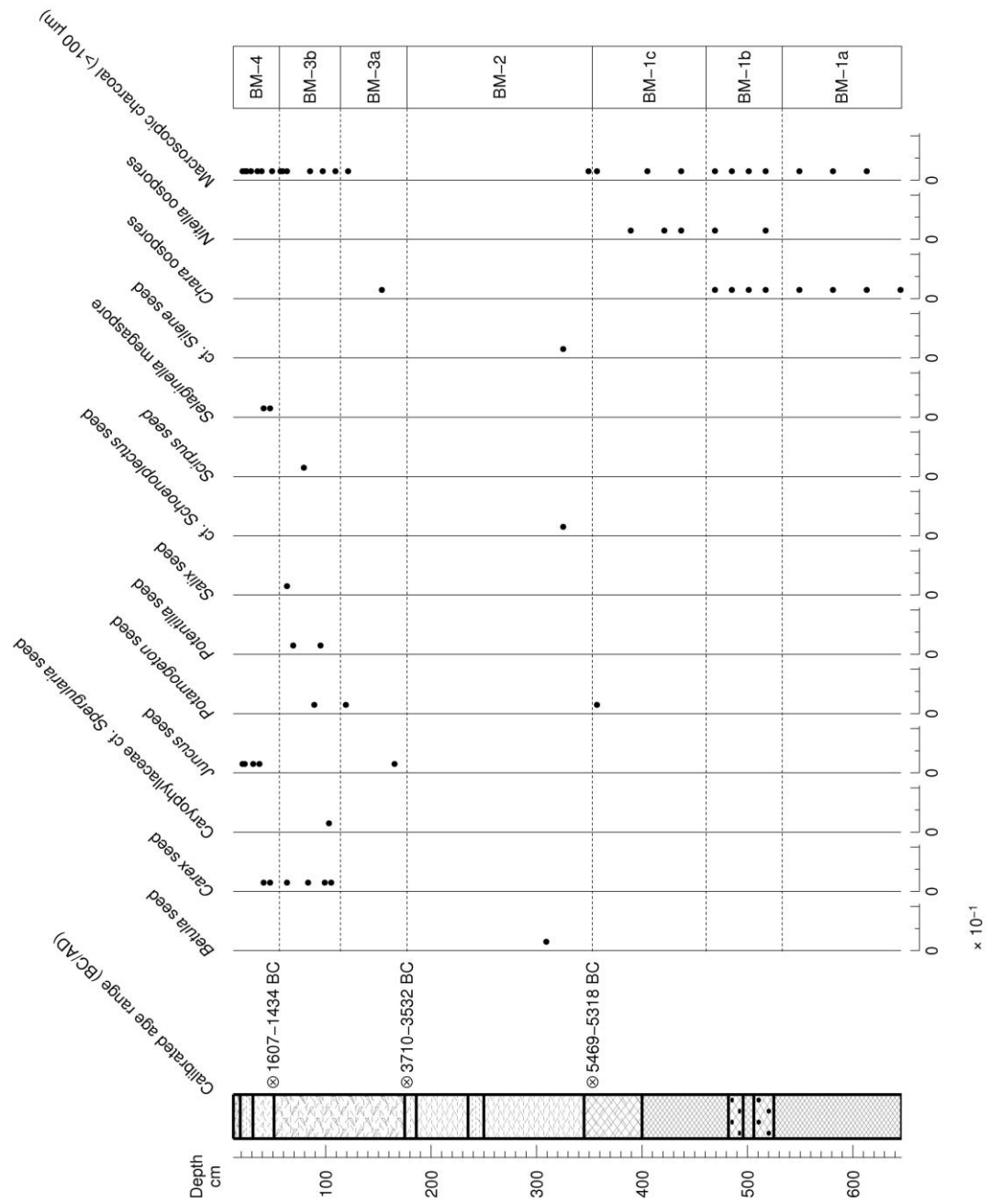
Figure 7.14 (continued) Results of microstructure analysis on sieve residues retained during pollen processing

Zone	Depth (cm)	Aboreal taxa		Fen taxa								Aquatic taxa		
		Betula seed	*Salix* seed	*Carex* seed	Caryophyllaceae cf. *Spergularia* seed	*Juncus* seed	*Potentilla* seed	cf. *Schoenoplectus* seed	*Scirpus* seed	cf. *Silene* seed	*Selaginella* megaspore	*Potamogeton* seed	*Chara* oospore	*Nitella* oospore
BM-4	21					2								
	23					1								
	31					1								
	37					1								
	41			1							1			
	47			1							1			
BM-3b	63		1	1										
	69						1							
	79								1					
	83			1										
	89											2		
	95						1							
	99			1										
	103				1									
	105			2										
BM-3a	119											2		
	153												2	
	165					1								
BM-2	309	2												
	325							1			1			
BM-1c	357											1		
	389													1
	421													6
	437													2
BM-1b	469												1	2
	485												2	
	501												1	
	517												2	1
BM-1a	549												*c.*50	
	581												*c.*50	
	613												*c.*20	
	645												*c.*10	

Table 7.3 Frequencies of seeds, megaspores and oospores retained from sieve residues

Zone BM-1 (645-353 cm; c. 8340-5390 cal. BC)

This zone is characterised by high quantities of unidentifiable organic matter (UOM), with increasing amounts of recognisably graminoid material towards the top. Small fragments of charcoal occur throughout the zone, as do Characeae oospores. The zone is comprised of three subzones, each described below.

Subzone BM-1a (645-533 cm; c. 8340-7210 cal. BC)

The samples in this subzone contained a high proportion of UOM, with an occasional presence of graminoid fragments. Small fragments of charcoal were recorded in most samples, and oospores of *Chara* occur throughout the subzone.

Subzone BM-1b (533-461 cm; c. 7210-6480 cal. BC)

The sieve residues in this subzone are again dominated by UOM, although proportions of identifiable graminoid material are higher than previously. Small charcoal fragments continue to be present throughout the subzone, as do *Chara* oospores. *Nitella* oospores are recorded for the first time at a depth of 517 cm.

Subzone BM-1c (461-353 cm; c. 6480-5390 cal. BC)

UOM is again dominant, although proportions of graminoid fragments continue to increase. Charcoal fragments are present throughout the subzone. *Chara* oospores cease to be recorded, although those of *Nitella* are still present. A single *Potamogeton* seed was noted at 357 cm.

Zone BM-2 (353-177 cm; c. 5390-3610 cal. BC)

This zone is characterised by high proportions of non-*Sphagnum* moss remains, with similar quantities of graminoid material as in the previous subzone. UOM proportions are negligible throughout the zone. Wood fragments were recorded at 227 cm, 245 cm, 213 cm and 181 cm. Charcoal only occurs in the basal sample of this zone. No Characeae oospores were recorded. Two seeds were recovered from a depth of 325 cm, and these were tentatively identified as *Schoenoplectus* and *Silene*. Two *Betula* seeds were observed at 309 cm.

Zone BM-3 (177-56 cm; c. 3610-1620 cal. BC)

Plant fragments in this zone were dominated by non-*Sphagnum* mosses, with similar amounts of graminoid material to the previous zone. Numerous occurrences of seeds of fen plants were also noted. The two subzones within this zone are described individually below.

Subzone BM-3a (177-114 cm; c. 3610-2580 cal. BC)

This subzone is dominated by fragments of non-*Sphagnum* moss, and proportions of graminoid fragments remain similar to the previous zone. UOM is recorded throughout

most of the subzone, although at lower levels than in zone BM-1. Small quantities of *Sphagnum* were also noted, and a single wood fragment was present at a depth of 173 cm. Charcoal fragments are present again above 120 cm, and there is an isolated occurrence of *Chara* oospores at 153 cm. Three seeds were recovered from samples within this subzone, one of *Juncus* at 165 cm and two of *Potamogeton* at 119 cm.

Subzone BM-3b (114-56 cm; c. 2580-1620 cal. BC)

Proportions of plant fragments in this subzone remain broadly similar to those in the previous subzone, dominated by non-*Sphagnum* moss and graminoid remains with the occasional fragment of *Sphagnum*. Wood fragments were noted in the upper part of the subzone, at 71 cm and 63 cm, and charcoal fragments were present throughout the subzone. Several seeds of fen plants were recorded (see Table 7.3 for quantities and depths), including *Carex, Potamogeton, Potentilla, Scirpus* and one Caryophyllaceae seed which was tentatively identified as *Spergularia*. A single *Salix* seed also occurred at a depth of 63 cm.

Zone BM-4 (56-13 cm; c. 1620-910 cal. BC)

Proportions of plant material remain broadly similar to those in zone BM-3, although proportions of non-*Sphagnum* moss and UOM decline and graminoid fragments increase towards the top of the zone. This change supports the hypothesis that a hiatus in the record occurs at about 19 cm. No wood was present in this zone. Charcoal was consistently recorded throughout. *Carex* seeds were identified at depths of 47 cm and 41 cm, and *Juncus* seeds occurred at 37 cm, 31 cm, 23 cm and 21 cm. *Selaginella selaginoides* megaspores were recorded at depths of 47 cm and 41 cm.

7.5 Discussion

The base of the Blows Moss sequence is dated to *c.* 8340 cal. BC by extrapolation, and the record appears to be complete up to a depth of around 19 cm, dated to *c.* 1010 cal. BC. The palaeoecological record from this site therefore provides evidence for environmental conditions from the early Mesolithic through to the late Bronze Age.

Initially, the basin at Blows Moss was occupied by an open water body, indicated by the presence of pollen of aquatic species including *Myriophyllum spicatum, Myriophyllum alterniflorum* and *Littorella uniflora*. This lake was probably fairly shallow, since Haas (1994) suggests that the majority of species of the aquatic plants *Chara* and *Nitella*, of

which several oospores occurred in the lower part of the sediment core, prefer water of 0-5 m in depth. The changes in vegetation and environment in the area surrounding Blows Moss will be discussed in terms of the broad archaeological periods defined in Chapter 1.

7.5.1 Mesolithic (*c*. 9000 – *c*. 4000 cal. BC)

The first *c*. 650 years of this period are not represented by the palaeoecological sequence from Blows Moss. It seems that some woodland was present in the landscape surrounding the site at around 8340 cal. BC, evidenced by arboreal pollen values of around 40% (Fig. 7.11). The main components of this woodland appear to have been *Betula* and *Salix*. Very little *Corylus avellana*-type pollen is recorded at first, and it seems that this taxon did not become a major component of the woodland until 629 cm (*c*. 7850 cal. BC) when total arboreal pollen values reach *c*. 75%. The establishment of *Betula-Corylus* woodland occurred significantly earlier at Blows Moss than at other Orcadian sites. Two sequences from west Mainland indicate that this woodland was present in the region by *c*. 6950 cal. BC (Bunting 1994), and a radiocarbon dated sequence from Scapa Bay in central Mainland indicates that birch-hazel scrub woodland became established there at around 7450 cal. BC (de la Vega-Leinert *et al*. 2007). A sequence from Deerness in east Mainland suggests that woodland developed in this region at *c*. 6500 cal. BC, although this date is unclear due to problems with radiocarbon dating of this core (Donaldson 1986). Pollen sequences from the islands of Hoy (Blackford *et al*. 1996; Bunting 1996) and Rousay (Bunting 1996) begin post-woodland establishment, so the timing of woodland development on these islands is unknown. The early establishment of woodland at Blows Moss lends some support to the hypothesis that the apparently late development of woodland in Orkney in comparison to Shetland is due to the exposed western situation of the sites sampled and dated so far (Bunting 1994).

The woodland around Blows Moss seems to have undergone a temporary decline at 533 cm (*c*. 7210 cal. BC), when total arboreal pollen percentages drop to around 50% (Fig. 7.11). *Corylus avellana*-type appears to have been the worst affected taxon. Herbaceous taxa, particularly *Filipendula*, *Phragmites*-type and Poaceae, and pteridophytes show a corresponding expansion at this time. Similar episodes of woodland disturbance were also recorded in the sequences from Quoyloo Meadow in west Mainland (Bunting 1994) and Keith's Peat Bank on Hoy (Blackford *et al*. 1996).

However these occurred much later than at Blows Moss, at *c*. 5450 cal. BC at Quoyloo Meadow and *c*. 5350 cal. BC at Keith's Peat Bank, where they were attributed to Mesolithic human activity (Bunting 1994; Blackford *et al*. 1996).

At Keith's Peat Bank, support for this hypothesis is provided by evidence of burning in the form of high charcoal concentrations and the presence of *Melampyrum* pollen, a species which has been linked with burnt ground and forest clearance. During the period of lower arboreal pollen percentages at Keith's Peat Bank percentages of pteridophyte spores also undergo a marked decline, and evidence from Shetland suggests that ferns were sensitive to grazing pressure (Bennett *et al*. 1992). The decline in fern spores, along with the occurrence of spores of fungal types indicative of the presence of grazing animals, is interpreted as further support for the hypothesis of anthropogenic clearance of woodland at this time by Blackford *et al*. (1996).

At Quoyloo Meadow, *Corylus avellana*-type was the taxon that seems to have been affected most by the woodland disturbance, and ferns and grasses increased in abundance in response to the decline in woodland cover. This is similar in character to the decline seen at Blows Moss. At Quoyloo Meadow, the decline in arboreal pollen is associated with a peak in microscopic charcoal, and is interpreted by Bunting (1994) as possible anthropogenic clearance for grazing. The expansion in ferns perhaps implies that grazing pressure was not intense around this site (Bunting 1994).

At Blows Moss, charcoal peaks are recorded immediately before and after the woodland decline, although only low values of charcoal occur during the period of lower arboreal pollen percentages (Fig. 7.11). However larger fragments (*c*. 1 mm) of charcoal were present in the sieve residues retained during pollen processing before, during and after the episode of decreased woodland cover (Fig. 7.14). Low percentages of pollen from heath taxa at the time of the woodland decline suggest that the charcoal does not result from natural fires affecting surrounding heathland, suggested by Blackford *et al*. (1996) as one alternative explanation for the charcoal peak seen at Keith's Peat Bank. Pine is the only native British tree which can be burnt standing (Rackham 1986), and percentages of *Pinus sylvestris* pollen are around 10% at the time of the woodland decline (Fig. 7.11). Percentages of *Pinus sylvestris* pollen between 20 and 30% are usually taken to indicate that this species grew locally (e.g. Bennett 1984; Gear and Huntley 1991; Charman 1994), and so it seems that pine was probably not locally

present around Blows Moss. It might therefore be suggested that the charcoal peaks are unlikely to be the result of natural forest fires.

However, based on a pollen diagram from Rhoin Farm on the Kintyre peninsula (Edwards 1990), near to which Mesolithic flints have been discovered, Moore (1996) argues that maintained levels of species such as *Corylus avellana* and *Alnus glutinosa*, coupled with the continuous presence of microscopic charcoal, could be representative of anthropogenic management of woodland using fire. It is suggested that rather than obvious fluctuations in vegetation cover associated with charcoal peaks, it is continuity in vegetation patterning, particularly of fire-responsive species such as hazel and alder, that indicates anthropogenic manipulation of the environment (Moore 1996). This could therefore imply that the woodland disturbance seen at Blows Moss is more likely to have had a natural cause than an anthropogenic one.

Very low percentages of *Sordaria*-type ascospores are present at 461 cm (*c*. 6480 cal BC; Fig. 7.13), suggesting the presence of low numbers of grazing mammals towards the end of the period of low arboreal pollen percentages at Blows Moss. Studies of surface sample NPPs from grazed and ungrazed woodlands have shown that almost no airborne dispersal of fungal taxa occurs, suggesting that coprophilous fungal spores provide a highly localised record of grazing directly at the sampling site (Blackford and Innes 2006). These studies also indicate that an absence of fungal spores does not necessarily mean that no animals were present, as particular types were absent from some grazed areas (Blackford and Innes 2006). Therefore it may be possible that grazing was also occurring in the vicinity of Blows Moss throughout the rest of the period of decreased arboreal pollen percentages despite the absence of fungal spores. However, the presence of grazing animals does not necessarily imply the presence of humans, since animals such as red deer could have reached Orkney by swimming from mainland Scotland, and the presence of their bones in small quantities at many archaeological sites implies hunting as opposed to herding (Hedges 1983a). Alternatively, Clutton-Brock (1979) has suggested that red deer were introduced to Orkney by Neolithic settlers. The ascospores of coprophilous fungi at Blows Moss indicate the presence of large herbivores much earlier than this, during the Mesolithic period, and the most likely large mammal species to have been present at this time is red deer, whether they were naturally present or introduced by Mesolithic people.

Overall, the evidence points to low-level disturbance of the woodland surrounding Blows Moss between 533 and 461 cm (*c*. 7210-6480 cal. BC). At present the earliest radiocarbon date for Mesolithic settlement in Orkney comes from the site of Long Howe in east Mainland, where a charred hazelnut shell found in soil below a Bronze Age barrow gave a date of *c*. 6740 cal. BC (Wickham-Jones and Downes 2007), although flint finds from Stronsay indicate that people were present in the islands prior to this (Woodward 2007). It is clear that humans were present in Orkney during the time of decreased arboreal pollen percentages at Blows Moss, although there is no artefactual evidence that they were present in South Ronaldsay. However, whether they were responsible for this temporary decline in woodland cover is less clear-cut. The presence of microscopic charcoal and of *Sordaria*-type ascospores could be interpreted as evidence of human activity, but they could equally be the result of natural processes.

At 461 cm (*c*. 6480 cal. BC), arboreal pollen percentages at Blows Moss increase again, although they do not reach their former levels, averaging *c*. 70% of the total pollen sum (Fig. 7.11). This suggests some woodland recovery following the disturbance, although it is likely that woodland cover was not as extensive as previously. This is similar to the situation seen at Quoyloo Meadow in west Mainland, although at this site tree pollen regained its former abundance (Bunting 1994).

At Quoyloo Meadow an increase in palynological richness following the woodland disturbance event is interpreted as representing diversification. *Corylus avellana* did not regain its former abundance following the disturbance, although *Betula* seems to have increased in abundance and *Alnus glutinosa* was present. Pollen frequencies of *Quercus* and *Pinus sylvestris* also increased during the phase of woodland recovery at Quoyloo Meadow (Bunting 1994). At Blows Moss there is a slight increase in palynological richness in subzone BM-1c when compared with BM-1a, suggesting that species diversification may also have occurred at this site (Fig. 7.11). Like at Quoyloo Meadow, *Corylus avellana*-type pollen percentages do not regain their former levels, although *Betula* and *Salix* appear to fully recover, and slight increases in the concentration of their pollen perhaps implies that these species were more important within the woodland than previously. There are also increases in the concentration of *Pinus sylvestris*, *Quercus* and *Alnus glutinosa* pollen when compared with subzone BM-1a, perhaps indicating that these species were also locally present (Fig. 7.12).

By analogy with Shetland (Bennett and Sharp 1993) and the Western Isles (Fossitt 1996), it seems likely that the woodland was more diverse in the more sheltered eastern areas of Orkney (Bunting 1994). Evidence for the local presence of *Quercus* in the east of Orkney is provided by the Scapa Bay sequence, where pollen percentages of this taxon of up to 8% led de la Vega-Leinert *et al*. (2007) to infer that this species grew in sheltered areas on the valley sides and formed part of a mixed deciduous woodland community from *c*. 5850 cal. BC. Small amounts of *Quercus* pollen (*c*. 5%) also occur in the sequence from Deerness, although these are interpreted as representing long distance transport from the Scottish mainland (Donaldson 1986). Frequencies of *Quercus* pollen at Blows Moss do increase slightly following the woodland disturbance (Fig. 7.11), although this taxon still only forms around 2-3% of the total pollen sum and it is therefore unlikely that oak formed part of the woodland around the site. Similarly, pollen percentages of *Pinus sylvestris* remain below 20%, suggesting this species probably did not grow locally at Blows Moss (Bennett 1984; Gear and Huntley 1991; Charman 1994). The Blows Moss sequence provides no support for the hypothesis that woodland was more diverse in the east of Orkney. However it is difficult to compare pollen percentages from the Scapa Bay and Blows Moss sequences, since they are likely to have different pollen source areas and have formed under different sedimentary systems.

Following woodland recovery at Blows Moss, arboreal pollen percentages remain at about 70% until 353 cm (*c*. 5390 cal. BC), when they decline to *c*. 30% of the total pollen sum (Fig. 7.11). The main taxa featuring in this decline are *Betula* and *Corylus avellana*-type, while percentages of *Pinus sylvestris, Quercus* and *Alnus glutinosa* remain more or less constant, perhaps providing further support for the hypothesis that these were not locally present. This decline occurs around 1800 years before the earliest radiocarbon dates for permanent settlement in Orkney (Ritchie 1983) and coincides with a change in sediment type from silty organic lake mud to well-humified peat with varying amounts of visible plant macrofossils (Table 7.2).

The primary woodland decline at Blows Moss occurred much earlier than elsewhere in Orkney. Pollen sequences from west Mainland indicate that the birch-hazel scrub woodland which was initially present in the area declined during the early Neolithic period between *c*. 3950 cal. BC and *c*. 3450 cal. BC, to be replaced by more open, herbaceous vegetation (Keatinge and Dickson 1979; Bunting 1994). However dating of

most of these sequences is problematic. Evidence that this woodland decline was widespread across Mainland is provided by a sequence from Scapa Bay, where a decrease in woodland cover surrounding the site occurs at *c.* 3950 cal. BC (de la Vega-Leinert *et al*. 2007).

Around the time of the primary woodland decline at Blows Moss there are no indications of burning in the form of microscopic charcoal, but evidence for low intensity grazing or disturbance near to the site occurs just after the woodland decline, in the form of small percentages of *Plantago lanceolata, Rumex* undiff., and *Artemisia*-type (Behre 1981). However these species were not consistently present following the woodland decline (Fig. 7.11). Further evidence for grazing is provided by low levels of *Sordaria*-type and *Podospora*-type ascospores in Fig. 7.13 (van Geel *et al*. 2003). It is unlikely that Mesolithic people would have been responsible for such a major woodland decline, and in the absence of any conclusive evidence for human activity at this time it is possible that the few indicators of grazing activity result from low numbers of red deer that were either naturally present in the islands or were introduced by Mesolithic people.

The cause of the primary woodland decline at Blows Moss is unclear. The early date (*c*. 5390 cal. BC) suggests that it is unlikely to have been the result of anthropogenic clearance, and the few indicators of low-intensity grazing pressure that are present could easily have been caused by wild deer. The coincidence of woodland decline with a change from lake to fen conditions is interesting, and is similar to the situation seen later at Crudale Meadow and Quoyloo Meadow in west Mainland, where it has been suggested that the switch may have been initiated by increased erosion as a consequence of woodland decline around the sites (Bunting 1994). It is possible that a similar sequence of events occurred at Blows Moss, although indications of increased erosion in the form of increased inorganic content of the sediment following the woodland decline are absent (Fig. 7.10). The processes which eventually led to the transition from open water to mire conditions at Blows Moss may have begun as early as *c*. 6480 cal. BC, when *Chara* oospores cease to occur in the macrofossil record and those of *Nitella* become more abundant (Fig. 7.14). According to Haas (1994) species of *Nitella* prefer shallower water depths and a lower pH than those of *Chara*, implying a change to shallower, more acidic aquatic conditions. However the cause of this sequence of events remains uncertain, and it is also possible that the change from open

water to fen conditions at Blows Moss reduced the relevant source area of pollen of the site, meaning that the pollen assemblage is increasingly dominated by local taxa such as Cyperaceae following this event. This may partially account for the reduction in arboreal pollen percentages seen at this time, although it is also likely that there was some woodland decline.

Following this initial woodland decline at Blows Moss, arboreal pollen percentages of *c*. 30% (mainly of *Corylus avellana*-type and *Betula*) suggest that some woodland was still present within the wider landscape (Bunting 2002). The occurrence of two *Betula* seeds and unidentified wood fragments in the macrofossil record at 309 cm (*c*. 4950 cal. BC; Fig. 7.14) indicates that birch and possibly other tree species were present fairly close to the sampling site. However the landscape seems to have started to become increasingly open at this time, with increased percentages of pteridophyte spores and pollen of Poaceae and Cyperaceae, as well as other herbaceous taxa including *Ranunculus acris*-type and *Filipendula* (Fig. 7.11).

7.5.2 Neolithic (*c*. 4000 – *c*. 2000 cal. BC)

The reduced woodland cover around Blows Moss seems to have persisted until 177 cm (*c*. 3610 cal. BC), when arboreal pollen percentages decline further to around 15% of the total pollen sum (Fig. 7.11). They remain at a similar level until the end of the complete sequence at 19 cm (*c*. 1010 cal. BC) in the late Bronze Age. This contrasts with the palaeoecological record from Liddle Bog (Bartlett 1983), where higher arboreal pollen percentages of around 50% in the earlier parts of the sequences were interpreted as evidence for some patches of woodland in the wider landscape during the late Neolithic/early Bronze Age. Bartlett (1983) also suggests that *Pinus sylvestris* and *Quercus* may have been present on South Ronaldsay at this time, based on pollen percentages of *c*. 20% and *c*. 10% respectively. It seems that the woodland around Liddle Bog persisted until some time during the Bronze Age (Bartlett 1983), although this sequence is dated only by biostratigraphic correlation so the timing of these events is unclear. If the inferred dates for the sequence are correct then the record from Liddle Bog provides a marked contrast to that from Blows Moss, where it seems that the landscape was dominated by open, herbaceous vegetation from the late Neolithic onwards (Fig. 7.11). There is also no evidence that the local woodland around Blows Moss was ever more diverse than birch-hazel scrub with some willow, although since Liddle Bog has a much smaller pollen source area it is possible that the sequence from

this site records more locally diverse woodland that is not detected in the pollen assemblage from Blows Moss.

The secondary woodland decline at Blows Moss occurs at around the same time as widespread woodland decline on Mainland which has been dated to between *c*. 3950 cal. BC and *c*. 3450 cal. BC (Keatinge and Dickson 1979; Bunting 1994; de la Vega-Leinert *et al*. 2007). At most Mainland sites the woodland loss took place over a few hundred years and coincided with the first solid records of the origin of pasture vegetation, leading to the suggestion that the primary cause of woodland decline was clearance by humans to make way for pastoral farming. However, at Crudale Meadow the decline took place much more slowly over a period of about a thousand years, and is interpreted as being due to autogenic processes as much as to direct anthropogenic influence (Bunting 1994). Keatinge and Dickson (1979) have also suggested that climatic changes may have been at least partly responsible for woodland decline in west Mainland, since blown sand deposits from coastal dunes at the Bay of Skaill stretch inland along the Loch of Skaill, and sand-blow events appear to have been occurring in the area since about 4950 cal. BC (de la Vega-Leinert *et al.* 2000). Keatinge and Dickson (1979) suggest that the increase in wind speed indicated by these sand deposits may have contributed to the woodland decline either by causing physical damage to the woodland species, or indirectly via salt spray and sand abrasion.

At the time of the secondary woodland decline at Blows Moss, several indicators of anthropogenic activity are present. Peaks in microscopic charcoal occur just prior to the decline, and there is an increase in Poaceae pollen percentages following the decline, indicating that more land suitable for grazing was present in the landscape (Fig. 7.11). That this grassland was exploited for pastoral farming is indicated by the presence of low frequencies of the pollen of anthropogenic indicator species including *Plantago lanceolata, Rumex* undiff. and *Artemisia*-type (Behre 1981). Further evidence for grazing activity is provided by increased abundance and diversity of coprophilous fungal spores (Fig. 7.13). Four different species are represented, and this increased diversity may indicate that different species of herbivore were now present in the islands, perhaps providing circumstantial evidence for the existence of domesticated animals such as sheep and cattle at this time. Fern spores increased in frequency following woodland decline (Fig. 7.11), indicating an expansion in ferns in response to the reduced canopy cover. Higher percentages of fern spores continue to be present

until 114 cm (*c*. 2580 cal. BC), suggesting that grazing pressure was relatively low at first (e.g. Bennett *et al*. 1992; Blackford *et al*. 1996).

Given the evidence for human activity in the vicinity of Blows Moss following the secondary woodland decline, it is likely that the cause of the reduction in woodland was at least partly anthropogenic. However the decrease in arboreal pollen percentages is also associated with a change in sediment type from well-humified peat to a more herbaceous peat (Table 7.2), perhaps indicating an increase in wetness at the site. This change in hydrological conditions may have been a contributing factor in the loss of woodland around the site, although it is also possible that the decline in tree cover contributed to increased waterlogging by allowing greater infiltration of precipitation. Following this final woodland decline at Blows Moss the landscape was predominantly open and dominated by herbaceous taxa including Poaceae, Caryophyllaceae, Rosaceae undiff., Asteraceae, *Potentilla*-type, *Ranunculus acris*-type and *Filipendula* (Fig. 7.11). High Cyperaceae pollen percentages reflect local conditions on the fen surface.

At 181 cm (*c*. 3660 cal. BC) there is some evidence from the microstructure analysis that the surface of the fen became drier (Fig. 7.14), and this coincides with an increase in the frequency of *Sordaria*-type ascospores (Fig. 7.13). Since fungal ascospores have been shown to provide a very localised record of grazing pressure, this may imply that animals were now grazing on the surface of the fen itself. It is possible that population expansion had forced the exploitation of more marginal areas for grazing land (e.g. Tipping *et al*. 2008a), and that at Blows Moss this was facilitated by a slight drying out of the fen at this time.

Hordeum-type pollen is recorded from 143 cm (*c*. 3060 cal. BC; Fig. 7.11), although only sporadically and at low frequencies. Despite the low numbers of *Hordeum*-type grains recorded at this time it is likely that arable cultivation was taking place somewhere near to the site, since cereal pollen is produced in low quantities and is not well-dispersed (Edwards and McIntosh 1988). Evidence for the cultivation of barley elsewhere in Orkney during the Neolithic is provided by macrofossils from Pool (Bond 2007b), Knap of Howar (Dickson 1983a) and Tofts Ness, where barley grains also occurred in Bronze Age contexts (Bond 2007c).

At 123 cm (*c*. 2730 cal. BC), in the late Neolithic, there is a distinct peak in *Sordaria*-type ascospores (Fig. 7.13), perhaps suggesting an intensification of grazing activity at this time. At 114 cm (*c*. 2580 cal. BC) pteridophyte spore percentages begin to decline (Fig. 7.11), providing further support for increased grazing activity in the vicinity of Blows Moss, since ferns are thought to be sensitive to grazing pressure (e.g. Bennett *et al*. 1992; Blackford *et al*. 1996). *Plantago lanceolata, Rumex* undiff. and *Artemisia*-type continue to be present in the pollen record until the sequence ends at *c*. 1010 BC, in the late Bronze Age, providing further evidence of pastoral activity during the Neolithic. Following this apparent pastoral intensification *Sordaria*-type spore percentages decline again, and apart from an isolated peak at 103 cm (*c*. 2400 cal. BC), remain low until 79 cm (*c*. 2000 cal. BC; Fig. 7.13).

Although no Neolithic settlements have been recorded in the Blows Moss study area, the presence of chambered cairns and standing stones clearly indicates that the area was used by Neolithic people. The majority of Neolithic sites in the area are coastal, and none have been recorded at a distance of less than about 2 km from Blows Moss. However the palaeoecological evidence from Blows Moss suggests that Neolithic agriculture occurred closer to the site than this, as the relative source area of pollen (RSAP) of the site is unlikely to be greater than 1 km (Sugita 1994).

7.5.3 Bronze Age (*c*. 2000 – *c*. 800 cal. BC)

The final 200 years of the Bronze Age are not represented by the palaeoecological record from Blows Moss. Arboreal pollen percentages remain at 10-20% throughout the Bronze Age (Fig. 7.11), which perhaps indicates that some isolated stands of woodland were still present in the landscape around Blows Moss at this time (e.g. Bunting 2002). Similar arboreal pollen percentages were observed in the sequence from Liddle burnt mound, leading Jones (1975) to suggest that some woodland was also present near this site in the early Bronze Age. The landscape around both sites is likely to have been very open at this time, with the pollen record from Blows Moss dominated by herbaceous taxa including Poaceae, Caryophyllaceae, Rosaceae undiff., Asteraceae, *Potentilla*-type, *Ranunculus acris*-type and *Filipendula* (Fig. 7.11). High Cyperaceae pollen percentages reflect local conditions on the fen surface.

Pollen percentages of heath taxa, including *Calluna vulgaris, Empetrum nigrum* and *Vaccinium*-type, begin to increase in the Blows Moss sequence at 56 cm

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(*c*. 1620 cal. BC; Fig. 7.11). This is indicative of some heath formation in the landscape around the site, although heath was probably never a major component of the vegetation in the region. Charcoal frequencies also increase at around the same, perhaps indicating that the heath was managed by burning at this time in order to improve grazing. However these increased charcoal frequencies do not necessarily imply the action of humans, since *Calluna* heath is readily combustible and therefore more susceptible to natural fires than herbaceous or woodland communities (e.g. Radley 1965; Tipping 1996).

In terms of anthropogenic activity during the Bronze Age, an increase in *Sordaria*-type ascospores and the more consistent presence of those of *Podospora*-type at 79 cm (*c*. 2000 cal. BC; Fig. 7.13) perhaps indicates a renewed intensification of pastoral activity at this time. As discussed earlier the spores of coprophilous fungi indicate highly localised grazing activity (Blackford and Innes 2006), and these increases may suggest that animals were grazing on the surface of the fen during the early Bronze Age.

At 47 cm (*c*. 1470 cal. BC) *Sordaria*-type ascospores decline and their frequency remains low until the end of the sequence at 19 cm (*c*. 1010 cal. BC; Fig. 7.13). Poaceae pollen percentages increase slightly at around the same time, perhaps because lower grazing pressure allowed greater flowering in this group of plant taxa. However, frequencies of *Plantago lanceolata* and *Rumex* undiff. pollen show a slight increase following this event (Fig. 7.11), and it would therefore seem that pastoral activity was still taking place on the drier land surrounding the fen. It may be that the focus of this activity shifted away from the surface of the fen itself to the land surrounding the site, accounting for the decline in fungal spores which provide a very localised record of grazing pressure (Blackford and Innes 2006). It is possible that there was less need for grazing land at this time so the fen was no longer used for this purpose, although the increases in percentages of anthropogenic indicator pollen imply that grazing pressure may actually have increased in the surrounding landscape, so it does not seem that there was a decline in the intensity of pastoralism at this time. Alternatively, the surface of the fen may have become wetter, forcing it to be abandoned as grazing land. However this is not supported by the microstructure evidence (Fig.7.14), which shows no indication of a shift to wetter conditions, suggesting that the shift in grazing away from the fen was not forced by environmental conditions.

Hordeum-type pollen maintains a fairly consistent presence throughout the Bronze Age and increases in frequency from 31 cm (*c*. 1210 cal. BC; Fig. 7.11), suggesting that the apparent decline in pastoral activity seen during the mid-late Bronze Age may represent a shift to an agricultural system in which arable cultivation was more important. It is likely that barley was cultivated quite intensively around Blows Moss during the Bronze Age, and the importance of this crop to the economy elsewhere in Orkney at this time is indicated by the application of domestic midden material to land covered by calcareous wind blown sand deposits at Tofts Ness on Sanday, allowing intensive arable cultivation in what would have been a very marginal farming environment (Simpson *et al.* 1998; Simpson *et al.* 2007).

At Liddle Bog, anthropogenic activity mainly seems to have been in the form of pastoral farming, although there is increasing evidence for arable cultivation over time. However it seems the economy remained predominantly pastoral throughout the Bronze Age at this site (Bartlett 1983), contrasting with evidence for an intensification in cereal cultivation at Blows Moss in the mid-late Bronze Age. The pollen sequence from Liddle burnt mound suggests a similar sequence of events to that seen at Blows Moss, with evidence for pastoral farming and low intensity cereal cultivation during the early Bronze Age (Jones 1979). By the middle Bronze Age, Jones (1979) suggests that increased frequencies of disturbance indicators and arable weeds as well as cereal pollen imply that fairly intensive mixed agriculture was taking place in the vicinity of the site.

Of particular interest at Blows Moss is an isolated occurrence of *Triticum*-type pollen at 37 cm (*c*. 1310 cal. BC; Fig. 7.11), since it is generally assumed that the Orcadian climate was too wet for successful wheat cultivation and there is no evidence that it was ever widely grown in the islands (Bond 1998). Carbonised grains of *Triticum dicoccum* (emmer wheat) were recovered from Neolithic deposits at Isbister (Lynch 1983), Skara Brae (Maclean and Rowley-Conwy 1984) and Pool (Bond 2007b), and *Triticum*-type pollen grains occurred in a sample from a Neolithic buried soil at the Knap of Howar (Whittington 1983). There are currently no records of wheat from later archaeological contexts in Orkney (Bond 2007b), and Barry (1805) stated that wheat was not successfully grown in the islands during the 18th century. Modern agricultural maps show the northern economic limit of wheat to be the low-lying land around the Dornoch Firth (Coppock 1976).

It is possible that prior to the widespread climatic decline that occurred in northwest Europe at *c*. 850 cal. BC (e.g. van Geel *et al*. 1996; Mauquoy *et al*. 2004; Blundell and Barber 2005; Swindles *et al*. 2007), conditions in Orkney were more favourable to the cultivation of wheat, although the presence of wheat in a Bronze Age context seems to be unique in Orkney. However Maclean and Rowley-Conwy (1984) have suggested that even if the climate in Neolithic Orkney was warmer and drier than it is today, wheat would still have been approaching the limits of successful growth and would not have been a reliable crop. Bond (2007b) proposes that the small numbers of wheat grains in comparison with those of barley recovered from archaeological contexts suggest that it was perhaps not introduced as a crop species but was present as a weed of the barley crop, and this seems a more likely explanation for the occurrence of *Triticum*-type pollen at Blows Moss than deliberate wheat cultivation.

Palaeoecological evidence for relatively intensive human activity in the Blows Moss study area during the Bronze Age is supported by the archaeological record. Presumed Bronze Age sites are well represented throughout the study area, with several burnt mounds and burial monuments recorded, although it has not been proven that these classes of monuments belong exclusively to the Bronze Age and some almost certainly belong to later periods. However the apparently dense distribution of Bronze Age archaeological sites in the region is to some extent supported by the palaeoecological evidence for relatively intensive agricultural practices at this time, and may in fact be a fairly accurate representation of the distribution of Bronze Age human activity in the region.

7.6 Summary

The palaeoecological record from Blows Moss begins at around 8340 cal. BC, during the early Mesolithic period. Some woodland was present at this time, dominated by *Betula* and *Salix*, and by *c*. 7850 cal. BC *Betula-Corylus* scrub woodland was established around the site. This is significantly earlier than dates for woodland development in west Mainland, providing some support for the hypothesis that the apparently late establishment of woodland in Orkney when compared with Shetland is due to the exposed western situation of the sites sampled so far (Bunting 1994). However, the data from Blows Moss provide no support for the suggestion that woodland may have been more diverse in the east of Orkney (e.g. Bartlett 1983; Bunting 1994; de la Vega-Leinert *et al*. 2007).

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Between around 7210 cal. BC and 6480 cal. BC the woodland surrounding Blows Moss underwent a temporary decline, similar to those seen at Quoyloo Meadow in west Mainland (Bunting 1994) and Keith's Peat Bank on Hoy (Blackford *et al.* 1996) which have been attributed to Mesolithic human activity. However the temporary decline at Blows Moss occurs much earlier than at these other sites, and its cause is unclear. The presence of ascospores of coprophilous fungi and microscopic charcoal at the time of the decline could be interpreted as evidence of human activity, but equally they could be the result of natural processes.

Following woodland recovery at Blows Moss, a permanent decline in tree cover occurred at *c*. 5390 cal. BC, associated with a change at the site from a shallow freshwater lake to fen conditions. Again the cause of this decline is not clear, although the early date and low levels of anthropogenic indicators recorded at this time suggest that it is unlikely to have been the result of anthropogenic clearance. After this decline the landscape started to become increasingly open, with herbaceous vegetation beginning to dominate.

The reduced woodland cover around the site persisted until around 3610 cal. BC when arboreal pollen percentages decline further. The timing of this secondary woodland decline is similar to that of the widespread woodland decline recorded in sequences from west Mainland, which occurs between *c*. 3950 cal. BC and *c*. 3450 cal. BC. Also in common with the situation in west Mainland, this secondary reduction in woodland cover is associated with several indicators of human activity including microscopic charcoal, pollen of *Plantago lanceolata, Rumex* undiff., *Artemisia*-type and *Hordeum*-type, and ascospores of coprophilous fungi. Given the evidence for human activity in the vicinity of Blows Moss following the secondary woodland decline it is likely that the cause was at least partly anthropogenic, although a change in sediment type at the site at around the same time suggests that a change in hydrological conditions may also have been a contributing factor.

Evidence for human activity during the Neolithic suggests a predominantly pastoral economy at this time, with low intensity barley cultivation also taking place. There is evidence for a consistent human presence from the Neolithic into the Bronze Age, and it is inferred that more intensive grazing activity took place during the earlier part of the Bronze Age. This may have been a result of population expansion or reorganisation of

settlement forcing the exploitation of more marginal areas such as the fen at Blows Moss for grazing. Following this apparent intensification of pastoral activity it then seems that the importance of pastoralism declined and there is evidence for the more intensive cultivation of barley near to the site. However the apparent decrease in grazing activity may simply reflect a move away from the fen itself to the surrounding grassland. There is continued evidence for the practicing of mixed agriculture around the site until the end of the record at around 1010 cal. BC, during the late Bronze Age.

Chapter 8: Synthesis and Discussion

In this chapter, all the available data (from this thesis and from previously published work) are used to answer the research questions identified in Chapter 1. Firstly the new palaeoecological records presented in this thesis are summarised and correlated. The results of this study are then combined with other available palaeoenvironmental data for Orkney in order to provide a new synthesis of Orcadian environmental history from the Mesolithic to the end of the Viking period, and the implications for archaeological interpretation are briefly considered. Evidence for environmental and land-use change in the islands during prehistory is then discussed in the wider geographic context of Shetland and mainland Scotland. The 'Bronze Age decline' hypotheses outlined in Chapter 1 are then reviewed from the perspective of longer-term environmental change.

8.1 Correlation of Sites Presented in this Thesis

In this study palaeoecological records were produced from sediment cores from three landscapes with differing degrees of marginality. Whaness Burn is a valley mire situated today within a large area of moorland where human impact is minimal, and is used as the marginal case study in this investigation. Hobbister is an area of blanket peat currently surrounded by mixed land-use regimes, including heathland and agricultural land with arable cultivation. The site is considered semi-marginal for the purposes of this study. Blows Moss is a low-lying wetland, around which current land-use is mainly improved pasture and arable, and this site provides the non-marginal, or 'optimal', case study for this research.

The results of a principal components analysis carried out on the combined data set from all three sites are presented in Figs. 8.1 and 8.2. The analysis was based on all pollen and spore taxa counted in the main sum which exceeded a value of 2% in at least one sample. The taxa included were *Pinus sylvestris*, *Ulmus*, *Quercus*, *Betula*, *Alnus glutinosa*, *Corylus avellana*-type, *Salix*, *Empetrum nigrum*, *Calluna vulgaris*, *Vaccinium*-type, *Ranunculus acris*-type, Chenopodiaceae, Caryophyllaceae, *Rumex* undiff., *Filipendula*, *Potentilla*-type, Rosaceae, Apiaceae, *Plantago major*, *Plantago lanceolata*, Asteraceae (Lactuceae), Asteraceae (Asteroideae), Cyperaceae, *Phragmites*-type, Poaceae, *Selaginella selaginoides*, *Pteridium aquilinum* and Pteropsida (monolete) undiff. Temporal correlation between the three sites, based on the radiocarbon chronologies established for each, is illustrated in Fig. 8.3. Fig. 8.4

shows the summary pollen curves for each site plotted against the same age scale to allow comparison.

Together, the first three axes from the principal components analysis explain 70.3% of the variance in the dataset. Axis 1 (eigenvalue = 0.107; percentage of explained variance = 43.5) differentiates between heathland taxa such as *Calluna vulgaris* and *Empetrum nigrum*, with strong positive scores, and fen taxa such as Cyperaceae and *Phragmites*-type which have strongly negative scores. This axis appears to be distinguishing between two local vegetation communities, heathland and fen. On axis 2 (eigenvalue = 0.043; percentage of explained variance = 17.4), fen taxa including Cyperaceae, Poaceae and *Selaginella selaginoides* have strong positive values and are separated from woodland taxa including *Pinus sylvestris*, *Betula*, *Corylus avellana*-type and *Salix*, which all have strong negative scores. Pteropsida (monolete) undiff. also has a strong negative score on this axis, suggesting ferns were a component of the woodland community. Axis 3 (eigenvalue = 0.023; percentage of explained variance = 9.4) distinguishes between taxa such as *Calluna vulgaris*, Cyperaceae and *Selaginella selaginoides*, all local 'heath' taxa, and *Filipendula*, *Potentilla*-type and Poaceae, all taxa which are indicative of either fen or 'good pasture'. 'Good pasture' is defined here as consisting of grasses and other small herbaceous taxa, with no dwarf shrubs, heath taxa or herb taxa that are indicative of wet, acidic conditions. The absence of a clear differentiation between fen and 'good pasture' community may be due to the relative importance of Poaceae in both communities, and to the overlap of some of the other taxa between the two communities. Sample scores for each site are plotted against axes 1 and 2 in Fig. 8.1 and axes 2 and 3 in Fig. 8.2.

Anthropogenic indicator taxa have low scores on all axes and do not display any strong direction on either biplot, indicating that the scores generated by the principal components analysis are driven by non-anthropogenic taxa. On Fig. 8.2 indicators of human activity mainly fall in the upper right hand quadrant, and therefore samples with scores in this location may have a stronger anthropogenic affinity than those which fall elsewhere on the biplot. The low scores, and hence position close to the origin, of anthropogenic indicator taxa on both Fig. 8.1 and Fig. 8.2 perhaps reflects modification by humans of all the main natural vegetation communities observed.
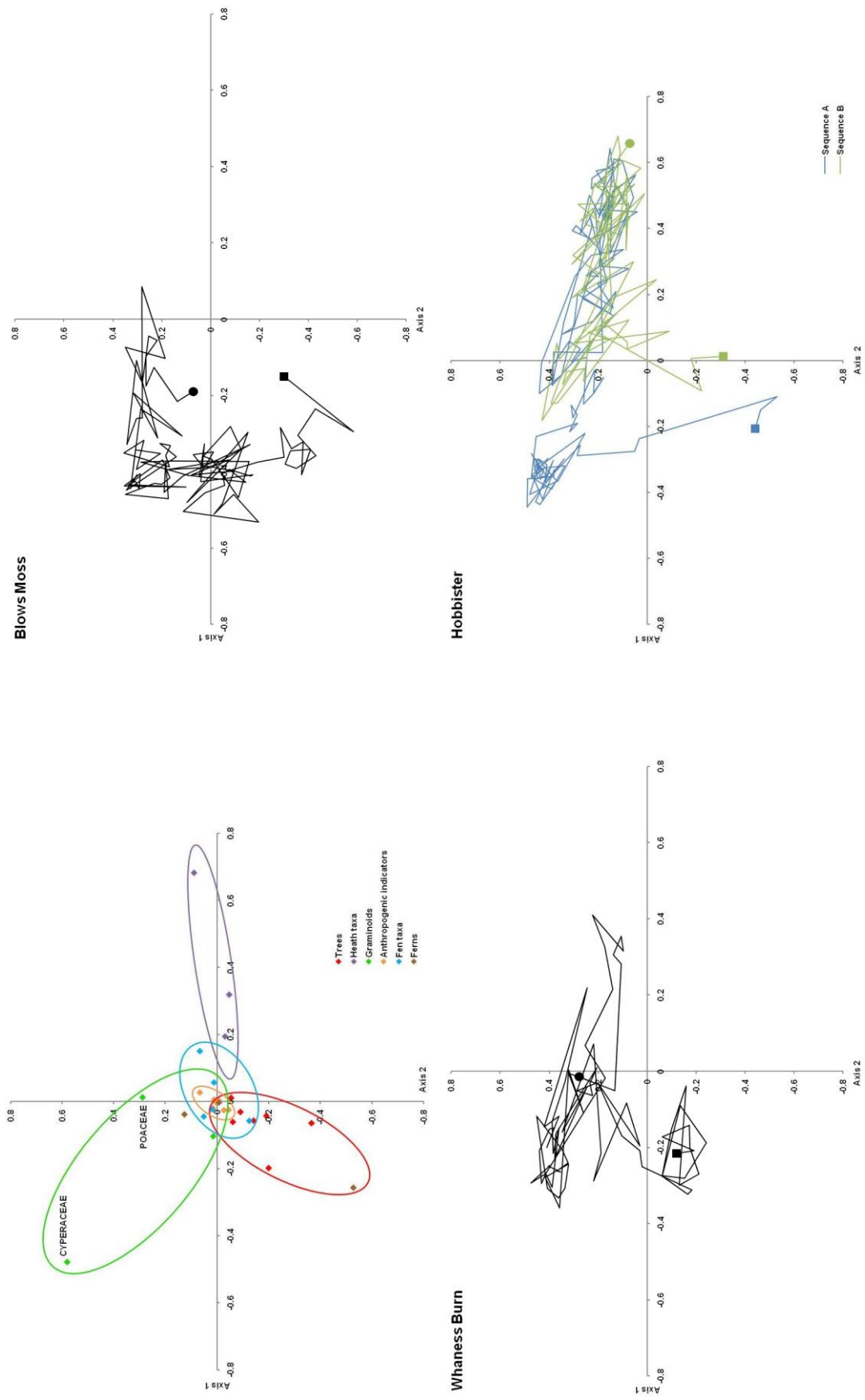
Figure 8.1 PCA scores plotted against axes 1 and 2 for Blows Moss, Whaness Burn and Hobbister (square markers = oldest samples; circular markers = youngest samples)

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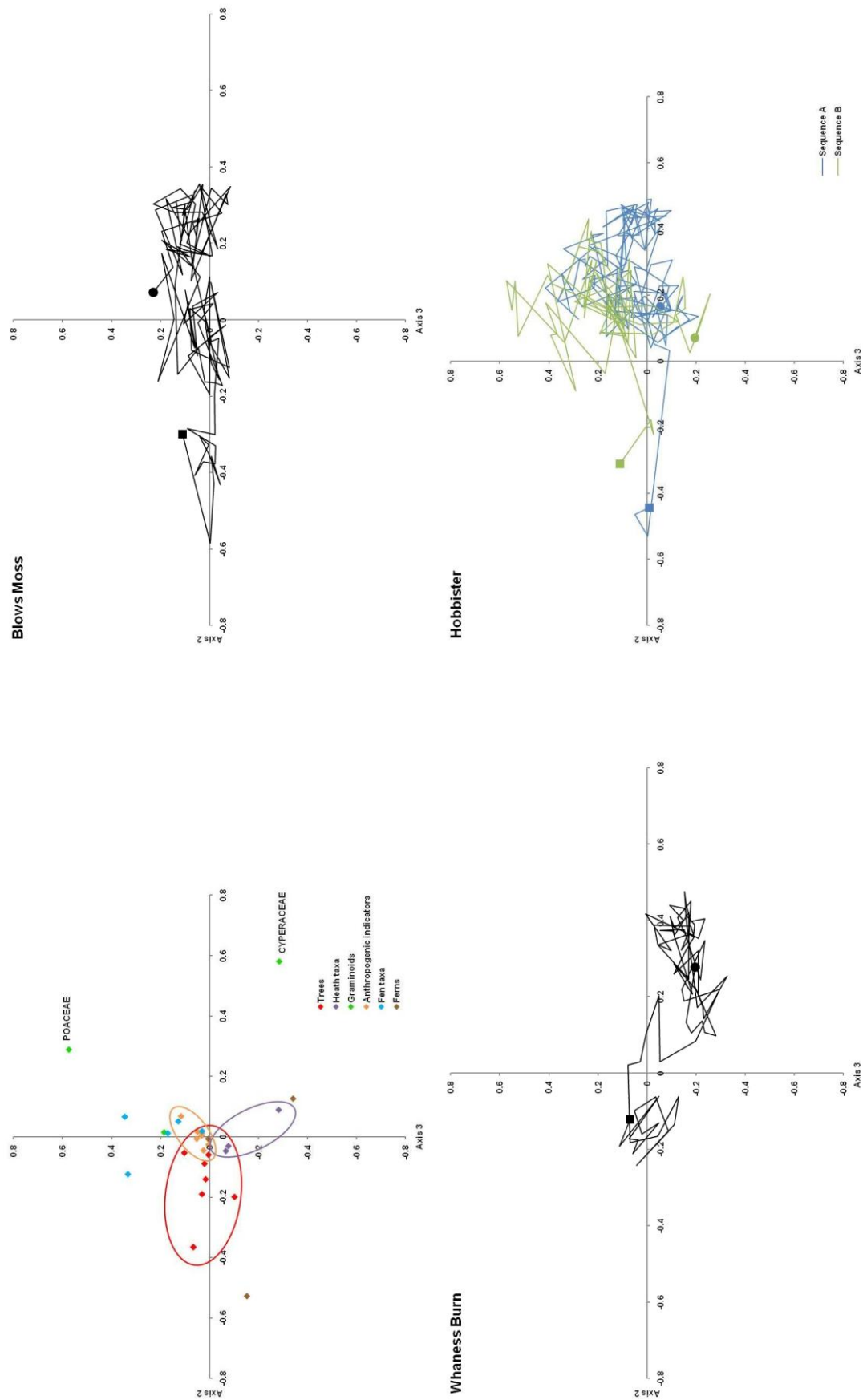
Figure 8.2 PCA scores plotted against axes 2 and 3 for Blows Moss, Whaness Burn and Hobbister (square markers = oldest samples; circular markers = youngest samples)
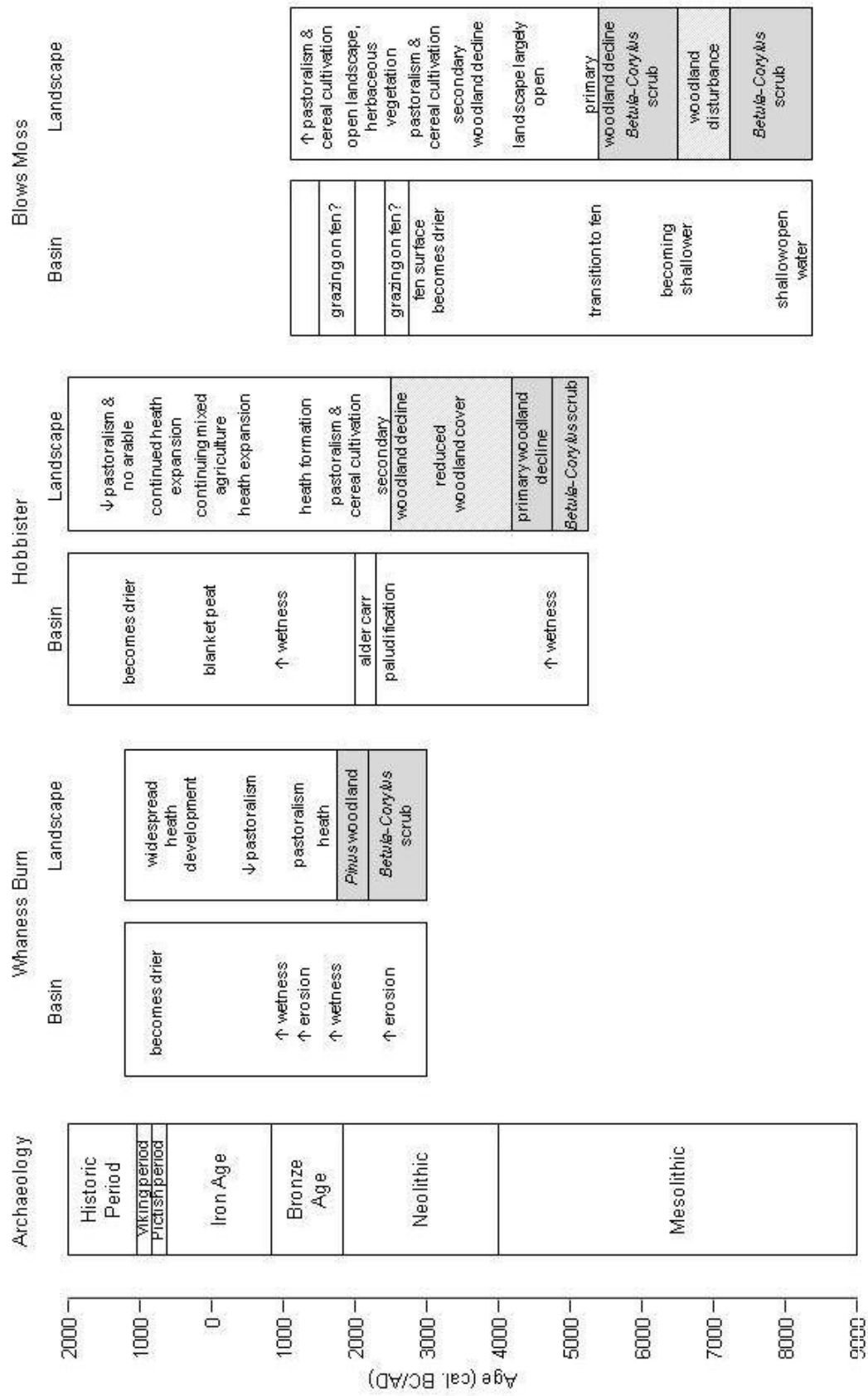
Figure 8.3 Comparison of records from sites presented in this thesis

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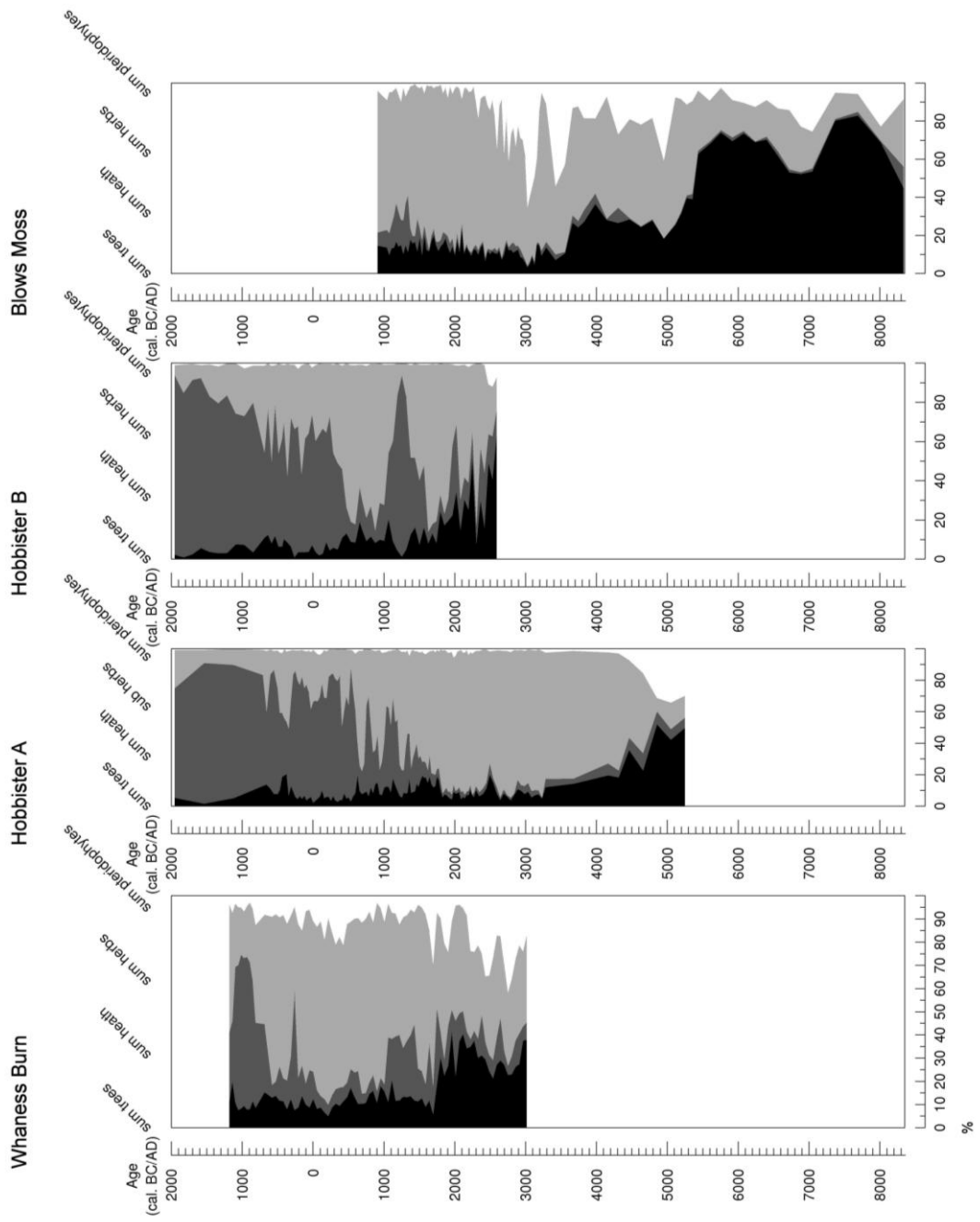
Figure 8.4 Summary pollen diagrams for each site plotted against the same age scale to facilitate comparison

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There is evidence for more extensive woodland than is present today at the base of all three records. Fig. 8.1 clearly shows this, with the oldest samples from all three sites falling in the lower left hand quadrant. At Blows Moss, there then follows a phase where arboreal taxa become less important and the samples begin to shift towards the upper left hand quadrant of the biplot, reflecting the increasing dominance of Cyperaceae. Following the final woodland decline at this site, samples are clustered in the upper left hand quadrant, reflecting the dominance of local fen taxa such as Cyperaceae and Poaceae. No samples fall within the upper right hand quadrant of the biplot, indicating that heathland was never a major component of the vegetation at this site. On Fig. 8.2, the later samples from Blows Moss are clustered in the upper right hand quadrant. This suggests that anthropogenic taxa are relatively important in the later record from this site, reflecting agricultural activity during the Neolithic and Bronze Age. Poaceae is the dominant herbaceous taxon in the later part of the record from Blows Moss, probably as part of an anthropogenically modified pasture vegetation community.

At Whaness Burn, the earliest samples are clustered within the lower left hand quadrant of Fig. 8.1, although the scores are not so strongly negative on either axis as those from Blows Moss. This reflects the greater importance of heathland at Whaness Burn and the possible local presence of pine at this site. Following woodland decline, the site goes through a transitional fen phase with samples clustering in the upper left hand quadrant of Fig. 8.1 before heathland becomes established. Following the development of heathland the site itself then reverts to a fen community by the end of the sequence (Fig. 8.1). Fig. 8.2 shows the same general pattern, with little evidence for human modification of the vegetation communities.

Both sequences from Hobbister begin in a woodland phase, although this does not last long (Fig. 8.1). The earliest samples from sequence B score less negatively on both axes than those from sequence A, reflecting the fact that some heathland had already become established in the wider landscape by the time peat began to accumulate at site B, and also that Poaceae are more dominant at this site. Following woodland decline at site A, the site goes through a transitional fen phase similar to that seen at Whaness Burn, before blanket peat becomes established. At site B, the vegetation switches from heath to fen and back to heath again following the loss of woodland around the site. The dominance of heathland vegetation during the later history of the site is

demonstrated by the clustering of the latest samples from both sequences in the upper right hand quadrant of Fig. 8.1. In Fig. 8.2 it can be seen that the later samples from both sequences tend to cluster in the upper right hand quadrant, reflecting the establishment of anthropogenically modified pasture vegetation around the site. With the dominance of heathland towards the end of the record, grasses and anthropogenic indicator taxa become less important, with the youngest samples from both sequences clustering in the lower right hand quadrant of Fig. 8.2.

It is clear that there are broad similarities in the records from the three sites studied here, with the oldest samples from each site falling within a woodland phase, and woodland eventually being replaced by more open vegetation communities. At Hobbister and Whaness Burn the woodland was replaced by heathland, whereas at Blows Moss heathland was apparently never a major component of the vegetation. Here woodland decline was followed by the establishment of open grassland communities. The extent to which the vegetation was affected by human activity also varies between sites, with evidence for anthropogenically modified 'good' pasture vegetation at Blows Moss and Hobbister but not at Whaness Burn.

Despite these broad similarities, the chronological synthesis shown in Figs. 8.3 and 8.4 indicates that there are also distinct differences between the three sites. Events such as woodland decline are not synchronous, and at two of the sites these events can be seen to occur in two stages. Prehistoric woodland in Orkney may not have been limited to birch-hazel scrub, as there is some evidence for the local presence of pine at Whaness Burn. At Blows Moss there is an additional complication to the story of woodland decline, with a period of disturbance occurring between *c*. 7210 and *c*. 6480 cal. BC, in the early Mesolithic. Following this event woodland around the site apparently recovered, although it does not seem to have regained its former extent.

The earliest record presented here is from Blows Moss. This sequence begins at *c*. 8340 cal. BC and shows that birch-hazel scrub woodland was well established around the site by *c*. 7850 cal. BC. The primary woodland decline at this site occurs at *c*. 5390 cal. BC, in the late Mesolithic, with arboreal pollen percentages decreasing to around 30% of the total pollen sum at this time.

The environmental record from Hobbister begins at around 5250 cal. BC, just after the primary woodland decline at Blows Moss. At this time, arboreal pollen percentages at Hobbister are higher than those at Blows Moss, averaging around 50%. These values suggest that some open woodland was still present around this site (e.g. Birks 1988). Since arboreal pollen percentages are lower at the base of this sequence than they are prior to the primary woodland decline at Blows Moss, it is possible that the woodland around Hobbister had undergone a partial decline before sedimentation began at the site. The first episode of woodland decline actually recorded at Hobbister occurs at around 4760 cal. BC, and appears to have continued until *c*. 4170 cal. BC.

At Blows Moss and Hobbister, secondary woodland declines occur at *c*. 3610 cal. BC and *c*. 2450 cal. BC respectively. Following these events, arboreal pollen percentages fall to around 15% at Blows Moss and *c*. 20% at Hobbister. At the start of the sequence from Whaness Burn, dated to *c*. 3020 cal. BC, arboreal pollen percentages are still around 30%, suggesting some birch-hazel scrub may have been present in north Hoy at this time. A short-lived period of local pine growth is inferred at Whaness Burn between *c*. 2170 cal. BC and *c*. 1750 cal. BC, when the only woodland decline recorded in this sequence occurs.

Following the final woodland decline at Blows Moss, the pollen signal is dominated by local taxa such as Cyperaceae and Poaceae, and it is inferred that the landscape around the site was dominated by open grassland until the end of the sequence at *c*. 1010 cal. BC. Heathland does not seem to have ever been a major component of the vegetation at or around Blows Moss, unlike Hobbister and Whaness Burn. At Whaness Burn, heathland formation began immediately following woodland decline, and widespread heath expansion took place at around 620 cal. AD. At Hobbister, heathland began to spread at the start of the Bronze Age at *c*. 1800 cal. BC and was the major component of the surrounding vegetation by about 600 cal. AD. These latter two records are very similar in terms of timing of both the initiation of heath formation and the widespread development of this vegetation community in the surrounding landscape. At Hobbister there seems to have been a substantial amount of pasture vegetation around the site before heathland began to dominate at around 600 cal. AD, which is not seen in the record from Whaness Burn.

The extent to which the vegetation around each of the three sites was modified by human activity also varies. The secondary woodland declines at Blows Moss and Hobbister, as well as the pine decline at Whaness Burn, are all accompanied by signs of anthropogenic activity, although at all sites these events were probably caused by a combination of environmental and anthropogenic factors. Alternatively there may have been no human contribution to woodland decline, and the signs of anthropogenic activity seen in the pollen records at this time may simply be the result of people beginning to exploit the increasingly open landscape for agriculture.

In terms of agricultural activity, a predominantly pastoral economy seems to have been practiced in the vicinity of all three sites at various times. Evidence for low intensity grazing activity is present in the record from Blows Moss during the early Neolithic, with apparent intensification in the later Neolithic and early Bronze Age, possibly including grazing of the fen surface. During the mid-late Bronze Age, there seems to be either a shift to less intensive pastoralism at this site, or a move away from the surface of the fen into the surrounding landscape. A similar pattern occurs at Hobbister, with evidence for low intensity pastoralism during the Neolithic and an apparent intensification of grazing activity in the Bronze Age. The level of grazing activity then seems to have declined again in the Iron Age and later periods. At Whaness Burn, it seems that the landscape was not affected by human activity during the Neolithic, although there is evidence for pastoral activity throughout the Bronze Age, perhaps on the site itself and associated with the occupation of the settlement in the valley. During the Iron Age and later periods low levels of grazing activity may have continued on the slopes surrounding Whaness Burn, although this was not as intensive as previously. Low intensity cereal cultivation is evidenced in the record from Blows Moss from the late Neolithic onwards, and at Hobbister there is evidence for low intensity arable farming around the site from the late Neolithic until the Iron Age. No cereal cultivation seems to have taken place around Whaness Burn at any time.

There is some evidence for a slight climatic deterioration during the mid-late Bronze Age, with all sites except Blows Moss showing indications of increasing wetness at this time. These events may coincide with the widespread climatic deterioration that seems to have occurred across northwest Europe at *c*. 850 cal. BC (e.g. van Geel *et al*. 1996; Mauquoy *et al*. 2004; Blundell and Barber 2005; Swindles *et al*. 2007), although in Orkney this was apparently not severe enough to significantly affect agricultural

activity. At Whaness Burn there was a decline in indicators of pastoral activity following this event, although human activity was never intensive around this site. Evidence for low intensity pastoralism and arable cultivation continues following this transition to wetter conditions at Hobbister.

8.2 Synthesis of Prehistoric Orcadian Environmental Change

Previous studies of the palaeoenvironment of Orkney (e.g. Moar 1969; Keatinge and Dickson 1979; Bunting 1994; 1996) have resulted in a broad understanding of the environmental history of the islands, which has been incorporated into discussions of Orcadian archaeology (e.g. Renfrew 1985; Ritchie 1995). Fig. 8.5 shows the locations of previously existing radiocarbon dated sequences from Orkney. If the dates for woodland decline and heath formation from the three sites presented in this thesis are added to the dates for these events from sites in Fig. 8.5, it can be seen that this picture is too simplified, and in some locations may actually be misleading (Fig. 8.6).

The sequence of later Holocene vegetation change, i.e. woodland decline followed by agricultural activity (mainly pastoral) and the spread of heathland at more exposed locations, is broadly consistent, but the timing of these changes is asynchronous across the archipelago. One example is the pattern of woodland loss. The general assumption seems to be that woodland decline in Orkney occurred at around 3500 cal. BC (e.g. Davidson and Jones 1985), with most woodland loss attributed to Neolithic agriculture, but the sites investigated here imply a more complex situation with both local and regional drivers of environmental change. At several sites, woodland loss occurred in multiple stages, and fragments of woodland persisted in the landscape into the Bronze Age.

Similarly, heath formation is generally accepted to have begun at around 1800 cal. BC, in the early Bronze Age, and the cause is usually attributed to climatic deterioration (e.g. Davidson and Jones 1985). However it can be seen from Fig. 8.6 that heathland became established in more exposed areas such as parts of Hoy and Rousay (Blackford *et al*. 1996; Bunting 1996) much earlier, during the late Mesolithic. In other locations, heathland development occurred later than the generally accepted early Bronze Age date, and in some cases did not take place until the Iron Age.
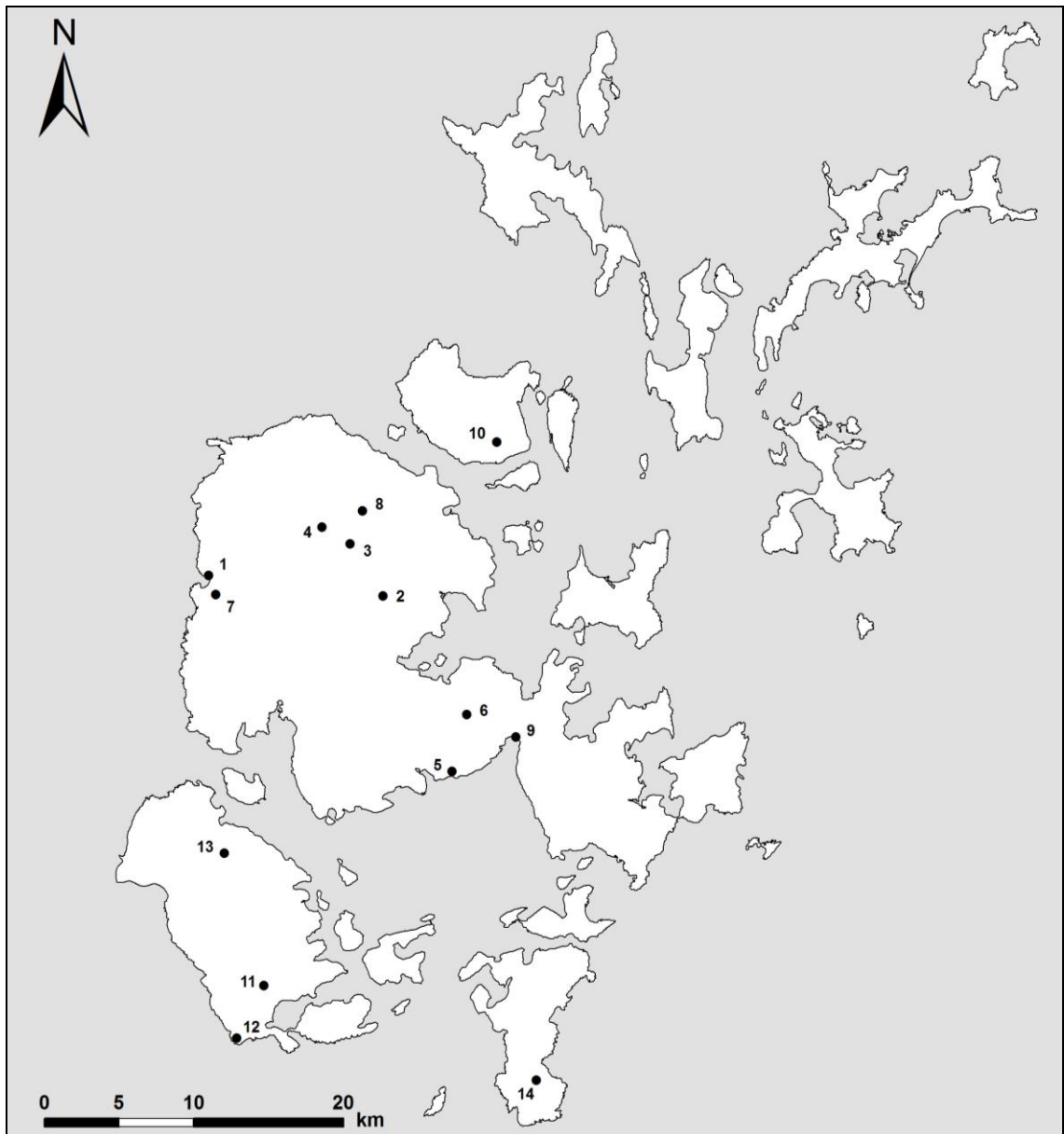
Figure 8.5 Location of radiocarbon dated palaeoecological sequences in Orkney: 1. Bay of Skaill (de la Vega-Leinert *et al.* 2000); 2. Braes of Aglath (Keatinge and Dickson 1979); 3. Burn of Rusht (Keatinge and Dickson 1979); 4. Glims Moss (Keatinge and Dickson 1979); 5. Hobbister (Chapter 6); 6. Lesliedale Moss (Davidson *et al.* 1976; Jones 1979); 7. Loch of Skaill (Keatinge and Dickson 1979); 8. Mid Hill (Keatinge and Dickson 1979); 9. Scapa Bay (de la Vega-Leinert *et al.* 2007); 10. Loch of Knitchen (Bunting 1996); 11. Keith's Peat Bank (Blackford *et al.* 1996); 12. Loch of Torness (Bunting 1996); 13. Whaness Burn (Chapter 5); 14. Blows Moss (Chapter 7).
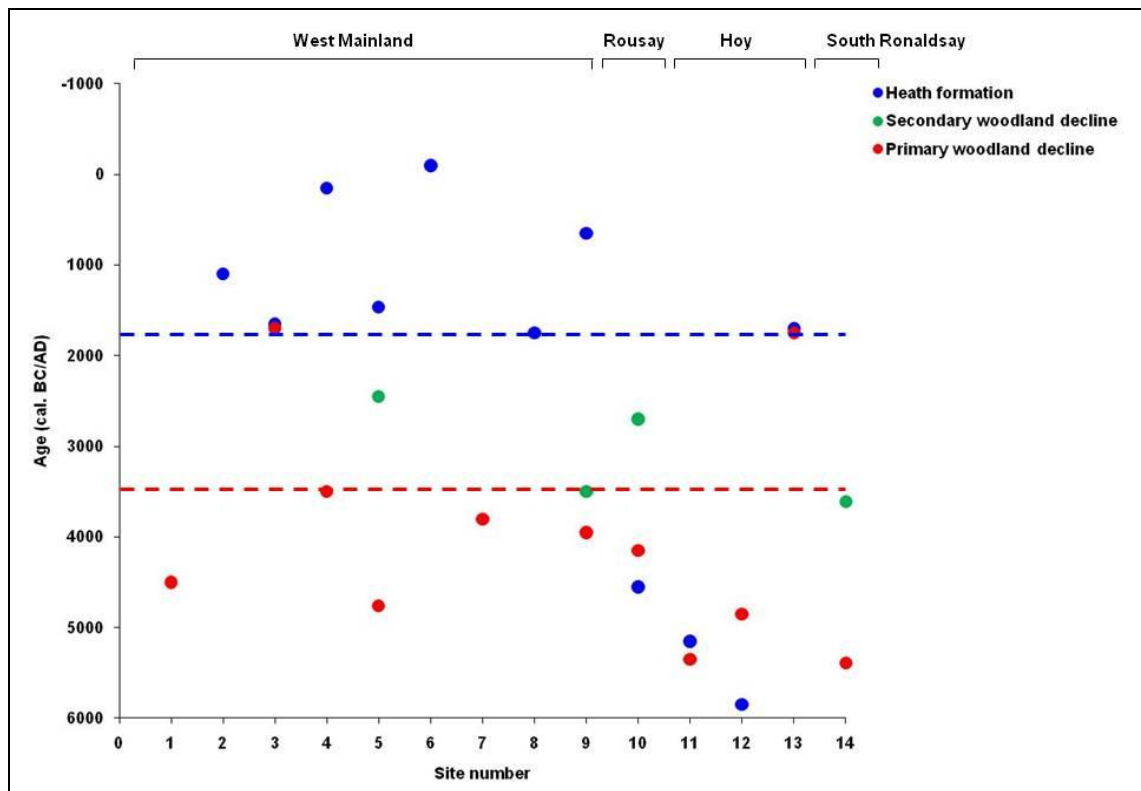
Figure 8.6 Woodland decline and heath formation dates from both previously published radiocarbon dated pollen sequences and new sequences presented in this thesis. Dashed lines represent the generally accepted dates for woodland decline (red) and widespread heath formation (blue) in the islands (e.g. Davidson and Jones 1985).

The high degree of heterogeneity in vegetation patterns during later prehistory has significant implications, both for archaeological interpretation in terms of local resource bases and resource management, landscape appearance, inter-site visibility and impacts of climate change (e.g. Tipping 1994b), and for understanding of past environments in Orkney. Given that the generally accepted model of environmental change in Orkney has been shown to be an over-simplification, and the potential implications that changes in prehistoric environments and vegetation cover have for archaeological interpretation, a new synthesis of Orcadian environmental change throughout prehistory is presented below. The Late Upper Palaeolithic is not considered in this discussion, since no new evidence for this period has been obtained during this investigation.

8.2.1 Mesolithic (*c*. 9000 – *c*. 4000 cal. BC)

The earliest date for woodland establishment in Orkney is now provided by the sequence from Blows Moss. When sediment began to accumulate at this site at *c*. 8340 cal. BC some woodland, dominated by *Betula* and *Salix*, was present, and by about 7850 cal. BC *Betula-Corylus* scrub woodland was established around the site.

This is significantly earlier than dates for development of similar scrub woodland elsewhere in Orkney, as two tephrochronologically dated sequences from west Mainland indicate that woodland was present in the region by *c*. 6590 cal. BC (Bunting 1994). A radiocarbon dated sequence from Scapa Bay in central Mainland shows that birch-hazel scrub woodland became established there at around 7450 cal. BC.

In the east of Shetland, woodland seems to have reached its fullest extent at around 8700 cal. BC (Bennett *et al*. 1992), leading to suggestions that the relatively late establishment of woodland in the west Mainland of Orkney is due to the exposed western nature of the sites sampled (Bunting 1994). This is supported by more recent evidence from Scapa Bay (de la Vega-Leinert *et al*. 2007) and by the new sequence from Blows Moss presented here. It seems that there is a gradient in the timing of woodland establishment from east to west across the islands, with the development of woodland occurring earliest in the east and latest in the west.

Three sites show evidence for temporary woodland disturbance during the Mesolithic period. At Blows Moss on South Ronaldsay (Chapter 7) this occurred at *c*. 7210 cal. BC, and at Keith's Peat Bank on Hoy woodland was reduced in extent from *c*. 5350 cal. BC (Blackford *et al*. 1996). At Quoyloo Meadow in west Mainland a period of woodland disturbance seems to have begun at around 5450 cal. BC (Bunting 1994), although dating of this site is problematic (O'Connor and Bunting 2009). At the latter two sites this disturbance has been attributed to anthropogenic clearance in order to provide land for the grazing of animals. However at Blows Moss, while there are indications of burning and of low levels of grazing by large mammals during the period of reduced woodland cover, it is unclear whether the disturbance is the result of natural or anthropogenic processes. In view of the early date of the disturbance at this site it is perhaps more likely to have had a natural cause.

Following these temporary disturbances, woodland apparently recovered at all three sites, although at Blows Moss it does not seem to have regained its former abundance. At Quoyloo Meadow woodland seems to have diversified following the period of reduced arboreal pollen percentages, and Bunting (1994) has suggested that *Quercus* and *Pinus sylvestris* may have been locally present around this site. This contrasts with other studies (e.g. Moar 1969; Keatinge and Dickson 1979), where the conclusion has been that pollen of these taxa must have originated on the Scottish mainland. It has

been suggested on the basis of analogy with the Western Isles and Shetland that woodland may have been more diverse in the east of Orkney, acting as a source from which these taxa were able to become established at Quoyloo Meadow following the brief opening of the woodland canopy which occurred at *c*. 5450 cal. BC (Bunting 1994). Some support for this hypothesis is provided by the sequences from Hobbister in Orphir (Chapter 6) where there is evidence for local pine growth, and from Scapa Bay, further to the east, where de la Vega-Leinert *et al.* (2007) inferred that *Quercus* grew locally from around 5850 cal. BC. However the sequence from Blows Moss on South Ronaldsay (Chapter 7) does not support the hypothesis that woodland was more diverse in the east of the archipelago, providing no evidence for the local growth of either *Quercus* or *Pinus sylvestris*.

Despite the general assumption that most woodland decline in Orkney occurred at around 3500 cal. BC as a result of Neolithic clearance (e.g. Davidson and Jones 1985), substantial loss of woodland occurred earlier at several sites. At most sites that exhibit early loss of woodland there are two distinct woodland decline events. At Loch of Torness woodland cover was never extensive and seems to have largely disappeared by around 4850 cal. BC. Initial woodland at Loch of Knitchen was similarly sparse, and at this site the primary woodland decline is radiocarbon dated to *c*. 4150 cal. BC (Bunting 1996). At Hobbister, primary woodland decline occurred at *c*. 4760 cal. BC and seems to have taken place over a period of about 600 years. Primary woodland decline at Blows Moss occurred much earlier at around 5390 cal. BC. Changes in climate and local hydrological conditions are invoked as the cause of woodland loss at all four sites, although small-scale human activity may also have been a contributing factor (Bunting 1996; Chapters 6 and 7).

In terms of vegetation communities other than woodland, heathland formation began at some locations during the late Mesolithic. This development is radiocarbon dated to *c*. 5850 cal. BC at Loch of Torness on Hoy (Bunting 1996), *c*. 5150 cal. BC at Keith's Peat Bank on Hoy (Blackford *et al*. 1996) and *c*. 4550 cal. BC at Loch of Knitchen on Rousay (Bunting 1996). Heath formation at Loch of Torness is attributed to a combination of climatic and autogenic processes, and at Loch of Kitchen the initial development of heath seems to have been caused by natural processes although it is likely that human activity had an impact on the later development of mire communities at this site (Bunting 1996). Basal pollen assemblages from the Bay of Skaill in west

Mainland indicate the formation of machair in the region between *c*. 5250 and *c*. 3550 cal. BC (de la Vega-Leinert *et al*. 2000).

8.2.2 Neolithic (*c*. 4000 – *c*. 2000 cal. BC)

Several sequences from west Mainland indicate that in this area woodland largely seems to have declined between about 3590 and *c*. 3450 cal. BC to be replaced by a more open, herbaceous vegetation (Keatinge and Dickson 1979; Bunting 1994). However, dating of these sequences is problematic, with age estimates for Crudale Meadow and Quoyloo Meadow being obtained by biostratigraphy and tephrochronology (Bunting 1994). Radiocarbon dates for the Loch of Skaill sequence are uncertain due to the 'hard water effect' (Keatinge and Dickson 1979). A securely radiocarbon dated sequence from Scapa Bay in central Mainland indicates that woodland decline in that location took place at *c*. 3950 cal. BC (de la Vega-Leinert *et al*. 2007).

At most of these sites woodland loss took place over a few hundred years and coincided with the origin of pastoral vegetation communities, leading to suggestions that the cause was principally anthropogenic (Bunting 1994; de la Vega-Leinert *et al*. 2007). However at Crudale Meadow the decline occurred over a period of about one thousand years, and is interpreted as being due to autogenic processes as much as to direct human influence (Bunting 1994). Keatinge and Dickson (1979) have also suggested that climatic change in the form of increased wind speeds may have been at least partly responsible for the loss of woodland at the Loch of Skaill.

At Blows Moss on South Ronaldsay (Chapter 7) a secondary woodland decline, accompanied by many signs of human activity in the pollen record, occurred at *c*. 3610 cal. BC. The decline is associated with a change to wetter conditions at the site, perhaps suggesting that this hydrological change may also have been a contributing factor in the loss of local woodland. Alternatively, the increase in surface wetness at the site may be the result of increased runoff due to woodland decline and devegetation of slopes by grazing activity. Following this final loss of woodland at Blows Moss the landscape around the site remained largely open and the vegetation was dominated by herbaceous taxa until the sequence ends in the late Bronze Age.

Following the primary woodland decline at Hobbister during the late Mesolithic period, open woodland still seems to have been present near to the site. Similarly, when peat

began to form in the basin at Whaness Burn at around 3020 cal. BC, there is evidence for the presence of small stands of trees in the wider landscape. It is clear therefore that woodland loss did not take place simultaneously across the islands, and only in west Mainland does the decline seem to have been relatively synchronous. However dating of most of the west Mainland sites is poor, and it is possible that woodland decline was also diachronous in this area. At Hobbister a further decline in woodland took place at *c*. 2450 cal. BC, in the late Neolithic. As at Blows Moss, this secondary woodland decline is associated with several indicators of anthropogenic activity and is followed by the development of pasture vegetation, suggesting that the cause was largely clearance by humans.

At Whaness Burn on Hoy (Chapter 5), there is evidence for a short-lived period of local pine growth near to the site between *c*. 2170 and *c*. 1750 cal. BC. It has been suggested that local pine forest occurred for a similarly short period at Cross Lochs in Sutherland on mainland Scotland, although at this site pine became established around 600 years earlier and declined at *c*. 2400 cal. BC (Charman 1994). This date roughly coincides with the widespread pine decline evidenced at sites further to the south (Pennington *et al*. 1972; Birks 1975; Gear and Huntley 1991). At Whaness Burn the pine woodland was probably fairly open with an understorey vegetation made up of heath taxa such as *Empetrum nigrum* and *Potentilla*-type. At Hobbister another woodland community may have been present during the Neolithic, as there is some evidence to suggest a short-lived period of alder carr growth between *c*. 2250 and *c*. 2020 cal. BC.

Anthropogenic activity is implicated as the cause of Neolithic woodland decline at several Orcadian sites, although the timing of these events varies across the archipelago. Following the decline of woodland at these sites the vegetation seems to have been of an open nature and largely dominated by herbaceous species. In terms of Neolithic agricultural practices, a predominantly pastoral economy appears to have been practised around Quoyloo Meadow, Scapa Bay, Glims Moss, Hobbister and Blows Moss. At Blows Moss, it seems that animals may have been grazing on the surface of the fen itself as well as in the surrounding landscape, perhaps indicating that population expansion had forced the exploitation of more economically marginal areas. However there is also evidence for a slight drying out of the fen surface at this time and this may provide an alternative explanation for the evidence that animals were grazing this area. There is also evidence for low intensity cereal cultivation at Quoyloo Meadow,

Hobbister and Blows Moss. At the latter two sites the main crop grown seems to have been barley. Further evidence for both pastoral and arable agriculture in west Mainland at this time is provided by archaeological pollen assemblages from Maeshowe (Jones 1979) and the Stones of Stenness (Caseldine and Whittington 1976). The landscape around the more marginal site of Whaness Burn does not seem to have been particularly affected by human activity during the Neolithic.

8.2.3 Bronze Age (*c*. 2000 – *c*. 800 cal. BC)

Existing evidence from the west Mainland sequences of Glims Moss (Keatinge and Dickson 1979), Lesliedale Moss and Wideford Hill (Jones 1979) indicates an open, largely treeless landscape throughout the Bronze Age. This also seems to have been the situation in central Mainland at Hobbister (Chapter 6) and on South Ronaldsay at Blows Moss (Chapter 7).

Despite this general picture of an open landscape, there is some evidence that small relict stands of birch-hazel scrub persisted during the Bronze Age, for example near the Burn of Rusht in the west Mainland hills (Keatinge and Dickson 1979) and at Liddle Bog on South Ronaldsay (Bartlett 1983). The latter sequence is not radiocarbon dated, but woodland availability is supported by evidence from Liddle burnt mound (Jones 1975) and Blows Moss, which implies that some isolated stands of woodland were still present in the landscape around these sites during the Bronze Age.

Woodland was also present at Whaness Burn (Chapter 5), in the form of relatively open pine forest, during the early Bronze Age. This woodland declined at around 1750 cal. BC, probably in response to climatic deterioration which caused increased surface wetness around the site. There is evidence for grazing activity at this time, and this would have resulted in a lower rate of tree seedling survival. Human activity may therefore have at least partially prevented woodland regeneration at the site.

Although widespread heath development generally did not occur until the Iron Age, the initiation of peat growth began at many sites during the Bronze Age. Radiocarbon dates from the bases of three peat cores from the west Mainland hills indicate that peat formation began in this area between *c*. 1750 and *c*. 1100 cal. BC (Keatinge and Dickson 1979). Some heathland seems to have been present at Whaness Burn from the start of the Bronze Age onwards, although widespread heath development does not

occur until later at this site. A similar situation occurs at Hobbister, and there is evidence that heathland at both sites was managed by burning, presumably in order to improve the quality of the vegetation for grazing.

In terms of human activity during the Bronze Age, there is evidence from organic deposits associated with archaeological sites in the more fertile areas of west Mainland and South Ronaldsay to suggest that low intensity mixed farming practices were carried out in the early to middle Bronze Age (Jones 1975; 1977; Downes 1994). As would be expected, data from some marginal sites such as Lesliedale Moss (Jones 1979) and Glims Moss (Keatinge and Dickson 1979) imply little Bronze Age agricultural activity, with evidence for some tree and shrub regeneration at Lesliedale Moss (Jones 1979). However, pollen assemblages from marginal areas of upland peat in west Mainland indicate that there was quite intensive pastoral activity in the uplands during the Bronze Age (Keatinge and Dickson 1979). This implies that agriculture had expanded into more economically marginal areas, perhaps in response to an increase in population or a reorganisation of settlement patterns that resulted in greater pressure on more fertile land and the need for more grazing land.

Although most of these pollen sequences are poorly dated, it has been suggested that there was a decline in anthropogenic activity in the more marginal areas of west Mainland in the late Bronze Age (Jones 1979; Keatinge and Dickson 1979). Only two sites from areas that are in agricultural use today provide evidence for Bronze Age land-use. There are indications of cereal cultivation at Loch of Skaill (Keatinge and Dickson 1979) and evidence for continuing pastoralism from the Neolithic until the present day around Scapa Bay (de la Vega-Leinert *et al*. 2007).

New evidence from the three sites studied here provides some support for the hypothesis that agriculture expanded into more marginal areas during the Bronze Age. At Blows Moss on South Ronaldsay (Chapter 7) this expansion seems to have begun during the late Neolithic. Although this site is considered to be the 'optimal' case study in this investigation, it seems that from the late Neolithic until the mid Bronze Age the surface of the fen itself was exploited. It appears that animals continued to graze on the surface of the fen at this site until around 1470 cal. BC, in the middle Bronze Age. Pastoral activity on the fen surface then seems to have ceased, although there is evidence that pastoralism continued in the surrounding landscape until the sequence

ends in the late Bronze Age at *c*. 1010 cal. BC. There is also evidence for cereal cultivation near to this site throughout the Bronze Age, with possible slight intensification in the later part of this period. A similar sequence of events is seen in the pollen record from nearby Liddle burnt mound, with evidence for pastoralism and low intensity arable cultivation during the early Bronze Age and a shift to more intensive mixed agriculture in the middle Bronze Age (Jones 1979).

At Whaness Burn on Hoy (Chapter 5) there is evidence for the grazing of animals on the valley floor between *c*. 1750 and *c*. 1170 cal. BC (early to middle Bronze Age), probably associated with the occupation of the enclosed settlement within the valley (Lamb 1989). It also seems that heathland was being managed by deliberate burning at this time, probably to improve the quality of the vegetation for grazing. An increase in surface wetness at the site occurs at *c*. 1030 cal. BC, which may have eventually led to the apparent decline in pastoral activity indicated by the pollen record at *c*. 1170 cal. BC. This decline perhaps indicates that the settlement in the valley was abandoned at this time. No cereal cultivation took place at this site, contrasting with evidence from elsewhere in Orkney which indicate mixed agriculture at most sites at this time (e.g. Jones 1975; 1977; Downes 1994; Dockrill *et al*. 2007). The sequence of events here again fits well with the hypothesis of expansion of farming into more marginal regions of Orkney during the early-mid Bronze Age.

The evidence from Hobbister (Chapter 6) shows that grazing activity continued near the site throughout the Bronze Age, possibly slightly more intensively than during the Neolithic. Sub-peat dykes identified at the site (Sharman 2007) may be the remains of Bronze Age field systems. It seems that at this site, as at Whaness Burn, heathland was being managed by deliberate burning, and there are indications that animals were grazing on the site itself as well as in the surrounding landscape. This again supports the idea of agricultural expansion into more marginal environments at this time. Towards the end of the Bronze Age there seems to have been a slight decline in grazing activity at Hobbister, perhaps in response to an increase in surface wetness at the site. Cereal cultivation took place near to the site throughout the Bronze Age.

From the new evidence presented in this thesis, it seems that mixed agriculture was practiced in more fertile regions of Orkney throughout the Bronze Age, and this is supported by palynological records associated with archaeological sites in west

Mainland and South Ronaldsay (Jones 1975; 1977; Downes 1994). More agriculturally marginal parts of the islands, including Whaness Burn (Chapter 5) and parts of the west Mainland hills (Keatinge and Dickson 1979), began to be used for the grazing of livestock in the Bronze Age, perhaps in response to an increase in population that resulted in greater pressure on more fertile land and the need for more grazing land (e.g. Tipping *et al*. 2008a). Evidence from Hobbister (Chapter 6) and Blows Moss (Chapter 7) supports this, as although these two sites are considered semi-marginal and non-marginal respectively, it seems that less productive parts of the landscape such as the heathland at Hobbister and the fen at Blows Moss may have been used for the grazing of animals during the Bronze Age.

The apparent decline in anthropogenic activity in marginal regions of Orkney in the late Bronze Age (Jones 1979; Keatinge and Dickson 1979) also seems to be supported by the new data. At Blows Moss pastoral activity seems to have shifted away from the surface of the fen to the surrounding landscape at this time. At Whaness Burn and Hobbister, indications of slight increases in surface wetness at the sites may explain the apparent decline in pastoral activity seen in the pollen records from both sites towards the end of the Bronze Age. This general increase in surface wetness may be indicative of climatic change, and while the widespread climatic deterioration that occurred at *c*. 850 cal. BC across north-west Europe (e.g. van Geel *et al*. 1996; Mauquoy *et al*. 2004; Blundell and Barber 2005; Swindles *et al*. 2007) was not severe enough to cause widespread agricultural abandonment in Orkney, it may have meant that exploitation of the more marginal areas was no longer economically viable.

8.2.4 Iron Age (*c*. 800 cal. BC – *c*. 600 cal. AD)

The Iron Age in Orkney generally seems to be a period of widespread heathland development at most studied sites. Heath began to form on the slopes surrounding Scapa Bay at *c*. 650 cal. BC (de la Vega-Leinert *et al*. 2007), and at Lesliedale Moss at *c*. 100 cal. AD (Jones 1979). Further heath development at Loch of Knitchen also occurred during the Iron Age (Bunting 1996). The cause of heath formation has generally been attributed to soil degradation resulting from intensive agricultural activity (Lesliedale Moss and Wideford Hill: Jones 1979; Glims Moss: Keatinge and Dickson 1979; Loch of Knitchen: Bunting 1996). However de la Vega-Leinert *et al*. (2007) suggest that, while human activity may have been a contributing factor to heath expansion around Scapa Bay, pedological and climatic factors probably played a more

significant role. At Hobbister (Chapter 6), heathland expansion began at around 600 cal. BC, seemingly in response to a combination of climatic deterioration leading to soil deterioration via leaching and podsolisation and human pressure on the environment.

The palaeoecological records from some sites imply that heathland was being managed by deliberate burning during the Iron Age. Charcoal is almost continually present in the record from Hobbister throughout this period, and there is evidence from the Loch of Knitchen on Rousay to suggest that heathland was being managed in this way from around 250 cal. AD (Bunting 1996).

In terms of agricultural activity during the Iron Age, there is evidence for continuing pastoralism at Scapa Bay (de la Vega-Leinert *et al*. 2007). The sequence from Loch of Skaill exhibits a slight decline in pastoral farming, but continuity of cereal cultivation (Keatinge and Dickson 1979). Other existing evidence for Iron Age vegetation and environments in Orkney comes from sites on marginal heathland, where it seems that there was a general decline in anthropogenic activity during the late Bronze Age (e.g. Keatinge and Dickson 1979). Of the new sites reported here, only Whaness Burn and Hobbister cover the Iron Age. It seems that at Whaness Burn small numbers of animals were grazed on the valley sides throughout this period, and pastoralism seems to have continued at Hobbister during the Iron Age. There is also some evidence for arable cultivation at Hobbister at this time.

The general picture of widespread heath formation and little anthropogenic activity during the Iron Age may be a biased view, since evidence from more marginal sites dominates the available record. The new evidence presented in this thesis demonstrates that agriculture continued throughout the Iron Age at some marginal and semi-marginal sites, although this activity was perhaps less intensive than in earlier periods at Whaness Burn. It is possible that the change to wetter conditions seen in the sequences from both Whaness Burn and Hobbister was widespread across Orkney, causing the abandonment of more marginal areas and leading to intensification of agriculture elsewhere. However the poor dating of published Iron Age pollen sequences and the relative lack of data from more fertile regions of Orkney means that it is difficult to accurately infer patterns of Iron Age land-use in the islands. Unfortunately the problem of more fertile regions being under-represented in the palaeoecological record has not been addressed

by this project, since the sequence from Blows Moss does not extend into the Iron Age. Despite this lack of palaeoecological data, several suggestions of agricultural intensification during the Iron Age have been drawn from archaeological sites in Orkney (e.g. Bond 2002; 2003; Simpson *et al*. 2007).

8.2.5 The Pictish Period (*c*. 600 – *c*. 800 cal. AD)

At Whaness Burn (Chapter 5), widespread heathland development began at the start of the Pictish period, apparently in response to climatic deterioration leading to soil degradation via leaching and podsolisation. This is the only major change recorded in post-Iron Age palaeoecological sequences from Orkney, and although much of the previously existing evidence for this period is poorly dated it seems likely that few significant changes occurred until the 20th century.

Charcoal from willow, birch and hazel has been identified at the Brough of Birsay, and it has been suggested that the wood was collected from small patches of local scrub woodland (Donaldson *et al*. 1981). It is possible that the wood recovered from the Brough of Birsay was collected as driftwood, although it is equally possible that patches of scrub woodland persisted in west Mainland. Arboreal pollen percentages of around 10%, which are recorded from Hobbister and Whaness Burn during the Pictish period, do not support the idea of trees being locally present at these sites, and most of the evidence points to the landscape at this time being largely open.

The sequence from Hobbister (Chapter 6) indicates that no arable cultivation took place in the vicinity of the site following the end of the Iron Age, but low intensity grazing of livestock was sustained. Heathland continued to expand around the site, although there is no evidence for continuing management of this vegetation community. The amount of pasture land near the site seems to have decreased, supporting the idea that less intensive pastoralism was taking place. At Whaness Burn small numbers of animals still seem to have been grazing on the slopes surrounding the valley during Pictish times. As at Hobbister, it seems that the heath at Whaness Burn was no longer managed. Arable cultivation was clearly occurring elsewhere in the islands, as grains of barley and oats were recovered during excavations of pre-Norse settlements on the Brough of Birsay in west Mainland (Donaldson *et al*. 1981).

8.2.6 The Viking Period (*c*. 800 – 1065 cal. AD)

As noted earlier, it seems that few significant changes in the vegetation and environment of Orkney occurred from the end of the Iron Age until the 20th century. Heathland reached its maximum extent around Whaness Burn during the Viking period, and continued to dominate the landscape until the sequence ends at *c*. 1080 cal. AD. Similarly, heathland was the dominant vegetation community at Hobbister at this time and has remained so until the present day. There is no evidence for heathland management at either site.

Evidence for the presence of small patches of local scrub woodland during Viking times is provided by charcoal recovered from the Brough of Birsay (Donaldson *et al*. 1981), as described above, and from the Brough of Deerness in eastern Mainland. At the latter site the only local species represented was willow, and Morris *et al*. (1986) have inferred from this that birch-hazel woodland was not present in the area and a local source of scrub willow was being exploited. As during the preceding Pictish period, there is no evidence for local woodland at either Whaness Burn or Hobbister, although there is no reason why it should not have been present elsewhere in the islands. Equally, the wood used for fuel at the Brough of Birsay and at the Brough of Deerness could have been collected as driftwood.

Evidence for arable cultivation during the Viking period is provided by finds of barley and oats at archaeological sites including those on the Brough of Birsay (Donaldson *et al*. 1981), Howe in Stromness (Dickson 1994) and Pool on Sanday (Bond 2007b). Further evidence for cultivation at this time comes from the site of Quoygrew on Westray (Barrett *et al*. 2005). The discovery of small querns at several sites suggests that flour production occurred on site, although the horizontal mill at the Earl's Bu in Orphir suggests that larger scale milling also occurred in the Viking period (Graham-Campbell and Batey 1998).

Despite the archaeological evidence for arable farming during the Viking period, these practices are not reflected in the palaeoecological record. Previously published palynological evidence for this period is not securely dated, and the new sequences from Whaness Burn and Hobbister show no indications that arable cultivation was practised at this time. The only inferred human activity in these records is possible low intensity rough grazing. This suggests that the intensive agriculture indicated by archaeological

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evidence from sites such as Pool (Bond 2007b) and Quoygrew (Barrett *et al.* 2005) was not viable in the increasingly marginal landscapes of northern Hoy and the Hobbister area. Since the sequence from Blows Moss does not cover the Viking period it is impossible to say whether intensive cultivation at this time would have been reflected in the pollen record from this site.

8.3 Wider Geographical Context

This thesis has provided some evidence that the apparently late development of woodland in Orkney in comparison to north-east mainland Scotland and Shetland may well be due to the exposed western situation of the sites sampled and dated prior to this investigation, as suggesting by Bunting (1994). Woodland in Shetland reached its maximum extent at *c*. 8700 cal. BC, and birch-hazel scrub woodland seems to have been present in north-east mainland Scotland from about 8750 cal. BC (Peglar 1979). In Orkney it seems that some woodland was present when sediment began to accumulate at Blows Moss at *c*. 8340 cal. BC, evidenced by arboreal pollen percentages of *c*. 40%. This woodland seems have reached its fullest extent at around 7850 cal. BC.

Early Holocene woodland composition in all three areas is ambiguous, with only the presence of birch and hazel universally agreed upon. Oak and alder, and possibly elm and ash, are also argued to have been present on Shetland during the early Holocene (Bennett *et al.* 1992). Despite this, the occurrence of small amounts of pollen from species such as oak, elm and pine in Orkney has generally been attributed to long-distance transport from the south (e.g. Moar 1969; Keatinge and Dickson 1979).

The palaeoecological records presented in this thesis show no indications that woodland was more diverse in the east of Orkney, as suggested by Bunting (1994). However there is some evidence that woodland was more diverse at some locations than was previously believed, for example at Whaness Burn in northern Hoy it seems that a short-lived period of local pine growth occurred between *c*. 2170 and *c*. 1750 cal. BC, in the mid-Holocene. Charman (1994) has demonstrated a short-lived occurrence of local pine forest at Cross Lochs in north-east Scotland, beginning at *c*. 2850 cal. BC and ending at around 2400 cal. BC. There is also evidence for the local growth of pine forest between *c*. 3250 and *c*. 2050 cal. BC at Loch Farlary in Sutherland (Tipping *et al.* 2008b). These events occur at around the same time as the range of pine in Scotland is

hypothesised to have expanded northwards in response to the drying out of blanket mire surfaces caused by changes in atmospheric circulation (Gear and Huntley 1991).

Reasons for the apparent greater diversity of woodland in Shetland may be due to differences in geology, since although the surface deposits in Shetland are much less diverse than those in Orkney, mostly consisting of peat with only very small areas of more fertile boulder clay, it has been demonstrated by several of the studies described in Chapter 3 that the spread of blanket peat in the islands is a relatively recent phenomenon, generally occurring in the mid to late Holocene (e.g. Bennett *et al.* 1992; Bennett *et al.* 1993; Edwards and Whittington 1998; Edwards *et al.* 2005). In addition, the solid geology of Shetland is much more varied than that of Orkney, comprising a mixture of igneous, metamorphic and sedimentary rocks, while Orkney mainly consists of sandstone. It is therefore possible that during the early Holocene when woodland was at its greatest extent Shetland supported a greater range of soil types, giving rise to more diversity in vegetation. The topography of Shetland also exhibits more variation than that of Orkney, again due to geological differences, creating more diversity of habitat and many more sheltered locations in which several tree species could grow. It is therefore possible that the differences in woodland composition between Orkney and Shetland are simply a result of the differences in underlying geology. Another explanation for the apparent differences in woodland composition may be provided by the distribution of sampled sites in Orkney, since the only site with clear evidence for the local growth of *Pinus sylvestris* is Whaness Burn, which is situated in a sheltered valley. Other palaeoecological records from Orkney come from more exposed locations.

It has been shown that woodland decline in Orkney is diachronous and occurred for a variety of reasons. It can be seen from Fig. 8.6 that there is a cluster of dates for woodland decline between about 4000 and 3500 cal. BC; at some sites however these represent the primary decline and others the secondary. In north-east Scotland woodland decline typically occurs at around 4000 cal. BC (Charman 1994). In Shetland, the timing of the major decline in tree species occurs later than in Orkney and north-east Scotland, at *c*. 1500 cal. BC (Bennett *et al.* 1992; Edwards *et al.* 2005).

Major human impact in Shetland is determined from palaeoecological records as occurring between *c*. 2000 and 500 cal. BC. This contrasts with the situation in Orkney,

where major landscape change has generally been associated with the arrival of the first Neolithic settlers in the islands at *c.* 4000 cal. BC. However landscape and vegetation changes were not synchronous across Orkney, and at the new sites presented here it seems that agricultural activity was most intensive during the Bronze Age. There are hints of agricultural intensification during the late Bronze Age and early Iron Age in palaeoecological records from other sites in Orkney, as well as in north-east Scotland and Shetland (Keatinge and Dickson 1979; Peglar 1979; Bennett *et al*. 1992), although the evidence from north-east Scotland is not accurately dated.

8.4 Bronze Age 'Decline'?

Three hypotheses regarding the apparent 'cultural decline' in Bronze Age Orkney were identified in Chapter 1. The evidence for each of these hypotheses, incorporating data from this study and from previously published work, is outlined and discussed below.

(1) Population collapse

A failure to respond adequately to changes in the situation of a particular social group may result in social fragmentation, famine, death and large scale emigration (Coles and Mills 1998). There have been suggestions that this may have occurred in Orkney during the Bronze Age on the basis of the archaeological record, which is relatively poorly understood for this period (e.g. Øvrevik 1985; Ritchie 1995). Much archaeological investigation in Orkney has been focused on the highly visible Neolithic and Iron Age structures, with the result that the Bronze Age has, until recently, been largely neglected. Downes (2005) notes that the apparent scarcity of Bronze Age settlement evidence in Orkney is probably the result of failure to identify it, rather than a real lack of occupation at this time.

The gap in settlement evidence for this period is now beginning to be addressed, with a wider range of Bronze Age settlement types being recognised from the islands (e.g. Downes 2005; see Chapter 2). Evidence from archaeological sites such as Crossiecrown (Downes and Richards 1998) and Tofts Ness (Dockrill *et al*. 2007) has demonstrated continuity of settlement occupation across the Neolithic-Bronze Age transition.

The environmental evidence from the islands does not support the hypothesis of population decline either – if the hypothesis were true then it would be expected that the

palaeoecological record would show an overall decrease in the level of human activity, and perhaps a retreat away from the more marginal parts of the landscape since the needs of a smaller population would not require the exploitation of these areas. If anything there is a slight increase in anthropogenic activity and more use is made of marginal regions during the Bronze Age. The population decline hypothesis is therefore an unlikely explanation for the changes seen in the archaeological record.

(2) Change in farming practices forced by environmental change

The apparent Bronze Age 'decline' is often attributed to environmental factors such as climatic deterioration, overuse of the soil in the late Neolithic, effects of the eruption of the Icelandic volcano Hekla in *c*. 1159 cal. BC, and/or the spread of blanket peat (e.g. Øvrevik 1985; Ritchie 1995). It has been suggested that the Hekla 3 eruption was responsible for widespread settlement abandonment across marginal regions of northern Scotland towards the end of the second millennium BC (Grattan and Gilbertson 2000). One proposed mechanism for this is that acid volatiles from Hekla 3 were deposited in quantities far exceeding the annual critical loads of many habitats in northern Scotland. Communities that were already living in marginal environments may have been unable to cope with the added pressures of volcanically induced crop damage and soil acidification, resulting in them being forced to abandon their settlements (Grattan and Gilbertson 2000). However no tephras were located at the three sites studied here, and no Hekla 3 tephra has been found in previous palaeoecological investigations in Orkney, making this an unlikely explanation for Bronze Age 'decline' in the islands.

The soil exhaustion hypothesis is a possibility, since overuse of the soil would lead to deterioration via leaching and podsolisation, perhaps resulting in the spread of heath into more marginal pastures. However no agriculture took place at Whaness Burn prior to the Bronze Age and only low intensity mixed farming was practised at Hobbister during the Neolithic. Widespread heath formation did not occur until after the Bronze Age at both sites, and therefore this explanation also seems unlikely.

The records from Whaness Burn and Hobbister do show indications of the climate becoming slightly wetter and of heath formation beginning during the Bronze Age. However, these changes do not seem to have been significant enough to affect the level of human activity (as measured by the presence of anthropogenic indicator taxa in the pollen record), which remained fairly constant throughout the Bronze Age. It does

seem that more marginal areas, such as blanket peat in the west Mainland hills (Keatinge and Dickson 1979), Whaness Burn, the surface of the fen at Blows Moss and the blanket heath at Hobbister, were exploited for the grazing of livestock during the Bronze Age. This suggests the expansion of agriculture into more environmentally and economically marginal areas at this time, implying increased levels of human activity rather than decline.

Tipping *et al*. (2008a) have demonstrated that at both Reidchalmai, a lowland site in north-east Scotland, and Loch Farlary, an upland site in the same catchment, mixed agriculture including arable cultivation and pastoralism was practised during the later Bronze Age. Following the widely recorded northwest European climatic deterioration at *c*. 850 cal. BC (e.g. van Geel *et al*. 1996; Mauquoy *et al*. 2004; Blundell and Barber 2005; Swindles *et al*. 2007), around the same time as a shift to wetter surface conditions occurred at Loch Farlary, arable cultivation appears to have ceased around this upland site, although the land continued to be grazed. In contrast, around the lowland site of Reidchalmai it appears that arable farming intensified following the shift to wetter conditions. Tipping *et al*. (2008a) suggest that the climate change at *c*. 850 cal. BC resulted in these changes in land-use as populations adapted to the new environmental conditions, with arable cultivation becoming dominant in the lowlands and a pastoral specialism developing in more marginal upland regions.

The new Orcadian evidence presented here could be another example of this process of adaptation and response to changing environmental conditions, with arable cultivation occurring during the Bronze Age at Blows Moss, the non-marginal site, and less intensively at Hobbister, the semi-marginal case study. At Whaness Burn, considered to be the most marginal of the three sites, there is no evidence for cereal cultivation and instead a pastoral economy is inferred throughout the Bronze Age. Pastoralism also seems to have taken place at Blows Moss and Hobbister at this time, with indications that more marginal parts of the landscape at each site, such as the surface of the fen at Blows Moss and the blanket heath at Hobbister, were being exploited for rough grazing. The use of these more marginal areas for the grazing of livestock may suggest that there was increased demand on the cultivation of more fertile regions, resulting in the need to find more grazing land elsewhere. Evidence that people adapted to the challenges posed by environmental change and greater population pressure is provided by the fact that heathland at Hobbister and Whaness Burn seems to have been managed by deliberate

burning throughout the Bronze Age, perhaps in order to improve the quality of the vegetation for grazing.

During the late Bronze Age, grazing activity on the surfaces of the sites studied here seems to have ceased. At Whaness Burn and Hobbister this is likely to be due to inferred increases in surface wetness at the sites themselves. The same pattern is seen at Blows Moss, and it is possible that similar changes in surface wetness occurred here that are not apparent in the palaeoecological record from the site. Arable cultivation continued at Blows Moss and Hobbister, and livestock grazing continued in the landscape surrounding all three sites. This suggests that the changes seen in the palaeoecological records were mainly confined to the wetland zone and were not landscape-wide.

Archaeological evidence from Tofts Ness on Sanday supports the idea of specialisation and adaptation to changing environmental conditions during the Orcadian Bronze Age, with evidence for intensive manuring of calcareous sandy soils which allowed sustained arable cultivation in what would have been an extremely marginal landscape for agriculture (Dockrill *et al*. 2007). Preliminary surveys of the Hacks Ness and Spurness peninsulas, also on Sanday, have revealed extensive evidence of anthropogenic soils around prehistoric structures, indicating that these intensive manuring practices were in use elsewhere (Simpson *et al*. 1998). Overall, it seems that during the Bronze Age in Orkney people adapted their farming practices to suit changing environmental conditions and fully exploit the available resources. This may imply a need to maximise production, either due to environmental change, population expansion, or the reorganisation of settlement patterns resulting in the need for more grazing land for individual households.

(3) Cultural change

Across Scotland and the rest of Europe during the Bronze Age cultural practices seem to reflect greater significance being given to individuals, as opposed to priority being given to belonging to a larger community (e.g. Ashmore 1996; Harding 2000). This is evidenced in Orkney where certain individuals were able to amass personal wealth, such as the person buried at the Knowes of Trotty with four gold discs and several amber beads, objects which indicate links with southern England (Coles 1969). Other than this site, very few finds of Bronze Age metalwork have been made in Orkney, and this has

led to suggestions that the islands were isolated from mainland Britain and the rest of Europe at this time, leading to growing cultural insularity (e.g. Øvrevik 1985). However with the tendency to focus on the highly visible Neolithic and Iron Age structures that has prevailed in archaeological research in Orkney, it is possible that more Bronze Age sites and items of material culture will be found in the future. This is supported by the recent find of a late Bronze Age socketed axe during peat cutting at Hobbister in 2006 (Cowie and O'Connor 2006).

Social organisation in Orkney during the Bronze Age appears to have developed along locally autonomous lines, continuing the process of social fragmentation and isolation which is now hypothesised to have begun towards the end of the Neolithic period (e.g. Richards 1998). The settlement evidence and the barrow cemeteries indicate a scattered settlement pattern, and support for the existence of a largely autonomous society during the Bronze Age is also provided by the massive linear earthworks that run for long distances across Orkney, known as 'treb dykes' (Lamb 1983). This process of social fragmentation and division of the landscape into territories seems to have taken place throughout Britain during the Bronze Age (e.g. Fleming 2008), perhaps as a result of the new emphasis on the importance of individuals in society.

There are clear cultural shifts at the transition from the Neolithic to the Bronze Age in Orkney, with a change from communal to individual burial and the establishment of a more dispersed settlement pattern. Similar shifts occur across Britain at this time, with a move away from communal constructions such as henges and chambered cairns towards smaller, extended family endeavours. Parker Pearson (2005: 96) states that during the Bronze Age 'from an archaeological point of view, the landscape of the dead was replaced by a landscape of the living', with communal burial monuments falling out of use and the landscape being divided up for agricultural purposes. The remains of the dead were no longer at the centre of life, and personal identities became less defined by lineage and more by territory, with control over land being as important as control over people (Parker Pearson 1999). In Orkney, the ceremonial monuments of the Stones of Stenness and the Ring of Brodgar were apparently still important to society at this time, since there is a concentration of Bronze Age burial monuments in the vicinity of the two sites. The move away from the tradition of building communal monuments such as chambered cairns and henges is more likely to have been influenced by changes

in culture and social organisation than by deteriorating environmental conditions leading to a lack of time for construction on such a large scale.

If the changes seen in Orkney are solely the result of cultural processes, then it may be expected that there would be no evidence for a decline in agricultural activity. However there would perhaps be a change in the distribution of agriculture, since a more dispersed population may require more land for grazing than a population clustered in village settlements and sharing common grazing land. The number of livestock kept may also have been indicative of status, and since demonstration of individual status seems to have become important during the Bronze Age (e.g. Harding 2000) it is possible that this could have resulted in the need for greater amounts of grazing land.

There may also be evidence for some specialisation of agriculture, perhaps with a pastoral specialism developing in the upland regions as has been hypothesised for the Garbh Allt catchment in north-east Scotland (Tipping *et al*. 2008a). In this case cereals may have been obtained by trade with other communities that were exploiting lowland areas for arable cultivation, as Tipping and McCullagh (1998) have suggested may have occurred at Lairg in Sutherland. Trade of foodstuffs has been identified as an important stress-buffering mechanism (Dodgshon *et al*. 2000) and may have allowed later prehistoric upland communities to have survived during times of environmental deterioration, although Tipping (2002) proposes that palaeoecological evidence from Scotland suggests that diversification of resources and land-use may actually have been the key to the resilience of these communities.

At Flag Fen in Cambridgeshire there is evidence that a specialisation in the farming of sheep developed during the Bronze Age (Pryor 2001), and it is possible that similar specialisation in stock-keeping developed in Orkney at this time, since sheep would be more suited to grazing the marginal regions of rough pasture that seem to have been exploited than cattle. This is supported by evidence from the relatively marginal site of Tofts Ness on Sanday, where there seems to have been a general shift in favour of sheep over cattle during the Bronze Age (Nicholson and Davis 2007). The evidence from Orkney indicates that during the Bronze Age the distribution of agriculture may have changed slightly with a pastoral specialism, possibly dominated by sheep farming, developing in the more marginal parts of the islands while elsewhere arable cultivation intensified, for example at Blows Moss. This lends some support to the hypothesis of

cultural and social change being responsible for the changes seen in the archaeological record at this time.

Chapter 9: Conclusions

This thesis presents palaeoecological evidence from three previously unstudied wetland basins in Orkney in order to satisfy two aims. The main aim was to investigate the possible Bronze Age 'decline' in the islands and assess the evidence for each of the three hypotheses outlined in Chapter 1 in order to determine the most likely explanation for the changes seen in the Orcadian archaeological record at this time, and to set the Bronze Age environment into its longer-term context. A secondary aim was to determine whether patterns of human activity and environmental impact in Orkney were distinctly different from the rest of Scotland during the Bronze Age. Five research objectives were identified in Chapter 1, and these are restated in simplified form below:

(1) To obtain sedimentary sequences from small (*c*. 100-500 m diameter) basins within landscapes with differing degrees of marginality.

(2) To establish secure chronologies for these sequences.

(3) To produce high-resolution palaeoecological records from these sequences from the period *c*. 3000 cal. BC to *c*. 600 cal. AD (late Neolithic to Iron Age).

(4) To assess the archaeological evidence for changes in settlement patterns in the vicinity of each coring location across the study period.

(5) To synthesise the palaeoecological and archaeological data in order to reconstruct changes in land-use, farming practices and settlement patterns from the late Neolithic to the Iron Age, and investigate the reasons for any changes seen:
  d) At the level of the individual sites studied here.
  e) At the intersite level in order to consider differences between 'marginal' and 'optimal areas' of Orkney.
  f) Across the whole island group, incorporating both new and existing data.
  g) At a regional level, comparing the Orcadian evidence with that from north-east mainland Scotland and Shetland.

Conclusions regarding the hypothesised 'Bronze Age decline' in Orkney are outlined in Section 9.1 of this chapter, and conclusions regarding the possible differentiation of

Orkney from the rest of Scotland during the Bronze Age are addressed in Section 9.2. It became apparent during the course of this research that the general model of Orcadian environmental change commonly incorporated into archaeological discussion (e.g. Renfrew 1985; Ritchie 1995) is overly simplistic, and conclusions relating to this aspect of the research are briefly discussed in Section 9.3. Finally, Section 9.4 discusses the implications of this work for future research in Orkney and presents some recommendations for future lines of investigation in the islands.

9.1 Bronze Age 'decline' in Orkney

The changes seen in the archaeological record of Orkney at the Neolithic-Bronze Age transition are likely to result from a combination of environmental, social and cultural factors. The available palaeoecological evidence indicates that during the Bronze Age a pastoral specialism, perhaps dominated by sheep farming, developed in the more marginal parts of the islands while elsewhere arable cultivation intensified, for example at Blows Moss. This seems to have occurred in response to expansion and/or fragmentation of population which resulted in the exploitation of more marginal landscapes. Changing environmental conditions at the same time meant that people had to adapt their ways of farming in order to fully exploit the available resources. For example, the quality of heathland for grazing seems to have been managed by deliberate burning at Hobbister and Whaness Burn. There is further evidence for adaptation of agricultural practices from Tofts Ness on the island of Sanday, where intensive manuring was carried out to allow continued cultivation in an increasingly marginal environment (Simpson *et al*. 1998; Dockrill *et al*. 2007). There may also have been specialisation in stock-keeping at this site, with an increasing emphasis on sheep rather than cattle developing throughout the Bronze Age (Nicholson and Davis 2007).

The gap in settlement evidence for the Orcadian Bronze Age is beginning to be addressed, with a wider range of Bronze Age settlement types now being recognised from the islands (e.g. Downes 2005; see Chapter 2). Evidence from archaeological sites such as Crossiecrown (Downes and Richards 1998) and Tofts Ness (Dockrill *et al*. 2007) demonstrates continuity of settlement location across the Neolithic-Bronze Age transition. Although there are distinct cultural differences between the Neolithic and Bronze Age, there is now no reason to suggest that Orkney underwent a 'decline' shaped by environmental deterioration during the latter period.

Environmental conditions may have had an indirect effect on cultural activity in Orkney. The islands were situated at the centre of Neolithic and Iron Age trade routes across the North Sea and along the Atlantic seaboard of Europe, resulting in a dense network of intercommunication. However it seems that during the Bronze Age Orkney was not situated on any trade routes, with the only evidence for outside contact provided by the presence of steatite from Shetland. A decline in trade with continental Europe is also argued to have resulted in an 'impoverished' culture in Wessex in southern England at this time (Parker Pearson 2005). It is possible that climatic deterioration (e.g. van Geel *et al*. 1996; Mauquoy *et al*. 2004; Blundell and Barber 2005; Swindles *et al*. 2007) had made the Atlantic sea routes more difficult to navigate, and this may explain the lack of Bronze Age metalwork in Orkney.

There are distinct differences in the way that the land was exploited during the Orcadian Bronze Age. The evidence presented here suggests that these differences were the result of changes in social organisation in combination with adaptation to changing environmental conditions. Bronze Age Orcadians seem to have adapted their farming practices to cope with increased population pressure, changes in social organisation, and changing environmental conditions, and recent archaeological research is beginning to fill in the gaps in the settlement record for this period. As Downes (2005: 23) states, 'It is quite clear that it is our approach to the Orcadian Bronze Age that is 'dull', and not that the Bronze Age society was uninspired.'

9.2 Wider Geographical Context

One of the aims of this thesis was to determine whether patterns of human activity and environmental impact really were distinct from the rest of Scotland during the Bronze Age. There is palaeoecological evidence for agricultural intensification in Shetland at this time (Bennett *et al*. 1992), and in a review of the evidence for Scottish woodland history, Tipping (1994b) identifies a common theme of renewed clearance, or the intensification of existing agriculture, during the early Bronze Age throughout Scotland as a whole. This apparently contrasted with ideas of population and/or cultural 'decline' suggested for Orkney at this time (e.g. Øvrevik 1985; Ritchie 1995), which was supported by the palaeoecological evidence for a predominantly pastoral economy (e.g. Keatinge and Dickson 1979). However this evidence comes from sites in areas of marginal blanket peat, and the new evidence presented in this thesis raises the possibility that a pastoral specialism developed in the more marginal regions of Orkney,

while the more fertile parts of the archipelago were fully exploited for arable cultivation. It now seems that Orkney was more of a part of the general trend of agricultural specialisation and intensification seen in Scotland as a whole during the Bronze Age than has previously been realised.

9.3 Models of Prehistoric Orcadian Environmental Change

It is apparent from the data presented in this thesis (see Section 8.2; Fig. 8.6) that the simple model of Orcadian environmental and vegetation change that has been incorporated into many discussions of the islands' archaeology (e.g. Renfrew 1985; Ritchie 1995) is an over-simplification of the true situation. There is still a lack of palaeoecological records from the North Isles of Orkney, and if this geographical imbalance is redressed in the future then the situation may turn out to be still more complex. Events such as woodland decline and the development of heathland did not occur synchronously across the archipelago, and these events were caused by a complex mixture of anthropogenic, climatic and pedological factors which vary between sites. The high degree of heterogeneity in vegetation patterns during later prehistory has significant implications, both for archaeological interpretation in terms of local resource bases and resource management, landscape appearance, inter-site visibility and impacts of climate change (e.g. Tipping 1994b), and for understanding of past environments in Orkney.

9.4 Implications and Proposals for Future Research

Although this thesis has gone some way towards redressing the balance of Orcadian palaeoecology, presenting evidence from sites with a range of 'marginalities' from three previously under-represented regions of the archipelago, and focussing on the late and post-Neolithic, there are still significant gaps in our knowledge and understanding of prehistoric Orcadian environments.

In the past Orkney has been seen as having low potential for palaeoecological work, with many earlier studies being hampered by dating problems due to the 'hard water effect' caused by the presence of calcareous sediments (e.g. Keatinge and Dickson 1979; Bunting 1994). In comparison with Shetland and the Western Isles, Orkney has relatively few lochs because it has much less topographic variation as a consequence of the smoothing action of the Quaternary ice sheets. The lochs that are present are shallow in comparison with those on mainland Scotland as they are underlain by flat

sedimentary rock and glacial drift deposits (Berry 2000). Shallow lochs do not tend to accumulate deep sediments, and are therefore unsuitable for palaeoecological reconstruction over long timescales. However survey work on several wetlands, including valley mires, fens and areas of blanket peat, was undertaken during fieldwork for this study and has demonstrated that many suitable sites are available (see Chapter 4 for details of all the sites investigated).

There are still no records from the North Isles, although preliminary survey work undertaken during fieldwork for this study has demonstrated the presence of suitable sites on Westray and Eday. It would be interesting to expand this survey work into other islands in the north of the archipelago, such as Sanday and Stronsay, both of which have substantial archaeological evidence for prehistoric human activity.

On-site palaeoenvironmental sampling is typically targeted at answering very specific research questions defined at the start of every individual excavation, and there has been no assessment of its potential to contribute to wider debates surrounding woodland decline and climate change. Orkney is often thought of as providing relatively poor conditions for preservation of some types of palaeoenvironmental data such as pollen grains, because in relation to other parts of Scotland it is seen as a dry and alkaline environment. However, some studies show that pollen preservation can be good (e.g. Bunting *et al*. 2001), and that sampling a wide range of contexts is potentially fruitful. On-site sampling for pollen analysis in Orkney may be particularly valuable in parts of the archipelago where there is a real lack of suitable coring sites.

A more focused programme of environmental sampling also needs to be developed and tested in a defined area of Orkney. This should involve detailed survey of all potential palaeoecological 'archives' (valley mires, blanket peat, lakes, fens, etc), in combination with archaeological survey at a landscape scale and on-site palaeoenvironmental sampling. This would allow a reconstruction of settlement patterns and land-use at a broad scale for the whole area investigated, while providing specific detail and context for particular archaeological sites within the landscape. Changes in agricultural practices over time as well as differences between sites of the same age could perhaps be elucidated in this manner for a specific area of the islands. It is clear that more site-specific and on-site palynology is required, in combination with other techniques

such as plant macrofossil analysis and soil thin section analysis, in order to fully establish the nature of prehistoric agricultural practices.

It would also be interesting to carry out an investigation specifically targeted at reconstructing the palaeoclimate of Orkney. Since the hydrology of raised bogs such as that at Glims Moss is primarily dependent on rainfall rather than runoff, it may be possible to obtain a palaeoclimate record from this site via the analysis of plant macrofossils, peat humification and testate amoebae (e.g. Mauquoy and Barber 2002). Glims Moss was previously investigated as part of a study of vegetational history by Keatinge and Dickson (1979). The record from this site has been shown to cover the period from *c*. 4550 cal. BC to *c*. 150 cal. BC by radiocarbon dating, and may extend to the present day. Re-coring this site may therefore allow the reconstruction of a palaeoclimate record from Orkney covering at least the period from the late Mesolithic to the middle Iron Age, allowing better assessment of the impact of climatic changes on human society in the islands.

During fieldwork for this project, surface samples were collected and the surrounding vegetation recorded. Analysis of these samples and comparison with the modern vegetation data may allow the development of an arable-pastoral index for Orkney, similar to that developed by Turner (1964) for southern Britain. This would allow more confident interpretation of changes in Bronze Age agricultural practices in the islands and refinement of the model of adaptation and specialisation proposed above.

The techniques for modelling pollen dispersal and deposition developed by the POLLANDCAL network (e.g. Bunting *et al*. 2007; Gaillard *et al*. 2008; Bunting and Middleton 2009) could be applied to the data from the three sites studied here in order to test hypotheses about the extent of woodland cover in Orkney, as well as the composition of prehistoric woodland in the islands. For example the hypothesised local presence of pine at Whaness Burn could be tested against the idea that all the pollen of this species originated on the Scottish mainland. The modelling techniques could also be used to investigate the likelihood of detection of prehistoric agriculture at the sites investigated (e.g. Tipping *et al*. 2009), in order to check whether the results presented here are a true reflection of human activity in Orkney from *c*. 3000 cal. BC to *c*. 600 cal. AD.

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Appendix 1: Tables of Uncalibrated Radiocarbon Dates

Site	Material dated	Radiocarbon age (years BP)	Laboratory reference	Calibrated age (BC/AD)	Reference
Sandside	Human bone from cist	865 ±55	GU-1067	1150 ±56 AD	Hedges (1978b)
Stones of Stenness	Animal bone from basal ditch deposit	4306 ±65	SRR-350	2972 ±146 BC	Ritchie (1976)

Table A1.1 Archaeological radiocarbon dates from Orkney as cited in the original publications (uncalibrated), alongside calibrated dates derived using CALIB 5.1 (Stuiver and Reimer 1993)

Site	Depth (cm)	Radiocarbon age (years BP)	Laboratory reference	Calibrated age (BC/AD)	Reference
Braes of Aglath	Not cited (base of peat)	2919 ±45	SRR-983	1123 ±72 BC	Keatinge and Dickson (1979)
Burn of Rusht	Not cited (base of peat)	3355 ±45	SRR-982	1635 ±55 BC	Keatinge and Dickson (1979)
Glims Moss	501-508	5681 ±55	SRR-976	4528 ±78 BC	Keatinge and Dickson (1979)
	454-450	4200 ±160	Birm-635	2842 ±247 BC	
	395-400	2960 ±110	Birm-634b	1168 ±132 BC	
	369-376	2886 ±65	SRR-975	1096 ±96 BC	
	288-295	2090±60	SRR-974	152 ±101 BC	
	225-232	2145 ±65	SRR-973	210 ±85 BC	
Keith's Peat Bank	155-161	6450 ±80	GU-3213	5417 ±94 BC	Blackford *et al.* (1996)
	149.5-153.5	5560 ±90	GU-3214	4441 ±104 BC	
	139-143	4750 ±100	GU-3215	3452 ±156 BC	
Knowes of Quoyscottie	Not cited (old ground surface below mound)	2866 ±150	Not cited	1110 ±163 BC	Hedges (1977)
Lesliedale Moss	270-275	3826 ±65	SRR-506	2261 ±104 BC	Jones (1979)
	205-210	3371 ±45	SRR-507	1647 ±60 BC	
Maeshowe North	68-70	4133 ±65	SRR-505	2693 ±97 BC	Jones (1979)
Maeshowe South	63-65	3446 ±50	SRR-524	1760 ±64 BC	Jones (1979)
	58-60	2880 ±45	SRR-523	1068 ±72 BC	
	53-55	1683 ±45	SRR-522	385 ±72 AD	
	43-45	1235 ±40	SRR-521	784 ±51 AD	
Maeshowe upper peat layer	80-85	3662 ±65	SRR-504	2078 ±99 BC	Jones (1979)
Mid Hill	Not cited (base of peat)	3422 ±45	SRR-981	1750 ±65 BC	Keatinge and Dickson (1979)
Ring of Brodgar	68-70	2207 ±60	SRR-502	253 ±71 BC	Jones (1979)
	58-60	2323 ±45	SRR-503	366 ±163 BC	

Table A1.2 Palaeoecological radiocarbon dates from Orkney as cited in the original publications (uncalibrated), alongside calibrated dates derived using CALIB 5.1 (Stuiver and Reimer 1993)

Site	Depth (cm)	Radiocarbon age (years BP)	Laboratory reference	Calibrated age (BC/AD)	Reference
Cross Lochs	728-744	11,100 ±90	SRR-3867	11,078 ±74 BC	Charman (1994)
	660-676	10,800 ±85	SRR-3866	10,849 ±60 BC	
	344-352	8995 ±50	SRR-3712	8135 ±80 BC	
	280-288	7575 ±45	SRR-3711	6389 ±58 BC	
	192-200	5880 ±45	SRR-3710	4744 ±65 BC	
	134-142	4250 ±45	SRR-3709	2840 ±83 BC	
	118-126	3920 ±45	SRR-3708	2401 ±83 BC	
	48-56	1470 ±45	SRR-3707	549 ±54 AD	
Loch of Winless	590-610	12,820 ±350	Q-1175	13,095 ±522 BC	Peglar (1979)
	435-445	10,765 ±310	Q-1176	10,549 ±394 BC	
	395-405	9430 ±110	Q-1325	8764 ±206 BC	
	350-360	8650 ±100	Q-1326	7845 ±163 BC	
	290-295	7570 ±80	Q-1327	6420 ±85 BC	
	220-225	6920 ±70	Q-1328	5826 ±77 BC	
	157.5-162.5	4840 ±85	Q-1443	3586 ±105 BC	
	115-120	3415 ±80	Q-1444	1719 ±99 BC	
	100-105	3065 ±80	Q-1445	1278 ±111 BC	
	70-80	2210 ±59	Q-1329	258 ±68 BC	

Table A1.3 Uncalibrated radiocarbon dates from north-east Scotland as cited in the original publications, alongside calibrated dates derived using CALIB 5.1 (Stuiver and Reimer 1993)

Site	Depth (cm)	Radiocarbon age (years BP)	Laboratory reference	Calibrated age (BC/AD)	Reference
Dallican Water	698-710	9350 ±90	Q-2755	8707 ±201 BC	Bennett et al. (1992)
	652-664	7775 ±90	Q-2756	6731 ±146 BC	
	578-590	5670 ±95	Q-2757	4529 ±93 BC	
	552-564	5085 ±100	Q-2758	3937 ±143 BC	
	478-486	3350 ±70	Q-2759	1666 ±104 BC	
	433-439	1565 ±65	Q-2760	493 ±71 AD	
Gunnister Water	Not cited	9785 ±80	Not cited	9147 ±151 BC	Bennett et al. (1993)
	Not cited	9405 ±70	Not cited	8793 ±162 BC	
	Not cited	9300 ±70	Not cited	8523 ±100 BC	
	Not cited	8605 ±110	Not cited	7774 ±197 BC	
	Not cited	7110 ±70	Not cited	6007 ±98 BC	
	Not cited	5660 ±125	Not cited	4527 ±133 BC	
	Not cited	2685 ±60	Not cited	876 ±51 BC	
	Not cited	1870 ±50	Not cited	139 ±57 AD	
Lang Lochs Mire	725-755	13,200 ±100	SRR-1552	13,703 ±212 BC	Hulme and Shirriffs (1994)
	645-650	10,450 ±70	SRR-1551	10,434 ±140 BC	
	515-520	9600 ±70	SRR-1550	9005 ±112 BC	
	370-375	7720 ±70	SRR-1549	6560 ±59 BC	
	295-300	7280 ±60	SRR-1548	6133 ±57 BC	
	280-285	6445 ±80	SRR-1648	5393 ±82 BC	
	195-200	5250 ±50	SRR-1547	4101 ±66 BC	
	180-185	4575 ±95	SRR-1647	3288 ±172 BC	
	65-70	1030 ±45	SRR-1646	1023 ±64 AD	
Murraster	Not cited	10,400 ±160	Not cited	10,305 ±272 BC	Bennett (1993)
	Not cited	10,110 ±160	Not cited	9845 ±281 BC	
	Not cited	7850 ±120	Not cited	6762 ±142 BC	
	Not cited	4650 ±80	Not cited	3373 ±132 BC	
	Not cited	520 ±70	Not cited	1450 ±82 AD	
Scord of Brouster	345-355	4680 ±50	SRR-1738	3497 ±67 BC	Keith-Lucas (1986)
	220-230	4180 ±100	Birm-966	2743 ±134 BC	
	200-210	3610 ±50	SRR-1737	1959 ±88 BC	
	150-160	3450 ±50	SRR-1736	1762 ±64 BC	
	Not cited (base of blanket peat)	2250 ±50	SRR-1744	299 ±49 BC	

Table A1.4 Uncalibrated radiocarbon dates from Shetland as cited in the original publications, alongside calibrated dates derived using CALIB 5.1 (Stuiver and Reimer 1993)